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INFLUENCE OF GROWTH REGULATORS ON GROWTH PARAMETERS AND FLOWERING IN KALMEGH (*ANDROGRAPHIS PANNICULATA* WALL. EX. NEES.) VAR. CIM MEGHA”

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ABSTRACT

Kalmegh is also known as Maha tita in Sanskrit, “Rice bitters” in West Indies and “King of bitters” in England. The major bitter constituent in kalmegh is due to the presence of secondary metabolite (diterpenoid lactone) called “andrographolide” which is 3 % in leaves and 2 % in stems. In the present study, among the 13 treatments significant variability was observed for yield and quality parameters. The growth parameters indicated that, among all treatments, T_2 : GA_3 @ 150 ppm observed significantly highest plant height (40.40, 58.62, 66.30 cm respectively), number of primary branches (19.63, 24.03, 28.02 respectively), number of secondary branches (7.10, 10.40, 13.52 respectively), number of leaves per plant (156.43, 362.08, 483.27 respectively), leaf area per plant (993.61, 1387.20, 1950.54 cm² respectively), leaf area index (1.665, 2.326, 3.302 respectively), leaf stem ratio (2.95, 1.84, 0.71 respectively), chlorophyll content (68.91, 75.45 respectively) and crop growth rate (6.86, 3.72 g/m²/day respectively) at 60, 90 DAT and at harvest respectively, over other treatments, whereas stem diameter (4.50, 5.12, 5.36 mm at 60, 90 DAT and at harvest respectively) was registered highest with T_7 : Cycocel @ 100 ppm. Growth regulators directly influence on the growth of the plant. These are chemical substances and when applied in small amounts, they bring rapid changes in the phenotypes of the plant and also influence the plant growth, right from seed germination to senescence either by enhancing or by stimulating the natural growth regulatory system.

Key words: Kalmegh, growth regulators, herb yield, GA_3 and Cycocel

Introduction

Kalmegh (*Andrographis paniculata* Wall. Ex. Nees.) belonging to the family Acanthaceae, is a well-known medicinal herb indigenous to India and widely recognized for its immense therapeutic potential. It has held an important place in the Indian systems of medicine, including Ayurveda, Siddha and Unani, since ancient times. The plant is popularly referred to as “Maha Tita” in Sanskrit, meaning “the great bitter” (Ashok *et al.*, 2002), due to its intensely bitter taste. Across the globe, it is known by various names: “Rice bitters” in the West Indies, “King of bitters” in England (Farooqui and Sreeramu, 2004), “Create” in English, “Bhuinimb” in Sanskrit, “Kirayat” in Hindi, “Kalmegh” in Bengali, and “Nela Vemu” in Telugu, highlighting its widespread recognition across different cultures and regions.

Botanically, Kalmegh is an erect or sometimes recumbent herbaceous plant, typically annual in nature, though it can survive as a perennial under managed cultivation. The plant is particularly valued for its major bioactive constituents, the diterpenoid lactones, of which andrographolide is the most significant. Andrographolide, which accounts for approximately 3% in the leaves and 2% in the stems, imparts the characteristic bitterness of the plant.

Plant Growth Regulators (PGRs), also called plant hormones or phytohormones, are organic compounds (natural or synthetic) that in small amounts modify or control one or more physiological processes in plants such as growth, development and responses to stimuli. They are active in very low concentrations, can promote, inhibit or modify growth and act locally or move to distant sites

in plants. Effect of plant growth regulators (PGRs), depends on concentration, plant type, age, and environment. (Bohm, 1980).

