

Effect of spraying with gibberellin on the growth, flowering and chemical content of *Calendula officinalis* L.

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Abstract

The study was conducted in one of the greenhouses of the Department of Horticulture and Landscaping, College of Agriculture and Forestry, University of Mosul, for the period from September 15, 2022, to June 1, 2023, on the pot Marigold plant *Calendula officinalis* L. cv. Pacific Beauty, in yellow and orange colors, with the aim of this study is the effect of spraying gibberellin at conc. (0, 200, 300 mg L⁻¹) conducted with a randomized complete block design (R.C. B. D.) was used. Spraying treatment with gibberellin at a concentration of 300 mg L⁻¹ resulted in a significant increase in plant height 49.04 cm and plant spread 29.46 cm compared to the control treatment and the total chlorophyll content showed significant differences. As for the flowering growth traits, it was noted that the least number of days for the first inflorescence to open was when spraying gibberellin at a concentration of 200 and 300 mg L⁻¹, and reached 66.67 and 79.67 days, respectively, while the largest diameter of the first inflorescence reached 58.58 mm, which was significantly excelled on the two treatments sprayed with gibberellin. While it was observed from the traits of the seeds and the content of carotenoids, it is noted from the table that the treatment of not spraying with gibberellin gave the highest values in the two traits of the number of total seeds and the total seed yield of 452.29 seeds. plant⁻¹ and 1.88 g. plant⁻¹, respectively, and it significantly excelled in the treatments spraying with gibberellin. While the traits of the content of carotenoids (alpha and beta) in the inflorescences did not show any significant differences between the treatments when sprayed with gibberellin or not, the highest values of alpha-carotene for yellow and orange inflorescences were for the treatment without spraying with gibberellin and reached 392.54 and 397.2 µg L⁻¹, respectively.

Keywords: spraying with gibberellin, *Calendula officinalis* L., gibberellin.

Introduction

Pot marigold is considered a winter herbaceous plant, reaching a height of 40-60 cm. Its leaves are simple, spoon-shaped, seated, 15-20 cm long, with a smooth texture and dark green color. From golden yellow to reddish-orange widely desired due to its content of the active substance are flavonoids and phenolic acids. The radial flowers are found in a single row (single) in the perianth around the disc florets or several rows (double) distributed in more than two perianths around the disc florets [1]. Gibberellins include a wide range of plant hormones. Gibberellins were first discovered

in the year 1930 AD, and only four of these species have biological effects on the plant. Among these species is gibberellic acid (GA3), which acts as a plant hormone and growth regulator, particularly affecting cell elongation and increasing fruit size. In addition to its effect on seed germination, many products contain gibberellin and are available commercially at present in the form of liquids or solid form with a high purity rate or in the form of mixtures with other compounds in certain proportions [6]. Researchers [11] 150, 200, 250, and 300 mg L⁻¹. It improved the quality of chrysanthemum inflorescences, as the treatment of spraying with gibberellin at a concentration of 250 mg L⁻¹ recorded the highest values for the traits of

inflorescence diameter and inflorescence fresh weight, which amounted to 6.43 cm, 3.77 g, while the control treatment recorded the lowest values, as it recorded 4.19 cm, 2.86 g. Spraying with a concentration of 200 mg L⁻¹, the lowest number of days until the emergence of the inflorescence bud and until the first inflorescence opens was 64.56, and 83.58 days, respectively. Compared with the control treatment, where the highest number of days was recorded, which was 43, 73, 77, and 99 days, respectively. The researcher [5] indicated that when gibberellin was sprayed at concentrations of 0, 200, 250, 300, and 350 mg L⁻¹ on chrysanthemum plants, an improvement in the number and quality of inflorescences was obtained. As it caused a significant increase in the total inflorescences yield of one plant, reaching 74.28 inflorescences plant⁻¹ at a concentration of 300 mg L⁻¹, significantly compared with the control treatment, which recorded the lowest number of inflorescences of 50.85 inflorescences plant⁻¹. While the plants sprayed with a concentration of 200 mg L⁻¹ excelled in inflorescence fresh weight and inflorescence diameter, which recorded 1.89 g and 4.84 cm, respectively, compared with the control treatment for both traits, which recorded the lowest values of 1.61 g and 4.41 cm, respectively. The research aims to demonstrate the effect of spraying with gibberellic acid and its role in redistributing the growth and development of the branches to come up with a pattern more suitable for potted plants.

