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EFFECT OF FOLIAR APPLICATION OF ELICITORS ON THE GROWTH OF KALMEGH (*Andrographis paniculata*)

M. Naga Chandana[1]*, A. Chandini Raj[1], M. Kalpana[1] and K. Uma Krishna[2]

[1]Departments of Plantation, Spices, Medicinal and Aromatic Crops, Dr.YSRHU-COH, Venkataramannagudem, West Godavari-534 101, Andhra Pradesh, India.

[2]Departments of Agricultural Statistics, Dr. YSRHU-COH, Venkataramannagudem, West Godavari, Andhra Pradesh-534 101, India.

*Corresponding author E-mail : chandanamaridi630@gmail.com

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ABSTRACT

The present investigation was conducted to evaluate the effect of elicitors on the growth parameters of Kalmegh (*Andrographis paniculata*). The experiment comprised ten treatments, including chitosan at 500, 750 and 1000 ppm, salicylic acid at 100, 150 and 200 ppm, jasmonic acid at 100, 150 and 200 ppm and a water-treated control. Among the treatments, foliar application of chitosan at 1000 ppm (T_3) recorded the maximum plant height of 35.70, 53.63 and 66.77 cm at 45 DAT, 75 DAT and harvest, respectively. Similarly, the maximum plant spread of 19.15 and 33.43 cm was recorded under T_3 at 45 and 75 DAT, respectively, while salicylic acid at 200 ppm (T_6) recorded the maximum plant spread of 38.27 cm at harvest, which was statistically on par with T3. Chitosan at 1000 ppm also recorded the highest number of primary branches, with 13.20, 20.00 and 27.77 branches per plant at 45 DAT, 75 DAT and harvest, respectively.

Regarding leaf characteristics, salicylic acid at 200 ppm (T_6) recorded the maximum leaf length of 6.07 cm and leaf width of 1.84 cm. In contrast, chitosan at 1000 ppm (T_3) recorded the highest individual leaf area of 6.52 cm², number of leaves per plant of 123.50, leaf area per plant of 806.87 cm² and leaf area index of 1.34. The water-treated control generally recorded lower values for the major growth parameters. Overall, chitosan at 1000 ppm promoted plant height, plant spread during the vegetative stages, primary branching, leaf production, individual leaf area, leaf area per plant and leaf area index, whereas salicylic acid at 200 ppm favourably influenced leaf length and width. The findings indicate that foliar application of chitosan at 1000 ppm and salicylic acid at 200 ppm improved different aspects of vegetative growth in Kalmegh.

Key words : *Andrographis paniculata*, Kalmegh, chitosan, Salicylic acid, Jasmonic acid, Hrowth parameters and Leaf area index.

Introduction

Medicinal crops play an important role in traditional healthcare systems and serve as valuable sources of bioactive compounds for pharmaceutical, herbal and nutraceutical industries. The growing interest in plant-based medicines has increased the importance of cultivating medicinal plants using suitable agronomic practices to ensure a consistent supply of quality plant materials. Improving the growth and productivity of medicinal crops is therefore important for meeting the increasing demand for plant-derived medicinal products.

Kalmegh (*Andrographis paniculata*), belonging to the family Acanthaceae, is an important medicinal herb commonly known as the “King of Bitters.” It is widely used in traditional systems of medicine, particularly in South and Southeast Asia. Its medicinal properties are primarily associated with diterpenoid lactones, particularly andrographolide, along with other important phytoconstituents such as neoandrographolide and dehydroandrographolide (Hossain *et al.*, 2014). The medicinal importance and diverse phytochemical composition of this plant highlight the need for suitable cultivation practices that promote healthy plant growth and biomass production.

Vegetative growth is an important indicator of plant vigour and development. Plant height reflects vertical

growth, whereas plant spread indicates horizontal canopy expansion. Primary and secondary branches contribute to plant architecture and provide additional sites for leaf development. Leaf length, leaf width and the number of leaves influence the development of the photosynthetically active surface, while individual leaf area and total leaf area per plant provide further information on leaf expansion and canopy development. Leaf area index (LAI), defined as the ratio of total leaf area to the ground area occupied by the crop, is an important parameter for assessing canopy development and potential light interception (Watson, 1947).

Plant growth and development can be influenced by elicitors and signalling compounds such as chitosan, salicylic acid and jasmonic acid. Chitosan has been reported to influence plant growth, physiological processes and responses to environmental stresses (Hidangmayum *et al*., 2019). Salicylic acid plays important roles in regulating plant growth, photosynthetic activity and responses to environmental stresses (Hayat et al., 2010). Jasmonic acid is involved in plant defence signalling and the regulation of growth and development (Wasternack and Hause, 2013). However, plant responses to these compounds may vary depending on their type and concentration, plant species and environmental conditions. Evaluating different concentrations is therefore important for identifying suitable treatments for improving the vegetative growth of medicinal crops.