Materials and Methods

The experiment was carried out at PG Students Research Block, College of Horticulture, SKLTSHU, India, during *khariif*. The experimental site is situated at a latitude of 17°32' north, longitude of 78°40' East and altitude of 542.3 m above mean sea level. The experiment was laid out in a complete RBD with thirteen treatments replicated thrice. The thirteen treatments viz., T₁ : GA₃ @ 100 ppm, T₂ : GA₃ @ 150 ppm, T₃ : GA₃ @ 200 ppm, T₄ : NAA @ 100 ppm, T₅ : NAA @ 150 ppm, T₆ : NAA @ 200 ppm, T₇ : Cycocel @ 100 ppm, T₈ : Cycocel @ 150 ppm, T₉ : Cycocel @ 200 ppm, T₁₀ : Benzyl amino purine @ 100 ppm, T₁₁ : Benzyl amino purine @ 150 ppm, T₁₂ : Benzyl amino purine @ 200 ppm, T₁₃ : Control (100 % RDF-87:75:50 kg NPK/ha + Distilled water spray) **Note:** Farm Yard Manure @10t/ha, as per recommended dose, was applied in the last plough prior to transplanting. RDF as per udyanapanchangam of SKLTSHU (NPK-87:75:50 kg/ha) was applied in control.

Plant growth regulators (GA₃, NAA, Cycocel, and Benzylaminopurine) of different concentrations (100, 150, and 200 mg/L) were prepared in the Department of Plant Physiology, College of Horticulture, Rajendranagar. The required quantities of growth regulator powders were initially dissolved in 2–5 drops of ethyl alcohol or alkaline solution, and the final volume was adjusted to 1000 mL with double-distilled water. Plants in the respective treatments were sprayed with the prepared solutions at 30, 60, and 90 days after transplanting, while control plants were treated with distilled water.

Table 1: Effect of growth regulators plant height (cm) and stem diameter (mm) at 60, 90 DAT and at harvest.

Treatments	Plant height (cm)			Stem diameter (mm)		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T ₁ : GA ₃ at 100 ppm	35.98	49.14	57.41	3.74	4.20	4.64
T ₂ : GA ₃ at 150 ppm	40.40	58.62	66.30	3.92	4.55	4.91
T ₃ : GA ₃ at 200 ppm	36.26	53.21	62.18	3.90	4.36	4.83
T ₄ : NAA at 100 ppm	32.83	45.20	52.90	3.86	4.30	4.78
T ₅ : NAA at 150 ppm	34.72	48.33	55.62	3.59	4.18	4.38
T ₆ : NAA at 200 ppm	39.51	55.26	64.49	3.80	4.23	4.59
T ₇ : Cycocel at 100 ppm	28.81	38.89	43.75	4.50	5.21	5.78
T ₈ : Cycocel at 150 ppm	29.54	37.27	40.33	4.37	5.18	5.63
T ₉ : Cycocel at 200 ppm	28.46	37.08	42.86	4.08	4.80	5.24
T ₁₀ : Benzylaminopurine at 100 ppm	25.40	34.01	30.82	4.21	5.12	5.36
T ₁₁ : Benzylaminopurine at 150 ppm	30.25	39.38	44.96	4.10	5.05	5.30
T ₁₂ : Benzylaminopurine at 200 ppm	26.28	35.25	41.57	4.02	4.56	5.42
T ₁₃ : Control (Distilled water spray)	31.43	41.36	46.54	3.18	3.63	4.04
S.E.m±	1.40	2.10	2.41	0.17	0.25	0.33
C.D.at 5%	4.09	6.14	7.04	0.49	0.72	0.96

Growth parameters

The data on growth parameters viz., Plant height (cm), stem diameter (mm), number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, leaf area (cm²), leaf area index (LAI), leaf stem ratio, fresh weight of leaves per plant (g), dry weight of leaves per plant (g), fresh herb weight (g), dry herb weight (g), Chlorophyll content (SPAD), Crop growth rate (CGR g/m²/day) as influenced by the effect of growth regulators were recorded at 60, 90 days after transplanting (DAT) at harvest and flowering parameters like days taken for flower initiation and days taken for 50 % flowering are presented in the Table 1,2,3,4,5 and 6.

