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Studies on response of cauliflower (*Brassica oleracea var. botrytis* L.) to NAA and GA_3 for growth and curd formation characters under Chhattisgarh plains

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Abstract
The present experiment was conducted during Rabi 2020-2021 at Precision Farming Development Centre (PFDC), Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The research was conducted in RBD with 9 treatment combinations in three replications. In this experiment the four different concentrations of NAA *viz*. (80, 100, 120 and 140 ppm) and four different concentrations of GA_3 (50, 100, 150 and 200 ppm) were used over control. Among all the treatments, it was concluded that for growth attributing characters T3- GA_3 150 ppm gave maximum plant height (cm) at 30, 45 and 60 DAT (28.77, 40.67, 45.00), No. of leaves/ plant at 30, 45 and 60 DAT (10, 14, 21), canopy spread (cm^2) at 30, 45 and 60 DAT (39.33, 55.50, 73.17), length of leaves (cm) at 30, 45 and 60 DAT (18.67, 30.00, 37.00), width of leaves (cm) at 30, 45 and 60 DAT(10.00, 16.33,19.20), minimum no. of days from transplant to the start of the curd (44.00), minimum no. of days from transplant to 50% curd formation (57.00), minimum no. of days from transplant to harvesting of crop (67.00), the minimum was recorded under T9-control. From this experiment, it was concluded that 150 ppm of GA_3 can be recommended in cauliflower for higher growth attributing characters.

Keywords: Cauliflower. *Brassica oleracea var. botrytis* L., plant growth regulators, growth

Introduction
Cauliflower (*Brassica oleracea* var. *botrytis* L.) is the major growing crop amongst the cole crops belongs to the family Brassicaceae (2n=18). Eastern mediterranean region is its centre of origin. Cauliflower was introduced in India in 1822 (Swarup and Chatterjee, 1972) [23]. lt is major winter vegetable crop grown as annual plant and it can be grown without branching. The edible part of the cauliflower is called as 'Curd'. According to botanical consideration, it is the pre-condition of inflorescence (prefloral fleshy apical meristem). The lifecycle of cauliflower can be divided into three phases i.e. growth phase, curd phase, flower or seed phase. It has small and thick stem, bears whorl of leaves with branched tap root system. Cauliflower is the most popular cole crop because of its appealing look, tasty flavour, mineral, protein, and vitamin content, and high yielding capability (Bana *et al.*, 2012) [1]. Cauliflower fresh curd are highly nutritive and contain moisture 90.8 g, protein 2.6 g, fat 0.4 g, minerals 1.0 g, fiber 1.2 g, carbohydrate 4.0 g, calcium 33 mg, phosphorous 57 mg, iron 1.5 mg, carotene 30 mg, thiamine 0.04 mg, riboflavin 0.10 mg, niacin 1.0 mg vitamin-C 56 mg per 100 g of edible portion (Jood & Neelam, 2011) [7]. Among the various plant growth regulators, NAA and GA_3 are very popular and are used on a commercial scale in various crops, including cauliflower. Plant growth regulators are organic chemicals other than nutrients that stimulate, suppress, or otherwise regulate plant physiological processes in small amounts. It improves quality and enhances yield by alerting plant behaviour and a variety of physiological processes in plant systems. Auxins are generally applied to the leaves of crop plants to improve their vigour and production. It is beneficial combined effects of auxin and gibberellin spraying on cauliflower crops at various concentrations and stages of plant growth. NAA is an essential plant growth regulators to stimulate vegetative growth and increase the yield of many vegetables (Rawat *et al.*, 2002) [14]. Growth and development behavior are main attribute for the performance and quality of cauliflower products. Plant growth regulators have been reported to affect cauliflower growth and performance.

Materials and Methods
The experiment was conducted in the years of 2020-2021 during the Rabi season at the

Precision Farming Development Centre (PFDC), Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in the Rabi season during the year 2020-2021. The research was conducted in RBD with 9 treatment combinations in three replications. In this experiment the four different concentrations of NAA *viz*. (80, 100, 120 and 140 ppm) and four different concentrations of GA_3 (50, 100, 150 and 200 ppm) were used over control. 30 days old seedlings were transplanted in the experimental field with The recommended dose of Farm Yard Manure @ 200 q/ha, N 100 kg per ha, P2O5 60 kg per ha and K2O 60 kg per ha was applied. The entire dose of P2O5, K2O and half the dose of N in different treatments were applied as a basal dose at the time of transplanting. The remaining dose of nitrogen was administered as a superior dressing in two doses divided at 30 and 45 days after the transplanting. All recommended doses of fertilizer were applied manually in experimental plot. All the intercultural operations were performed in the field as per the requirement of the crop such as irrigation, weeding and earthing up etc. From each plot randomly five plants were selected and used for taking observations for growth attributes.

