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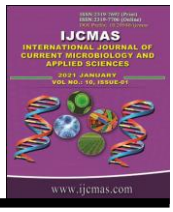

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Effect of Cultivar and Different Plant Spacing on Growth and Yield of Cauliflower under Southern Agro-climatic Zone of Andhra Pradesh

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A B S T R A C T

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 for growth and yield parameters. Among the cultivars Pusa Meghana (V_2) was found to be superior for all growth parameters under study *viz*., plant height, stalk length, number of leaves per plant, petiole length, leaf area, leaf area index and total dry matter content. Among the spacing levels S_3 (60 cm x 45 cm) recorded highest in all growth parameters while, among the interaction effects Pusa Meghana with S_3 (60 cm x 45 cm) spacing levels (V_2S_3) recorded highest in all growth parameters. Regarding yield parameters Pusa Meghana recorded maximum curd weight, curd diameter, curd size index and yield per hectare. Whereas, spacing level 45 cm x 45 cm (S_2) 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.

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.

Materials and Methods

A 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 growth parameters *viz*. plant height, stalk length, number of leaves per plant, petiole length, leaf area, leaf area index and total dry matter content and yield parameters *viz*., curd weight, curd diameter, curd size index and yield per hectare 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

Effect of cultivar and spacing levels on growth parameters of cauliflower

The results pertaining to influence of cultivars, spacing levels and combined effect of cultivars and spacing levels on growth parametrs is presented in Table 1 and 2. Results indicated significant differences among the cultivars, spacing levels and interaction effects pertaining to growth parameters.

Plant height (cm)

Pusa Meghana (64.62) and 60 cm x 45 cm (59.20) had showed significantly highest plant height among the cultivars and different plant spacings respectively at harvest. Among the interactions Pusa Meghana with 60 x 45 cm spacing (V_2S_3) recorded highest plant height (68.89) followed by V_2S_2 (68.47). Lowest plant height (36.26) was recorded in Pusa Ashwini with 45 x 30 cm spacing (V_4S_1). The increased plant height of cauliflower during this study due to wider plant spacing might be due to lesser competition for nutrients, moisture, and CO_2 among the roots of the plants. In contrary to this, closer spacing created more competition for the resources in the roots of plants and resulted in lower plant height. This might be due to more terminal increase in closer spaced plants than wider spaced plants, where lateral growth is more. These findings agreed with Joshi *et al.*, (2018), Gurjeet *et al.*, (2016) in broccoli, Saikia *et al.*, (2010), Sani *et al.*, (2018), Kannan *et al.*, (2016), and Khatiwada (2000) also reported the taller height of cabbage under greater spacing..

Stalk length (cm)

Pusa Meghana (15.49) and 60 cm x 45 cm (13.36) had showed significantly highest stalk length among the cultivars and different plant spacings respectively at harvest. Combined effect of Pusa Meghana with 60 x 45 cm spacing (V_2S_3) recorded highest stalk length (15.96) followed by V_2S_2 (15.27). Pusa Karthiki with 45 x 45 cm spacing (V_3S_2) was recorded by lowest stalk length (11.30). The observed differences in stalk length of cultivars are mainly due to the genotype of

each cultivar. Similar findings have been also found by Srivastava *et al.,* (2011) and Gabhale *et al.,* (2014) in cauliflower, Giri *et al.,* (2013) and Zaki *et al.,* (2015) in broccoli.

Number of leaves per plant

Pusa Meghana (24.41) and 45 cm x 45 cm (23.31) had showed significantly highest number of leaves among the cultivars and different plant spacings respectively at harvest. Among the interactions Pusa Meghana with 60 x 45 cm spacing (V_2S_3) recorded highest number of leaves (25.89) followed by V_2S_2 (25.68). Pusa Sharad with 60 x 45 cm spacing (V_1S_3) has recorded lowest number of leaves (21.51). Number of leaves per plant was increased with plant spacing and decreased with closer spacing. This might be due to lesser competition for nutrients and light amongst the plants with wider plant spacing. Hence, in wider spacing due to the availability of more space and light, the crop might have produced a greater number of leaves per plant. The higher numbers of leaves in 60 ×45 cm spacing might be due to more availability of resources for the growth and development of the leaves. The more space also provides the better exposure of plants tor photosynthesis. These results were in conformity with the results of Archana *et al.,* (2019), Bacha *et al.,* (2017), Arora *et al.,* (2002), Durate and Fortuno (2005) in Chinese cabbage, Joshi *et al.,* (2018), Gabhale *et al.,* (2014), Yadav *et al.,* (2013), Srivastava *et al.,* (2011) in cauliflower and Agarakar *et al.,* (2010), Giri *et al.,* (2013) and Zaki *et al.,* (2015) in broccoli. Arin *et al.,* (2003) and EI-Bassiony *et al.,* (2014) in kohlrabi.

