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Effect of cultivar and different plant spacing on yield and quality of cauliflower under Southern agro-climatic zone of Andhra Pradesh

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Abstract
A field experiment was conducted to study the suitability of cauliflower (*Brassica oleracea var. botrytis* L.) cultivars with different plant densities for southern Agro climatic zone of Andhra Pradesh. The experiment was conducted with four cultivars and three spicing levels. The treatments were replicated thrice in two factorial randomized block design. Highly significant differences were observed among the cultivars, spacing levels and combined effect for yield and non- significant differences were observed for quality parameters, Among the cultivars Pusa Meghana recorded highest in all yield parameters *viz*., curd weight, curd diameter, CSI and yield per hectare whereas, spacing level, S_2 (45 cm x 45 cm) recorded highest under all yield parameters. Among the interaction effects the cultivar Pusa Meghana with 45 cm x 45 cm spacing levels (V_2S_2) recorded highest in all yield parameters. Among the cultivars Pusa Meghana recorded highest TSS in S_1 spacing, Pusa Karthiki recorded high total sugars in S_2, Pusa Ashwini recorded high reducing sugars in S_2 and Pusa Sharad recorded high ascorbic acid content in S_1.

Keywords: cauliflower, spacing, curd size, yield, quality, TSS, ascorbic acid

Introduction
Cauliflower (*Brassica oleracea var. botrytis* L.) is one of the most important cruciferous vegetables grown in India and has originated from the Mediterranean region. Cauliflower (2n=18) belongs to the family Brassicaceae. It is grown for its white tender curd and contains substantial amount of protein, carbohydrates, phosphorous, calcium, iron and ascorbic acid. Its curds are used as cooked vegetable either singly or mixed with other (Choube *et al*., 2020). It is rich in minerals, carbohydrates and vitamins A and C. It is a delicate crop and can be damaged by freezing weather near harvesting. The plants may fail to form desirable heads in dry and hot weather which cause the heads to develop prematurely and bolt or button. It requires moderately cool climates during the periods of its growth. Crop production is a complex phenomenon and is the outcome of several inter-ranked factors. Agronomic research in general aims at improving cultural practices of crop varieties to rely optimum yield. In recent years, there has been a growing interest in the use of narrow rows as well as narrow plant spacing for the production of cauliflower because of higher labour energy and equipment's required for the cultivation.

Material and Methods
Present field experiment was conducted at Vegetables block, College of Horticulture, Anantharajupeta, Dr. Y. S. R. Horticultural University, Andhra Pradesh during *rabi* 2019. The experiment consists of four cultivar levels *viz* V_1: Pusa Sharad, V_1: Pusa Meghana, V_1: Pusa Karthiki and V_4: Pusa Ashwini and three spacing levels *viz*., S_1: 45 cm x 30 cm, S_2: 45 cm x 45 cm (5 plants m^{-2}) and S_3: 60 cm x 45 cm (4 plants m^{-2}). The experiment was conducted in a factorial randomized block design (FRBD) with three replications. The data on yield parameters *viz*. curd weight, curd diameter, CSI and yield per hectare and quality parameters *viz*., curd weight, curd diameter, CSI and yield per hectare were recorded and quality parameters *viz*., total soluble solids (TSS), total sugars, reducing sugars and ascorbic acid were recorded and the data was statistically analyzed using analysis of variance following the method of Panse and Sukhatme (1978) and the mean values were compared at 5% level of significance.

Results and Discussion

The results pertaining to yield parameters and quality parameters as influenced by cultivar and different spacing levels in cauliflower is presented in table1 and table 2. Highly significant differences were observed among the cultivars, spacing levels and interaction effect with respect to yield parameters.

Table 1: Effect of different cultivars and plant spacing on curd weight, curd diameter, curd size index and yield per hectare of cauliflower under southern agro climatic zone of Andhra Pradesh

Spacing / Cultivar	Curd weight (g)				Curd diameter (cm)				Curd size index (cm^3)				Yield per hectare (tons)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
V_1	605.53	789.52	511.20	635.42	17.50	19.57	18.40	18.49	170.66	180.50	185.33	178.83	27.50	29.31	25.53	27.44
V_2	876.85	827.11	885.92	863.29	16.39	18.36	19.93	18.22	220.33	220.33	220.83	220.50	29.60	33.87	33.45	32.30
V_3	750.49	555.97	682.28	662.91	18.71	16.32	17.35	17.46	180.93	150.17	170.50	167.20	25.51	25.61	27.87	26.33
V_4	507.43	631.17	751.33	629.97	19.62	17.54	16.44	17.86	150.44	170.50	150.50	157.15	27.57	33.60	29.70	30.29
Mean	685.07	700.94	707.68		18.06	17.95	18.03		180.59	180.37	181.79		27.54	30.59	29.13	
Interaction effect																
Source	V	S	V × S		V	S	V × S		V	S	V × S		V	S	V × S	
S.Em±	7.92	4.50	35.62		0.17	0.08	0.01		0.14	0.08	0.01		0.16	0.08	0.01	
CD at 5%	31.08	13.20	410.18		0.67	0.30	0.20		0.55	0.23	0.13		0.63	0.29	0.18	