Previous research has demonstrated that elicitor application can influence the growth, yield and quality of Kalmegh. Gowda *et al*. (2023) investigated elicitor-mediated responses in Kalmegh and reported variations in growth, yield and quality attributes following treatment application. Kalariya *et al*. (2023) evaluated the effects of methyl jasmonate and salicylic acid on *A. paniculata* under deficit soil-moisture conditions, highlighting the importance of growing conditions when assessing elicitor responses. These studies provide a basis for further investigating the effects of elicitors on Kalmegh. However, comparative evaluation of different concentrations of chitosan, salicylic acid and jasmonic acid remains valuable for understanding their effects on vegetative growth, particularly leaf dimensions, individual leaf area, leaf area per plant and leaf area index under specific growing conditions.

In view of the above, the present investigation was undertaken to evaluate the effects of different concentrations of chitosan, salicylic acid and jasmonic acid on the growth parameters of Kalmegh (*Andrographis paniculata*) variety CIM Megha. The study focused on plant height, plant spread, number of primary branches, number of secondary branches, leaf length, leaf width, number of leaves, individual leaf area, leaf area per plant and leaf area index, with the objective of identifying suitable elicitor treatments for improving vegetative growth under the prevailing experimental conditions.

Materials and Methods

The field experiment was conducted during 2025–2026 at the experimental farm of the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, Andhra Pradesh, India, using Kalmegh (*Andrographis paniculata*) variety CIM Megha.

Seeds were sown in portrays containing vermicompost and cocopeat as the growing medium. The seedlings were maintained under nursery conditions and irrigated using overhead sprinklers at the College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem. Healthy seedlings were transplanted into the main field 45 days after sowing (DAS).

The experiment comprised ten treatments arranged in a Randomized Block Design (RBD) with three replications, resulting in 30 experimental plots. Each plot measured 2 m × 2 m, covering an area of 4 m² and the seedlings were transplanted at a spacing of 30 cm × 20 cm. The treatments consisted of T_1: chitosan @ 500 ppm; T_2: chitosan @ 750 ppm; T_3: chitosan @ 1000 ppm; T_4: salicylic acid @ 100 ppm; T_5: salicylic acid @ 150 ppm; T_6: salicylic acid @ 200 ppm; T_7: jasmonic acid @ 100 ppm; T_8: jasmonic acid @ 150 ppm; T_9: jasmonic acid @ 200 ppm; and T_{10}: water spray (control).

Chitosan, salicylic acid and jasmonic acid were applied as foliar sprays at their respective concentrations. Two foliar applications were given at 30 and 60 days after transplanting (DAT). Five healthy plants were randomly selected and tagged in each plot for recording observations.

Plant height, plant spread, and the number of primary and secondary branches per plant were recorded at 45 DAT, 75 DAT and at harvest. Plant height was measured from the soil surface to the growing tip of the main stem using a measuring scale and expressed in centimetres (cm). Plant spread was measured across the canopy in two perpendicular directions and expressed in centimetres. Primary branches arising directly from the main stem and secondary branches arising from primary

branches were counted and expressed as the number of branches per plant.

Leaf parameters were recorded on the tagged plants at harvest. Leaf length was measured from the base to the tip of the leaf, while leaf width was measured at the broadest portion of the leaf. The number of leaves per plant was determined by counting the leaves on each tagged plant. Leaf area was measured using a leaf area meter and expressed in cm^2. Leaf area per plant was expressed in cm^2 $plant^{-1}$, Leaf area per plant was calculated by summing the leaf area of all leaves on an individual plant and expressed in (cm^2 $plant^{-1}$). following the procedure used during the experiment.

Results and Discussion

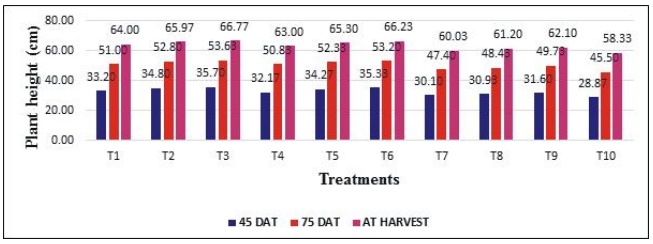
Plant height (cm)

The maximum plant height was recorded in 45 DAT at T_3 (chitosan @ 1000 ppm) (35.70cm), which was on par with T_6 (Salicylic acid @200 ppm) (35.33cm), T_2 (Chitosan @750 ppm) (34.80cm) and T_5 (Salicylic acid @ 150 ppm) (34.27cm). The minimum plant height was recorded in T_{10} (control) (28.87). Similar pattern was observed in 75DAT and at harvest stage. The data on plant height (cm) presented in Table 1 and Fig. 1.