Materials and Methods

The experiment was conducted in one of the greenhouses of the Department of Horticulture and Landscaping, College of Agriculture and Forestry, University of Mosul, during the period from September 15, 2022, to June 1, 2023. Winter annual Pot marigold plants, a mixture of yellow and orange, were used. *Calendula officinalis* cultivar Pacific Beauty. The seeds were sown on September 15, 2022, in seed propagation trays filled with peat moss

and placed inside the greenhouse. After the germination of seeds and the growth of seedlings, the seedlings were transplanted on 27/12/ 2022 directly to circular pots with a diameter of 13 cm and a volume of 2 liters. The specifications of the transferred seedlings had 3-5 true leaves and a height of 10 cm. The following gibberellin concentrations were prepared:

- Control treatment at a concentration of 0 mg L⁻¹
- Spraying with gibberellin at a concentration of 200 mg L⁻¹
- GA3 spraying with gibberellin at a concentration of 300 mg L⁻¹

Gibberellin was sprayed with two sprays, the first on January 26, 2023, and the second 15 days after the first spraying, as the plants were sprayed with an equal number of sprays to the extent of fully wetting the plants. The following traits were measured:

Plant height (cm): The height of the plant was measured at the appearance of the first inflorescence using a measuring tape, as the measurement was taken from the soil surface to the highest inflorescence.

Plant spread (cm): The maximum plant spread was measured when the first inflorescence appeared and the inflorescences opened by tape measure by fixing wooden sticks on both sides of the plant and the area was taken from one point to another. Number of leaves (plant leaf⁻¹): All leaves formed on the plant were calculated at the end of the experiment. Total leaf area (cm²): The cloning method was used to calculate the leaf area of one plant leaf, then the leaf area of one plant was calculated by multiplying the average leaf area One x the number of leaves for each plant, according to [9].

Leaves total chlorophyll content (mg g⁻¹ fresh weight): Total chlorophyll was estimated using the method of [7]. Number of days until the first inflorescence opens (day): The number of days was calculated from seedling until the full flowering of the first inflorescence. The number of inflorescences (inflorescence plant⁻¹): by counting all the

inflorescences formed on the plant [3]. Diameter of the first inflorescence (mm): The diameter of the first inflorescence was measured at full flower by calculating the distance between the two furthest points using the Vernier foot.

Flowering period (day): calculated from the appearance of the color on the first inflorescence until when the plant stops opening new inflorescences. The content of carotenoids in the petals ($\mu\text{g L}^{-1}$): The content of carotenoids in the inflorescences of yellow and orange petals, of both alpha-carotene and beta-carotene types, was estimated by taking 0.5 g of the petals and crushed in 10 ml of ethanol in a ceramic mortar, after which the filtration process was carried out with a centrifugal apparatus. At a number of cycles of 2500 at a wavelength of 450 nm to measure the content of alpha-carotene and according to the method reported by [8]. Inflorescences fresh yield (g plant^{-1}): The fresh weight of all inflorescences was recorded after flowering. Total number of seeds (plant seed^{-1}): This is done by calculating the total number of seeds for each plant in the stage of full maturity of the seeds through manual counting. Total seed yield (g. plant^{-1}): The total seed yield of each plant was weighed at the stage of full maturity of the seeds using a sensitive scale.

statistical analysis is Randomize complete block design and the means were compared according to Duncan's polynomial test under the probability level of $P < 0.05$ [2], and the SAS statistical analysis program (V.9) (SAS, 2002) was used to analyze the data and extract the correlation between the studied traits.

Results and discussion

It can be seen from Table (1) that the spraying with concentrations of gibberellin increased significantly in plant height, from 30.96 then 43.33 until it reached 49.03 cm with a higher concentration of gibberellin. The data showed that there are significant differences when spraying with a concentration of 300 mg L^{-1} , which recorded the highest plant spread of 29.46 cm, compared to the control treatment and spraying with a concentration of 200 mg L^{-1} , as it gave the lowest values of the spread of 25.58 and 26.13 cm, respectively. There were no significant differences in the number of leaves and total leaf area between the concentrations used. The non-spraying gibberellin treatment recorded the highest total chlorophyll content of 15.67 mg g^{-1} fresh weight, which was found to be significantly overcome by the two other concentrations (200 and 300 mg L^{-1}), which recorded the lowest total chlorophyll content of 11.93 and 10.82 mg gm^{-1} fresh weight, respectively.