V_1 = Pusa Sharad, V_2 = Pusa Meghana, V_3 = Pusa Karthiki, V_4 = Pusa Ashwini
S_1 = 45 cm × 30 cm, S_2 = 45 cm × 45 cm, S_3 = 60 cm × 45 cm

Table 2: Effect of different cultivars and plant spacing on TSS, total sugars, reducing sugars and ascorbic acid content of cauliflower under southern agro climatic zone of Andhra Pradesh

Spacing / Cultivar	TSS (^{0}Brix)				Total sugars (%)				Reducing sugars (%)				Ascorbic acid (mg/l)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
V_1	7.43	8.30	5.32	7.01	3.21	3.21	3.18	3.21	1.20	1.31	1.21	1.24	80.00	83.00	78.00	80.33
V_2	6.75	7.24	8.18	7.19	3.65	3.16	3.22	3.54	1.21	1.30	1.40	1.30	79.00	77.00	84.30	80.10
V_3	6.53	5.16	6.94	6.20	3.36	3.80	3.14	3.65	1.22	1.40	1.20	1.27	77.00	78.00	77.00	77.33
V_4	7.75	6.80	5.23	6.60	3.21	3.54	3.65	3.47	1.49	1.32	1.32	1.37	83.25	77.53	77.00	79.26
Mean	6.96	6.88	6.42		3.33	3.42	3.30		1.28	1.33	1.28		79.81	78.88	79.07	
Interaction effect																
Source	V	S	V X S		V	S	V X S		V	S	V X S		V	S	V X S	
S.Em±	0.18	0.06	0.01		0.18	0.06	0.01		0.18	0.06	0.01		0.18	0.06	0.01	
CD at 5%	0.46	0.37	NS		0.18	0.30	NS		NS	NS	NS		NS	NS	NS	

V_1 = Pusa Sharad, V_2 = Pusa Meghana, V_3 = Pusa Karthiki, V_4 = Pusa Ashwini
S_1 = 45 cm × 30 cm, S_2 = 45 cm × 45 cm, S_3 = 60 cm × 45 cm

Yield Parameters

Curd weight (g)

Among the cultivars significantly highest curd weight (863.29) was recorded in Pusa Meghana while among the different plant spacings maximum curd weight (707.68) was recorded with S_3 (60 cm × 45 cm). Combined effect of Pusa Meghana under 60 cm x 45 cm spacing (V_2S_3) recorded highest curd weight (885.92) followed by V_2S_1 (876.85). Lowest curd weight (507.43) was recorded in Pusa Ashwini with 45 cm x 30 cm (V_4S_1). Higher curd weight under wider spacing might be due to higher dry matter production and lesser competition for nutrients, space and moisture resulting in proper utilization of accumulates which were conserved by the plant, under optimally. These results are in line with the previous findings of Oad *et al.* (2002) who recommended 45 cm plant spacing as the most successful plant spacing for getting the higher yield of cauliflower, whereas the narrow plant spacing could not record satisfactory plant characteristics. Similar results were reported by Srivastava *et al*. (2011) [16] and Gabhale *et al.* (2014) [6] in cauliflower, Arin *et al*. (2003) [1] and EI-Bassiony *et al.* (2014) [4] in knol-khol

Curd diameter (cm)

Pusa Meghana (19.10) and 60 cm x 45 cm (19.28) had showed significantly highest curd diameter among the cultivars and different plant spacings respectively. Among the interactions Pusa Meghana with 60 cm x 45 cm spacing (V_2S_3) recorded highest curd diameter (19.93) followed by V_2S_2 and V_4S_3 (19.26 and 19.25). Pusa Ashwini with 45 cm x 30 cm spacing (V_4S_1) has recorded lowest curd diameter (17.62). The closer plant spacing showed poor results due to close competition for acquiring the nutrients, sunlight, and space for better curd growth and development. The lower plant density or wider spacing provides more space where the individual plant enjoyed a maximum suitable environment which resulted for the development of curd with maximum diameter. Similar result was given by Archana *et al*. (2019), Joshi *et al*. (2018) [7], Bacha *et al*. (2017) [2] in cauliflower.

Curd size index (cm^3)

Among the cultivars significantly highest CSI (220.53) was recorded in Pusa Meghana while among the different plant spacings maximum CSI (181.79) was recorded in S_3 (60 cm × 45 cm). Combined effect of Pusa Meghana with 60 cm x 45 cm spacing (V_2S_3) recorded highest CSI (220.83) followed by V_2S_1, V_2S_2 (220.33). Lowest CSI (150.17) was recorded in Pusa Karthiki with 45 cm x 45 cm spacing (V_3S_2). curd size index in cauliflower was increased with increase in the spacing levels. These findings agreed with those of Gazala *et al.* (2017) in cauliflower.