Results and Discussion

The present experiment was conducted during *Rabi* 2020-2021 at Precision Farming Development Centre (PFDC), Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The research was conducted in RBD with 9 treatment combinations in three replications. In this section, a brief description involving to the observations recorded on various aspects of investigation has been given. Research results are presented with the help of tables, graphics and interpretation are prepared of only significant findings on the basis of statistical analysis. The results have been supported with suitable reasoning along with research work of other workers.

Growth parameters of cauliflower

The data on the growth parameters *i.e.* plant height (cm) at 30, 45 and 60 DAT, No. of leaves/ plant at 30, 45 and 60 DAT, canopy spread (cm²) at 30, 45 and 60 DAT, 10. length of leaves (cm) at 30, 45 and 60 DAT, width of leaves (cm) at 30, 45 and 60 DAT, days from transplant to the start of the curd, days from transplant to 50% curd formation, days from transplant to harvesting of crop as influenced by variety, plant growth regulators are furnished in Tables 1(a) and 1(b).

Plant height (cm)

The data on plant height (cm) of cauliflower recorded at 30, 45 and 60 DAT as influenced by variety, plant growth regulators are presented in Table 1(a).

The plant height showed significant differences and it was recorded at 30 DAT ranged from 28.77 cm to 22.77 cm. The maximum plant height (cm) was recorded in treatments T3-GA3 150 ppm (28.77cm), however it was found statistically at par with treatments *viz*. T7 (27.50 cm), T2 (27.33 cm), and T6 (26.40 cm) respectively whereas, the minimum plant height was recorded in T9-control (22.77 cm).

The plant height showed significant differences and it was recorded at 45 DAT ranged from 40.67 cm to 28.33 cm. The maximum plant height (cm) was recorded in treatments T3-GA3 150 ppm (40.67 cm), however it was found statistically at par with treatments *viz*. T7 (38.67 cm), T2 (36.67 cm), and T6 (33.67 cm) respectively whereas, the minimum plant height was recorded in T9-control (28.33 cm).

The plant height showed significant differences and it was recorded at 60 DAT ranged from 45.00 cm to 39.00 cm. The maximum plant height (cm) was recorded in treatments T3-GA3 150 ppm (45.00 cm), however it was found statistically at par with treatments *viz*. T7 (44.33 cm), T2 (43.55 cm), and T4 (43.33 cm) respectively whereas, the minimum plant height was recorded in T9-control (39.00 cm).

Besides this, GA_3 50 ppm treated plots stimulated quick cell division and cell enlargement and contributed to good results, Mishra *et al*., (1986) reported that GA_3 (50 mg / L) + urea (1%) have also been enhanced curd yield in cauliflower.

The treatment used GA_3- 150 ppm gave maximum growth parameters of plants of cauliflower. This might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3 stimulate growth and cell expansion of cells through increasing the plasticity of cells (Dhengle and Bhosle, 2007) [4].

No. of leaves/ plant

The data on no. of leaves/ plant of cauliflower recorded at 30, 45 and 60 DAT as influenced by variety, plant growth regulators are presented in Table 1(a).

The no. of leaves/ plant showed significant differences and it was recorded at 30 DAT ranged from 10 to 8. The maximum no. of leaves/ plant was recorded in treatments T3-GA3 150 ppm (10) and T7 (10), however it was found statistically at par with treatments *viz.* T2 (9), T1 (9), T4 (9), and T6 (9) respectively whereas, the minimum no. of leaves/ plant was recorded in T9-control (8).

The no. of leaves/ plant showed significant differences and it was recorded at 45 DAT ranged from 14 to 12. The maximum no. of leaves/ plant was recorded in treatments T3-GA3 150 ppm (14), however it was found statistically at par with treatments *viz*. T7 (13), T2 (13), T4 (13) and respectively whereas, the minimum no. of leaves/ plant was recorded in T9-control (12).

The no. of leaves/ plant showed significant differences and it was recorded at 60 DAT ranged from 21 to 16. The maximum no. of leaves/ plant was recorded in treatments T3-GA3 150 ppm (21), however it was found statistically at par with treatments *viz*. T7 (20), T2 (20), T8, T5, and T1 respectively whereas, the minimum no. of leaves/ plant was recorded in T9-control (16).