Table (1) Effect of spraying with gibberellin on some vegetative growth traits of *Calendula officinalis* L.

gibberellin	plant height (cm)	Number of leaves (leaf.plant ⁻¹)	Total leaf area (cm ²)	Total chlorophyll content (mg g ⁻¹ fresh weight)	plant spread (cm)
0	30.96c	103.88a	2246.1a	15.67a	25.58b
200	43.33b	96.04a	2251.5a	11.93b	26.13b
300	49.04a	98.17a	2322.4a	10.82b	29.46a

The same-letter values for each factor or their interactions separately did not differ significantly according to Dunckin's multiple range test under the 5% probability level.

It can be seen from Table (2) that the control treatment was delayed, as it recorded 69.75 days until the first inflorescence opens, significantly compared with the two concentrations of 200 and 300 mg L^{-1} , which took the least number of days to open the first

inflorescence, which recorded 66.67 and 66.79 days, respectively and there were no significant differences in the number of inflorescences and the flowering duration with the effect of spraying with gibberellin. The non-spraying treatment with gibberellin excelled in recording the highest inflorescence diameter of 58.58 mm, and significantly, with the two concentrations of gibberellin 200 and

300 mg L⁻¹, which recorded 53.38 and 54.17 mm, respectively. We notice that the treatment of no spraying significantly excelled in the total fresh inflorescences yield, which recorded 22.79 g. Plant⁻¹, and no spraying, and with the increase in concentration, there was a significant decrease in the total fresh inflorescences yield, which amounted to 17.38 and 13.71 g. Plant⁻¹, respectively.

Table (2) Effect of spraying with gibberellin on some flowering growth traits of chrysanthemum plant *Calendula officinalis* L.

gibberellin	Number of days until the first inflorescence flowering (day)	Number of inflorescences (inflorescence-1)	flowering period (day)	First inflorescences diameter (mm)	Total fresh inflorescence yield (g)
0	69.75a	20.29a	60.29a	58.58a	22.79a
200	66.67b	20.25a	63.67a	53.38b	17.38b
300	66.79b	20.33a	63.17a	54.17b	13.71c

The same-letter values for each factor or their interactions separately did not differ significantly according to Dunkin's multiple range test under the 5% probability level.

Table (3) shows that there were no significant differences in the alpha and beta-carotene content of the yellow and orange petals in the used concentrations of gibberellin. While there are differences when spraying with gibberellin, as it excelled in the control treatment, and the number of seeds amounted

to 452.29 seeds. plant⁻¹, and significantly with the treatment of spraying with gibberellin at concentrations of 200 and 300 mg L⁻¹, as they recorded 252.05 and 231.75 seeds plant⁻¹, respectively. It was found that the no-spray treatment, which gave the highest seed yield, which recorded 1.88 g plant⁻¹, significantly excelled compared to the other two concentrations, which recorded 1.25 and 1.11 g, respectively.

Table (3) Effect of spraying with gibberellin on some seed traits and carotenoids content of chrysanthemum plant *Calendula officinalis* L.

gibberellin	Total number of seeds (plant-1 seed)	Total seed yield (gm plant-1)	Alpha-carotene for yellow inflorescences (µg L-1)	Alpha-carotene for orange inflorescences (µg L-1)	Beta-carotene for yellow inflorescences (µg L-1)	Beta-carotene for orange inflorescences (µg L-1)
0	452.29a	1.88a	392.54a	397.20a	449.13a	448.70a
200	252.05b	1.25b	391.33a	394.54a	449.92a	451.46a
300	231.75b	1.11b	392.12a	413.50a	451.08a	443.25a

The same-letter values for each factor or their interactions separately did not differ significantly according to Dunkin's multiple range test under the 5% probability level.

Discussion:

The results indicated that there is an effect of gibberellin acid on the traits of vegetative growth, it shows there is an increase in plant height with the increases of the concentration. This effect of gibberellin may be caused by its physiological role in cell extension which increases the meristemic area as well as, increase the number of cells and new stem extended [4]. The high concentration of 300 mg L⁻¹ caused an increase in plant spread in comparison with not spraying treatment(control), as well as the plants that were not sprayed with gibberellin were significantly overcome in the total chlorophyll content in the leaves. Among the results of flowering traits and the effect of spraying with gibberellic acid, it is showed that the inflorescence opening date, the plants sprayed with both concentrations of gibberellin showed an improvement in the diameter of the first inflorescence holder, the diameter of the first inflorescence, as well as the yield fresh weight of the inflorescences when spraying with gibberellin. It may be caused by the role of gibberellin effect in cell division and the interaction with internal auxin and the important role of nutrient transition from leaves to the inflorescence [10] In addition to the results that spraying with gibberellin caused a decrease in the total number of total seeds and the yield of seeds, in comparison with control.

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