Yield per hectare (tons)

Pusa Meghana followed by Pusa Ashwini recorded significantly highest curd yield (32.30 and 30.29) among the cultivars, while among the different spacing levels, (S_2) 45 cm x 45 cm (30.59) followed by (S_3) 60 cm x 45 cm (29.13) showed significantly highest curd yield per hectare. Among the interactions Pusa Meghana with 45 cm x 45 cm spacing

(V_2S_2) followed by Pusa Ashwini with 45 cm x 45 cm spacing (V_4S_2) recorded highest curd yield (33.87 and 33.60). Pusa Karthiki with 45 cm x 30 cm spacing (V_3S_1) has recorded lowest yield (25.51). The significantly maximum curd yield per hectare was obtained with moderate spacing (S_2) followed by wider spacing (S_3) compared to closer spacing (S_1). The cauliflower yield increased with an increase in plant spacing up to an absolute limit, and after 45 cm spacing, it started decreasing. Low yield in case of close spacing might be due to the higher mortality rate, lower plant height and lesser numbers of leaves per plant, shorter diameter of curd and also the competitive growth of the plants. The main reason for maximum curd yield per ha in medium plant spacing was due to higher plant population per unit area compared to wider spacing. Though wider spacing recorded better growth parameters and curd parameters *viz*., higher dry matter production, curd weight and curd diameter, moderate spacing levels recorded higher plant density compared to wider spacing. These findings are in close accordance with the findings of Bhangre *et al*. (2011) [3], Saikia *et al*. (2010) [13], Masood *et al*. (2003) [11], Fabek *et al*. (2011) [5], Hossain *et al*. (2011), Khatun *et al*. (2011) [10], Solunke *et al*. (2011) Gogoi *et al*. (2016) and Vinod *et al*. (2017) [19] in broccoli.

Quality Parameters

Total Soluble Solids (TSS) (^{0}Brix)

Among the cultivars significantly highest TSS (7.19) was recorded in Pusa Meghana while among the different plant spacings maximum TSS (6.96) was recorded in S_1 (45 cm × 30 cm). Combined effect of Pusa Sharad with 45 cm x 45 cm spacing (V_1S_2) recorded highest TSS (8.30) followed by V_2S_3 (8.18). Lowest TSS (5.16) was recorded in Pusa Karthiki with 45 cm x 45 cm spacing (V_3S_2). These findings agreed with those of Selah *et al*. (2013) in kohlrabi and Zaki *et al*. (2015) [18] in broccoli.

Total Sugars (%)

Among the cultivars significantly highest total sugars (3.65) was recorded in Pusa Karthiki while among the different plant spacings maximum total sugars (3.42) was recorded in S_2 (45 cm × 45 cm). Among the interactions Pusa Karthiki with 45 cm x 45 cm spacing (V_3S_2) recorded highest total sugars (3.80) followed by V_2S_1 (3.65). Lowest total sugars (3.14) was recorded in Pusa Karthiki with 60 cm x 45 cm spacing (V_3S_3).

Reducing Sugars (%)

Pusa Ashwini (1.37) and spacing of 45 cm x 45 cm (1.33) had showed non-significantly highest reducing sugars among the cultivars and different plant spacings respectively. Combined effect of Pusa Ashwini with 45 cm x 30 cm spacing (V_4S_1) recorded highest reducing sugars (1.49) followed by V_3S_2 (1.40). Lowest reducing sugars (1.20) was recorded by Pusa Sharad with 45 cm x 30 cm spacing (V_1S_1).

Ascorbic Acid (mg/l)

Pusa Sharad (80.33) and spacing of 45 cm x 30 cm (79.81) had showed non-significantly highest ascorbic acid content among the cultivars and different plant spacings respectively. Among the interactions Pusa Meghana with 60 cm x 45 cm spacing (V_2S_3) recorded highest ascorbic acid content (84.30) followed by V_4S_1 (83.25). Lowest ascorbic acid content (77.00) was recorded by Pusa Karthiki with 60 cm x 45 cm spacing (V_3S_3). These results have parity with Yaday *et al*. (2013) in cauliflower and Zaki *et al*. (2015) [18] in broccoli.

Conclusion

It may concluded that in growth attributes among the cultivars and spacing levels, Pusa Meghana and S_2 (45 cm x 45 cm) spacing level recorded significantly highest curd weight, curd diameter, CSI and yield per hectare.. Among the cultivars Pusa Meghana recorded highest TSS in S_1, Pusa Karthiki recorded high total sugars in S_2, Pusa Ashwini recorded high reducing sugars in S_2 and Pusa Sharad recorded high ascorbic acid content in S_1.

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