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EFFECT OF MICROALGAE AND THEIR METHOD OF APPLICATION ON GROWTH AND FLOWERING OF ANNUAL CHRYSANTHEMUM (*Glebionis coronaria* L.)

G. Manasa^{1*}, P. Prasanth², D. Laxminarayana³, D. Vijaya⁴ and S. Praneeth Kumar⁵

¹Department of Horticulture (Department of Floriculture and Landscaping), Post Graduate Institute for Horticultural Sciences (PGIHS), Sri Konda Laxman Telangana Horticultural University (SKLTGHU), Mulugu, Siddipet-502 279, Telangana, India.

²Department of Horticulture, College of Horticulture, Sri Konda Laxman Telangana Horticultural University (SKLTGHU), Rajendranagar, Rangareddy-500 030, Telangana, India.

³Director of Research, Department of Horticulture, Sri Konda Laxman Telangana Horticultural University (SKLTGHU), Mulugu, Siddipet-502 279, Telangana, India.

⁴Department of Soil Science and Agricultural Chemistry, Post Graduate Institute for Horticultural Sciences (PGIHS), Sri Konda Laxman Telangana Horticultural University (SKLTGHU), Mulugu, Siddipet-502 279, Telangana, India.

⁵Department of Crop Physiology, Horticultural Polytechnic College, Ramagirikhilla, Peddapalli- 505 212, Telangana, India.

*Corresponding author E-mail: manasa.g1092@gmail.com

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ABSTRACT

The investigation entitled “Effect of microalgae and their method of application on growth and flowering of annual chrysanthemum (*Glebionis coronaria* L.)” was conducted during *Rabi* season of 2025-2026 at the Post Graduate Institute of Horticultural Sciences, Sri Konda Laxman Telangana Horticultural University, Mulugu, Siddipet, Telangana, India. The experiment was laid out in a Factorial Randomized Block Design comprising 14 treatment combinations with two replications, comprised of two methods of application, viz., soil drenching and foliar spray and seven microalgal treatments, viz., Spirulina at 2000, 3000 and 4000 ppm, Chlorella at 2000, 3000 and 4000 ppm, along with a water as control. Among the methods of application, soil drenching significantly improved plant height (63.36 cm), stem diameter (2.19 cm), number of branches per plant (42.86), plant spread (63.25 cm E-W and 60.60 cm N-S) and flowering performance, recording minimum days to flower bud initiation (35.97 days), 50 per cent flowering (45.56 days) and flower bud initiation to full bloom (10.72 days), along with maximum flowering duration (51.46 days), fresh flower weight (5.47 g), flowers per plant (160.59) and florets per flower (196.85), whereas foliar spray recorded higher chlorophyll content (43.08 SPAD). Among the microalgal treatments, Spirulina at 4000 ppm recorded the maximum plant height (68.38 cm), stem diameter (2.38 cm), number of branches per plant (45.40), plant spread (67.25 cm E-W and 65.92 cm N-S), chlorophyll content (46.60 SPAD), flowering duration (57.10 days), fresh flower weight (6.16 g), flowers per plant (179.00) and florets per flower (242.90), followed by Chlorella at 4000 ppm, while Spirulina at 4000 ppm promoted earlier flowering. Significant interaction effects were observed for most of the growth and flowering parameters, except number of branches per plant. Soil drenching of Spirulina at 4000 ppm recorded the maximum plant height (74.65 cm), stem diameter (2.54 cm), plant spread (73.65 cm E-W and 71.52 cm N-S), flowering duration (58.60 days), fresh flower weight (6.40 g), flowers per plant (194.00) and florets per flower (274.00), whereas foliar spraying of Spirulina at 4000 ppm recorded the highest chlorophyll content (51.14 SPAD). Soil drenching of Spirulina at 3000 ppm recorded the earliest flower bud initiation (33.00 days), 50 per cent flowering (41.50 days) and flower bud initiation to full bloom (9.45 days), which were statistically at par with Soil drenching of Spirulina at 4000 ppm. Overall, Soil drenching of Spirulina at 4000 ppm was the most effective treatment for improving growth and flowering performance, while Soil drenching of Spirulina at 3000 ppm promoted early flowering in annual chrysanthemum.

