Int.J.Curr.Microbiol.App.Sci (2020) *9*(12): 575-591

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 9 Number 12 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.912.069

Interaction Effects of Genotypes and Sowing Dates on the Growth and Yield of Cauliflower (*Brassica oleracea* L. var. *botrytis*) in Kerala

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Keywords

Brassica oleracea L. var. *botrytis*, Tropical cauliflower, Genotypes, Date of sowing, Interactions, Curd compactness, Net curd weight, NS 60 N

Article Info

Accepted:
07 November 2020
Available Online:
10 December 2020

A B S T R A C T

Twelve cauliflower genotypes were evaluated against four sowing dates viz, October 1st, October 15th, November 1st, November 15th at Kerala. Analysis of variance revealed significant difference among sowing dates, genotypes and their interactions for all the characters studied. Among the sowing dates, November 1st sowing recorded highest curd and yield characters. Better plant height, leaves per plant, gross plant weight and leaf size were also exhibited by November 1st sowing. Among the varieties, NS 60N was the highest yielder based on yield characters. Curd depth, curd diameter and curd size index were also highest for NS 60N followed by G 45. Earliest among the varieties was Himshort followed by NS 60N. The interaction effects were significant for all the characters studied. Yield characters were best for NS 60N sown on November 1st. Best curd characters were exhibited by November 1st sowing of NS 60N. The study identified two high yielding hybrids namely NS 60N and G 45 as promising and November 1st sowing as the best sowing time for cultivation in the plains of Kerala.

Introduction

Cauliflower (*Brassica oleracea* L. var. *botrytis*) a member of Brassicaceae, is one of the most important vegetables in the world. It occupies the pride of place among the cole crops due to its delicious taste, flavour and nutritive value. Cauliflower is grown for its white tender compact curd formed by the shortened flower parts. Curd is a hypertrophied pre floral meristamatic growth, which terminates main stem of the plant.

Cauliflower was introduced to India, from England in 1822 by the British (Nath *et al.*, 1994). The initial introduction was Cornish types followed by European types. Since then it has undergone acclimatisation and selection as a result of which the Indian cauliflower or tropical type has attained characteristically different form as a result of intercrossing between Cornish and other European types (Swarup and Chatterjee, 1972). The Indian cauliflowers are earlier in maturity and are adapted to warm humid conditions.

Temperature plays crucial role in curd formation of cauliflower. Indian cauliflower varieties were classified into three categories *viz*., early, mid and late on the basis of temperature requirement for curd formation (Seshadri and Chatterjee, 1996).

Cauliflower is comparatively a new crop in Kerala particularly in the plains. Though it has great demand in Kerala, we largely depend on the neighbouring states for this highly esteemed vegetable. The high ranges of Kerala offers ample scope for the cultivation of cole crops, which in turn would reduce the dependence on neighbouring states. Until recently, cultivation of cauliflower was possible only in the hill tracts of Idukki and Wynad districts. Of late, with the advent of tropical cauliflower genotypes, cultivation is made possible in plains of Kerala also. So identification of suitable cauliflower genotypes for the plains would in turn increase internal production and reduce the consumer dependence on supply from neighbouring states.

Apart from genotypes, time of planting is another key factor which determines the productivity. In general, the cooler months of October - January is ideal for cauliflower cultivation in Kerala. Since the genotypes are very specific in its temperature requirement for curding, identification of the most suitable time of sowing for a particular genotype will definitely help in increasing productivity. Therefore, an attempt was made in the present investigation to identify superior genotypes with high yield and to identify the most suitable time of sowing of these genotypes and to study the interaction effect of sowing dates and genotypes in the plains of Kerala.

Materials and Methods

The present experiment was carried out at Department of Vegetable Science, College of Agriculture, Vellayani, Kerala Agricultural University during October 2012 to March 2013. The experimental site was located at 8^{o} $5^{'}$ N latitude and 77^{o} $1^{'}$ E longitude at an altitude of 29 m above mean sea level. Split plot design was adopted for the layout of the experiment with four sowing dates as main plot treatments and twelve genotypes as sub plot treatments (Fig. 1). The mainplot treatments viz, October 1^{st}, October 15^{th}, November 1^{st}, November 15^{th} sowing dates and subplot treatments viz, Pusa Meghna, Pusa Sharad, Pusa Paushja, Pusa Hybrid 2, Pusa Shukti, NS 60 N, Himshort, Himlatha, Himpriya- 60, Indam 2435, G 45, White Snow. The seedlings were raised in protrays and one month old seedlings were transplanted into the main field at a spacing of 60 x 60 cm. All cultural operations like weeding, fertilizer application, irrigation, earthing up and spraying of pesticides were done as per the recommendations (KAU, 2011). Observations were recorded on five randomly selected competitive plants per replication for each entry on sixteen traits, *viz*., plant height (cm), leaves per plant, gross plant weight (kg), leaf size (cm^2), days to curd initiation, days to curd harvest, curd depth (cm), curd diameter (cm), curd size index (cm^2), curd compactness (g/cm^3), stalk length (cm), net curd weight (g), gross curd weight (g), yield per hectare (t. ha^{-1}), harvest index, percentage curding (%).

