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Nandishagowda GB
M.Sc. Scholar, College of Horticulture, Anantharajupeta, Dr. YSR Horticultural University, Andhra Pradesh, India

G Thanuja Sivaram
Senior Scientist, Regional Horticultural Research Station, Tirupati, Dr. YSR Horticultural University, Andhra Pradesh, India

KM Yuvaraj
Principal Scientist, Horticultural Research Station, Anantharajupeta, Dr. YSR Horticultural University, Andhra Pradesh, India

VV Padmaja
Associate Professor, College of Horticulture, Anantharajupeta, Dr. YSR Horticultural University, Andhra Pradesh, India

D Sreedhar
Senior Scientist (Horticulture), Krishi Vigyan Kendra, Periyavaram Periyavaram

Corresponding Author:
Nandishagowda GB
M.Sc. Scholar, College of Horticulture, Anantharajupeta, Dr. YSR Horticultural University, Andhra Pradesh, India

Modulating growth and herbage yield in *Artemisia pallens via* plant growth regulators

Nandishagowda GB, G Thanuja Sivaram, KM Yuvaraj, VV Padmaja and D Sreedhar

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Abstract
Davana (*Artemisia pallens* Wall.), an esteemed aromatic plant of the Asteraceae family is chiefly cultivated in South India during the winter season as a short-duration crop. It is valued for its aromatic herbage used in rituals and floral decor. Its essential oil, rich in bioactive compounds, prized in perfumery and cosmetics and exhibits antimicrobial, anti-inflammatory and analgesic properties. In many of the aromatic species, plant growth regulators have been shown to positively modulate both the growth and yield. To assess the impact of plant growth regulators on davana growth and yield, eight treatments were applied: T_1 (Control, Water spray), T_2 (Triacontanol @ 1000 ppm), T_3 (Salicylic acid @ 150 ppm), T_4 (GA_3 @ 200 ppm), T_5 (Cycocel @ 200 ppm), T_6 (Benzyl adenine @ 10 ppm), T_7 (Homobrassinolide @ 1000 ppm) and T_8 (Ethephon @ 100 ppm). Plants treated with T_7 (Homobrassinolide @ 1000 ppm) showed marked improvement in plant height, branch number and stem girth. T_4 (GA_3 @ 200 ppm) treated plants led to the earliest first and 50% flowering. Homobrassinolide also significantly enhanced fresh and dry herbage yield, while T_1 (Control) recorded the lowest growth.

Keywords: Davana, Foliar application, GA, HBR, PGR

Introduction
Davana (*Artemisia pallens* Wall.), a species in the Asteraceae family, is an esteemed aromatic herb mainly cultivated in South India as a quick-growing winter crop. Renowned for its essential oil content, this species is locally referred by several names, including 'Davana', 'Davanam' and 'Marikolunthu' (Yogendra *et al*., 2024) [28]. A wide array of bioactive compounds, particularly triterpenes and esters such as davanone, davana ether, davanafuran, linalool, methyl cinnamate and geranyl acetate, have been identified in *Artemisia pallens*, contributing to its aromatic and therapeutic properties. In India, it thrives at elevations ranging from 600 to 1000 meters above mean sea level, predominantly on moist and humid soils particularly sandy loam to medium black types. The aromatic herbage is traditionally utilized in religious rituals, garland-making, floral arrangements, and decorative bouquets, imparting a sense of freshness and a luxuriant fragrance to ceremonial occasions (Balakubahan *et al*., 2011) [2].

Davana is cultivated primarily for its essential oil, which finds extensive use in perfumery, food flavouring, and medicinal applications. The aromatic oil extracted from its leaves and flowers is prized for its exquisite, delicate fragrance and is a key ingredient in premium perfumes and cosmetic formulations (Ramachandriah *et al.*, 1987) [19].