Key words : Annual chrysanthemum, *Glebionis coronaria*, Spirulina, Chlorella, Microalgae, Soil drenching, Foliar spray, Growth, Flowering.

Introduction

Annual chrysanthemum (*Glebionis coronaria* L.), belonging to the family Asteraceae, is an important ornamental crop cultivated for loose flowers and landscaping (Mohanty *et al.*, 2025). Its attractive blooms, adaptability to diverse agro-climatic conditions and short crop duration have contributed to its increasing commercial importance in India, including Telangana. It grows excellently in mild or slightly cold temperature, but high temperature fluctuations in the environment leads to premature flowering (Thakur *et al.*, 2022). Besides its ornamental value, the crop possesses edible and medicinal properties, making it a multifunctional species with considerable cultivation potential.

The intensive use of chemical fertilizers has contributed to soil degradation, reduced microbial diversity and environmental pollution, creating a need for sustainable crop production practices. In this context, microalgae have emerged as promising eco-friendly biostimulants owing to their ability to enhance plant growth, nutrient uptake, photosynthetic efficiency and stress tolerance while reducing dependence on synthetic inputs.

Among microalgae, Spirulina and Chlorella are rich in amino acids, proteins, vitamins, minerals, phytohormones, pigments and other bioactive compounds that can stimulate plant growth, improve nutrient availability and promote beneficial soil microbial activity (Goncalves *et al.*, 2023). Despite their reported benefits in several agricultural and horticultural crops, information on their application in annual chrysanthemum, particularly through different application methods and concentrations, remains limited under Telangana conditions.

Therefore, the present investigation was undertaken to evaluate the effect of Spirulina and Chlorella applied through soil drenching and foliar spray on the growth and flowering of annual chrysanthemum, with the objective of identifying an effective and sustainable microalgal application strategy for commercial cultivation.

Materials and Methods

A field experiment was conducted during the *Rabi* season of 2025-2026 at the Post Graduate Institute for Horticultural Sciences, Sri Konda Laxman Telangana Horticultural University, Mulugu, Siddipet District, Telangana. The experimental site is located at a latitude of 17°43'02" N and a longitude of 78°37'34" E, at an altitude of 451 m above mean sea level.

The study was laid out in a Factorial Randomized Block Design (FRBD) with two factors: Factor 1 - Methods of application (A_1 - Soil drenching and A_2 - Foliar

spray) and Factor 2 - Microalgae (M_1 - Spirulina at 2000 ppm, M_2 - Spirulina at 3000 ppm, M_3 - Spirulina at 4000 ppm, M_4 - Chlorella at 2000 ppm, M_5 - Chlorella at 3000 ppm, M_6 - Chlorella at 4000 ppm and M_7 - Water (control)). The study comprised fourteen treatment combinations (T_1 to T_{14}), each replicated twice.

The experimental plots measured 2.5×1.5 m with a spacing of 60 cm $\times$ 45 cm and 12 plants per plot. Healthy and uniform one-month-old seedlings of annual chrysanthemum were transplanted. Spirulina and Chlorella in powdered form were procured from MAAYI India Private Limited, Ahmedabad, Gujarat. For preparation of the treatment solutions, 2, 3 and 4 g of the respective microalgal powder were dissolved separately in 1000 ml of distilled water to obtain 2000, 3000 and 4000 ppm concentrations, respectively. The prepared microalgal solutions were applied to the standing crop by soil drenching and foliar spraying at 30 and 45 days after transplanting.

From each treatment and replication, five plants were randomly selected and tagged for recording observations. Growth parameters including plant height, number of branches per plant, stem diameter, plant spread in E-W and N-S directions and chlorophyll content were recorded at 45 and 60 days after transplanting. Flowering parameters including days to flower bud initiation, days to 50 per cent flowering, days from flower bud initiation to full bloom, flowering duration, fresh flower weight, number of flowers per plant and number of florets per flower were recorded. Data recorded for different parameters were subjected to Analysis of Variance (ANOVA) appropriate for Factorial Randomized Block Design as described by Panse and Sukhatme (1985). Standard error of mean (SEm $\pm$) and critical difference (CD) at the 5 per cent level of significance were calculated to test the significance of treatment differences.