Results and Discussion

Plant height was significantly different for sowing dates and genotypes (Table 1). It was highest (66.50 cm) for November 1^{st} sowing and lowest (55.07 cm) for October 1^{st} sowing. Maximum plant height (67.03 cm) was recorded for Himpriya 60 and minimum (54.11 cm) for Himshort. The interaction between sowing dates and genotypes was significant for plant height and highest plant height (70.86 cm) was recorded for Pusa

Paushja sown on November 1st and lowest (39.25 cm) for Pusa Meghna sown on October 1st.

Leaves per plant differed significantly for sowing dates and genotypes. It was highest (25.85) for November 1st sowing followed by October 15th (24.92) and lowest (22.69) for October 1st. Himpriya- 60 recorded maximum leaves per plant (28.33) followed by Pusa Hybrid 2 (27.56) and minimum (21.78) for Pusa Paushja (Table 1). The interactions among various treatment combinations were also significant. The results showed that among the treatment combinations, October 15th sowing of Himpriya- 60 (32.84) which was on par with November 15th sowing of Pusa Hybrid 2 (32.79) had maximum number of leaves and November 15th sowing of Pusa Paushja (19.18) had minimum.

Gross plant weight varied significantly for sowing dates and November 1st sowing resulted in maximum gross plant weight (1.37 kg) while lowest (1.17 kg) was noticed in November 15th sowing. Significant difference was obtained for genotypes also. Himpriya-60, Pusa Hybrid 2 and G 45 were superior and on par for gross plant weight (1.64, 1.47 and 1.31 kg). Interaction effect was also significant. Maximum gross plant weight (2.29 kg) was observed for Himpriya-60 sown on November1st which was on par with Pusa Hybrid-2 (1.71 kg) sown on the same time. Pusa Paushja sown on 15th October (0.84 kg) resulted in least value (Table 1).

Leaf size of plants varied significantly for sowing dates and genotypes and November 1st sowing resulted in maximum leaf size (1159.77 cm^2) and lowest leaf size (860.18 cm^2) was noticed in October 1st sowing (Table 2). Himpriya- 60 was superior (1247.29 $cm^{2)}$ in leaf size and smallest leaf size (835.01 cm^2) was recorded for Himshort. Interaction effect was also significant. Maximum leaf size (1344.65 cm^2) was obtained for November 1st sowing of Himpriya- 60 which was on par with October 15th sowing of Himpriya- 60 (1315.068 cm^2), November 1st sowing of G 45 (1302.96 cm^2) and November 1st sowing of Pusa Hybrid 2 (1301.83 cm^2). Smallest leaf size (740.96 cm^2) was obtained for October 1st sowing of Pusa Sharad.

Different sowing dates exerted significant influence on days to curd initiation in cauliflower (Table 2). Sowing on November 15th resulted in earliest curd initiation (47.14 days) while on October 15th resulted in latest (55.52 days). Genotype differences also influenced days to curd initiation in cauliflower. Himshort (38.72 days) followed by NS 60N (44.42 days) was earliest. Maximum number of days taken for curd initiation was observed in T2, Pusa Sharad (66.57 days). Significant difference was observed between interactions for this character. November 15th sowing of Pusa Shukti (37.04 days) which was on par with October 1st sowing of Himshort (37.22 days), November 1st sowing of Himshort (38.16 days) and October 15th sowing of Himshort (39.23 days) recorded least number of days for curd initiation. Maximum number of days for curd initiation (79.50 days) was taken by October 1st sowing of Pusa Sharad which was on par with October 15th sowing of Pusa Hybrid 2 (78.97 days).

Days to curd harvest were influenced by different sowing dates and genotypes. Sowing on October 1st (61.61days) resulted in minimum days to harvest and that on October 15th (69.13 days) resulted in maximum days for harvest (Table 2). Among the genotypes, Himshort (49.04 days) followed by NS 60N (55.44 days) which was on par with Pusa Meghna (56.76 days) was earliest whereas Pusa Sharad (86.39 days) was late for harvest. Significant difference was observed between interactions also. Minimum days for curd

harvest (47.91 days) were observed in October 1st sowing of Himshort which was on par with November 1st sowing of Himshort (48.18 days), October 15th sowing of Himshort (49.80 days) and November 15th sowing of Himshort (50.27 days). Maximum number of days for harvest (102.52 days) was taken by October 15th sowing of Pusa Hybrid 2 followed by October 1st sowing of Pusa Sharad (96.50 days).

Curd depth was significantly influenced by different sowing dates and genotypes. November 1st sowing recorded maximum curd depth (8.31 cm) while November 15th sowing recorded the minimum (6.25 cm). Among genotypes, it was highest (9.82 cm) for NS 60 N followed by G 45 (8.67 cm) and lowest (3.72 cm) for Pusa Sharad (Table 3). Interaction effect was significant for curd depth. Maximum depth (11.93 cm) was observed for October 1st sowing of Pusa Hybrid 2 which was on par with November 1st sowing of NS 60 N (10.78 cm), October 1st sowing of NS 60 N (10.53 cm), October 15th sowing of Indam 2435 (10.36 cm) and November 1st sowing of Himlatha (10.30 cm). Least value (2.24 cm) was obtained for October 15th sowing of Pusa Hybrid 2 followed by November 15th sowing of Pusa Sharad (2.96 cm).