Artemisia pallens is recognized for its diverse therapeutic properties, including anti-inflammatory, antipyretic and analgesic activities. Its volatile oil is rich in bioactive constituents that exhibit anti-spasmodic, anti-fungal, anti-microbial, anti-bacterial, stimulant, antiseptic and disinfectant effects. Owing to its aromatic profile, the oil holds significant commercial value. Additionally, the plant has been traditionally used in Indian folk medicine for managing *Diabetes mellitus* (Ruikar *et al.*, 2009) [21].

Among growth regulators, gibberellins, brassinosteroids and CCC are particularly effective in enhancing aromatic crop quality. Their timely application at optimal concentrations significantly improves herbage and essential oil yield (Bhagya *et al*., 2015) [5].

Triacontanol enhances biomass and secondary metabolite synthesis by improving photosynthesis, chlorophyll content, nutrient uptake, and stress tolerance. Cytokinins regulate cell division, shoot initiation, chloroplast development, and delay senescence. Gibberellins influence plant height, germination, flowering, and fruiting, while promoting phase transitions. Ethylene modulates germination, growth, senescence, abscission, ripening, and defense responses. Brassinosteroids control cell elongation, vascular development, and stress adaptation. Low concentrations of Cycocel increase branching and inflorescence number. In many of the aromatic species, plant growth regulators have been shown to positively modulate both the yield and chemical profile of essential oils (Bano *et al.*, 2016) [3].

India is the leading global producer of davana essential oil, where herbage yield serves as a critical economic trait directly influencing oil output. In aromatic crops, biomass accumulation and herbage yield are key determinants of essential oil productivity. Plant growth regulators (PGRs) have been widely recognized for their role in enhancing vegetative growth and biomass in various crops. Therefore, the present study was undertaken to evaluate the impact of selected PGRs on growth parameters and herbage yield enhancement in davana (*Artemisia pallens* Wall.).

Materials and Methods

The present investigation was conducted during the late *Rabi* season of 2024-25 at the PSMA Block, College of Horticulture, Anantharajupeta. The experiment was laid out in a Randomized Block Design (RBD) comprising eight treatments with three replications. The treatment structure included seven distinct plant growth regulators and one treatment as control. Those treatments are namely T_1 (Control, Water spray), T_2 (Triacontanol @ 1000 ppm), T_3 (Salicylic acid @ 150 ppm), T_4 (GA_3 @ 200 ppm), T_5 (Cycocel @ 200 ppm), T_6 (Benzyl adenine @ 10 ppm), T_7 (Homobrassinolide @ 1000 ppm) and T_8 (Ethephon @ 100 ppm).

A local cultivar from the Salem region of Tamil Nadu was selected for this experiment. Seedlings were transplanted with a spacing of 15 x 15 cm in beds measuring 1 m². Recommended dose of NPK 120:40:40 kg ha^{-1} was applied and essential agronomical practices were done timely to raise a healthy crop. For recording observations, five randomly chosen plants were picked from each treatment of a replication. Observations were recorded on various plant growth parameters, including plant height (cm), number of branches per plant, stem girth (cm), days to first flowering and days to 50% flowering. Yield-related attributes such as fresh weight per plant (g), fresh and dry herbage yield (t ha^{-1}) were also documented at harvest. Growth parameters were assessed on the 45th day after planting and again at harvest, while yield attributes were evaluated during the harvest.

Fresh weight per plant (g) was recorded by harvesting the plants at 5 cm above ground level. Additionally, fresh herbage from the net plot area (1 m²) was weighed to determine the mean fresh herbage yield per square meter, which was subsequently extrapolated to calculate the yield per hectare. For dry weight estimation, the harvested herbage was shade- dried for 2-3 days. The mean dry herbage yield per m^2 was then recorded and converted to dry herbage yield per hectare.

Results and discussion

Growth parameters

The data on growth parameters including plant height (cm), number of branches and stem girth (cm) are presented in Table 1, while Table 2 outlines the observations for days to first flowering and 50% flowering. Notable variations among treatments were recorded at both the 45th day and at the time of harvest.