Gibberllic acid (GA3) is used extensively to increase the growth of some vegetables such as tomatoes, cabbage and cauliflower (Weaver *et al*., 1961). This could be due to the role of GA3 in stimulating both cell elongation and cell division.

Canopy spread (cm²)

The data on canopy spread (cm²) of cauliflower recorded at 30, 45 and 60 DAT as influenced by variety, plant growth regulators are presented in Table 1(a).

The canopy spread (cm²) showed significant differences and it was recorded at 30 DAT ranged from 39.33 cm² to 32.33 cm². The maximum canopy spread (cm²) was recorded in treatments T3-GA3 150 ppm (39.33 cm²), however it was found statistically at par with treatments *viz*. T7 (39.00 cm²), T2 (36.00 cm²), and T8 (34.67 cm²) respectively whereas, the minimum canopy spread (cm²) was recorded in T9-control (32.33 cm²).

The canopy spread (cm²) showed significant differences and it was recorded at 45 DAT ranged from 55.50 cm² to 47.00 cm². The maximum canopy spread (cm²) was recorded in

treatments T3-GA3 150 ppm (55.50 cm²), however it was found statistically at par with treatments *viz*. T7 (55.17 cm²), T2 (54.83 cm²), and T6 (52.83 cm²) respectively whereas, the minimum canopy spread (cm²) was recorded in T9-control (47.00 cm²).

The canopy spread (cm²) showed significant differences and it was recorded at 60 DAT ranged from 73.17 cm² to 69.00 cm². The maximum canopy spread (cm²) was recorded in treatments T3-GA3 150 ppm (73.17 cm²), however it was found statistically at par with treatments *viz*. T7 (72.83 cm²), T2 (72.70 cm²), and T8 (72.00 cm²) respectively whereas, the minimum canopy spread (cm²) was recorded in T9-control (69.00 cm²).

This might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3 stimulate growth and cell expansion of cells through increasing the plasticity of cells (Dhengle and Bhosle, 2007) [4].

Length of leaves (cm)

The data on length of leaves (cm) of cauliflower was recorded at 30, 45 and 60 DAT as influenced by variety, plant growth regulators are presented in Table 1(b).

The length of leaves showed significant differences and it was recorded at 30 DAT ranged from 18.67 cm to 12.67 cm. The maximum length of leaves (cm) was recorded in treatments T3-GA3 150 ppm (18.67 cm), however it was found statistically at par with treatments *viz*. T7 (18.50 cm), T2 (17.50 cm), and T6 (16.67 cm) respectively whereas, the minimum length of leaves was recorded in T9-control (12.67 cm).

The length of leaves showed significant differences and it was recorded at 45 DAT ranged from 30.00 cm to 22.00 cm. The maximum length of leaves (cm) was recorded in treatments T3-GA3 150 ppm (30.00 cm), however it was found statistically at par with treatments *viz*. T7 (29.33 cm), T2 (27.67 cm), and T4 (27.33 cm) respectively whereas, the minimum length of leaves was recorded in T9-control (22.00 cm).

The length of leaves showed significant differences and it was recorded at 60 DAT ranged from 37.00 cm to 30.67 cm. The maximum length of leaves (cm) was recorded in treatments T3-GA3 150 ppm (37.00 cm), however it was found statistically at par with treatments *viz*. T7 (36.17 cm), T2 (35.67 cm), and T6 (35.33 cm) respectively whereas, the minimum length of leaves was recorded in T9-control (30.67 cm).

The increase in length of leaves might be due to increase in meristematic activity of the apical tissue on GA3 application. Also GA3 was involved in increasing photosynthetic activity, efficient translocation and utilization of photosynthates causing rapid cell division, cell elongation and cell differentiation at growing region of the plant leaves leading to stimulation of growth. Similar findings were observed by Kadiri *et al.* (1996) [8], Iqbal *et al.* (2001) [6], Poudel (2006) [13], Sharma (2006) [19], Sud (2008) [22], Kumar *et al*. (2008) [9], Sengupta *et al.*(2008) [18], Sarada *et al.*(2008) [17], Helaly (2009) [5], Ud-Deen (2009) [25], Kumar *et al.*(2011) [10], Sitapara *et al.*(2011), Rohamare *et al.*(2013) [16], Chaudhary *et al.* (2013) [2], Thapa *et al.*(2014), Chaurasiya *et al.*(2014) [3], Netam and Sharma (2014) [12] and Kumar *et al.*(2014).

