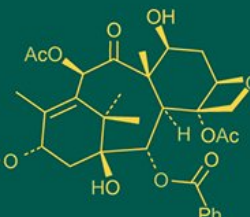
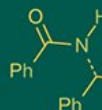
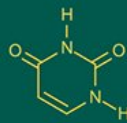


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Physiological responses and flowering attributes of Goldenrod (*Solidago canadensis* L.) under different bio-stimulants

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Abstract

An experiment entitled Physiological responses and flowering attributes of Goldenrod (*Solidago canadensis* L.) under different bio-stimulants was conducted at the experimental block of Department of Floriculture and Landscaping, School of Post Graduation Studies, Iruvakk, under Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, during 2025-26. The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of nine treatments viz., T₁ (Humicel @ 0.3%), T₂ (Humicel @ 0.5%), T₃ (Spic Cytozyme @ 0.3%), T₄ (Spic Cytozyme @ 0.5%), T₅ (Kelpak @ 0.3%), T₆ (Kelpak @ 0.5%), T₇ (Samras @ 0.3%), T₈ (Samras @ 0.5%) and T₉ (Control) replicated thrice. The plants were sprayed with bio-stimulants at 30, 60 and 90 days after transplanting. The results revealed that, treatment T₇ (Samras @ 0.3%) recorded the maximum plant height (101.70 cm), number of leaves per plant (138.33), leaf area (4975.50 cm²/plant), leaf area index (5.53), plant spread (38.67 cm E-W and 34.50 cm N-S directions), number of branches per plant (20.17), number of suckers per plant (20.33), stem girth (8.37 mm) and internodal length (4.62). Among different treatments, minimum number of days taken for flower bud initiation (59.07), first flowering (70.10), 50 per cent flowering (81.00) and flower stalk harvesting (102.37) was recorded in the treatment T₇ (Samras @ 0.3%). Hence, foliar application of (Samras @ 0.3%) at 30, 60 and 90 days after transplanting may be recommended as an effective bio-stimulant for commercial cultivation of Goldenrod.

Keywords: Bio-stimulants, goldenrod, *Solidago canadensis*, growth and flowering

Introduction

Goldenrod (*Solidago canadensis* L.), belonging to the family Asteraceae, is an important ornamental cut foliage crop valued for its attractive golden yellow flower spikes, excellent filler value in floral arrangements and long vase life (Patil *et al.*, 1997) ^[12]. Owing to its adaptability, ease of cultivation and increasing market demand, it is widely grown for the cut flower industry. Besides its commercial importance, Goldenrod is an excellent landscape plant and serves as a rich source of nectar and pollen, attracting honey bees, butterflies and other beneficial pollinators (Moron *et al.*, 2019) ^[10].

In recent years, bio-stimulants have gained importance as eco-friendly inputs that enhance nutrient uptake, plant growth, flowering, quality and yield while improving tolerance to abiotic stress (Traon *et al.*, 2014) ^[23]. However, information on the comparative performance of different bio-stimulants in Goldenrod is limited. Therefore, the present investigation was carried out to study the effect of bio-stimulants on the growth and flowering of Goldenrod.

Materials and Methods

The investigation was carried out at the Experimental Block, Department of Floriculture and Landscaping, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, during 2025-26. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and nine treatments comprising different bio-stimulants, namely Humicel, Spic Cytozyme, Kelpak and Samras at 0.3 and 0.5 per cent, along with a control. Healthy rooted suckers of Goldenrod were planted in flat beds at a spacing of 30 × 30 cm. Foliar application of the respective bio-stimulants was carried out

at 30, 60 and 90 days after transplanting (DAT). Standard cultural practices were followed throughout the crop period. Observations were recorded from five randomly selected and tagged plants for growth parameters viz., plant height, number of leaves per plant, leaf area per plant, leaf area index, plant spread (E-W and N-S directions), number of branches per plant, number of suckers per plant, stem girth, internodal length and flowering parameters viz., days taken

for flower bud initiation, first flower opening, 50 per cent flowering and flower stalk harvesting.

Results and Discussion

The findings of the present investigation were interpreted and are presented in Tables 1 and 2 based on the observations recorded during the study.

Table 1: Effect of foliar application of bio-stimulants on growth parameters of Goldenrod (*Solidago canadensis* L.)