Plant height (cm)

At 45 DAP, Homobrassinolide (HBR) @ 1000 ppm (T_7) produced the tallest plants (48.35 cm) significantly exceeding other treatments (Table.1). GA_3 @ 200 ppm (T_4) and Triacontanol @ 1000 ppm (T_2) followed with 46.40 cm and 45.90 cm respectively. The shortest height was recorded in the control (T_1) 44.17 cm. Similarly at harvest, Homobrassinolide @ 1000 ppm (T_7) produced the tallest plants (57.20 cm) significantly outperforming other treatments. Triacontanol (T_2) and GA_3 (T_4) followed with comparable heights of 53.50 cm and 53.13 cm. The shortest plants were observed in the control (T_1) 51.80 cm closely matched with 52.00 cm of (T_8) Ethephon @ 100 ppm.

The progressive increase in plant height observed with foliar application of Homobrassinolide may be attributed to its stimulatory effects on meristematic tissues and its ability to enhance both cell number and size (Prakash *et al*., 2008) [17]. Additionally, brassinosteroids are known to promote vertical growth by facilitating cell elongation and division (Gudesblat & Russinova, 2011; Wei & Li, 2016) [11, 27]. In the present study, Enhanced plant height by Homobrassinolide application may result from stimulated mitosis and cell elongation via activation of genes linked to cell wall loosening and expansion. Similar findings were reported by Swamy and Rao in coleus (2011) [26], Eskandari and Eskandari (2014) [8] in savory and Raghu *et al*. (2015) [18] in tinospora, all highlighting the positive impact of Homobrassinolide on plant height.

Table 1: Effect of plant growth regulators on plant height, number of branches and stem girth of Davana (*Artemisia pallens* wall.).

Plant height (cm)			No of branches			Stem girth (cm)		
Treatments	**@ 45 DAP**	**At harvest**	**Treatments**	**@ 45 DAP**	**At harvest**	**Treatments**	**@ 45 DAP**	**At harvest**
T_1	44.17	51.8	T_1	10.40	16.50	T_1	0.66	1.14
T_2	45.90	53.5	T_2	11.00	17.23	T_2	0.75	1.26
T_3	44.70	52.33	T_3	10.87	17.00	T_3	0.72	1.18
T_4	46.40	53.13	T_4	10.80	17.47	T_4	0.67	1.20
T_5	44.27	51.06	T_5	11.23	17.50	T_5	0.71	1.18
T_6	44.73	52.16	T_6	11.20	17.23	T_6	0.73	1.19
T_7	48.35	57.2	T_7	13.00	18.80	T_7	0.72	1.27
T_8	44.60	52	T_8	10.80	16.63	T_8	0.72	1.14
Mean	45.39	52.9	Mean	11.16	17.30	Mean	0.71	1.20
S. EM ±	0.47	0.55	S. EM ±	0.55	0.24	S. EM ±	0.02	0.03
C.D @ 5%	1.43	1.65	C.D @ 5%	1.68	0.73	C.D @ 5%	0.07	0.08

Number of branches

At 45 DAP, the highest number of branches (13) were recorded in plants treated with Homobrassinolide @ 1000 ppm (T_7) followed by Cycocel @ 200 ppm (T_5, 11.23) and Benzyl adenine @ 10 ppm (T_6, 11.20) which were statistically at par (Table.1). The lowest count was observed in the control (T_1, 10.40). At harvest, T_7 again showed the maximum branching (18.80) followed by T_5 (17.50) and T_4 - GA_3 @ 200 ppm (17.47) which both were statistically on par. Whereas the control (T_1, 16.50) recorded the least number and was statistically on par to Ethephon @ 200 ppm (T_8, 16.63).