Leaf area index

Leaf area index was calculated using the formula given by Williams (1946).

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Leaf area occupied by the plant (cm}^2\text{)}}$$

Crop growth rate (CGR)

By using the total dry weight of the plant, CGR was calculated by using the formula given by Watson (1952) and expressed in g/m² /day1 at 30-60, 60-90 - and 90-120-days intervals.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{A}$$

Where,

W₁ = Dry weight of the plant (g) at time T₁

W₂ = Dry weight of the plant (g) at time T₂

Table 2: Effect of growth regulators number of primary branches per plant and secondary branches per plant at 60, 90 DAT and at harvest.

Treatments	No. of primary branches per plant			No. of secondary branches per plant		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T ₁ : GA3 at 100 ppm	6.26	8.57	11.24	15.80	17.46	24.28
T ₂ : GA3 at 150 ppm	7.10	10.40	13.52	19.63	24.03	28.02
T ₃ : GA3 at 200 ppm	5.73	8.01	11.09	15.06	17.12	23.00
T ₄ : NAA at 100 ppm	5.16	7.13	10.25	14.52	17.04	22.35
T ₅ : NAA at 150 ppm	5.39	7.42	10.34	14.67	17.08	22.44
T ₆ : NAA at 200 ppm	7.07	10.15	13.06	19.11	22.23	26.21
T ₇ : Cycocel at 100 ppm	6.76	9.32	12.75	18.29	21.04	25.18
T ₈ : Cycocel at 150 ppm	6.28	9.30	12.62	18.05	20.26	24.75
T ₉ : Cycocel at 200 ppm	5.06	7.10	10.12	12.24	15.21	20.10
T ₁₀ : Benzylaminopurine at 100 ppm	5.10	7.11	10.18	13.27	16.00	21.29
T ₁₁ : Benzylaminopurine at 150 ppm	6.13	8.08	11.17	15.21	17.12	23.06
T ₁₂ : Benzylaminopurine at 200 ppm	4.86	7.10	10.09	11.49	14.83	19.37
T ₁₃ : Control (Distilled water spray)	3.18	6.03	8.29	9.47	11.09	15.24
S.E.m±	0.42	0.69	0.82	0.67	1.05	1.08
C.D.at 5%	1.23	2.02	2.40	1.82	3.06	3.17

$T_2 - T_1$ = Time interval in days

A = Land area (m²)

Results and Discussions

The data on growth parameters viz., Plant height (cm), stem diameter (mm), number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, leaf area (cm²), leaf area index (LAI), leaf stem ratio, Chlorophyll content (SPAD), Crop growth rate (CGR g/m²/day) as influenced by the effect of growth regulators were recorded at 60, 90 days after transplanting (DAT) at harvest and flowering parameters like days taken for flower initiation and days taken for 50 % flowering are presented in the Table 1, 2, 3, 4, 5 and 6.

Growth parameters

Plant height (cm)

The data revealed that the plant height (cm) in all the treatments increased with increase in the age of the plant up to harvest.

The data presented in Table: 1 revealed that significantly maximum plant height (40.40, 58.62 and 66.30 cm at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (39.51, 55.26 and 64.49 cm) followed by T₃ (GA₃ @ 200 ppm) recording the plant height of 36.26, 53.21 and 62.18 cm 60, 90 DAT and at harvest respectively. The minimum plant height of 25.40, 34.01 and 30.82 cm at 60, 90 DAT and at harvest respectively was recorded with T₁₀ (Benzylaminopurine @100 ppm).

Plant height continually increased with increasing crop age up to harvest. The increase in plant height may be due to internodal elongation. The application of growth promoters increased the plant height and such effect was due to increased photosynthetic activity, enhancement in the mobilization of photosynthates and change in the membrane permeability. Similar results reported on the medicinal plant (*Gloriosa Superba* L.) by K. Kannabiran and Padmanaban (2016).