Petiole length(cm)

Pusa Meghana (11.53) and 60 cm x 45 cm (11.07) had showed significantly highest petiole length among the cultivars and different plant spacings respectively at harvest. Combined effect of Pusa Meghana with 60 x 45 cm spacing (V_2S_3) recorded highest petiole length (12.88) followed by V_4S_1 (12.59). Pusa Sharad with 60 cm x 45 cm spacing (V_1S_3) has recorded lowest petiole length (9.36). This might be due to lesser competition for nutrients and light amongst the plants with wider plant spacing. The more space also provides the better exposure of plants to photosynthesis. Similar results have been found by Srivastava *et al.,* (2011) in cauliflower and Chaudhari *et al.,* (2015) in knol-khol.

Leaf area (cm^2)

Pusa Meghana (827.43) and 60 cm x 45 cm (773.32) had showed significantly highest leaf area among the cultivars and different plant spacings respectively at harvest. Among the interactions Pusa Meghana with 60 x 45 cm spacing (V_2S_3) recorded highest leaf area (845.33) followed by V_2S_2 (843.71). Pusa Ashwini with 45 x 30 cm spacing (V_4S_1) has recorded lowest leaf area (684.98). During the different stages of crop growth, wider spacing (S_3) gave significantly superior leaf area over other levels of spacing.

These results might be attributed to optimum use of natural resources by reducing the competition for uptake of nutrients in widely spacing plants compared to the narrow spacing ones.

The above results were in accordance with Criollo and Garcia (2009) in radish and Agarkar *et al.,* (2010) in broccoli. At harvest, the maximum leaf area was observed in Pusa Sharad and Pusa Meghana at S_1 and S_2 respectively. While, the minimum leaf area was observed in Pusa Ashwini at S_3. The plant spread was increased as the plant spacing increases.

Table.1 Effect of different cultivars and plant spacing on plant height, Stalk length, Number of leaves per plant and petiole length of cauliflower

Spacing / Cultivar	Plant height (cm)				Stalk length (cm)				Number of leaves per plant				Petiole length(cm)			
	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	68.29	62.58	49.51	60.12	12.36	13.06	13.48	12.96	22.66	23.51	21.51	22.56	10.10	11.74	9.36	10.40
V_2	56.52	68.47	68.89	64.62	15.23	15.27	15.96	15.49	21.67	25.68	25.89	24.41	9.54	12.17	12.88	11.53
V_3	62.61	49.13	56.24	55.99	13.37	11.30	12.64	12.44	23.37	21.58	22.29	22.41	11.43	9.51	10.73	10.56
V_4	36.26	38.85	62.39	45.83	11.31	12.68	11.38	11.79	25.18	22.47	23.50	23.71	12.59	10.11	11.32	11.34
Mean	55.92	54.76	59.20		13.07	13.08	13.36		23.22	23.31	23.30		10.92	10.88	11.07	
Interaction effect																
Source	V	S	VX S		V	S	VXS		V	S	VX S		V	S	VXS	
S.Em±	0.18	0.12	0.02		0.17	0.08	0.02		0.17	0.08	0.01		0.08	0.05	0.01	
CD at 5%	0.69	0.34	0.24		0.68	0.25	0.17		0.67	0.31	0.20		0.33	0.14	0.05	

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 Leaf area, Leaf Area Index and Total dry matter per plant of cauliflower

Spacing / Cultivar	Leaf area (cm^2)				Leaf Area Index (%)				Total dry matter per plant(g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
V_1	765.05	794.59	685.85	748.49	13.49	18.89	11.47	14.62	140.22	155.48	155.76	150.49
V_2	793.24	843.71	845.33	827.43	18.25	17.73	17.61	17.87	165.45	165.41	165.85	165.57
V_3	793.11	685.11	765.62	747.94	17.51	11.39	13.24	14.05	155.54	125.40	140.62	140.52
V_4	684.98	764.41	848.59	765.99	11.56	13.91	18.75	14.74	125.26	140.31	125.78	130.45
Mean	772.12	771.96	773.32		15.20	15.48	15.27		146.61	146.65	147.00	
Interaction effect												
Source	V	S	V × S		V	S	V×S		V	S	V × S	
S.Em±	1.43	0.79	1.13		0.13	0.08	0.01		0.15	0.07	0.01	
CD at 5%	5.61	2.55	14.30		0.53	0.22	0.12		0.57	0.20	0.11	