The maximum plant height under chitosan @ 1000 ppm may be attributed to improve in development. Comparable results were reported by Gowda *et al*. (2023) in Kalmegh evaluated elicitor treatments for improving growth, yield and quality. The favourable response to chitosan may be associated with improved nutrient utilization and assimilate production, whereas the comparatively lower plant height in the water control may

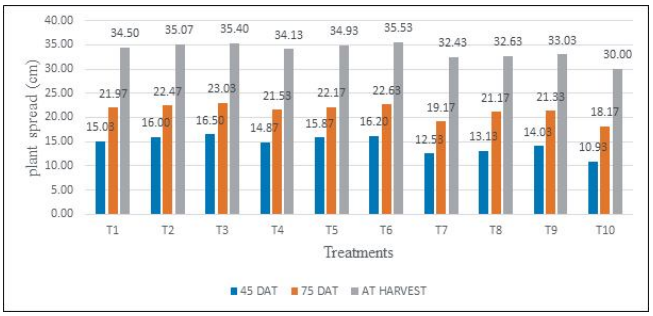
Table 1 : Effect of different elicitor treatments on Plant height (cm) of Kalmegh variety CIM Megha.

Treatments	Plant height (cm)		
	45 DAT	75 DAT	At harvest
T_1: Chitosan @ 500 ppm	33.20	51.00	64.00
T_2: Chitosan @750 ppm	34.80	52.80	65.97
T_3: Chitosan @ 1000 ppm	35.70	53.63	66.77
T_4: Salicylic acid @ 100 ppm	32.17	50.83	63.00
T_5: Salicylic acid @ 150 ppm	34.27	52.33	65.30
T_6: Salicylic acid @200 ppm	35.33	53.20	66.23
T_7: Jasmonic acid @100 ppm	30.10	47.40	60.03
T_8: Jasmonic acid @150 ppm	30.93	48.83	61.20
T_9: Jasmonic acid @200 ppm	31.60	49.73	62.10
T_{10}: Water spray (Control)	28.87	45.50	58.33
Mean	32.70	50.50	63.29
S E m±	0.480	0.630	0.647
C D @ 0.05%	1.43	1.87	1.92



T_1 = Chitosan @ 500 ppm
T_2 = Chitosan @750 ppm
T_3 = Chitosan @ 1000 ppm
T_4 = Salicylic acid @ 100 ppm
T_5 = Salicylic acid @ 150 ppm
T_6 = Salicylic acid @ 200 ppm
T_7 = Jasmonic acid @ 100 ppm
T_8 = Jasmonic acid @ 150 ppm
T_9 = Jasmonic acid @ 200 ppm
T_{10} = Water spray(control)

Fig. 1 : A graphical representation of effect of different elicitor treatments on Plant height (cm) of Kalmegh variety CIM Megha.



T_1 = Chitosan @ 500 ppm
T_2 = Chitosan @750 ppm
T_3 = Chitosan @ 1000 ppm
T_4 = Salicylic acid @ 100 ppm
T_5 = Salicylic acid @ 150 ppm
T_6 = Salicylic acid @ 200 ppm
T_7 = Jasmonic acid @ 100 ppm
T_8 = Jasmonic acid @ 150 ppm
T_9 = Jasmonic acid @ 200 ppm
T_{10} = Water spray(control)

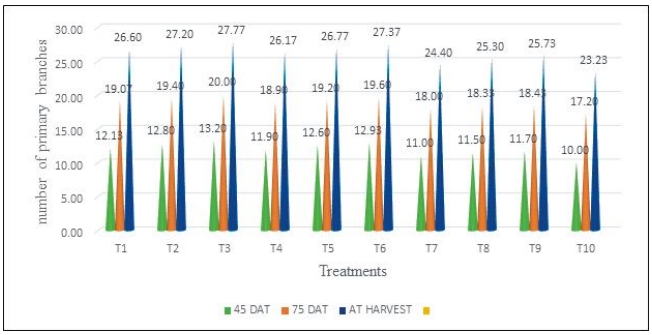
Fig. 2 : A graphical representation of effect of different elicitor treatments on Plant spread (cm) of Kalmegh variety CIM Megha.

reflect the absence of elicitor-associated growth benefits.

Plant spread (cm)

The maximum plant spread recorded at 45 DAT in T_3 (chitosan @ 1000 ppm) (16.50cm), which was on par with T_6 (salicylic acid @ 200 ppm) (16.20cm), T_2(Chitosan @ 750 ppm) (16.00cm) and T_5 (Salicylic acid @ 150 ppm) (15.87cm). The minimum plant spread recorded in T_{10}(control)(10.93cm). similar pattern was observed 75 DAT and at Harvesting stages. The data on plant spread(cm) presented in Table 2 and Fig. 2.