Stem diameter (mm)

The data presented in Table 1 that significantly maximum stem diameter (4.50, 5.21 and 5.78 mm at 60, 90 DAT and at harvest respectively) was observed with T₇ (Cycocel @ 100 ppm) and was at par with T₈ (Cycocel @ 150 ppm) (4.37, 5.18 and 5.63 mm) ,T₁₀ (Benzylaminopurine @ 100 ppm) (4.21, 5.12 and 5.36 mm) followed by T₁₁ (Benzylaminopurine @ 150 ppm) recording the stem diameter of 4.10, 5.05 and 5.30 mm 60, 90 DAT and at harvest respectively. The minimum stem diameter of (3.18, 3.63 and 4.04 mm at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Plant growth retardants can delay cell division and elongation of plant aerial parts as well restrict gibberellin biosynthesis, thereby resulting in reduced internodal length, vegetative growth and increase stem diameter. These results are in conformity with findings of Rajiv *et al.*, (2018) in Nerium

Number of primary branches per plant

The data presented in Table 2. revealed that significantly maximum number of primary branches per

Table 3: Effect of growth regulators number of leaves per plant and leaf stem ratio at 60, 90 DAT and at harvest.

Treatments	Number of leaves/plant			Leaf stem ratio		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T ₁ : GA ₃ at 100 ppm	133.29	315.27	435.84	2.63	1.64	0.51
T ₂ : GA ₃ at 150 ppm	156.43	362.08	483.27	2.95	1.84	0.71
T ₃ : GA ₃ at 200 ppm	137.08	321.90	442.96	2.67	1.69	0.55
T ₄ : NAA at 100 ppm	122.03	264.42	400.26	2.50	1.52	0.49
T ₅ : NAA at 150 ppm	129.37	277.49	438.57	2.46	1.55	0.42
T ₆ : NAA at 200 ppm	149.63	347.15	467.21	2.86	1.80	0.68
T ₇ : Cycocel at 100 ppm	143.57	330.23	458.34	2.77	1.70	0.60
T ₈ : Cycocel at 150 ppm	124.49	291.37	420.19	2.52	1.60	0.57
T ₉ : Cycocel at 200 ppm	103.61	234.48	364.17	2.24	1.48	0.40
T ₁₀ : Benzylaminopurine at 100 ppm	118.85	250.18	383.39	2.38	1.48	0.46
T ₁₁ : Benzylaminopurine at 150 ppm	130.41	297.58	423.73	2.58	1.61	0.49
T ₁₂ : Benzylaminopurine at 200 ppm	101.25	231.06	343.38	2.20	1.47	0.41
T ₁₃ : Control (Distilled water spray)	90.17	201.37	294.19	1.59	1.21	0.32
S.E.m±	4.69	10.06	11.77	0.07	0.04	0.04
C.D.at 5%	13.69	29.37	34.34	0.14	0.11	0.09

plant (19.63, 24.03 and 28.02 at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm), T₇ (Cycocel @ 100 ppm) (19.11, 22.23 and 26.21), (18.29, 21.04 and 25.18), T₈ (Cycocel @ 150 ppm) (18.05, 20.26 and 24.75) followed by T₁ (GA₃ @ 100 ppm) recording the number of primary branches per plant of 15.80, 17.46 and 24.28 at 60, 90 DAT and at harvest respectively. The minimum number of primary branches per plant of (9.47, 11.09 and 15.24 at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray)

Number of secondary branches per plant

The data presented in Table 2 revealed that significantly maximum number of secondary branches per plant (7.10, 10.40 and 13.52 at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm), T₇ (Cycocel @ 100 ppm) (7.07, 10.15 and 13.06), (6.76, 9.32 and 12.75), T₈ (Cycocel @ 150 ppm) (6.28, 9.30 and 12.62) followed by T₁ (GA₃ @ 100 ppm) recording the number of secondary branches per plant of 6.26, 8.57 and 11.24 at 60, 90 DAT and at harvest respectively. The minimum number of secondary branches per plant of (3.18, 6.03 and 8.29 at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Higher number of primary and secondary branches in the plants applied with GA₃ and NAA can be related to enhance physiological activities such as cell division, cell elongation, photosynthesis and translocation of nutrients and photosynthates (Saxena, 1989).