Width of leaves (cm)

The data on width of leaves (cm) of cauliflower recorded at 30, 45 and 60 DAT as influenced by variety, plant growth regulators are presented in Table 1(b).

The width of leaves showed significant differences and it was recorded at 30 DAT ranged from 10.00 cm to 7.67 cm. The maximum width of leaves (cm) was recorded in treatments T3-GA3 150 ppm (10.00 cm), however it was found statistically at par with treatments *viz*. T7 (9.67 cm), T2 (9.33 cm), and T4 (9.00 cm) respectively whereas, the minimum width of leaves was recorded in T9-control (7.67 cm).

The width of leaves showed significant differences and it was recorded at 45 DAT ranged from 16.33 cm to 13.00 cm. The maximum width of leaves (cm) was recorded in treatments T3-GA3 150 ppm (16.33 cm), however it was found statistically at par with treatments *viz*. T7 (16.00 cm), T2 (15.67 cm), and T6 (15.33 cm) respectively whereas, the minimum width of leaves was recorded in T9-control (13.00 cm).

The width of leaves showed significant differences and it was recorded at 60 DAT ranged from 19.20 cm to 17.33 cm. The maximum width of leaves (cm) was recorded in treatments T3-GA3 150 ppm (19.20 cm), however it was found statistically at par with treatments *viz*. T7 (19.00 cm), T2 (18.77 cm), and T6 (18.33 cm) respectively whereas, the minimum width of leaves was recorded in T9-control (17.33 cm). Similar findings were also reported by Rahman *et al.* (2016).

The increase in width of leaves might be due to increase in meristematic activity of the apical tissue on GA3 application. Also GA3 was involved in increasing photosynthetic activity, efficient translocation and utilization of photosynthates causing rapid cell division, cell elongation and cell differentiation at growing region of the plant leaves leading to stimulation of growth. Similar findings were observed by Kadiri *et al.* (1996) [8], Iqbal *et al.* (2001) [6], Poudel (2006) [13], Sharma (2006) [19], Sud (2008) [22], Kumar *et al*.(2008) [9], Sengupta *et al.*(2008) [18], Sarada *et al.*(2008) [17], Helaly (2009) [5], Ud-Deen (2009) [25], Kumar *et al.*(2011) [10], Sitapara *et al.*(2011), Rohamare *et al.*(2013) [16], Chaudhary *et al.* (2013) [2], Thapa *et al.*(2014), Chaurasiya *et al.*(2014) [3], Netam and Sharma (2014) [12] and Kumar *et al.*(2014).

Days from transplanting to curd initiation

The data on days from transplanting to curd initiation of cauliflower recorded as influenced by variety, plant growth regulators are presented in Table 1(b).

The days from transplanting to curd initiation showed significant differences and it was recorded and ranged from 44.00 to 47.00. The minimum days from transplanting to curd initiation was recorded in treatments T3-GA3 150 ppm (44.00), however it was found statistically at par with treatments *viz*. T7 (44.33), T2 (44.67), and T5(44.80) respectively whereas, the maximum days from transplanting to curd initiation was recorded in T9-control (47.00). Similar findings were also reported by Sawant *et al.* (2010) [20].

Minimum days (44.00 days) were taken to days from transplanting to curd initiation with the application of GA_3. This was might be due to maximum division of cells and elongation of cell with the increase in photosynthetic activity and better accumulation of food (Yadav *et al*., 2000) [26].

Days from transplanting to 50% curd formation

The data on days from transplant to 50% curd formation of cauliflower recorded as influenced by variety, plant growth regulators are presented in Table 1(b).

The days from transplant to 50% curd formation showed

significant differences and it was recorded and ranged from 57.00 to 60.33. The minimum days from transplant to 50% curd formation was recorded in treatments T3-GA3 150 ppm (57.00), however it was found statistically at par with treatments *viz*. T7 (57.20), T2 (57.30), T5, and T1 respectively whereas, the maximum days from transplant to 50% curd formation was recorded in T9-control (60.33).

Minimum days (57.00 days) were taken to 50% curd initiation with the application of GA_3. This was might be due to maximum division of cells and elongation of cell with the increase in photosynthetic activity and better accumulation of food (Yadav *et al*., 2000) [26].

Days from transplant to harvest

The data on days from transplant to harvest of cauliflower recorded as influenced by variety, plant growth regulators are presented in Table 1(b).