Curd diameter for different sowing dates varied significantly and was highest (12.57 cm) for November 1st sowing which was on par with October 1st sowing (12.56 cm). Lowest curd diameter (9.51 cm) was noticed in November 15th sowing which was on par with October 15th sowing (9.53 cm). It was influenced significantly by different cauliflower genotypes. Maximum curd diameter (14.54 cm) was obtained for NS 60N and lowest (5.61 cm) for Pusa Sharad. Interaction effect was also significant for curd diameter (Table 3). Maximum curd diameter was obtained for November 1st sowing of NS 60N (16.54 cm) and minimum for October 15th sowing of Pusa Hybrid 2 (2.71 cm) followed by November 1st sowing of Pusa Hybrid 2 (3.91 cm).

Curd size index is the product of curd depth and curd diameter of observation plants and different sowing dates and genotypes exerted significant influence on curd size index of cauliflower. Highest curd size index (104.42 cm^2) was associated with November 1st sowing which was on par with October 1st sowing (102.18 cm^2). Least curd size index (59.45 cm^2) was obtained for November 15th sowing (Table 4). It was maximum (142.68 cm^2) for NS 60N followed by G 45 (112.61cm^2) and minimum (20.84 cm^2) for Pusa Sharad. Significant difference was observed between interactions also. Maximum curd size index (190.93 cm^2) was observed in October 1st sowing of Pusa Hybrid 2 which was on par with November 1st sowing of NS 60 N (178.21 cm^2) and minimum (6.07 cm^2) was observed in October 15th sowing of Pusa Hybrid 2.

The compactness index of the curd was worked out by the formula given by Pearson (1931) as given below: where, Z is an index of compactness, C is the net weight of the curd and W is the average of depth and diameters of the curd. A higher value of z indicates a more compact curd.

$$Z = \frac{C}{W3} \times 100$$

Curd compactness varied significantly for sowing dates and genotypes. It was observed that November 15th sowing (47.53 g/cm^3) produced highly compact curds and October 1st sowing (30.38 g/cm^3) on produced least compact curds. Pusa Sharad (84.22 g/cm^3) on par with Pusa Hybrid-2 (72.31 g/cm^3) produced highly compact curds and NS 60 N (25.15 g/cm^3) which was on par with Pusa

Meghna produced least compact curds (29.81 g/cm^3). Interaction effect was also highly significant (Table 4). Highly compact curds (356.18 g/cm^3) were obtained for October 15th sowing of Pusa Hybrid 2 and least compact curds (17.21 g/cm^3) were obtained for October 1st sowing of Pusa Hybrid 2.

Stalk length varied significantly for different sowing dates and November 1st sowing recorded minimum stalk length (3.83 cm) whereas, maximum (4.98 cm) recorded for October 15th sowing. Stalk length was influenced significantly by different cauliflower genotypes (Table 4). Least stalk length (3.50 cm) was observed for NS 60 N while it was maximum (5.55 cm) for Pusa Sharad. Interaction effect was highly significant for stalk length. Least stalk length (2.99 cm) was obtained for November 1st sowing of Pusa Meghna which was on par with November 1st sowing of NS 60 N (3.11 cm), November 1st sowing of White Snow (3.15 cm) and November 1st sowing of G 45 (3.17 cm) and maximum stalk lengths were obtained for October 15th sowing of Pusa Sharad (6.39 cm).

Net curd weight was influenced by different sowing dates and genotypes. It was maximum (361.69 g) for November 1st sowing. Lowest net curd weight (212.77 g) was observed for October 15th sowing (Table 5). Among genotypes, highest curd weight (454.02 g) was obtained for NS 60 N followed by G 45 (362.27 g) and lowest (85.31 g) for Pusa Sharad. Significant difference was observed between interactions also. Highest net curd weight (629.33 g) was obtained for November 1st sowing of NS 60 N. It was minimum for November 1st sowing of Pusa Hybrid 2.

Gross curd weight was influenced by different sowing dates and genotypes (Table 5). It was maximum for (408.68 g) November 1st sowing and lowest for October 15th sowing (263.81 g) and November 15th sowing (278.67 g). Maximum curd weight (505.08 g) was obtained for NS 60 N followed by G 45 (415.58 g). Lowest gross curd weight (132.66 g) was recorded for Pusa Sharad followed by Pusa Hybrid 2 (207.64 g), Pusa Shukthi (273.92 g), Pusa Paushja (255.75 g). Interaction effects also varied significantly. Maximum gross curd weight (670.00 g) was obtained for November 1st sowing of NS 60 N and was minimum for November 1st sowing of Pusa Hybrid 2 (80.67 g).