Number of leaves per plant

The data presented in Table 3 revealed that significantly maximum number of leaves per plant (156.43, 362.08 and 483.27 at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (149.63, 347.15 and 467.21), T₇ (Cycocel @ 100 ppm) (143.57, 330.23 and 458.34) followed by T₃ (GA₃ @ 200 ppm) recording the number of leaves per plant of 137.08, 321.90 and 442.96 at 60, 90 DAT and at harvest respectively. The minimum number of leaves per plant of (90.17, 201.37 and 294.19 at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Leaf stem ratio

At 60, 90 DAT and at harvest data revealed that significantly maximum leaf stem ratio (2.95, 1.84 and 0.71 at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (2.86, 1.80 and 0.68) followed by T₇ (Cycocel @ 100 ppm) recording the leaf stem ratio of 2.77, 1.70 and 0.60 at 60, 90 DAT and at harvest respectively. The minimum leaf stem ratio of (1.59, 1.21 and 0.32 at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Plant growth regulators like GA₃ had the potential to accelerate the nutrients partitioning towards cells and active growth sites and simultaneously increases those nutrients absorption via increased root potential, and finally intensifies minerals and their related bio-molecules accumulation in shoots especially new leaves and apical

Table 4: Effect of growth regulators leaf area (cm²) and Leaf area index (LAI) at 60, 90 DAT and at harvest.

Treatments	Leaf area (cm ²)			Leaf area index (LAI)		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T ₁ : GA ₃ at 100 ppm	881.87	1195.42	1760.35	1.479	2.007	2.949
T ₂ : GA ₃ at 150 ppm	993.61	1387.20	1950.54	1.665	2.326	3.302
T ₃ : GA ₃ at 200 ppm	924.73	1246.61	1818.91	1.548	2.086	3.045
T ₄ : NAA at 100 ppm	656.46	1066.51	1407.63	1.128	1.777	2.346
T ₅ : NAA at 150 ppm	760.39	1099.38	1478.74	1.182	1.833	2.460
T ₆ : NAA at 200 ppm	954.58	1345.51	1910.69	1.593	2.242	3.183
T ₇ : Cycocel at 100 ppm	942.15	1302.14	1876.80	1.555	2.163	3.118
T ₈ : Cycocel at 150 ppm	800.39	1117.20	1554.10	1.246	1.830	2.547
T ₉ : Cycocel at 200 ppm	646.28	1021.43	1324.13	1.093	1.687	2.187
T ₁₀ : Benzylaminopurine at 100 ppm	661.54	1036.29	1381.29	1.103	1.714	2.293
T ₁₁ : Benzylaminopurine at 150 ppm	840.41	1168.70	1584.86	1.413	1.947	2.640
T ₁₂ : Benzylaminopurine at 200 ppm	636.35	1013.17	1134.45	1.078	1.685	1.892
T ₁₃ : Control (Distilled water spray)	507.04	929.32	1005.68	0.976	1.212	1.597
S.E.m±	16.89	30.16	35.64	0.052	0.071	0.080
C.D.at 5%	49.29	88.04	104.02	0.112	0.207	0.233

shoots passing active growth and development. This result was in accordance with Shah *et al.*, (2006) in *Nigella sativa* L. and Hassanpouraghdam *et al.*, (2011) in Lavender.