The days from transplant to harvest showed significant differences and it was recorded and ranged from 67.00 to 70.67. The minimum days from transplant to harvest was recorded in treatments T3- GA_3 150 ppm (67.00), however it was found statistically at par with treatments *viz*. T7 (67.17), T2 (67.33), T6, and T8 respectively whereas, the maximum days from transplant to harvest was recorded in T9-control (70.67). Similar findings were also reported by Sawant *et al.* (2010) [20].

Early initiation of curd resulted into the decrease in number of days (67.00 days) for harvest. This might be due to increase in transportation of nutrient from root to aerial parts of plant (Reddy, 1989) [15].

Table 1(a): Mean performance of effect of foliar spray of plant growth regulators on the growth parameters of cauliflower

Treatments	Plant height (cm)			No. of leaves/ plant			Canopy spread (cm^2)		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T1- GA_3 - 50 ppm	24.47	32.67	43.00	9	12	18	35.33	47.33	72.33
T2- GA_3 - 100 ppm	27.33	36.67	43.55	9	13	20	36.00	54.83	72.70
T3- GA_3 - 150 ppm	28.77	40.67	45.00	10	14	21	39.33	55.50	73.17
T4- GA_3 - 200 ppm	23.00	33.00	43.33	9	13	20	33.67	49.83	69.33
T5- NAA - 80 ppm	24.33	29.00	42.17	8	12	18	33.67	47.67	72.00
T6- NAA - 100 ppm	26.40	33.67	42.00	9	12	17	33.67	52.83	70.17
T7- NAA - 120 ppm	27.50	38.67	44.33	10	13	20	39.00	55.17	72.83
T8- NAA - 140 ppm	24.33	32.67	40.67	8	12	18	34.67	50.67	70.00
T9- Control	22.77	28.33	39.00	8	12	16	32.33	47.00	69.00
Mean	25.43	33.93	42.56	9	12	19	35.30	51.20	71.28
S Em+	0.47	1.28	1.10	0.35	0.03	0.57	1.49	1.96	0.95
CD (0.05)	1.40	3.84	3.31	1.05	0.93	1.71	4.49	5.88	2.84
CV	3.19	6.54	4.87	6.86	4.32	5.32	7.35	6.64	2.30

Table 1(b): Mean performance of effect of foliar spray of plant growth regulators on the growth parameters of cauliflower

Treatments	Length of leaves (cm)			Width of leaves (cm)			Days from transplanting to curd initiation	Days from transplanting to 50% curd formation	Days from transplanting to harvest
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT			
T1- GA_3 - 50 ppm	15.00	24.67	35.67	8.00	14.00	18.33	46.33	58.00	68.00
T2- GA_3 - 100 ppm	17.50	27.67	35.67	9.33	15.67	18.77	44.67	57.30	67.33
T3- GA_3 - 150 ppm	18.67	30.00	37.00	10.00	16.33	19.20	44.00	57.00	67.00
T4- GA_3 - 200 ppm	16.33	27.33	34.00	9.00	14.33	18.23	46.00	58.33	69.33
T5- NAA - 80 ppm	17.33	25.67	34.00	9.00	13.33	18.00	44.80	58.00	70.33
T6- NAA - 100 ppm	16.67	26.00	35.33	8.67	15.33	18.33	45.00	58.67	67.33
T7- NAA - 120 ppm	18.50	29.33	36.17	9.67	16.00	19.00	44.33	57.20	67.17
T8- NAA - 140 ppm	16.33	24.33	33.67	7.93	14.33	18.00	45.00	58.67	69.67
T9- Control	12.67	22.00	30.67	7.67	13.00	17.33	47.00	60.33	70.67
Mean	16.56	26.33	34.69	8.81	14.70	18.36	45.24	58.17	68.54
S Em+	0.81	1.44	1.05	0.39	0.60	0.35	0.57	0.58	0.62
CD (0.05)	2.43	4.32	3.16	1.18	1.81	1.06	1.70	1.75	1.87
CV	8.48	9.48	5.27	7.72	7.11	3.33	2.18	1.74	1.58