Yield per hectare was significantly influenced by different sowing dates and genotypes. It was maximum (10.05 t. ha^{-1}) for November 1st sowing and lowest yield (5.91 t. ha^{-1}) was observed for October 15th sowing (Table 6). The top yielder was NS 60N (12.61 t. ha^{-1}) followed by G 45 (10.06 t. ha^{-1}), Himlatha (9.85 t. ha^{-1}), Himpriya-60 (9.53 t. ha^{-1}), White snow (9.13 t. ha^{-1}) and Pusa Meghna (9.03 t. ha^{-1}) and lowest for Pusa Sharad (2.37 t. ha^{-1}) followed by Pusa Hybrid 2 (4.58 t. ha^{-1}). Significant difference was observed between interactions between different sowing dates and genotypes for yield per hectare. Highest yield (17.48 t. ha^{-1}) was obtained for November 1st sowing of NS 60 N. It was lowest for November 1st sowing of Pusa Hybrid 2 (1.44 t. ha^{-1}).

Harvest Index is the ratio of economic yield (net curd weight) to biological yield (gross plant weight) and was influenced by different sowing dates and genotypes (Table 5). Harvest index was maximum (0.28) for November 1st sowing. Lowest harvest index (0.19) was observed for October 15th sowing which was on par with November 15th sowing (0.19). Among genotypes, highest harvest index (0.35) was obtained for NS 60 N followed by Himshort (0.29) and Himlatha (0.29) and lowest (0.08) for Pusa Sharad followed by Pusa Hybrid 2 (0.12). Interaction effects were highly significant for harvest

index. November 1st sowing of NS 60 N (0.45) and November 1st sowing of Himshort (0.44) recorded high harvest index whereas D3T4 (0.03) recorded low.

Percentage of curding varied significantly among different sowing dates, genotypes and their interactions (Table 6). November 1st sowing recorded highest curding percentage (82.66 %) and lowest (76.00 %) for October 15th sowing. Among genotypes NS 60 N, Himpriya- 60, G 45 recorded complete curding, whereas Pusa Shukti (23.00 %), Pusa Hybrid 2 (30.00 %) and Pusa Sharad (33.00 %) exhibited least curding percentage. Complete curding was observed for October 1st sowing of Pusa Meghna, NS 60 N, Himshort, Himlatha, Himpriya- 60, G 45, Indam 2435, White Snow, October 15th sowing of NS 60 N, Himpriya- 60, G 45, Indam 2435, November 1st sowing of Pusa Meghna, NS 60 N, Himshort, Himlatha, Himpriya- 60, G 45, Indam 2435, White Snow, November 15th sowing of NS 60 N, Himpriya- 60 and G 45. Least curding was observed in October 1st sowing of Pusa Sharad (12.00 %).

The response of cauliflower to different sowing dates, genotypes and their interaction revealed significant differences with respect to vegetative, curd and yield characters

Vegetative characters

In the present study, November 1st sowing resulted in maximum plant height, leaves per plant, gross plant weight and leaf size. These results are in agreement with the findings of Srivastava *et al.,* (2002). Similarly, influence of sowing dates on different vegetative characters like leaves per plant, leaf area index, plant weight were reported by Ajithkumar (2005), Kaur *et al.,* (2007) and Din *et al.,* (2007). The better plant growth of November 1st sowing might be due to conducive climatic conditions which in turn resulted in high dry matter accumulation.

Among the genotypes Himpriya 60 excelled other varieties in overall performance with respect to all the vegetative characters like plant height, leaves per plant, gross plant weight and leaf size whereas, Himshort recorded the least values. Varietal variation for vegetative characters of cauliflower was reported by Jindal and Thakur (2004), Hamid *et al.,* (2005), Kumar *et al.,* (2006), Sharma *et al.,* (2006), Singh *et al.,* (2006), Devraju *et al.,* (2010) and Yadav *et al.,* (2013).

Interaction effects for dates of sowing and genotypes were also significant for all vegetative characters. Cumulative effect of best sowing date and variety for vegetative characters were reflected in their interaction too. Maximum plant height and leaves per plant were recorded for November 1st sowing of Pusa Paushja and October 15th sowing of Himpriya 60 whereas, highest gross plant weight and leaf size were recorded for November 1st sowing of Himpriya 60. Findings of Pradeepkumar *et al.,* (2002), Jana and Mukhopadhyay (2006), Sharma *et al.,* (2006) were in line with the present results.

Earliness

Earliness in curd initiation and harvest are preferred characters in cauliflower since the duration of winter is too short in Kerala especially in the plains. According to Booij (1987) days to curd initiation was influenced by the number of days until the 19th leaf was initiated and by the mean temperature from that date until curd initiation. The plants will remain in their vegetative phase till the advent of favorable temperature for curd initiation. A temperature of 20-24^{o}C is optimum for curding in early cultivars of cauliflower (Nieuwhof, 1969).