Leaf area (cm²)

The data presented in Table 4. revealed that significantly maximum leaf area (cm²) (993.61, 1387.20 and 1950.54 cm² at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (954.58, 1345.51 and 1910.69 cm²), T₇ (Cycocel @ 100 ppm) (942.15, 1302.14 and 1876.80 cm²) followed by T₃ (GA₃ @ 200 ppm) recording the leaf area (cm²) of 924.73, 1246.61 and 1818.91 cm² at 60, 90 DAT and at harvest respectively. The minimum leaf area (cm²) of (507.04, 929.32 and 1005.68 cm² at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Leaf area Index (LAI)

The data presented in Table 4 revealed that significantly maximum leaf area index (1.665, 2.326 and 3.302 at 60, 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (1.593, 2.242 and 3.183), T₇ (Cycocel @ 100 ppm) (1.555, 2.163 and 3.118) followed by T₃ (GA₃ @ 200 ppm) recording the leaf area index of 1.548, 2.086 and 3.045 at 60, 90 DAT and at harvest respectively. The minimum leaf area index of (0.976, 1.212 and 1.597 at 60, 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Foliar spray GA₃ and NAA brings the inherent

genetic potential of plant to cause increased cell division and cell wall- extensibility thereby resulting in increasing leaf area. The co-relation between the number of leaves per plant and number of branches increase in case of application of PGRs helps to increased leaf area and leaf area index as compared to control. These results are same with previous finding of El-Sayed, (2014) in *Schefflera arboricola*, Raidas *et al.*, (2020) in kalmegh, Kumari *et al.*, (2016) in kalmegh, Yogita *et al.*, (2013) in Ajwain.

SPAD chlorophyll meter readings

The data presented in Table 5 for Chlorophyll content (SPAD) revealed that at 60 DAT did not differ significantly among the treatments. However, maximum Chlorophyll content (SPAD) reading was recorded in T₂: GA₃ @ 150 PPM (54.80).

At 90 DAT and at harvest data revealed that significantly maximum Chlorophyll content (SPAD) (68.91 and 75.45 at 90 DAT and at harvest respectively) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (67.14 and 72.36) followed by T₃ (GA₃ @ 200 ppm) recording the Chlorophyll content (SPAD) of 66.28 and 71.81 at 90 DAT and at harvest respectively. The minimum Chlorophyll content (SPAD) of 50.38 and 60.60 at 90 DAT and at harvest respectively) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Chlorophyll is one of the important constituents of photosynthesis is generally influenced by the application of phytohormones. In the present investigation, all the phytohormones treated plants contained higher chlorophyll content than control plants. The higher level of chlorophyll

Table 5: Effect of growth regulators chlorophyll content (SPAD) and crop growth rate (g/cm²/day) at 60, 90 DAT and at harvest.

Treatments	Chlorophyll content (SPAD)			Crop growth rate (g/cm ² /day)		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T ₁ : GA3 at 100 ppm	52.10	65.27	70.49	6.40	3.11	
T ₂ : GA3 at 150 ppm	54.80	68.91	75.45	6.81	3.72	
T ₃ : GA3 at 200 ppm	52.89	66.28	71.81	6.42	3.23	
T ₄ : NAA at 100 ppm	52.56	64.83	70.34	5.82	3.07	
T ₅ : NAA at 150 ppm	50.73	63.85	69.60	6.14	2.79	
T ₆ : NAA at 200 ppm	53.96	67.14	72.36	6.60	3.65	
T ₇ : Cycocel at 100 ppm	52.48	66.17	70.28	6.49	3.37	
T ₈ : Cycocel at 150 ppm	52.37	64.58	69.23	6.21	2.91	
T ₉ : Cycocel at 200 ppm	53.64	58.10	68.42	5.26	2.56	
T ₁₀ : Benzylaminopurine at 100 ppm	52.41	59.24	68.53	5.82	2.61	
T ₁₁ : Benzylaminopurine at 150 ppm	50.36	66.17	70.02	6.38	2.69	
T ₁₂ : Benzylaminopurine at 200 ppm	50.67	54.76	68.14	4.47	2.59	
T ₁₃ : Control (Distilled water spray)	50.11	50.38	60.60	3.92	2.34	
S.Em±	0.74	1.22	1.24	0.14	0.11	
C.D.at 5%	NS	3.55	3.61	0.43	0.31	

content may be due to delay in degradation of chlorophyll caused by the exogenous application of phytohormones. This findings were supported with the results of Raidas *et al.*, (2020) in kalmegh and Pooja *et al.*, (2020) in stevia.