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.3 Effect of different cultivars and plant spacing on curd weight, curd diameter, curd size index and yield per hectare of cauliflower at different growth intervals

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

Significantly, superior plant spread was attained in cauliflower at all the stages of growth with higher plant spacing (60 cm × 45 cm), which could be attributed to the fact that in wider spacing, the individual plant gets plenty of light and more nutrients in comparison to narrow spacing. Wider plant spacing leads to good growth and development, less competition for the uptake of nutrients, water and sunlight, which leads to more lateral growth and spread. The results of present findings agreed with the findings of Munro *et al.,* (2007), Bhangre *et al.,* (2010) and Tejaswini *et al.,* (2018) in broccoli, Saikia *et al.,* (2010), Ali *et al.,* (2018) in turnip and Sharma and Chaudhary (1996) in cauliflower.

Leaf area index (LAI)

Pusa Meghana (17.87) and 45 cm x 45 cm (15.48) had showed significantly highest LAI among the cultivars and different plant spacings respectively at harvest. Combined effect of Pusa Sharad with 45 cm x 45 cm spacing (V_1S_2) has recorded highest LAI (18.89) followed by V_4S_3 (18.75). Pusa Karthiki with 45 cm x 45 cm spacing (V_3S_2) has recorded lowest LAI (11.39). The leaf area index (LAI) is mainly noticed the photosynthetic area of any plant. The results of present findings agreed with the findings of Dipak (2019) in cauliflower.

Dry matter per plant (g)

Pusa Meghana (165.57) and 60 cm x 45 cm (147.00) had showed significantly highest dry matter among the cultivars and different plant spacings respectively at harvest. Among the interactions Pusa Meghana with 45 cm x 30 cm spacing (V_2S_1) recorded highest dry matter (165.45) followed by V_2S_2 (165.41). Pusa Ashwini with 45 cm x 30 cm spacing (V_4S_1) has recorded lowest dry matter (125.26). The increased stomatal conductance may help in increased gaseous exchange thereby increased rate of photosynthesis, higher crop growth rate per unit area in coordination with increased dry matter production. These results were in conformity with the findings of Tejaswini *et al.,* (2018) in

cauliflower, Chandan *et al.,* (2013), Uddain *et al.,* (2012) in Knol-khol, Kalloo *et al.,* (2005) in vegetable pea. Bhangre *et al.,* (2011) in cabbage. The highest dry matter content might be due to its higher plant height, a greater number of leaves and leaf area. These findings are in accordance with Thakur *et al.,* (1991) and Sani *et al.,* (2018) in cabbage.

Effect of cultivar and spacing levels on yield parameters of cauliflower

The results pertaining to influence of cultivars, spacing levels and combined effect of cultivars and spacing levels on yield parameters is presented in Table 3. Results indicated significant differences among the cultivars, spacing levels and interaction effects pertaining to 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) and Gabhale *et al.,* (2014) in cauliflower, Arin *et al.,* (2003) and EI-Bassiony *et al.,* (2014) 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), Bacha *et al.,* (2017) 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)

Among the cultivars, Pusa Meghana followed by Pusa Ashwini recorded significantly highest curd yield (32.30 and 30.29), while among the different spacing levels, 45 cm x 45 cm (S_2) (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), Saikia *et al.,* (2010), Masood *et al.,* (2003), Fabek *et al.,* (2011), Hossain *et al.,* (2011), Khatun *et al.,* (2011), Solunke *et al.,* (2011) Gogoi *et al.,* (2016) and Vinod *et al.,* (2017) in broccoli

It may concluded that in growth attributes among the cultivars and spacing levels. significantly highest plant height, stalk length (cm), number of leaves per plant, petiole length (cm), leaf area, leaf area index and total dry matter content were recorded in the cultivar Pusa Meghana in S_2 spacing level (45 cm x 45 cm) . Pusa Meghana in S_2 (45 cm x 45 cm) spacing level recorded significantly highest curd weight, curd diameter, CSI and yield per hectare among the cultivars and different plant spacings.

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