Table.1 Effect of sowing dates, genotypes and their interactions on plant height, leaves per plant and gross plant weight of cauliflower

Genotypes	Plant height (cm)					Leaves per plant					Gross plant weight (kg)				
	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean
Pusa Meghna	39.25	60.50	67.52	58.72	56.50	21.61	23.78	27.95	22.05	23.85	1.30	1.09	1.17	0.96	1.13
Pusa Sharad	45.24	68.22	69.98	68.00	62.86	21.63	19.73	22.92	26.21	22.62	1.27	1.37	1.01	0.99	1.16
Pusa Paushja	42.48	66.56	70.86	60.34	60.06	19.83	24.81	23.30	19.18	21.78	1.34	0.84	1.09	1.00	1.07
Pusa Hybrid 2	65.44	65.60	69.02	60.04	65.03	24.42	29.73	23.30	32.79	27.56	1.27	1.61	1.71	1.29	1.47
Pusa Shukti	59.04	55.92	61.68	57.70	58.59	21.43	20.93	21.52	27.02	22.73	1.12	1.40	1.23	1.11	1.22
NS 60 N	64.13	64.53	66.76	60.36	63.94	28.20	27.50	26.52	24.37	26.65	1.16	1.11	1.43	1.43	1.28
Himshort	49.56	47.06	57.78	62.02	54.11	19.41	19.76	29.18	23.65	23.00	1.06	0.99	0.97	0.94	0.99
Himlatha	44.41	60.12	63.90	59.14	56.89	23.00	27.33	27.15	22.10	24.89	1.25	0.96	1.47	1.24	1.23
Himpriya- 60	67.67	66.26	70.04	64.16	67.03	26.82	32.84	29.91	23.75	28.33	1.53	1.22	2.29	1.53	1.64
Indam 2435	62.00	62.42	65.78	61.20	62.85	21.41	25.87	26.20	24.15	24.41	1.22	1.33	1.31	0.96	1.21
G 45	63.55	63.72	70.16	64.80	65.56	22.08	24.48	26.23	23.47	24.07	1.29	1.24	1.43	1.27	1.31
White Snow	58.03	61.42	64.54	57.78	60.44	22.52	22.23	25.96	21.91	23.15	1.27	1.26	1.34	1.27	1.29
Mean	55.07	61.86	66.50	61.19		22.69	24.92	25.85	24.22		1.26	1.20	1.37	1.17	
CD (5%)	D				0.828					0.385					0.020
	G				1.134					0.708					0.340
	DxG				2.268					1.415					0.680

Table.2 Effect of sowing dates, genotypes and their interactions on leaf size, days to curd initiation and curd harvest of cauliflower

Genotypes	Leaf size (cm^2)					Days to curd initiation					Days to curd harvest				
	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean
Pusa Meghna	839.59	876.94	1042.50	854.45	903.37	46.140	46.83	42.97	46.31	45.56	58.66	57.93	54.19	56.27	56.76
Pusa Sharad	740.96	924.52	1001.00	872.81	884.82	79.50	73.39	63.70	49.70	66.57	96.50	90.67	83.46	74.92	86.39
Pusa Paushja	953.28	1013.67	1193.06	924.39	1021.10	52.94	66.20	58.10	45.61	55.71	66.23	80.52	70.79	66.68	71.06
Pusa Hybrid 2	845.72	1065.12	1301.83	1159.55	1093.06	43.34	78.97	64.44	47.05	58.44	54.66	102.52	86.76	77.21	80.29
Pusa Shukti	844.04	1114.14	1220.84	988.41	1041.86	48.80	65.60	48.60	37.04	50.00	64.13	84.16	62.78	80.04	72.78
NS 60 N	861.41	1043.69	1147.38	1027.91	1020.10	43.56	45.81	44.47	43.84	44.42	55.67	56.33	55.08	54.69	55.44
Himshort	780.24	797.72	1015.64	746.42	835.01	37.22	39.23	38.16	40.27	38.72	47.91	49.80	48.18	50.27	49.04
Himlatha	797.00	1025.09	1063.18	874.33	939.90	48.90	45.48	52.42	49.07	48.97	60.48	56.78	64.29	60.02	60.39
Himpriya- 60	1103.18	1315.07	1344.65	1226.25	1247.29	49.44	60.85	59.20	48.20	54.42	61.83	72.46	70.49	59.61	66.10
Indam 2435	788.03	856.36	1054.80	857.71	889.22	44.48	43.95	53.77	53.39	48.90	56.56	55.10	64.62	64.18	60.12
G 45	880.62	1157.84	1302.96	977.85	1079.82	41.03	47.23	51.53	51.43	47.80	53.70	59.07	63.11	62.81	59.67
White Snow	888.06	1117.73	1229.39	916.63	1037.95	50.29	52.72	60.39	53.82	54.31	62.93	64.27	72.26	66.10	66.39
Mean	860.18	1025.66	1159.77	952.23		48.80	55.52	53.15	47.14		61.61	69.13	66.33	64.40	
CD (5%)	D				27.227					0.968					0.885
	G				35.223					1.374					1.444
	DxG				70.445					2.747					2.889

Table.3 Effect of sowing dates, genotypes and their interactions on curd depth and diameter of cauliflower