Results and Discussion

Growth parameters

Plant height (cm) : A significant variation in plant height was observed among the different methods of application of microalgae. The maximum plant height (63.36 cm) was recorded with soil drenching (A_1), while the minimum (56.81 cm) was observed with foliar spray (A_2). The maximum plant height (68.38 cm) was recorded in Spirulina at 4000 ppm (M_3), whereas the minimum plant height (49.60 cm) was recorded in the water control (M_7). A significant interaction effect between microalgae and method of application was observed, with the maximum plant height (74.65 cm) recorded in Soil drenching of Spirulina at 4000 ppm

(A_1M_3), while the minimum plant height (47.50 cm) was recorded in Soil drenching of water (A_1M_7). Similar findings were observed by Shedeed *et al.* (2022) in *Lupinus*.

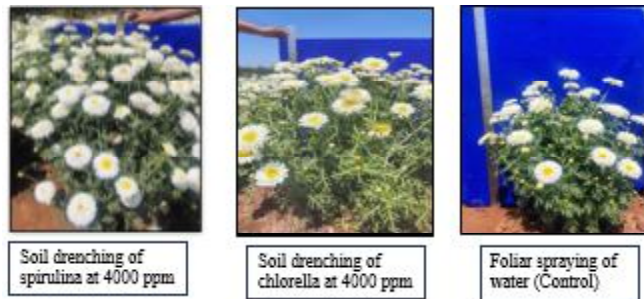


Fig. 1 : Effect of Soil drenching of spirulina at 4000 ppm (T_3) and Soil drenching of chlorella at 4000 ppm (T_6) on plant height in comparison with control (T_{14}).

Stem diameter (cm) : A significant variation in stem diameter was observed among the methods of application of microalgae, with the maximum stem diameter (2.19 cm) recorded in Soil drenching (A_1) and the minimum (2.02 cm) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the maximum stem diameter (2.38 cm), while the minimum (1.75 cm) was recorded in Water treatment (Control) (M_7). The interaction effect was also significant, with the maximum stem diameter (2.54 cm) recorded in Soil drenching of Spirulina at 4000 ppm (A_1M_3), while the minimum (1.62 cm) was recorded in Foliar spraying of water treatment (Control) (A_2M_7). The results were in agreement with those reported by Rapalo-Cruz *et al.* (2025) in garden geranium and Rashed *et al.* (2025) in african marigold.

Number of branches per plant : A significant variation in the number of branches was observed among the methods of application of microalgae, with the maximum number of branches (42.86) recorded in Soil drenching (A_1) and the minimum (41.19) in Foliar spray (A_2). Among the microalgal treatments, M_3 - Spirulina at 4000 ppm recorded the maximum number of branches (45.40), while the minimum (38.60) was recorded in M_7 - Water treatment. The interaction effect between the method of application and microalgal treatments was non-significant. Similar findings were reported by Ali and Hassan (2016) in chrysanthemum.

Plant spread (E-W) (cm) : A significant difference in plant spread (E-W) was observed among the methods of application of microalgae, with the maximum plant spread (63.25 cm) recorded in Soil drenching (A_1) and the minimum (55.08 cm) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the maximum plant spread (67.25 cm), while

the minimum (49.11 cm) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the maximum plant spread (73.65 cm) recorded in Soil drenching of Spirulina at 4000 ppm (A_1M_3), while the minimum (48.91 cm) was recorded in Soil drenching of water (Control) (A_1M_7).

Plant spread (N-S) (cm) : A significant variation in plant spread (N-S) was observed among the methods of application of microalgae, with the maximum plant spread (60.60 cm) recorded in Soil drenching (A_1) and the minimum (54.62 cm) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the maximum plant spread (65.92 cm), while the minimum (49.00 cm) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the maximum plant spread (71.52 cm) recorded in Soil drenching of Spirulina at 4000 ppm (A_1M_3), while the minimum (46.68 cm) was recorded in Soil drenching of water treatment (Control) (A_1M_7). The results were in agreement with those reported by Jena and Topno (2023) in pansy and Rapalo-Cruz *et al.* (2025) in garden geranium.