Treatment No.	Treatments	Plant height (cm)	Number of leaves /plant	Leaf area (cm ²)	Leaf area index	Plant spread (cm)		Number of branches per plant	Number of suckers per plant	Stem girth (mm)	Internodal length (cm)
						E-W	N-S				
T ₁	Humicel @ 0.3%	77.53	114.33	3778.50	4.20	32.17	28.17	11.17	14.67	6.92	3.23
T ₂	Humicel @ 0.5%	82.67	110.50	3708.17	4.12	30.33	27.67	11.08	13.33	6.65	3.19
T ₃	Spic Cytozyme @ 0.3%	86.83	119.33	3849.33	4.38	34.97	29.17	12.33	15.67	6.97	3.25
T ₄	Spic Cytozyme @ 0.5%	85.30	118.33	3942.75	4.28	33.33	29.67	13.00	16.67	6.99	3.27
T ₅	Kelpak @ 0.3%	83.17	124.33	4256.67	4.73	35.50	30.17	13.17	17.50	7.43	3.29
T ₆	Kelpak @ 0.5%	87.27	125.67	4393.00	4.88	35.83	30.50	14.17	18.67	7.54	4.12
T ₇	Samras @ 0.3%	101.70	138.33	4975.50	5.53	38.67	34.50	20.17	20.33	8.37	4.62
T ₈	Samras @ 0.5%	96.77	126.67	4471.92	4.97	36.17	33.00	19.08	18.83	7.92	4.17
T ₉	Control	76.77	94.67	2690.50	2.99	29.50	26.33	10.00	10.67	5.70	2.72
S. Em $\pm$		4.01	5.64	229.29	0.25	1.49	1.55	0.77	0.78	0.39	0.23
C.D at 5%		12.12	17.06	693.33	0.77	4.50	4.70	2.34	2.35	1.17	0.69

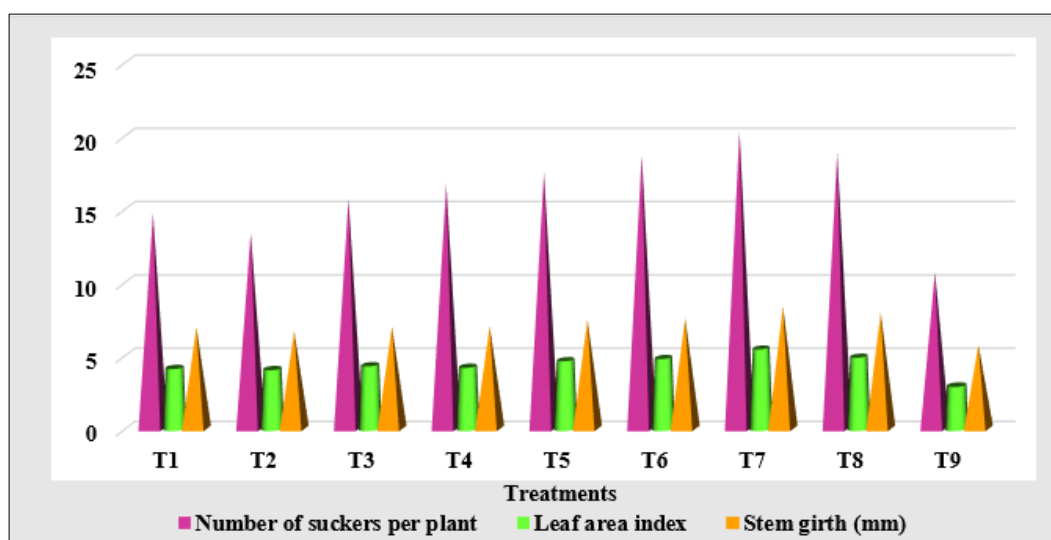


Fig 1: Effect of foliar application of bio-stimulants on number of suckers per plant, leaf area index and stem girth at the peak growth stage of Goldenrod (*Solidago canadensis* L.)

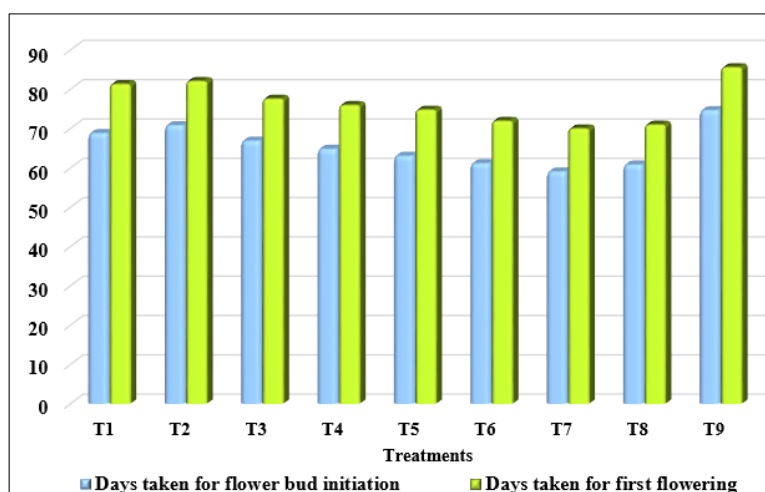
A. Growth parameters

Significant variation was observed in the growth parameters of Goldenrod under different bio-stimulant treatments. The maximum plant height (101.70 cm), number of leaves per plant (138.33), leaf area (4975.50 cm²), leaf area index (5.53), plant spread in east-west (38.67 cm) and north-south (34.50 cm) directions, number of branches per plant (20.17), number of suckers per plant (20.33), stem girth (8.37 mm) and internodal length (4.62 cm) were recorded in the treatment T₇ (Samras @ 0.3%). The superior growth performance under Samras @ 0.3 per cent may be attributed to the presence of free amino acids and bioactive peptides, which enhance nutrient uptake, nitrogen metabolism, protein synthesis, enzymatic activity and endogenous phytohormone activity, thereby promoting cell division, cell elongation,