Genotypes	Curd depth (cm)					Curd diameter (cm)				
	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean
Pusa Meghna	7.53	7.77	8.89	7.04	7.81	12.96	11.35	14.95	11.84	12.77
Pusa Sharad	3.47	4.24	4.20	2.96	3.72	5.90	6.26	5.84	4.42	5.61
Pusa Paushja	8.31	4.91	8.34	3.17	6.18	13.16	6.53	13.05	4.79	9.38
Pusa Hybrid 2	11.93	2.24	3.13	4.35	5.41	16.01	2.71	3.91	4.59	6.80
Pusa Shukti	8.38	5.00	8.38	4.22	6.50	12.38	6.86	12.38	4.14	8.94
NS 60 N	10.53	9.25	10.78	8.71	9.82	14.69	12.97	16.54	13.95	14.54
Himshort	6.44	8.46	10.30	6.96	8.04	9.55	11.35	14.17	11.40	11.62
Himlatha	7.76	8.15	9.11	8.14	8.29	14.17	11.54	13.85	12.99	13.14
Himpriya- 60	8.77	6.07	9.75	7.85	8.11	13.97	9.03	14.47	12.05	12.38
Indam 2435	7.46	10.36	8.61	6.61	8.26	11.99	12.93	13.14	9.94	12.00
G 45	8.44	8.73	9.18	8.33	8.67	12.34	12.63	13.67	13.30	12.99
White Snow	8.65	6.67	9.02	6.69	7.76	13.56	10.23	14.89	10.67	12.34
Mean	8.14	6.82	8.31	6.25		12.56	9.53	12.57	9.51	
CD (5%)	D				0.266					0.279
	G				0.329					0.582
	Dx G				0.658					1.164

Table.4 Effect of sowing dates, genotypes and their interactions on curd compactness, curd size index and stalk length of cauliflower

Genotypes	Curd compactness (g/cm^3)					Curd size index (cm^2)					Stalk length (cm)				
	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean
Pusa Meghna	37.52	27.15	25.18	27.66	29.82	97.59	88.13	132.91	83.35	99.73	3.35	4.54	2.97	3.70	3.64
Pusa Sharad	58.41	57.70	74.03	206.99	84.22	20.45	26.56	24.53	13.08	20.84	5.64	6.39	5.20	4.98	5.55
Pusa Paushja	28.52	69.52	28.96	103.89	47.88	109.34	32.10	108.91	15.16	58.02	3.91	5.29	4.08	5.08	4.59
Pusa Hybrid 2	17.21	356.18	118.46	94.61	72.31	190.93	6.07	12.24	19.97	36.82	5.36	5.32	4.54	4.79	5.00
Pusa Shukti	27.54	65.22	27.54	142.40	46.56	103.74	34.30	103.74	17.47	58.06	4.94	6.06	4.70	5.31	5.25
NS 60 N	22.06	23.58	24.71	28.97	25.15	154.60	120.05	178.21	121.43	142.68	3.49	3.77	3.11	3.63	3.50
Himshort	41.72	24.44	23.47	34.73	30.26	61.52	95.99	145.90	79.34	93.40	3.95	4.61	3.66	4.15	4.09
Himlatha	30.04	28.14	27.92	28.08	28.83	109.93	94.09	126.10	105.77	108.91	3.55	5.68	4.43	4.15	4.45
Himpriya- 60	27.07	43.47	23.26	37.97	31.89	122.50	54.86	141.10	94.58	100.42	3.46	4.60	3.37	3.91	3.84
Indam 2435	29.85	23.37	25.268	31.16	27.54	89.47	133.95	113.09	65.74	99.13	4.24	4.88	3.59	4.95	4.41
G 45	31.89	23.89	28.85	29.24	28.53	104.15	110.33	125.46	110.83	112.61	3.85	4.39	3.17	4.11	3.88
White Snow	26.60	38.90	26.77	39.51	32.40	117.25	68.29	134.23	71.44	95.72	3.51	4.17	3.15	3.96	3.70
Mean	30.38	38.90	31.80	47.53		102.18	65.04	104.42	59.45		4.10	4.98	3.83	4.39	
CD (5%)	D				14.635					4.323					0.118
	G				18.703					7.077					0.135
	D x G				37.417					14.153					0.269

Table.5 Effect of sowing dates, genotypes and their interactions on net curd weight, gross curd weight and harvest index of cauliflower

Genotypes	Net curd weight (g)					Gross curd weight (g)					Harvest index				
	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean
Pusa Meghna	403.50	237.00	426.43	232.67	324.90	452.33	294.67	474.70	288.33	377.51	0.31	0.22	0.37	0.24	0.28
Pusa Sharad	60.00	83.57	93.66	104.00	85.31	110.00	141.80	136.83	142.00	132.66	0.05	0.06	0.09	0.10	0.08
Pusa Paushja	352.77	130.33	354.67	65.33	225.78	408.67	171.33	408.67	107.00	273.92	0.26	0.16	0.33	0.06	0.20
Pusa Hybrid 2	468.93	54.00	51.67	84.50	164.78	533.40	91.50	80.67	125.00	207.64	0.37	0.03	0.03	0.07	0.12
Pusa Shukti	308.00	136.00	308.00	104.00	214.00	344.20	190.60	344.20	144.00	255.75	0.28	0.10	0.25	0.09	0.18
NS 60 N	442.07	323.67	629.33	421.00	454.02	516.67	368.33	670.00	465.33	505.08	0.38	0.29	0.45	0.29	0.35
Himshort	213.3	237.33	429.70	268.67	287.26	259.67	295.33	469.00	317.33	335.33	0.20	0.24	0.44	0.29	0.29
Himlatha	395.87	268.67	422.00	331.33	354.47	444.67	322.00	470.33	372.67	402.37	0.32	0.28	0.29	0.27	0.29
Himpriya- 60	397.87	187.33	413.00	374.00	343.05	460.67	239.67	484.67	433.67	404.67	0.26	0.15	0.18	0.24	0.21
Indam 2435	274.67	369.00	324.80	176.67	286.28	325.00	417.50	349.27	221.33	328.27	0.22	0.28	0.25	0.18	0.23
G 45	357.73	291.34	430.00	370.00	362.27	401.00	341.67	496.00	423.67	415.58	0.28	0.23	0.30	0.29	0.28
White Snow	364.07	235.00	457.00	258.67	328.68	446.80	291.33	519.83	303.67	390.4	0.29	0.19	0.34	0.20	0.25
Mean	336.57	212.77	361.69	232.57		391.91	263.81	408.68	278.67		0.27	0.19	0.28	0.19	
CD (5%)	D				15.212					16.883					0.014
	G				19.570					22.498					0.018
	D x G				39.140					44.995					0.035