The maximum plant spread under chitosan @ 1000 ppm at 45 and 75 DAT may be attributed to improved vegetative growth, lateral branch development and canopy expansion. The higher plant spread under salicylic acid @ 200 ppm at harvest may be associated with improved photosynthetic activity and assimilate availability, supporting the development and expansion of lateral shoots. Comparable research on elicitor-mediated growth



T_1 = Chitosan @ 500 ppm
T_2 = Chitosan @750 ppm
T_3 = Chitosan @ 1000 ppm
T_4 = Salicylic acid @ 100 ppm
T_5 = Salicylic acid @ 150 ppm
T_6 = Salicylic acid @ 200 ppm
T_7 = Jasmonic acid @ 100 ppm
T_8 = Jasmonic acid @ 150 ppm
T_9 = Jasmonic acid @ 200 ppm
T_{10} = Water spray(control)

Fig. 3 : A graphical representation of effect of different elicitor treatments on Number of Primary branches per plant of Kalmegh variety CIM Megha.

Table 2 : Effect of different elicitor treatments on Plant spread (cm) of Kalmegh variety CIM Megha.

Treatments	Plant spread (cm)		
	45 DAT	75 DAT	At harvest
T_1: Chitosan @ 500 ppm	15.03	21.97	34.50
T_2: Chitosan @ 750 ppm	16.00	22.47	35.07
T_3: Chitosan @ 1000 ppm	16.50	23.03	35.40
T_4: Salicylic acid @ 100 ppm	14.87	21.53	34.13
T_5: Salicylic acid @ 150 ppm	15.87	22.17	34.93
T_6: Salicylic acid @ 200 ppm	16.20	22.63	35.53
T_7: Jasmonic acid @ 100 ppm	12.53	19.17	32.43
T_8: Jasmonic acid @ 150 ppm	13.13	21.17	32.63
T_9: Jasmonic acid @ 200 ppm	14.03	21.33	33.03
T_{10}: Water spray (Control)	10.93	18.17	30.00
Mean	14.51	21.36	33.77
S E m±	0.234	0.296	0.329
C D @ 0.05%	0.69	0.88	0.98

responses in Kalmegh was reported by Gowda *et al*. (2023). The minimum plant spread in the water control may be due to the absence of elicitor-associated benefits for vegetative growth.

Number of primary branches (cm)

The maximum number of primary branches was recorded in 45 DAT in T_3 (chitosan @ 1000 ppm) (T_3) (13.20), which was on par with T_6 (Salicylic acid @ 200 ppm) (12.93), T_2 (Chitosan @ 750 ppm) (12.80) and T_5 (Salicylic acid @ 150 ppm) (12.60). The minimum number of primary branches was recorded in the water control T_{10} (control) (10.00). Similar pattern was observed75DAT and at harvest stage. The data on plant spread(cm) presented in Table 3 and Fig. 3.

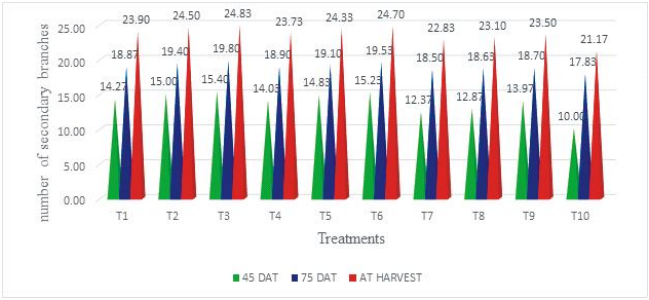


Fig. 4 : A graphical representation of effect of different elicitor treatments on Number of secondary branches per plant of Kalmegh variety CIM Megha.

Table 3 : Effect of different elicitor treatments on Number of primary branches per plant of Kalmegh variety CIM Megha.

Treatments	Number of primary branches per plant		
	45 DAT	75 DAT	At harvest
T_1: Chitosan @ 500 ppm	12.13	19.07	26.60
T_2: Chitosan @ 750 ppm	12.80	19.40	27.20
T_3: Chitosan @ 1000 ppm	13.20	20.00	27.77
T_4: Salicylic acid @ 100 ppm	11.90	18.90	26.17
T_5: Salicylic acid @ 150 ppm	12.60	19.20	26.77
T_6: Salicylic acid @ 200 ppm	12.93	19.60	27.37
T_7: Jasmonic acid @ 100 ppm	11.00	18.00	24.40
T_8: Jasmonic acid @ 150 ppm	11.50	18.33	25.30
T_9: Jasmonic acid @ 200 ppm	11.70	18.43	25.73
T_{10}: Water spray (Control)	10.00	17.20	23.23
Mean	11.98	18.81	26.05
S E m±	0.251	0.302	0.346
C D @ 0.05%	0.75	0.90	1.03

The maximum number of primary branches under chitosan @ 1000 ppm may be attributed to enhanced vegetative growth and improved physiological activity, which promote the development of primary shoots. The favourable response may also be associated with improved nutrient utilization and assimilate availability, supporting branch development. Comparable research on elicitor-mediated growth responses in Kalmegh was reported by Gowda *et al.* (2023). The minimum number of primary branches in the water control may reflect the absence of elicitor-associated benefits for vegetative growth.