The superior growth observed under soil drenching might be attributed to the direct application of microalgal biomass to the rhizosphere, where it interacts with the soil-root interface, enhances nutrient availability through biological processes and stimulated soil microbial activity (Kapoore *et al.*, 2021). Soil drenching also promotes root development and favourable rhizosphere interactions, thereby improving the uptake of essential macro and micronutrients required for vigorous higher plant height, stem diameter, number of branches and plant spread (Parmar *et al.*, 2023).

The superior vegetative growth with Spirulina at 4000 ppm might be attributed to its higher concentration and rich content of amino acids, phytohormones, vitamins, polysaccharides and micronutrients, which might have stimulated root growth, cell elongation, nutrient uptake, photosynthesis and protein synthesis (Cakirsoy *et al.*, 2022). Its cytokinin content might have promoted lateral bud development, while auxins and gibberellins might have enhanced stem elongation, leaf expansion and plant spread (Gonzalez-Perez *et al.*, 2022). Thus, the combined effects of improved nutrition, hormonal stimulation and physiological activity resulted in higher plant height, branching, plant spread and stem diameter.

Chlorophyll content (SPAD) : Chlorophyll content differed significantly among the methods of application of microalgae, with the highest value (43.08 SPAD) recorded under Foliar spray (A_2) and the lowest (38.01

SPAD) under Soil drenching (A_1). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the maximum chlorophyll content (46.60 SPAD), while the minimum (31.99 SPAD) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the highest chlorophyll content (51.14 SPAD) recorded in Foliar spraying of Spirulina at 4000 ppm (A_2M_3), while the lowest (31.25 SPAD) was recorded in Foliar spraying of water treatment (Control) (A_2M_7).

The higher chlorophyll content under foliar spraying might be attributed to direct and rapid absorption of nutrients and bioactive compounds through leaves, bypassing soil-related constraints (Fernandez and Brown, 2013). The high chlorophyll content recorded with Spirulina at 4000 ppm might be attributed to its supply of essential nutrients, particularly magnesium and iron, which support chlorophyll synthesis and chloroplast development (Maddiboyina *et al.*, 2023; De Bang *et al.*, 2021). Its biostimulatory compounds further enhance nutrient assimilation and photosynthetic activity, resulting in greater chlorophyll accumulation.

Flowering parameters

Number of days taken for flower bud initiation :

Days to flower bud initiation differed significantly among the methods of application of microalgae, with the minimum (35.97 days) recorded in Soil drenching (A_1) and the maximum (39.04 days) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the minimum (34.30 days), which was at par with Spirulina at 3000 ppm (M_2) (35.08 days), while the maximum (42.48 days) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the minimum days to flower bud initiation (33.00 days) recorded in Soil drenching of Spirulina at 3000 ppm (A_1M_2), which was at par with Soil drenching of Spirulina at 4000 ppm (A_1M_3) (33.50 days), whereas the maximum (42.85 days) was recorded in Foliar spraying of water (Control) (A_2M_7).

Number of days taken to 50 per cent flowering

: Days to 50 per cent flowering differed significantly among the methods of application of microalgae, with the minimum (45.56 days) recorded in Soil drenching (A_1) and the maximum (49.84 days) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the minimum (43.58 days), which was at par with Spirulina at 3000 ppm (M_2) (44.55 days), while the maximum (54.10 days) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the minimum days to 50 per cent flowering (41.50 days) recorded in Soil drenching of

Spirulina at 3000 ppm (A_1M_2), which was at par with Soil drenching of Spirulina at 4000 ppm (A_1M_3) (42.45 days), whereas the maximum (54.80 days) was recorded in Foliar spraying of water (Control) (A_2M_7).

Number of days taken from bud initiation to full bloom :

The method of application of microalgae significantly influenced the days from bud initiation to full bloom, with the minimum duration (10.72 days) recorded in Soil drenching (A_1) and the maximum (11.79 days) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the minimum duration (10.35 days), which was at par with Spirulina at 3000 ppm (M_2) (10.45 days), while the maximum (12.70 days) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the minimum duration (9.45 days) recorded in Soil drenching of Spirulina at 3000 ppm (A_1M_2), which was at par with Soil drenching of Spirulina at 4000 ppm (A_1M_3) (10.10 days), whereas the maximum (12.80 days) was recorded in Foliar spraying of water (Control) (A_2M_7).