Table.6 Effect of sowing dates, genotypes and their interactions on yield and curding percentage of cauliflower

Varieties	Yield (t. ha^{-1})					Percentage of curding (%)				
	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean	Oct 1st	Oct 15th	Nov 1st	Nov 15th	Mean
Pusa Meghna	11.21	6.58	11.84	6.46	9.03	96.00	84.00	100.00	100.00	95.00
Pusa Sharad	1.67	2.32	2.60	2.89	2.37	12.00	40.00	56.00	24.00	33.00
Pusa Paushja	9.80	3.62	9.85	1.81	6.27	96.00	64.00	80.00	72.00	78.00
Pusa Hybrid 2	13.03	1.50	1.43	2.35	4.58	32.00	28.00	28.00	32.00	30.00
Pusa Shukti	8.56	3.78	8.56	2.89	5.94	12.00	20.00	32.00	28.00	23.00
NS 60 N	12.28	8.99	17.48	11.69	12.61	100.00	100.00	100.00	100.00	100.00
Himshort	5.93	6.59	11.94	7.463	7.98	100.00	92.00	100.00	96.00	97.00
Himlatha	10.99	7.46	11.72	9.20	9.85	100.00	88.00	100.0	92.00	95.00
Himpriya- 60	11.05	5.20	11.47	10.39	9.53	100.00	100.00	100.0	100.00	100.00
Indam 2435	7.63	10.25	9.02	4.91	7.95	100.00	100.00	96.00	88.00	96.00
G 45	9.94	8.09	11.94	10.28	10.06	100.00	100.00	100.00	100.00	100.00
White Snow	10.11	6.53	12.69	7.18	9.13	100.00	96.00	100.0	96.00	98.00
Mean	9.35	5.91	10.05	6.46		79.00	76.00	82.66	77.33	
CD (5%)					0.422					1.941
					0.545					5.399

Fig.1 Field view of experiment

Fig.2 Top Yielders

NS 60N

G 45

In the present study, the days to curd initiation and harvest were significantly altered by sowing dates, genotypes and their interaction. November 15th sowing resulted in early curd initiation (47.14 days) while, sowing on October 1st and November 15th resulted in early curd maturity and harvest, since they received high temperature during the curd maturity stage. These finding are in conformity with the findings of Pradeepkumar *et al.*, (2002) who reported a similar range for days to maturity in cauliflower.

Among the genotypes, Himshort was the earliest followed by NS 60N and the late ones were Pusa Sharad and Pusa Hybrid 2 which are mid season varieties. Similar variation among genotypes for earliness were reported

by many workers (Thapa *et al.*, 2002; Jindal and Thakur, 2004; Sharma *et al.*, 2005 and Dhatt and Garg, 2008).

October 1st sowing of Himshort resulted in earliest curd initiation (37.22 days) and curd harvest (47.91 days) whereas November 1st sowing of the same resulted in early maturity (48.20 days). Interaction between sowing dates and genotypes for days to curd initiation was earlier reported by Yadav *et al.*, (1995), Callens *et al.*, (2000) and Pradeepkumar *et al.*, (2002).

Curd characters

Among the different sowing dates, November 1st sowing recorded highest curd depth (8.31 cm), curd diameter (12.57 cm) and curd size index (104.42 cm^2). Such result may be attributed to the fact that plants in November 1st sowing got better opportunity to develop vegetatively, since they received favorable weather.

Adequate vegetative growth and carbohydrate accumulation contributes a lot in the development of economic part in cauliflower. Hence, vigorous plants ultimately led to larger curd size. In contrast, those sowing dates having inadequate vegetative growth resulted into small curds. Significant differences among sowing dates and curd characters were earlier reported by Yadav *et al.*, (1995), Ghanti and Mallik (1995), Mohanty and Srivastava, (2002) and Kaur *et al.*, (2007).

Curd characters like curd depth, curd diameter and curd size index were highest for NS 60N and lowest for Pusa Sharad and Pusa Hybrid 2. Earlier findings for variability among genotypes for curd characters were reported by Kumar (2002), Sharma *et al.*, (2005), Devraju *et al.*, (2010), Mahesh *et al.*, (2011) and Yadav *et al.*, (2013).