chlorophyll biosynthesis, photosynthetic efficiency and assimilate production. These physiological responses collectively favour leaf initiation and expansion, canopy development, lateral shoot and sucker formation, stem thickening and internode elongation, resulting in vigorous vegetative growth. These results are in conformity with Rakesh (2022) ^[17] in Goldenrod, Harish *et al.* (2019) ^[3] and Manasa *et al.* (2017) ^[8] in Gladiolus, Taih *et al.* (2023) ^[22] in Pot marigold, Bhargavi *et al.* (2018) ^[1], Suchitha *et al.* (2021) ^[21] and Sainath *et al.* (2014) ^[18] in Chrysanthemum, Hegde *et al.* (2021) ^[5] in Dendrobium orchid, Ragini *et al.* (2019) ^[16] in Asiatic lily, Praveen *et al.* (2021) ^[14] in Floribunda rose, Shukla *et al.* (2023) ^[20] in Dahlia, Kumar *et al.* (2015) ^[7] and Munikrishnappa and Chandrashekar (2014) ^[11] in China aster and Patra *et al.* (2015) ^[13] in Gerbera.

Table 2: Effect of foliar application of bio-stimulants on flowering attributes of Goldenrod (*Solidago canadensis* L.)

Treatment No.	Treatments	Days taken for flower bud initiation	Days taken for first flowering	Days taken for 50% flowering	Days taken for flower stalk harvesting
T ₁	Humicel @ 0.3%	68.83	81.40	90.90	112.50
T ₂	Humicel @ 0.5%	70.83	82.17	93.07	114.17
T ₃	Spic Cytozyme @ 0.3%	66.90	77.67	89.17	110.07
T ₄	Spic Cytozyme @ 0.5%	64.83	76.07	87.03	108.03
T ₅	Kelpak @ 0.3%	63.07	74.87	84.83	104.37
T ₆	Kelpak @ 0.5%	61.17	72.03	82.83	104.75
T ₇	Samras @ 0.3%	59.07	70.10	81.00	102.37
T ₈	Samras @ 0.5%	60.83	71.07	81.83	103.27
T ₉	Control	74.67	85.67	97.17	118.67
S. Em $\pm$		2.69	3.19	3.32	3.18
C.D at 5%		8.14	9.65	10.04	9.62

**Fig 2:** Effect of foliar application of bio-stimulants on days taken for flower bud initiation and first flowering of Goldenrod (*Solidago canadensis* L.)

B. Flowering parameters

The flowering behaviour of Goldenrod was significantly influenced by the application of different bio-stimulant treatments. The treatment T₇ (Samras @ 0.3%) recorded the minimum days taken for flower bud initiation (59.07), first flowering (70.10), 50 per cent flowering (81.00) and flower stalk harvesting (102.37), indicating its effectiveness in promoting early flowering. The earliness in flowering under Samras @ 0.3 per cent may be attributed to the presence of free amino acids and bioactive peptides, which enhance physiological and biochemical processes, improve nutrient assimilation and promote the transition from vegetative to reproductive growth. The bio-stimulant may also enhance

endogenous phytohormone activity and efficient translocation of photosynthates towards developing floral buds, thereby promoting early floral differentiation, flower opening and stalk maturity. These results are in conformity with Rakesh (2022) ^[17] and Youssef *et al.* (2022) ^[24] in Goldenrod, Munikrishnappa and Chandrashekar (2014) ^[11] in China aster, Memon *et al.* (2014) ^[9] and Khan *et al.* (2020) ^[6] in Zinnia, Hasan (2019) ^[4] in Pot marigold, Salem *et al.* (2016) ^[19] in Gerbera, Pruthvi *et al.* (2017) ^[15] and Suchitha *et al.* (2021) ^[21] in Chrysanthemum, Chaithra *et al.* (2020) ^[2] in Spider lily and Hegde *et al.* (2021) ^[5] in Dendrobium orchid.



Crop growth at early stage

Flower bud initiation

Fully opened florets of Goldenrod

Plate 1: Different development stages of Goldenrod



Plate 2: General view of the plot at peak flowering stage of Goldenrod

Conclusion

The present investigation revealed that foliar application of bio-stimulants significantly improved the growth and flowering performance of Goldenrod. Among the treatments, Samras @ 0.3 per cent (T₇) recorded superior growth and the earliest flowering compared to other treatments. Hence, the treatment (Samras @ 0.3%) applied at 30, 60 and 90 DAT can be recommended for commercial cultivation of Goldenrod and offers an effective and sustainable approach for enhancing crop growth and flowering performance.

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