The shorter duration for flower bud initiation, 50 per cent flowering and bud to full bloom under soil drenching might be due to continuous water and nutrient availability, promoting rapid floral development and assimilate translocation (El-Serafy *et al.*, 2021). Adequate phosphorus and potassium further supported floral development and flower opening. The reduced duration for flowering with Spirulina at 3000 and 4000 ppm might be due to its bioactive compounds enhancing metabolic activity, photosynthesis and assimilate supply, thereby promoting faster flower development and opening (Youssef *et al.*, 2022). Similar improvements were reported by Sewedan *et al.* (2024) in tuberose.

Duration of flowering (days) : The method of application of microalgae significantly influenced flowering duration, with the maximum (51.46 days) recorded in Soil drenching (A_1) and the minimum (49.97 days) in Foliar spray (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the

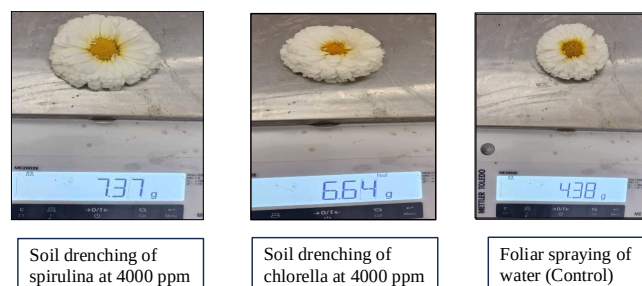


Fig. 2 : Effect of Soil drenching of spirulina at 4000 ppm (T_3) and Soil drenching of chlorella at 4000 ppm (T_6) on flower weight in comparison with control (T_{14}).

Table 1 : Effect of microalgae and their method of application on growth and flowering of annual chrysanthemum (*Glebionis coronaria* L.).

Treatments	Plant height (cm)	Stem diameter (cm)	Number of branches	Plant spread (cm)		Chlorophyll content (SPAD)	Number of days taken for			Duration of flowering (days)	Flower weight (g)	Number of flowers per plant	Number of florets per flower
				50 per cent flowering to full bloom			Bud initiation	Bud initiation					
				E-W	N-S								
Method of application (A)													
A ₁	63.36	2.19	42.86	63.25	60.60	38.01	35.97	45.56	10.72	51.46	5.47	160.59	196.85
A ₂	56.81	2.02	41.19	55.08	54.62	43.08	39.04	49.84	11.79	49.97	5.10	150.84	169.11
S. Em ±	0.81	0.01	0.50	0.65	0.81	0.55	0.22	0.29	0.09	0.18	0.04	1.46	2.00
CD @ 5%	2.49	0.03	1.53	2.00	2.47	1.67	0.67	0.89	0.28	0.54	0.12	4.47	6.10
Microalgae (M)													
M ₁	58.44	2.09	40.85	57.10	55.77	40.56	36.53	46.65	11.01	49.10	4.73	149.56	146.05
M ₂	63.01	2.13	43.48	61.37	59.79	42.58	35.08	44.55	10.45	53.60	5.53	163.13	185.85
M ₃	68.38	2.38	45.40	67.25	65.92	46.60	34.30	43.58	10.35	57.10	6.16	179.00	242.90
M ₄	57.32	2.00	40.05	56.63	53.81	38.44	39.15	49.90	11.75	46.90	4.61	149.69	151.78
M ₅	60.16	2.09	42.05	59.70	58.12	40.31	38.30	48.78	11.43	51.10	5.68	153.73	196.98
M ₆	63.70	2.29	43.75	62.98	60.85	43.36	36.73	46.35	11.08	54.30	5.86	168.75	224.05
M ₇	49.60	1.75	38.60	49.11	49.00	31.99	42.48	54.10	12.70	42.90	4.41	126.18	133.25
S. Em ±	1.52	0.02	0.93	1.22	1.51	1.02	0.41	0.55	0.17	0.33	0.07	2.74	3.73
CD @ 5%	4.65	0.06	2.86	3.74	4.63	3.12	1.25	1.67	0.52	1.02	0.22	8.37	11.40
Interaction (A × M)													
T ₁ -A ₁ M ₁	61.87	2.17	41.50	61.50	59.52	37.68	35.05	44.80	10.53	49.60	4.70	151.88	140.60
T ₂ -A ₁ M ₂	67.75	2.19	44.70	64.80	63.27	38.25	33.00	41.50	9.45	54.80	5.66	167.73	190.30
T ₃ -A ₁ M ₃	74.65	2.54	46.80	73.65	71.52	42.07	33.50	42.45	10.10	58.60	6.40	194.00	274.00
T ₄ -A ₁ M ₄	59.79	2.09	40.40	61.15	56.78	36.61	37.10	47.35	11.25	47.60	4.76	153.38	163.20
T ₅ -A ₁ M ₅	64.05	2.18	42.80	64.71	61.85	38.18	36.10	45.80	10.70	52.00	6.06	156.18	216.15
T ₆ -A ₁ M ₆	68.00	2.31	44.80	68.00	64.58	40.56	34.95	43.60	10.40	55.00	6.31	174.13	258.90
T ₇ -A ₁ M ₇	47.50	1.88	39.00	48.91	46.68	32.73	42.10	53.40	12.60	42.60	4.41	126.85	134.80