Plants treated with Homobrassinolide @ 1000 ppm (T_7) showed superior branching at both 45 DAP (13) and harvest (18.8). HBR promotes axillary bud activation by reducing auxin dominance and enhancing cytokinin influence (Singh & Salvadi, 2016), while also improving chlorophyll content and photosynthesis to support shoot development (Eskandari & Eskandari, 2014) [8]. The increased branching observed in this study may be attributed to HBR-induced mitotic activity in meristematic tissues, promoting cell division and elongation in nodal regions, especially at the shoot apex, leading to enhanced shoot proliferation. These results align with earlier findings reported by Swamy and Rao in geranium (2008) [25], Bera *et al.* (2013) [4] in lentil, Ghosh *et al.* (2020) [10] in chilli and Sridhara *et al.* (2021) [24] in tomato.

Stem girth (cm)

During the 45th DAP, maximum stem girth (0.75 cm) was recorded in T_2 (Triacontanol @ 1000 ppm) followed by T_6 (Benzyl adenine @ 10 ppm, 0.73 cm) both statistically similar (Table.1). T_4 (GA_3 @ 200 ppm) and the control (T_1) showed the lowest values measuring 0.67 cm and 0.66 cm, respectively. However, at harvest T_7 (Homobrassinolide @ 1000 ppm) recorded the highest stem girth (1.27 cm) followed closely by T_2 (1.26 cm) and T_4 (1.20 cm) which were statistically on par. All treatments outperformed the control (T_1, 1.14 cm) except T_8 (Ethephon @ 100 ppm) which showed a comparable value.

Brassinosteroids enhance stem girth by promoting cell division, elongation and vascular differentiation in the cambial zone (Wei & Li, 2016) [27]. Triacontanol enhances photosynthesis and metabolism, stimulating cell division and enlargement in stem tissues, which supports vascular development and stem thickening (Chettri *et al.*, 2021) [7]. Similarly, GA_3 activates vascular cambium, promoting xylem and phloem formation and also increases secondary growth by enhanced lateral meristematic activity (Hossain *et al.*, 2019) [12].

In the present study, (T_7) Homobrassinolide @ 1000 ppm and (T_2) Triacontanol @ 1000 ppm significantly enhanced stem girth, followed by (T_4) GA_3 @ 200 ppm, likely due to improved photosynthesis and stomatal conductance promoting carbohydrate allocation to stem thickening. Similar enhancements in stem girth due to Homobrassinolide were reported by Pavani *et al.* (2022) [16] in banana, while GA_3-induced improvements were observed by Kazaz and Karaguzel (2010) [13] in goldenrod and Singh *et al.* (2018) [23] in chrysanthemum.

Days to first flowering

Significant variation in days to first flowering was observed among treatments (Table. 2) indicating a pronounced influence of plant growth regulators on floral initiation in davana. The earliest flowering occurred in plants treated with GA_3 @ 200 ppm (T_4) initiating at 43.33 days, followed by Salicylic acid @ 150 ppm (T_3) and Homobrassinolide @ 1000 ppm (T_7), both at 44.33 days. These treatments effectively accelerated reproductive transition. In contrast, delayed flowering was noted in the control (T_1) and Cycocel @ 200 ppm (T_5) each requiring 47.33 days.

Table 2: Effect of plant growth regulators on days to first and 50% flowering of Davana (*Artemisia pallens* wall.).

Treatments	Days to 1st flowering	Days to 50% flowering / harvesting
T_1	47.33	75.67
T_2	45.67	73.33
T_3	44.33	71.67
T_4	43.33	69.67
T_5	47.33	73.33
T_6	46.67	73.67
T_7	44.33	71.00
T_8	44.67	72.00
Mean	45.46	72.54
S. EM ±	0.23	0.42
C.D @ 5%	0.7	1.27

Days to 50% flowering

GA_3 @ 200 ppm (T_4) induced the earliest flowering at 69.67 days (Table. 2) followed by Homobrassinolide @ 1000 ppm (T_7) at 71.00 days and Salicylic acid @ 150 ppm (T_3) at 71.67 days. These were significantly earlier than the control (T_1), which recorded the latest flowering at 75.67 days, followed by Benzyl adenine @ 10 ppm (T_6) at 73.67 days.

