Original Research Article

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 spacing 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 (V₂) 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 S₃ (60 cm x 45 cm) recorded highest in all growth parameters while, among the interaction effects Pusa Meghana with S₃ (60 cm x 45 cm) spacing levels (V₂S₃) 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 (S₂) recorded highest under all yield parameters. Among the interaction effects the cultivar Pusa Meghana with 45 cm x 45 cm spacing levels (V₂S₂) recorded highest in all yield parameters.

Keywords
Cauliflower, Spacing, Growth, Curd diameter, Curd weight and yield

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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. V₁: Pusa Sharad, V₁: Pusa Meghana, V₁: Pusa Karthiki and V₄: Pusa Ashwini and three spacing levels viz., S₁: 45 cm x 30 cm, S₂: 45 cm x 45 cm (5 plants m⁻²) and S₃: 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 parameters 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 (V₂S₃) recorded highest plant height (68.89) followed by V₂S₂ (68.47). Lowest plant height (36.26) was recorded in Pusa Ashwini with 45 x 30 cm spacing (V₄S₁). The increased plant height of cauliflower during this study due to wider plant spacing might be due to lesser competition for nutrients, moisture, and CO₂ 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 (V₂S₃) recorded highest stalk length (15.96) followed by V₂S₂ (15.27). Pusa Karthiki with 45 x 45 cm spacing (V₃S₂) 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 (V2S3) recorded highest number of leaves (25.89) followed by V2S2 (25.68). Pusa Sharad with 60 x 45 cm spacing (V1S3) 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. 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 (cm²)**

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 (V2S3) recorded highest leaf area (845.33) followed by V2S1 (843.71). Pusa Ashwini with 45 x 30 cm spacing (V4S1) has recorded lowest leaf area (684.98). During the different stages of crop growth, wider spacing (S3) 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 S1 and S2 respectively. While, the minimum leaf area was observed in Pusa Ashwini at S3. 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 | Plant height (cm) | Stalk length (cm) | Number of leaves per plant | Petiole length(cm) |
|---------|------------------|------------------|---------------------------|-------------------|
|         | S1   | S2   | S3   | Mean | S1   | S2   | S3   | Mean | S1   | S2   | S3   | Mean |
| V1      | 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 |
| V2      | 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 |
| V3      | 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 |
| V4      | 36.26 | 38.85 | 62.39 | 45.83 | 11.31 | 12.68 | 11.30 | 11.79 | 25.18 | 22.47 | 21.58 | 22.41 | 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          | VX S      | V          | S          | VX S      | V          | S          | VX S |
|--------|------------|------------|-----------|------------|------------|-----------|------------|------------|-----------|------------|------------|------|
| 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 |

V1 = Pusa Sharad, V2 = Pusa Meghana, V3 = Pusa Karthiki, V4 = Pusa Ashwini
S1 = 45 cm × 30 cm, S2 = 45 cm × 45 cm, S3 = 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 | Leaf area (cm²) | Leaf Area Index (%) | Total dry matter per plant(g) |
|---------|----------------|---------------------|-------------------------------|
|         | S1   | S2   | S3   | Mean | S1   | S2   | S3   | Mean | S1   | S2   | S3   | Mean |
| V1      | 765.05 | 794.59 | 685.85 | 748.49 | 13.49 | 18.89 | 11.47 | 14.62 | 140.22 | 155.48 | 155.76 | 150.49 |
| V2      | 793.24 | 843.71 | 845.33 | 827.43 | 18.25 | 17.73 | 17.61 | 17.87 | 165.45 | 165.41 | 165.85 | 165.57 |
| V3      | 793.11 | 685.11 | 765.62 | 747.94 | 17.51 | 11.39 | 13.24 | 14.05 | 155.54 | 125.40 | 140.62 | 140.52 |
| V4      | 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          | VX S      | V          | S          | VX S      | V          | S          | VX S      | V          | S          | VX S |
|--------|------------|------------|-----------|------------|------------|-----------|------------|------------|-----------|------------|------------|------|
| S.Em±  | 1.43       | 0.79       | 1.13      | 0.13       | 0.08       | 0.01      | 0.15       | 0.07       | 0.01      | 0.33       | 0.14       | 0.05 |
| CD at 5% | 5.61      | 2.55       | 14.30     | 0.53       | 0.22       | 0.12      | 0.57       | 0.20       | 0.11      |            |            |      |