Table 1 continued....

Table 1 continued....

T ₈ -A ₂ M ₁	55.00	2.01	40.20	52.70	52.01	43.43	38.00	48.50	11.50	48.60	4.75	147.25	151.50
T ₉ -A ₂ M ₂	58.27	2.08	42.25	57.94	56.31	46.90	37.15	47.60	11.45	52.40	5.39	158.53	181.40
T ₁₀ -A ₂ M ₃	62.20	2.21	44.00	60.85	60.32	51.14	35.10	44.70	10.60	55.60	5.93	164.00	211.80
T ₁₁ -A ₂ M ₄	54.85	1.91	39.70	52.10	50.84	40.27	41.20	52.45	12.25	46.20	4.47	146.00	140.35
T ₁₂ -A ₂ M ₅	56.27	2.00	41.30	54.68	54.39	42.44	40.50	51.75	12.15	50.20	5.30	151.28	177.80
T ₁₃ -A ₂ M ₆	59.40	2.28	42.70	57.95	57.12	46.15	38.50	49.10	11.75	53.60	5.42	163.38	189.20
T ₁₄ -A ₂ M ₇	51.70	1.62	38.20	49.32	51.32	31.25	42.85	54.80	12.80	43.20	4.40	125.50	131.70
S.Em±	2.15	0.03	1.32	1.73	2.14	1.45	0.58	0.77	0.24	0.47	0.10	3.87	5.28
CD @ 5%	6.58	0.09	NS	5.29	6.54	4.42	1.77	2.37	0.74	1.44	0.31	11.83	16.13

A₁ - Soil drenching, A₂ - Foliar spray
M₁ - Spirulina at 2000 ppm, M₂ - Spirulina at 3000 ppm, M₃ - Spirulina at 4000 ppm, M₄ - Chlorella at 2000 ppm,
M₅ - Chlorella at 3000 ppm, M₆ - Chlorella at 4000 ppm, M₇ - Control (Water)

maximum flowering duration (57.10 days), while the minimum (42.90 days) was recorded in Water treatment (Control) (M₇). The interaction effect was significant, with the maximum flowering duration (58.60 days) recorded in Soil drenching of Spirulina at 4000 ppm (A₁ M₃), while the minimum (42.60 days) was recorded in Soil drenching of water (Control) (A₁ M₇).

The prolonged flowering duration under soil drenching might be due to continuous water and nutrient availability, sustaining photosynthesis and assimilate supply, thereby delaying flower senescence (El-Serafy *et al.*, 2021). The increased flowering duration with Spirulina might be due to its bioactive compounds and antioxidant pigments, which maintain chlorophyll content, delay senescence and sustain assimilate production (Wu *et al.*, 2016).