Number of secondary branches

The maximum number of secondary branches at 45 DAT was recorded in T_3 (chitosan @ 1000 ppm) (15.40) which was on par with T_6 (salicylic acid @ 200 ppm) (15.23), T_2 (Chitosan @ 750 ppm) (15.00) T_5 (Salicylic acid @ 150 ppm) (14.83). The minimum number of

Table 4 : Effect of different elicitor treatments on Number of secondary branches per plant of Kalmegh variety CIM Megha.

Treatments	Number of Secondary branches per Plant		
	45 DAT	75 DAT	At harvest
T_1: Chitosan @ 500 ppm	14.27	18.87	23.90
T_2: Chitosan @ 750 ppm	15.00	19.40	24.50
T_3: Chitosan @ 1000 ppm	15.40	19.80	24.83
T_4: Salicylic acid @ 100 ppm	14.03	18.90	23.73
T_5: Salicylic acid @ 150 ppm	14.83	19.10	24.33
T_6: Salicylic acid @ 200 ppm	15.23	19.53	24.70
T_7: Jasmonic acid @ 100 ppm	12.37	18.50	22.83
T_8: Jasmonic acid @ 150 ppm	12.87	18.63	23.10
T_9: Jasmonic acid @ 200 ppm	13.97	18.70	23.50
T_{10}: Water spray (Control)	10.00	17.83	21.17
Mean	13.80	18.93	23.66
S E m±	0.221	0.265	0.268
C D @ 0.05%	0.66	0.79	0.80

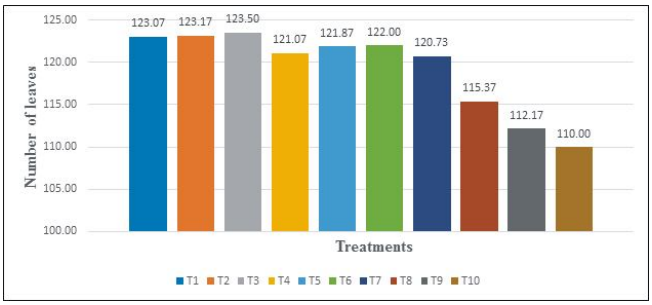
secondary branches was recorded T_{10} (control) (10.00). Similar pattern was observed in all stages in 75 DAT and at harvest. The data on plant spread (cm) presented in Table 4 and Fig. 4.

The maximum number of secondary branches under chitosan @ 1000 ppm may be attributed to enhanced vegetative growth and improved physiological activity, which promote lateral shoot development. The favourable response may also be associated with improved nutrient utilization and assimilate availability, supporting the formation of secondary branches. Comparable research on elicitor-mediated growth responses in Kalmegh was reported by Gowda *et al*. (2023). The minimum number of secondary branches in the water control may reflect the absence of elicitor-associated benefits for vegetative growth.

Number of leaves

The maximum number of leaves per plant was recorded in T_3 (chitosan @ 1000 ppm) (123.50) which was on par with T_2 (Chitosan @ 750 ppm) (123.17), T_1 (Chitosan @ 500 ppm) (123.07), T_6 (Salicylic acid @ 200 ppm) (122.0) and T_5 (Salicylic acid @ 150 ppm). The minimum number of leaves per plant (110.00) was recorded in the control T_{10} (control) (110.00). The data on plant spread(cm) presented in Table 5 and Fig. 6.

The maximum number of leaves per plant recorded under chitosan @ 1000 ppm may be attributed to enhanced vegetative growth and improved shoot development, which support the formation and



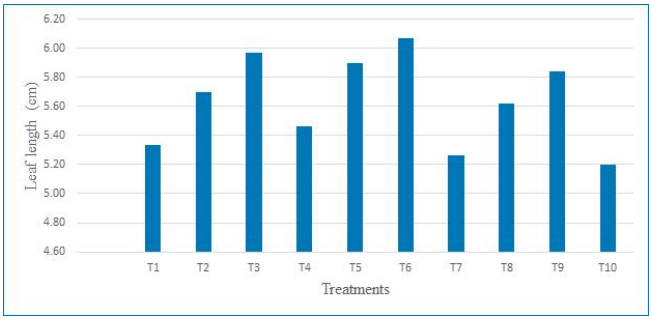
T_1 = Chitosan @ 500 ppm
T_2 = Chitosan @750 ppm
T_3 = Chitosan @ 1000 ppm
T_4 = Salicylic acid @ 100 ppm
T_5 = Salicylic acid @ 150 ppm
T_6 = Salicylic acid @ 200 ppm
T_7 = Jasmonic acid @ 100 ppm
T_8 = Jasmonic acid @ 150 ppm
T_9 = Jasmonic acid @ 200 ppm
T_{10} = Water spray(control)