Plants treated with GA_3 @ 200 ppm (T_4) exhibited accelerated flowering, with reduced days to first and 50% flowering, coinciding with the harvest stage. GA_3 likely promotes early flowering by accelerating flower primordia formation, cellular differentiation and nutrient uptake, thereby shortening the juvenile phase (Rani and Singh, 2013). In this study, GA_3-induced early flowering may be attributed to enhanced enzyme activity promoting the vegetative-to-reproductive transition and its role in breaking bud dormancy. These findings align with earlier reports by Bhat *et al.* (1990) in davana, Nandre *et al.* (2014) [14] in China aster and Singh *et al.* (2018) [23] in chrysanthemum.

Yield parameters

Fresh weight of plant (g)

Plant growth regulators significantly improved biomass accumulation in davana, with fresh weight ranging from 42.53 to 49.73 g and a mean of 45.53 g per plant (Table. 3). Application of homobrassinolide @ 1000 ppm (T_7) resulted in the highest fresh weight (49.73 g), significantly surpassing all other treatments. This was followed by (T_2) Triacontanol @ 1000 ppm and (T_5) Cycocel @ 200 ppm which both recorded (46.53, 46.17 g) respectively and were statistically on par. The lowest fresh weight (42.53 g) was observed in the control (T_1) which was statistically at par with 43.00 g of (T_8) Ethephon @ 200 ppm.

Fresh herbage yield (t ha^{-1})

The highest fresh herbage yield (21.93 t/ha) was recorded in plants treated with T_7 (Homobrassinolide @ 1000 ppm) significantly outperforming all other treatments (Table. 3). This was followed by (T_2) Triacontanol @ 1000 ppm and (T_5) Cycocel @ 200 ppm with 20.67 and 20.52 t/ha and was statistically at par to (T_4) GA_3 200 ppm. Application of Salicylic acid @ 200 ppm (T_3) yielded 19.77 t/ha, while the lowest yield was recorded in the control (T_1) at 18.93 t/ha and was statistically on par to (T_8) Ethephon @ 100 ppm with 19.10 t/ha.

Overall, all plant growth regulator treatments except T_8 untreated control. Significantly enhanced fresh herbage yield compared to the

Table 3: Effect of plant growth regulators on fresh weight, fresh and dry herbage yield of Davana (*Artemisia pallens* wall.).

Treatments	Fresh weight / plant (g)	Herbage yield (t ha^{-1})	
		Fresh	Dry
T_1	42.53	18.93	5.78
T_2	46.53	20.67	6.25
T_3	44.43	19.77	6.01
T_4	45.53	20.47	6.18
T_5	46.17	20.52	6.18
T_6	45.80	20.37	6.10
T_7	49.73	21.93	6.49
T_8	43.00	19.10	6.00
Mean	45.47	20.22	6.12
S. Em. ±	0.69	0.16	0.04
C.D @ 5%	2.11	0.48	0.11

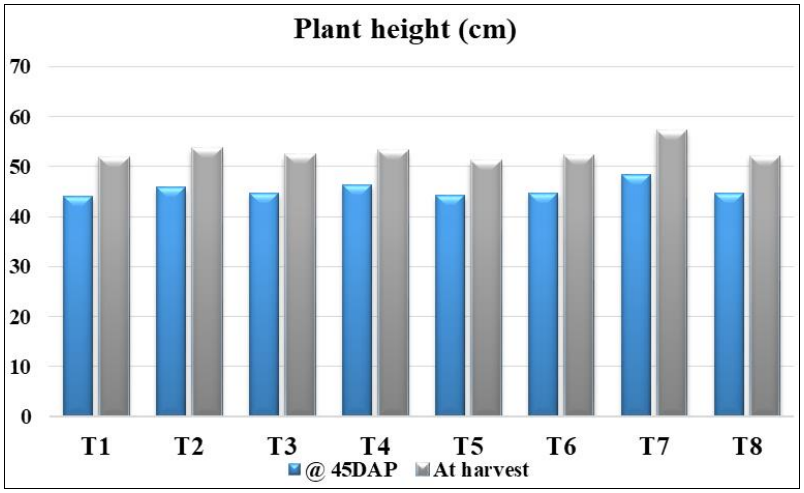

Fig 1: Plant height (cm) as influenced by foliar application of plant growth regulators