Flower weight (g) : Fresh flower weight varied significantly among the methods of application of microalgae, with the maximum (5.47 g) recorded in Soil drenching (A₁) and the minimum (5.10 g) in Foliar spraying (A₂). Among the microalgal treatments, Spirulina at 4000 ppm (M₃) recorded the maximum fresh flower weight (6.16 g), followed by Chlorella at 4000 ppm (M₆) (5.86 g), while the minimum (4.41 g) was recorded in Water treatment (Control) (M₇). The interaction effect was significant, with the maximum fresh flower weight (6.40 g) recorded in Soil drenching of Spirulina at 4000 ppm (A₁ M₃), which was at par with Soil drenching of Chlorella at 4000 ppm (A₁ M₆) (6.31 g), while the minimum (4.40 g) was recorded in Foliar spraying of water (Control) (A₂ M₇).

The higher flower weight under soil drenching was attributed to improved nutrient uptake and efficient assimilate translocation, which enhanced cell expansion and dry matter accumulation in floral tissues (Rouphael and Colla, 2020). The increased flower weight under spirulina at 4000 ppm might be attributed to improved vegetative growth, particularly greater leaf area, chlorophyll content and biomass, which enhanced photosynthetic capacity and assimilate availability for developing flowers, thereby increasing petal biomass and flower weight (Marcelis, 1996). The results were in agreement with those reported by Rashed *et al.* (2025) in marigold.

Number of flowers per plant : The method of application of microalgae significantly influenced the number of flowers per plant, with the maximum (160.59) recorded in Soil drenching (A₁) and the minimum (150.84) in Foliar spraying (A₂). Among the microalgal treatments, Spirulina at 4000 ppm (M₃) recorded the maximum number of flowers per plant (179.00), while the minimum

(126.18) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the maximum number of flowers per plant (194.00) recorded in Soil drenching of Spirulina at 4000 ppm (A_1M_3), while the minimum (125.50) was recorded in Foliar spraying of water (Control) (A_2M_7).

The higher number of flowers under soil drenching might be attributed to improved nutrient availability and assimilate partitioning, reducing bud abortion and promoting flowering (Marcelis, 1996). The higher number of flowers with Spirulina at 4000 ppm might be due to enhanced branching, chlorophyll synthesis and carbohydrate production, along with its natural growth-promoting compounds that stimulate floral initiation and development (Prisa, 2019).

Number of florets per flower : The method of application of microalgae significantly influenced the number of florets per flower, with the maximum (196.85) recorded in Soil drenching (A_1) and the minimum (169.11) in Foliar spraying (A_2). Among the microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the maximum number of florets per flower (242.90), while the minimum (133.25) was recorded in Water treatment (Control) (M_7). The interaction effect was significant, with the maximum number of florets per flower (274.00) recorded in Soil drenching of Spirulina at 4000 ppm (A_1M_3), which was at par with Soil drenching of Chlorella at 4000 ppm (A_1M_6) (258.90), while the minimum (131.70) was recorded in Foliar spraying of water (Control) (A_2M_7).

The highest number of florets under soil drenching and spirulina might have attributed to greater flower diameter, as the increased flower-head diameter might have provided sufficient area for floret development. Further, adequate nutrient availability (El-Serafy *et al.*, 2021) and enhanced carbohydrate accumulation resulted in higher number of florets.

Conclusion

The findings indicated that Soil drenching (A_1) was superior for growth and flowering of annual chrysanthemum, while Foliar spray (A_2) recorded higher chlorophyll content. Among microalgal treatments, Spirulina at 4000 ppm (M_3) recorded the best overall performance. The interaction A_1M_3 - Soil drenching of Spirulina at 4000 ppm recorded maximum growth, flowering duration, fresh flower weight, flowers per plant and florets per flower, while A_1M_2 - Soil drenching of Spirulina at 3000 ppm promoted early flowering. Thus, Soil drenching of Spirulina at 4000 ppm was found to be the most effective treatment followed by Soil drenching of chlorella at 4000 ppm for improving growth and

flowering of annual chrysanthemum.

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