Fig. 5 : A graphical representation of effect of different elicitor treatments on Number of leaves per plant of Kalmegh variety CIM Megha.

maintenance of leaves. The favourable response may also be associated with improved physiological activity and nutrient utilization, contributing to leaf production. Comparable research on elicitor-mediated growth responses in Kalmegh was reported by Gowda *et al*. (2023). The minimum number of leaves per plant in the water control may reflect the absence of elicitor-associated benefits for vegetative growth.

Leaf length (cm)

The maximum leaf length was recorded in T_6 (salicylic acid @ 200 ppm) (6.07 cm), which was on par with T_3 (Chitosan @ 1000 ppm) (5.97 cm) and T_5 (salicylic acid @ 150 ppm) (5.90cm). The minimum leaf length was recorded in T_{10} (control) (5.20cm). The data on leaf width presented in Table 5 and Fig. 6.



T_1 = Chitosan @ 500 ppm
T_2 = Chitosan @750 ppm
T_3 = Chitosan @ 1000 ppm
T_4 = Salicylic acid @ 100 ppm
T_5 = Salicylic acid @ 150 ppm
T_6 = Salicylic acid @ 200 ppm
T_7 = Jasmonic acid @ 100 ppm
T_8 = Jasmonic acid @ 150 ppm
T_9 = Jasmonic acid @ 200 ppm
T_{10} = Water spray(control)

Fig. 6 : A graphical representation of effect of different elicitor treatments on Leaf length (cm) of Kalmegh variety CIM Megha.

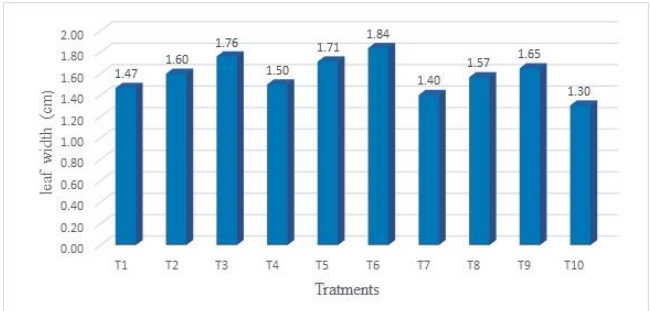
Table 5 : Effect of different elicitor treatments on Number of leaves per plant, Leaf length(cm) and Leaf width (cm) of Kalmegh variety CIM Megha.

Treatments	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)
T_1: Chitosan @ 500 ppm	123.07	5.33	1.47
T_2: Chitosan @750 ppm	123.17	5.70	1.60
T_3: Chitosan @ 1000 ppm	123.50	5.97	1.76
T_4: Salicylic acid @ 100 ppm	121.07	5.47	1.50
T_5: Salicylic acid @ 150 ppm	121.87	5.90	1.71
T_6: Salicylic acid @200 ppm	122.00	6.07	1.84
T_7: Jasmonic acid @100 ppm	120.73	5.27	1.40
T_8: Jasmonic acid @150 ppm	115.37	5.62	1.57
T_9: Jasmonic acid @200 ppm	112.17	5.84	1.65
T_{10}: Water spray (Control)	110.00	5.20	1.30
Mean	119.29	5.64	1.58
S E m±	0.747	0.089	0.069
C D @ 0.05%	2.22	0.26	0.20

The maximum leaf length recorded under salicylic acid @ 200 ppm may be attributed to its regulatory role in plant growth and physiological processes, which support leaf expansion. The favourable response may also be associated with improved photosynthetic activity, nutrient utilization and assimilate availability, contributing to leaf development. Comparable research on elicitor-mediated growth responses in Kalmegh was reported by Gowda *et al*. (2023). The minimum leaf length in the water control may reflect the absence of elicitor-associated benefits for leaf growth and expansion.

Leaf width (cm)

The maximum leaf width was recorded in T_6 (salicylic acid @ 200 ppm) (1.84 cm), which was on par with T_3 (chitosan @ 1000 ppm) (1.76 cm) and T_5 (salicylic acid @ 150 ppm) (1.71cm). The minimum leaf width was recorded in the control T_{10} (control) (1.30 cm). The data on leaf width presented in Table 5 and Fig. 7.



T_1 = Chitosan @ 500 ppm
T_2 = Chitosan @750 ppm
T_3 = Chitosan @ 1000 ppm
T_4 = Salicylic acid @ 100 ppm
T_5 = Salicylic acid @ 150 ppm
T_6 = Salicylic acid @ 200 ppm
T_7 = Jasmonic acid @ 100 ppm
T_8 = Jasmonic acid @ 150 ppm
T_9 = Jasmonic acid @ 200 ppm
T_{10} = Water spray(control)

Fig. 7 : A graphical representation of effect of different elicitor treatments on Leaf width(cm) of Kalmegh variety CIM Megha.