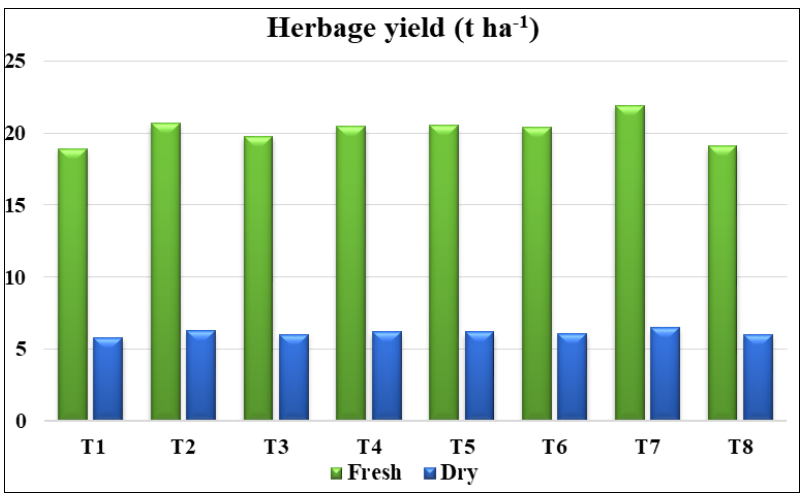

Fig 2: Herbage yield (t ha^{-1}) as influenced by foliar application of plant growth regulators

Dry herbage yield (t ha^{-1})

Dry herbage yield in davana was significantly influenced by the application of plant growth regulators. The highest yield (6.49 t/ha) was achieved with T_7 (Homobrassinolide @ 1000 ppm), which was statistically superior to all other treatments (Table. 3). T_2 (Triacontanol @ 1000 ppm) followed with 6.25 t/ha, while T_5 (Cycocel @ 200 ppm) and T_4 (GA_3 @ 200 ppm) each recorded 6.18 t/ha and were statistically at par. The lowest yield was observed in the control (T_1, water spray) at 5.78 t/ha, closely followed by T_8 (Ethephon @ 100 ppm) with 6.00 t/ha, which was statistically comparable to T_6 (BA @ 10 ppm). Overall, all PGR treatments significantly enhanced dry herbage yield compared to the untreated control.

Foliar application of T_7 (Homobrassinolide @ 1000 ppm) boosted biomass significantly, increasing fresh weight, fresh herbage, and dry herbage yields by 16.92%, 15.84% and 13.26% over the control, respectively. Swamy and Rao (2011) [26] reported that homobrassinolide application elevated reducing sugars, non-reducing sugars and starch levels in coleus, contributing to enhanced biomass and shoot hydration. Its role in improving osmotic balance and water uptake enables plants to retain more water under stress, potentially increasing fresh weight (Geethika *et al*., 2013) [9]. It also enhances nutrient uptake and translocation, thereby improved biomass and leaf area in black gram (Badhe *et al*., 2022) [1].

In this study, homobrassinolide treatment enhanced fresh weight and herbage yield, likely due to increased cell division, cell elongation, better water retention and improved nutrient translocation. These findings are in consistent with earlier reports by Swamy & Rao (2008) [25] in geranium, Eskandari and Eskandari (2014) [8] in savory and Raghu *et al*. (2015) [18] in tinospora.

Conclusion

The outcomes of this study concluded that foliar application of homobrassinolide at 1000 ppm significantly improved plant growth and herbage yield in davana and data clearly demonstrated the effectiveness of plant growth regulators in enhancing crop performance. HBR's action likely involves activation of genetic and physiological mechanisms that promote biomass accumulation, leading to increased yield.

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