V1 = Pusa Sharad, V2 = Pusa Meghana, V3 = Pusa Karthiki, V4 = Pusa Ashwini
S1 = 45 cm × 30 cm, S2 = 45 cm × 45 cm, S3 = 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 (cm²) | Yield per hectare (tons) |
|------------------|-----------------|--------------------|-----------------------|-------------------------|
|                   | S₁               | S₂               | S₃               | Mean               | S₁       | S₂       | S₃       | Mean       | S₁       | S₂       | S₃       | Mean       |
| V₁                | 605.5 ± 3       | 789.5 ± 2        | 511.2 ± 0        | 635.4 ± 2        | 17.5 ± 0 | 19.5 ± 7 | 18.4 ± 0 | 18.49 ± 0 | 170.6 ± 6 | 180.5 ± 0 | 185.3 ± 3 | 178.8 ± 3 |
| V₂                | 876.8 ± 5       | 827.1 ± 1        | 885.9 ± 2        | 863.2 ± 9        | 16.3 ± 9 | 18.3 ± 6 | 19.9 ± 3 | 18.22 ± 3 | 220.3 ± 3 | 220.3 ± 3 | 220.8 ± 3 | 220.5 ± 0 |
| V₃                | 750.4 ± 9       | 555.9 ± 7        | 682.2 ± 8        | 662.9 ± 1        | 18.7 ± 1 | 16.3 ± 2 | 17.3 ± 5 | 17.46 ± 1 | 180.9 ± 3 | 150.1 ± 7 | 170.5 ± 0 | 167.2 ± 0 |
| V₄                | 507.4 ± 3       | 631.1 ± 7        | 751.3 ± 3        | 629.9 ± 7        | 19.6 ± 2 | 17.5 ± 4 | 16.4 ± 4 | 17.86 ± 4 | 150.4 ± 4 | 170.5 ± 0 | 150.5 ± 0 | 157.1 ± 5 |
| Mean              | 685.0 ± 7       | 700.9 ± 4        | 707.6 ± 8        | 681.0 ± 5        | 18.0 ± 6 | 17.9 ± 5 | 18.0 ± 3 | 18.05 ± 6 | 180.5 ± 9 | 180.3 ± 7 | 181.7 ± 9 | 27.5 ± 8  |

Interaction effect

| Source | V × S | V × S | V × S | V × S | V × S | 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  | 0.63  | 0.29  | 0.18  |
| CD at 5%| 31.08 | 13.20 | 410.18| 0.07  | 0.30  | 0.20  | 0.55  | 0.23  | 0.13  | 0.63  | 0.29  | 0.18  | 0.63  | 0.29  | 0.18  |

V₁ = Pusa Sharad, V₂ = Pusa Meghana, V₃ = Pusa Karthiki, V₄ = Pusa Ashwini
S₁ = 45 cm x 30 cm, S₂ = 45 cm x 45 cm, S₃ = 60 cm x 45 cm

Significantly, superior plant spread was attained in cauliflower at all the stages of growth with higher plant spacing (60 cm x 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 (V₁S₂) has recorded highest LAI (18.89) followed by V₄S₃ (18.75). Pusa Karthiki with 45 cm x 45 cm spacing (V₃S₂) 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 (V₂S₁) recorded highest dry matter (165.45) followed by V₂S₂ (165.41). Pusa Ashwini with 45 cm x 30 cm spacing (V₄S₁) 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 S1 (60 cm x 45 cm). Combined effect of Pusa Meghana under 60 cm x 45 cm spacing (V2S3) recorded highest curd weight (885.92) followed by V2S1 (876.85). Lowest curd weight (507.43) was recorded in Pusa Ashwini with 45 cm x 30 cm (V4S1). 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 (V2S3) recorded highest curd diameter (19.93) followed by V2S2 and V4S3 (19.26 and 19.25). Pusa Ashwini with 45 cm x 30 cm spacing (V4S1) 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 (cm³)**

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 S3 (60 cm x 45 cm). Combined effect of Pusa Meghana with 60 cm x 45 cm spacing (V2S3) recorded highest CSI (220.83) followed by V2S1, V2S2 (220.33). Lowest CSI (150.17) was recorded in Pusa Karthiki with 45 cm x 45 cm spacing (V3S2). 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<sub>2</sub>) (30.59) followed by (S<sub>3</sub>) 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<sub>2</sub>S<sub>2</sub>) followed by Pusa Ashwini with 45 cm x 45 cm spacing (V<sub>4</sub>S<sub>2</sub>) recorded highest curd yield (33.87 and 33.60). Pusa Karthiki with 45 cm x 30 cm spacing (V<sub>0</sub>S<sub>1</sub>) has recorded lowest yield (25.51). The significantly maximum curd yield per hectare was obtained with moderate spacing (S<sub>2</sub>) followed by wider spacing (S<sub>3</sub>) compared to closer spacing (S<sub>1</sub>). 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<sub>2</sub> spacing level (45 cm x 45 cm). Pusa Meghana in S<sub>2</sub> (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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