The maximum leaf width recorded under salicylic acid @ 200 ppm may be attributed to its regulatory effects on plant growth and leaf expansion. The favourable response may also be associated with improved physiological activity and assimilate availability, which support lateral expansion of the leaf lamina. Comparable research on elicitor-mediated growth responses in Kalmegh was reported by Gowda *et al*. (2023). The minimum leaf width in the water control may reflect the absence of elicitor-associated benefits for leaf development and expansion.

Leaf area(cm²)

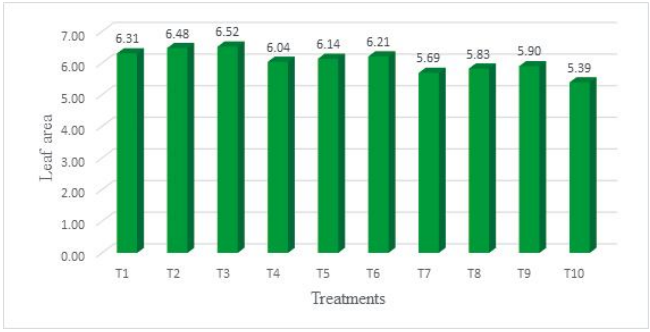
The maximum leaf area (cm²) was recorded in T_3 (chitosan @ 1000 ppm) (6.52 cm²), which was on par with T_2 (chitosan @ 750 ppm) (6.48),T_1 (chitosan @ 500 ppm) (6.31 cm²) T_6 (Salicylic acid @200 ppm) (6.21 cm²) and T_5 (Salicylic acid @150 ppm) (6.14 cm²). The minimum leaf area (5.39 cm²) was recorded in the T_{10} (control) (5.39 cm²**).** The data on leaf area (cm²) presented in Table 6 and Fig. 8.

The maximum leaf area recorded under chitosan @ 1000 ppm may be attributed to enhanced leaf expansion and improved vegetative growth, supported by better physiological activity and assimilate availability. Comparable findings on elicitor-mediated growth responses in Kalmegh were reported by Gowda *et al.* (2023). Similarly, foliar application of chitosan improved leaf area and growth parameters in lettuce, as reported by Ibrahim *et al*. (2023). These findings suggest that chitosan may promote leaf expansion and contribute to improved canopy development. The minimum leaf area in the water control may reflect the absence of elicitor-associated benefits for leaf growth and expansion.

Leaf area per plant (cm²)

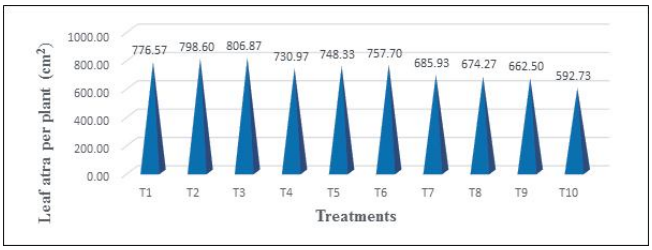
The maximum leaf area per plant was recorded in T_3 (chitosan @ 1000 ppm) (805.22 cm²), followed by T_2 (chitosan @ 750 ppm) (798.14 cm²). The minimum leaf area per plant was recorded in the T_{10} (control) (592.90 cm²). The data on leaf area per plant (cm²) presented in Table 6 and Fig. 9.

The maximum leaf area per plant recorded under chitosan @ 1000 ppm may be attributed to the combined effect of increased leaf area and improved vegetative growth, contributing to greater total leaf surface per plant.



T_1	=	Chitosan @ 500 ppm	T_6	=	Salicylic acid @ 200 ppm
T_2	=	Chitosan @750 ppm	T_7	=	Jasmonic acid @ 100 ppm
T_3	=	Chitosan @ 1000 ppm	T_8	=	Jasmonic acid @ 150 ppm
T_4	=	Salicylic acid @ 100 ppm	T_9	=	Jasmonic acid @ 200 ppm
T_5	=	Salicylic acid @ 150 ppm	T_{10}	=	Water spray(control)

Fig. 8 : A graphical representation of effect of different elicitor treatments on Leaf area (cm^2) of Kalmegh variety CIM Megha.