Crop growth rate (g/m²/day)

The crop growth rate was shown increased up to 60-90 days after transplanting then decreased during the 90-At harvest i.e. after reproductive stage to maturity phase of growth, crop growth rate decline. The effect of phytohormones represent significant differences among the treatment at all growth phases. The data recorded on Crop growth rate (g/m²/day) at 60-90 days interval and 90-At harvest as influenced by the spraying of growth regulators on crop growth rate (g/m²/day) are presented in Table 5.

At 60-90 days interval data revealed that significantly maximum crop growth rate (g/m²/day) (6.83 g/m²/day) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (6.60 g/m²/day) followed by T₇ (Cycocel @ 100 ppm) of 6.49 g/m²/day. The minimum crop growth rate (g/m²/day) of (3.92 g/m²/day) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray)

At 90-At Harvest data revealed that significantly maximum crop growth rate (g/m²/day) (3.72 g/m²/day) was observed with T₂ (GA₃ @ 150 ppm) and was at par with T₆ (NAA @ 200 ppm) (3.65 g/m²/day) followed by T₇ (Cycocel @ 100 ppm) of 3.37 g/m²/day. The minimum crop growth rate (g/m²/day) of (2.34 g/m²/day) was recorded with T₁₃ Control (100% RDF- 87:75:50 + Distilled water spray).

Crop growth rate (CGR) is used as a character for

estimating production efficiency of crop stand, which is influenced by LAI, photosynthetic rate and leaf angle and is an index of amount of light interception. CGR was recorded the highest in T₂ at 60-90 DAT due to more sun shine hours available for photosynthetic activity and temperature recorded the highest in 60-90 days interval. Crop growth increased at period 90 DAT there after crop growth was shown steady decrease due to transport of photosynthate towards the reproductive phase. (Faldu, 2018). Similar results were reported by Shende (2016) in kalmegh, Parashar *et al.*, (2011) in kalmegh.

Table 6: Effect of growth regulators days taken flower initiation and days taken for 50 % flowering at 60, 90 DAT and at harvest.

Treatments	Days taken flower initiation	Days taken for 50% flowering
T ₁ : GA3 at 100 ppm	86.58	97.25
T ₂ : GA3 at 150 ppm	84.16	98.19
T ₃ : GA3 at 200 ppm	84.94	98.43
T ₄ : NAA at 100 ppm	86.23	99.52
T ₅ : NAA at 150 ppm	86.54	98.69
T ₆ : NAA at 200 ppm	86.74	98.14
T ₇ : Cycocel at 100 ppm	85.65	96.32
T ₈ : Cycocel at 150 ppm	84.27	95.19
T ₉ : Cycocel at 200 ppm	86.76	95.16
T ₁₀ : Benzylaminopurine at 100 ppm	86.58	86.58
T ₁₁ : Benzylaminopurine at 150 ppm	84.66	97.52
T ₁₂ : Benzylaminopurine at 200 ppm	83.32	96.13
T ₁₃ : Control (Distilled water spray)	89.18	99.72
S.Em±	0.98	1.21
C.D.at 5%	NS	NS

Flowering parameters

Days taken for flower initiation and days taken for 50 % flowering

The data pertaining to the effect of different growth regulators treatments on days taken for flower initiation and days taken for 50 % flowering of kalmegh are presented in Table 6 revealed that the different treatments in this experiment did not exert their significant effect on kalmegh .