Among interaction effects, maximum curd depth, curd diameter and curd size index were observed in October 1st sowing of Pusa Hybrid 2 and November 1st sowing of NS 60N. Studies by Ghanti and Mallick, (1994), Yadav *et al.*, (1995), Rooster and Callens (1999), Pradeepkumar *et al.*, (2002), Sharma *et al.*, (2006) support the present findings.

Curd compactness is a preferred curd character in cauliflower and expressed as an index. Pearson (1931) had explained this index as the ratio of net curd weight and cube of mean curd depth and diameter. In the present investigation, high temperature and adverse climate during curding time of November 15th sown plants resulted in formation of buttons which in turn resulted in high compactness index. Buttons resulted in high compactness value since they had low net curd weight, curd depth and curd diameter. This is not in line with the earlier findings of Yadav *et al.*, (1995).

High compactness values were observed for Pusa Sharad and Pusa Hybrid-2 which produced buttons and low for NS 60 N and Pusa Meghna which produced normal curds. This result was not in line with previous findings by Kumar (2002), Sharma *et al.*, (2005) and Mahesh *et al.*, (2011).

In the present study highest compactness was obtained for October 15th sowing of Pusa Hybrid 2, which showed buttoning. In other varieties and sowing dates where normal curding was observed, the curd compactness ranged between 23.26 and 43.47 which was in accordance with the findings of Yadav *et al.*, (1995) and Ghanti and Mallik (1995).

Stalk length determines the stability of curds. It is generally understood that short stalks results in stable compact curds whereas long stalks results in toppling of curds which ultimately resulted in yield loss. Short stalks

were attributed by low temperature whereas long stalks were attributed by high temperature. Similar trend was observed in the present study also i.e., November 1st sowing coinciding with low temperature recorded minimum stalk length (3.83 cm). This corroborates with the early findings of Choudhary and Ramphal (1961). Stalk length was influenced significantly by different cauliflower genotypes also. Least stalk length was observed for NS 60, Pusa Meghna, Himpriya 60 and G 45. Interaction effect showed that least stalk length was obtained for the above varieties sown on November 1st.

Yield characters

Yield is the most important factor in any crop production. In cauliflower, curd is the economic part and the net curd weight was found to be influenced by different sowing dates. It was highest for November 1st sowing (361.69 g) followed by that of October 1st (336.57 g) hence curd weight was greatly influenced by temperature. It was clear from the result that in southern Kerala, a difference of 15 days in sowing resulted in remarkable reduction in curd yield. This is in accordance with the findings of Pradeepkumar *et al.,* (2002) and Karthika *et al.,* (2013). Similarly, gross curd weight, harvest index, yield and curding percentage were high for November 1st sowing. Similar reports were suggested Jaya *et al.,* (2002), Mohanty and Srivastava, (2002), Srivastava *et al.,* (2002) and Thapa *et al.,* (2002), Amoli *et al.,* (2007), Din *et al.,* (2007), Kaur *et al.,* (2007) and Karthika *et al.,* (2013).

Among genotypes, the best performers with respect to net curd weight, gross curd weight and yield per plot were NS 60 N followed by G 45 whereas Pusa Sharad and Pusa Hybrid 2 were poor yielders. The present result is in accordance with the finding Narayanankutty (2012) who identified NS 60N as the suitable variety for the warm humid tropics of Kerala. Variability among genotypes for yield were reported by several workers confirming the present findings (Jana and Mukhopadhyay, 2006; Kumar *et al.,* 2006; Sharma *et. al.,* 2006; Dhatt and Garg, 2008; and Yadav *et al.,* 2013).

Harvest index gives an indication about the extent of economic yield to total biological yield. In the present study it was high for NS 60 N, Himshort and Himlatha and low for Pusa Sharad and Pusa Hybrid 2. Similar findings were made by Sharma *et al.,* (2000), Jindal and Thakur (2004) and Sharma *et al.,* (2005) who obtained differences in harvest index while comparing different genotypes.

The interaction of November 1st sowing of NS 60N resulted in highest net curd weight (629.33 g), gross curd weight (670.00 g), harvest index (0.45) and yield (17.48 t. ha^{-1}). Similar higher yield was reported by several workers confirming to the present findings (Callens *et al.,* 2000; Pradeepkumar *et al.,* 2002; Thapa *et al.,* 2002; Sharma *et al.,* 2006; Jana and Mukhopadhyay, 2006; Ara *et al.,* 2009). Complete curding was observed for Pusa Meghna, NS 60N, Himshort, Himpriya 60 and G 45 in all the four sowing dates.

The results of the present study identified two genotypes namely NS 60 N and G 45 as promising for cultivation in the southern parts of Kerala. The most ideal time of sowing was November 1st for better quality and yield (Fig. 2).

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How to cite this article:

Shruthy, O. N., V. A. Celine, I. Sreelathakumary and Abdul Vahab, M. 2020. Interaction Effects of Genotypes and Sowing Dates on the Growth and Yield of Cauliflower (*Brassica oleracea* L. var. *botrytis*) in Kerala. *Int.J.Curr.Microbiol.App.Sci.* 9(12): 575-591.
doi: https://doi.org/10.20546/ijcmas.2020.912.069