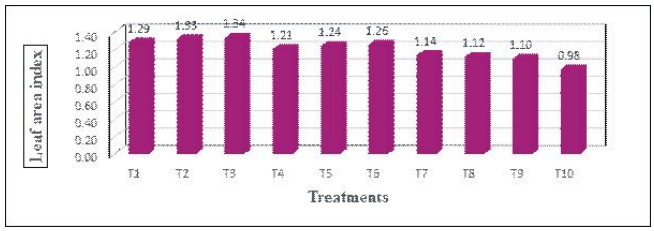
T_1	=	Chitosan @ 500 ppm	T_6	=	Salicylic acid @ 200 ppm
T_2	=	Chitosan @750 ppm	T_7	=	Jasmonic acid @ 100 ppm
T_3	=	Chitosan @ 1000 ppm	T_8	=	Jasmonic acid @ 150 ppm
T_4	=	Salicylic acid @ 100 ppm	T_9	=	Jasmonic acid @ 200 ppm
T_5	=	Salicylic acid @ 150 ppm	T_{10}	=	Water spray(control)

Fig. 9 : A graphical representation of effect of different elicitor treatments on Leaf area per plant (cm^2) of Kalmegh variety CIM Megha.

Enhanced leaf development may also increase the plant's capacity to intercept light and support photosynthesis and assimilate production. Comparable research on elicitor-mediated growth responses in Kalmegh was reported by Gowda *et al.* (2023). Similarly, Ibrahim *et al.* (2023) reported improvements in leaf area and growth parameters following foliar chitosan application in lettuce. These findings support the potential role of chitosan in promoting leaf development and canopy growth. The minimum leaf area per plant in the water control may be associated with comparatively reduced leaf development in the absence of elicitor application.

Leaf area index

The maximum leaf area index was recorded in T_3 (chitosan @ 1000 ppm) (1.34), which was on par with T_2 (chitosan @ 750 ppm), (1.33). The minimum leaf area index was recorded in the T_{10} (control) (0.98). The data



T_1	=	Chitosan @ 500 ppm	T_6	=	Salicylic acid @ 200 ppm
T_2	=	Chitosan @750 ppm	T_7	=	Jasmonic acid @ 100 ppm
T_3	=	Chitosan @ 1000 ppm	T_8	=	Jasmonic acid @ 150 ppm
T_4	=	Salicylic acid @ 100 ppm	T_9	=	Jasmonic acid @ 200 ppm
T_5	=	Salicylic acid @ 150 ppm	T_{10}	=	Water spray(control)

Fig. 10 : A graphical representation of effect of different elicitor treatments on Leaf area Index of Kalmegh variety CIM Megha.

Table 6 : Effect of different elicitor treatments on Leaf area (cm^2) Leaf area per plant (cm^2) and Leaf Area Index of Kalmegh variety CIM Megha.

Treatments	Leaf area (cm^2)	Leaf area /plant (cm^2)	Leaf area index (LAI)
T_1: Chitosan @ 500 ppm	6.31	776.57	1.29
T_2: Chitosan @750 ppm	6.48	798.14	1.33
T_3: Chitosan @ 1000 ppm	6.52	805.22	1.34
T_4: Salicylic acid @ 100 ppm	6.04	731.26	1.21
T_5: Salicylic acid @ 150 ppm	6.14	748.28	1.24
T_6: Salicylic acid @200 ppm	6.21	757.62	1.26
T_7: Jasmonic acid @100 ppm	5.69	686.95	1.14
T_8: Jasmonic acid @150 ppm	5.83	672.61	1.12
T_9: Jasmonic acid @200 ppm	5.90	661.80	1.10
T_{10}: Water spray (Control)	5.39	592.90	0.98
Mean	6.05	723.14	1.20
S Em ±	0.132	0.563	0.019
C D @ 0.05%	0.39	1.67	0.06

on leaf are index presented in Table 6 and Fig. 10.

The maximum leaf area index recorded under chitosan @ 1000 ppm may be attributed to improved leaf development and greater leaf surface area per plant, resulting in increased ground-area coverage by the foliage. A higher leaf area index can improve light interception and support photosynthetic activity, thereby contributing to plant growth and biomass accumulation. Comparable findings on elicitor-mediated growth responses in Kalmegh were reported by Gowda *et al.* (2023). Similarly, Ibrahim *et al*. (2023) reported improvements in leaf area and vegetative growth following foliar chitosan application in lettuce. These findings support the potential role of chitosan in promoting canopy development. The minimum leaf area index in

the water control may be associated with comparatively lower leaf development and reduced canopy coverage in the absence of elicitor application.

Conclusion

Chitosan at 1000 ppm (T_3) promoted greater plant height, plant spread during the vegetative growth stages, primary and secondary branching, number of leaves, individual leaf area, leaf area per plant and leaf area index. Salicylic acid at 200 ppm (T_6) recorded the maximum leaf length and leaf width. The lowest values for the major growth and leaf parameters were recorded in the water control (T_{10}). Thus, chitosan at 1000 ppm (T_3) favoured overall vegetative growth and canopy development, while salicylic acid at 200 ppm (T_6) was more effective in promoting leaf length and width.

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