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References

- Ashok, K., Amit A., Sujatha A., Murali B. and Anand M.S. (2002). Effect of aging on andrographolide content in *Andrographis paniculata*. *Journal of natural remedies*. **2(2)**, 179-181.
- Bohm, H. (1980). The formation of secondary metabolites in plant tissue and cell culture. *International Review of Cytology*. **11(B)**, 183-208.
- El-Sayed, A.A., El-Hanafy S.H. and El-Ziat R.A. (2012). Effect of chicken manure and humic acid on herb and essential oil production of *Ocimum spp.* *American-Eurasian Agricultural Environmental Science*. **15(3)**, 367-379.
- Faldu, T. (20180). Effect of growth regulators on growth, yield and nutrient uptake of groundnut CV. GJG-9 (*Arachis hypogaea* L.) Master's thesis, JAU, Junagadh.
- Hassanpouraghdam, M.B., Hajisamadi A.B. and Khalighi A. (2011). Gibberellic Acid Foliar Application Influences Growth, Volatile Oil and Some Physiological Characteristics of Lavender (*Lavandula officinalis* Chaix.). *Romanian Biotechnological Letters*. **16(4)**.
- Kannabiran, K. and Padmanaban (2016). Effect of Growth Regulators and Tuber Weight on Plant Height and Number of Branches in Glory Lily (*Gloriosa superba* L.). *International Journal of Innovative Research and Development*. **2278**, 342.
- Parasher, R., Upadhyay A., Khan N.A. and Kumar Dwivedi S (2011a). Biochemical estimation and quantitative determination of medicinally important Andrographolide in *Andrographis paniculata* at different growth stages. *Electronic Journal of Environmental Agriculture and Food chemistry*. **10(7)**, 2479-2486.
- Pooja, R.D. and Gopinath G. (2020). Influence of pinching and growth regulators geeon yield and stevioside content in stevia (*Stevia rebaudiana* Bertoni). *Journal of Pharmacognosy and Phytochemistry*. **9(5)**, 2285-2288.
- Raidas, D.K., Upadhayaya S.D., Sharma A. (2020). Effect of different plant growth hormones on morphological-physiological and yield attributing characteristics in kalmegh (*Andrographis paniculata* Burn F. Ex). *International Journal of Current Microbiology and Applied Sciences*. **9(2)**, 519-524.
- Rajiv, G., Jawaharlal M., Subramanian S., Sudhakar D. and Uma D. (2018). Effect of Plant Growth Retardants on the Growth and Flowering of Nerium (*Nerium Oleander* L.) Cv. Red. *Chemical Science Review and Letters*. **7(28)**, 875-879.
- Saxena, O.P. (1989). Role of plant growth regulators in plant productivity studies. In: proceedings, National seminar on strategies in physiological regulation of plant productivity. *Indian Society of Plant Physiology*. New Delhi. 13-17.
- Shah, S.H., Ahmad I. and Samiullah (2006). Effect of gibberellic acid spray on growth, nutrient uptake and yield attributes during various growth stages of black cumin (*Nigella sativa* L.). *Asian Journal of Plant Sciences*. **5**, 881-884.
- Shende, P. (2016). Influence of plant growth regulators, nipping and different leaf removal levels on morpho-physiological parameters, biomass yield and quality of kalmegh (*Andrographis paniculata* (Burm. f.) Wall. Ex Nees). (Doctoral thesis, AAU, Anand).
- Watson, D.J. (1952). The physiological basis of variation in yield. *In Advances in Agronomy*. **4**, 101-145.
- Williams, R.F. (1946). The physiology of plant growth with special reference to the concept of net assimilation rate. *Annals of botany*. **10**, 9-16.
- Yogita, R., Nikam T.D. and Dhumal K.N. (2013). Effect of foliar application of plant growth regulators on growth, yield and essential oil components of ajwain (*Trachyspermum ammi* L.). *International Journal of Seed Spices*. **3(2)**, 34-41.