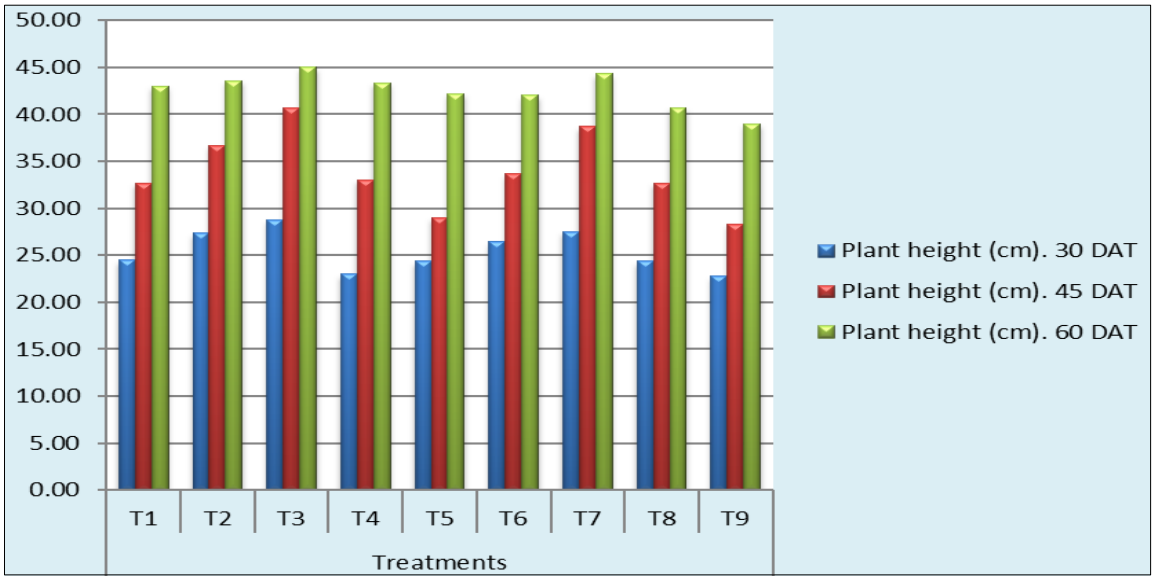

Fig 1: Effect of plant growth regulators on plant height (cm) of cauliflower

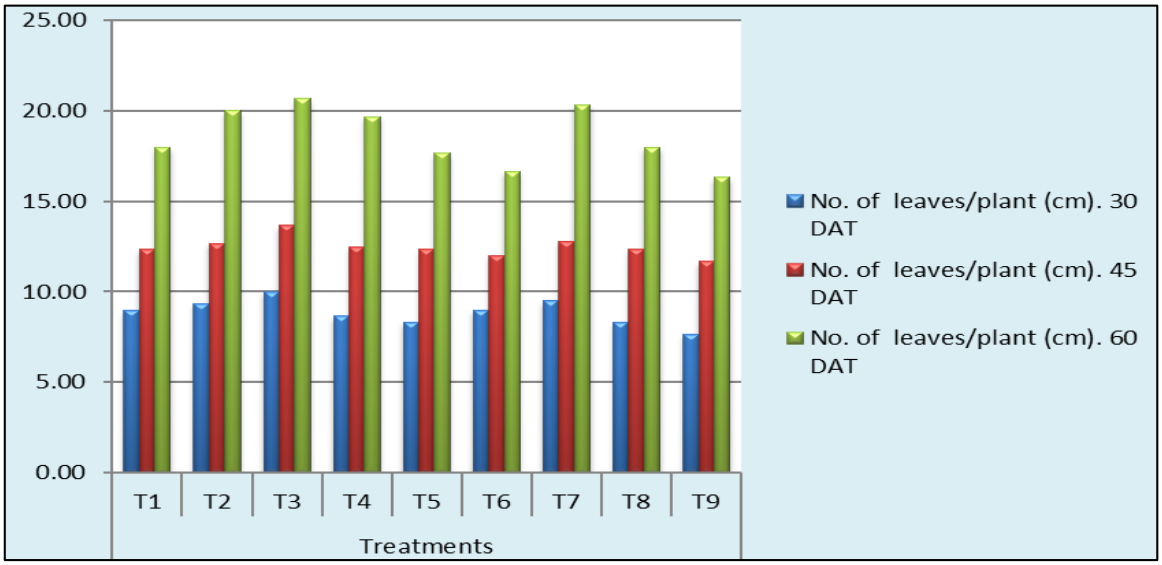

Fig 2: Effect of plant growth regulators on number of leaves in cauliflower

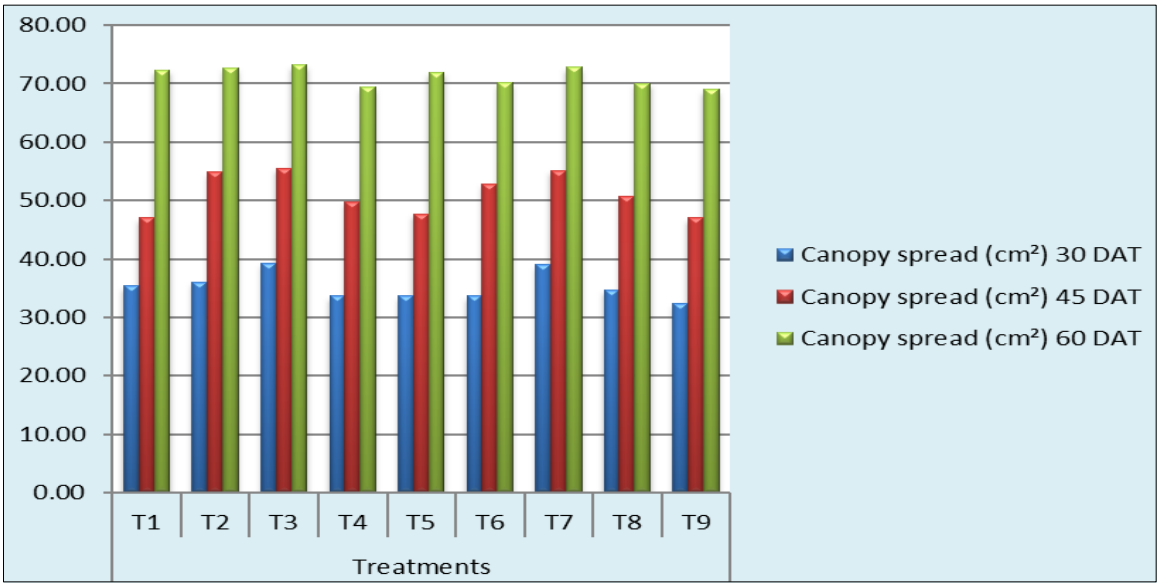

Fig 3: Effect of plant growth regulators on canopy spread (cm²) of cauliflower

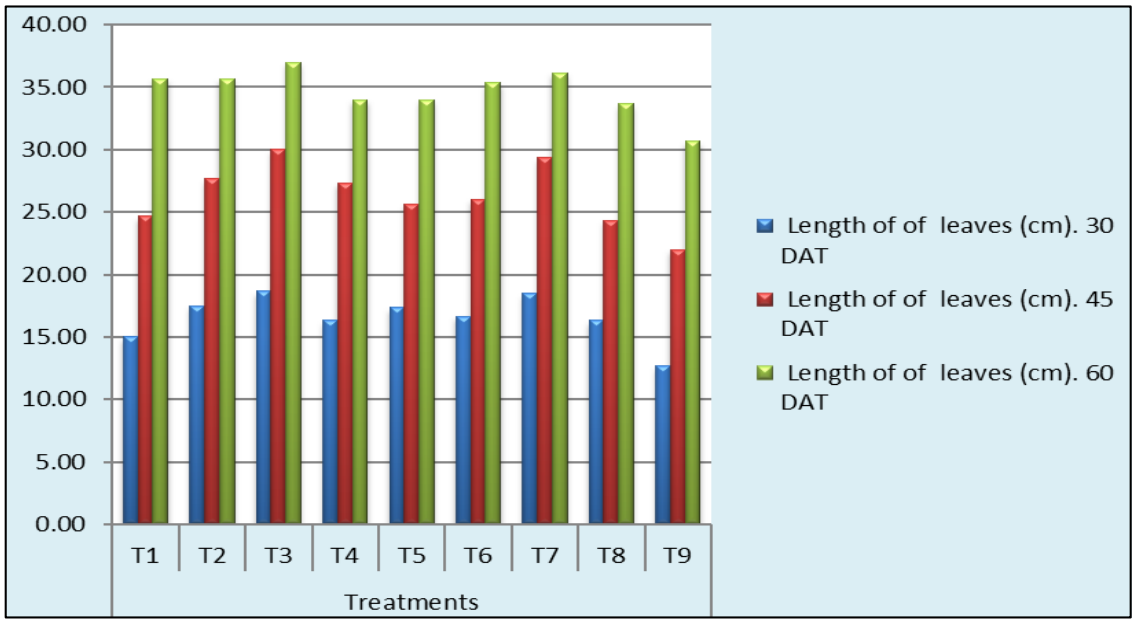

Fig 4: Effect of plant growth regulators on length of leaves (cm) of cauliflower

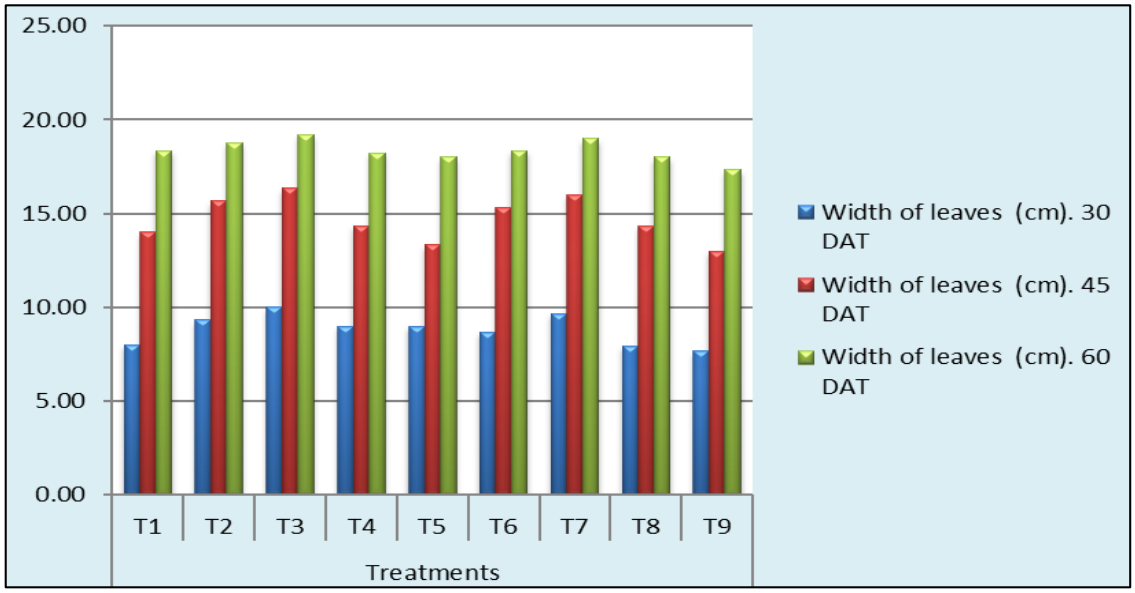

Fig 5: Effect of plant growth regulators on leaf width (cm) of cauliflower

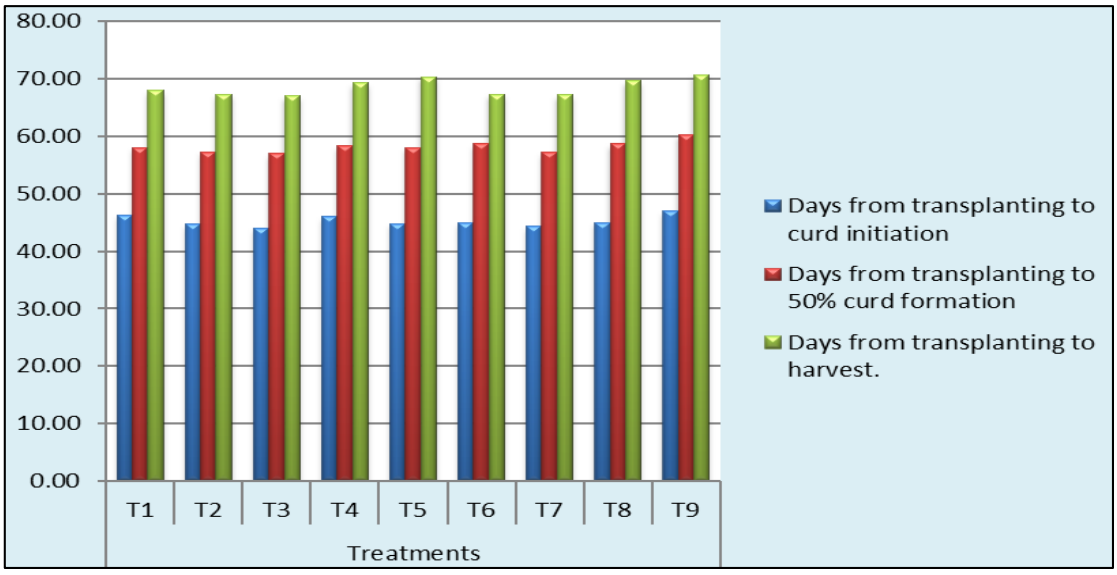

Fig 6: Effect of plant growth regulators on days from transplanting to curd initiation, days from transplanting to 50% curd formation, days from transplanting to harvest of cauliflower

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