The Effect of Foliar Spraying with Garlic and Licorice Extracts on the Growth and Flowering of Chrysanthemums

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Abstract
This study was conducted in the wooden greenhouse of the Department of Horticulture and Landscape gardening, college of Agriculture, Tikrit University, to investigate the effect of foliar spraying with garlic and licorice extracts on the growth and flowering of chrysanthemum plants. The experiment was conducted according to a randomized complete block design (RCBD) with two factors: garlic extract concentrations and licorice extract concentrations, in addition to studying the effect of the interaction between them on many vegetative, floral, and physiological characteristics of the plant.
The results showed that G3L3 significantly outperformed all other treatments in all features studied. The highest plant height (20.70 cm), highest number of leaves (24.96 plant leaves^{-1}), largest flower diameter (7.96 mm), largest flower weight (4.36 g), and highest chlorophyll content (35.73 SPAD) were recorded compared to the remaining treatments.
This superiority can be attributed to the positive effect of the bioactive compounds and nutrients present in garlic extract, as well as the active ingredients of licorice extract, such as glycyrrhizin and flavonoids, which stimulate cell division, improve vegetative and floral growth, and enhance the physiological efficiency of the plant. The results also showed a synergistic effect between the two extracts, improving photosynthesis processes as well as promoting the growth and flowering of chrysanthemum plants.

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Introduction

Chrysanthemum (Chrysanthemum spp.) is a member of the Asteraceae family, and one of the most economically important ornamental herbaceous plants grown worldwide. Its significance lies in its large-scale application in garden landscaping, floral decoration, and the cut-flower market, which gives it an important status in commercial flower production (Nguyen *et al*., 2021; Pathania *et al*., 2024).
This plant genus is primarily distributed across Asia and Europe and includes a large number of species that vary in their morphological characteristics, such as the shape of the lobed leaves and the multi-colored composite flower heads. The plant's annual or perennial nature depends on the species and environmental factors (Chen *et al*., 2020; Fu *et al*., 2022). Chrysanthemums are characterized by their high
economic value, as they are considered one of the most important ornamental crops globally and rank second only to roses in the floral industry. Furthermore, they come in different colors and have a long blooming time, making
them a significant part of landscape design (Zhang *et al*., 2025; Pathania *et al*., 2024). Chrysanthemum is not only an ornamental plant but is also an important source of phytochemicals that are beneficial for health. The bioactive components include flavonoids, terpenoids, and polysaccharides, exhibiting numerous biological activities such as antioxidant, anti-inflammatory, and antimicrobial activities. These attributes have led to the broad application of chrysanthemums in traditional medicine and

pharmaceutical and food industry applications (Bailly, 2025; Mohamad *et al*., 2024)**.** The chrysanthemum plant is an important model of economic, ornamental, and medicinal value, and is the focus of many recent studies in the fields of agriculture, biotechnology, and the pharmaceutical industry (Nguyen *et al*., 2021)**.** Chrysanthemum is considered a high-value ornamental crop because of its extensive commercial application and the crop's sensitivity to better horticultural management conditions. In the last few years, more and more focus has been placed on the use of natural biostimulants such as extracts from plants and organic growth promoters as environmentally friendly solutions to optimize plant growth and ornamental appearance. These alternatives provide an environmentally friendly approach as alternatives to chemical fertilizers and synthetic growth regulators, and contribute to more sustainable floricultural production systems (Nguyen *et al*., 2021; Pathania *et al*., 2024). Foliar spraying is used as an effective method to supply the plant with nutrients and bioactive compounds directly through the leaves, thereby increasing absorption efficiency and accelerating the plant's physiological response (Khalid & Da Silva, 2012) Garlic extract and licorice extract were used as natural organic fertilizers.

Garlic extract (Allium sativum) is one of the most important plant extracts proven to improve plant growth, as it contains active sulfur compounds such as allicin, as well as vitamins and amino acids, which contribute to stimulating vital processes, increasing cell division, and improving the plant's resistance to environmental stresses (Pundir *et al*., 2021). Furthermore, numerous studies have shown that applying garlic extract as a foliar spray leads to increased vegetative growth and improved floral traits due to its stimulatory effect on enzymes and metabolic processes.

Licorice extract (Glycyrrhiza glabra) is natural source rich in active compounds such as glycyrrhizin and flavonoids, in addition to containing nutrients and natural growth regulators (similar to auxins and gibberellins), making it an important stimulant for plant growth, increasing photosynthetic efficiency, and improving floral traits (Chandurkar *et al*., 2015; Pundir *et al*., 2021). Recent studies have indicated that foliar spraying with licorice extract leads to increased plant height and number of branches, as well as improved flower number and diameter. The synergy between garlic extract and licorice extract is crucial because garlic exhibits biostimulant and disease inhibitory properties, while licorice has growth-promoting and physiological regulatory capabilities, potentially resulting in enhanced chrysanthemum growth, flowering, and bloom longevity (Nguyen *et al*., 2021; Pathania *et al*., 2024). Accordingly, there is a need to study the effect of foliar spraying with these natural extracts on chrysanthemum plants, with the aim of improving their productivity and floral characteristics through sustainable and environmentally friendly methods, which aligns with modern trends in organic agriculture and reducing reliance on chemical inputs.

Materials and Methods

This experimental work was conducted in a wooden greenhouse of the Department of Horticulture and Landscape Architecture, College of Agriculture, University of Tikrit, during the growing season 2025–2026. The chrysanthemum plants used in the study were grown from seeds in plastic pots of 10 cm diameter. Irrigation was applied as needed for the maintenance of proper moisture conditions for plant growth throughout the experiment. The plants were also supplied with a balanced water-soluble fertilizer (20:20:20 NPK) at the rate of 1 g L^{-1}, dissolved in irrigation water, and applied at two-week intervals.

The experiment was conducted using a completely randomized block design (RCBD) with two factors and three replicates, and each experimental unit contained three pots. The first factor was spraying with garlic extract at three concentrations (control treatment, 1 and^{2} mL/L$^{)}$; the second factor was spraying with licorice extract at three concentrations (control treatment, 2$^{,\text{ and}}$ 4 $^{\text{mL/L}}$). Subsequently, data on the studied traits were collected and statistically analyzed using SAS (2012), and means were compared using Duncan's multiple range test at a significance level of 0.05 (Al-Rawi and Khalafallah, 2000).

First factor: Spraying the plants with garlic extract according to the following treatments:

1. **G1:** Control treatment (no spraying).
2. **G2**: Spraying 1 mL/L
3. **G3**: Spraying $^{\text{with}}$ 2 mL/L

Second factor: Spraying with licorice extract at four concentrations:

1. **L1:** No addition.
2. **L2:** Spraying 2 ml/L
3. **L2**: Spraying 4 ml/L

The garlic powder was dried and then the aqueous extract from garlic was prepared. In brief, 50 g of garlic powder was suspended in 250 mL distilled water and stirred continuously for 45 min with a magnetic stirrer and then a uniform mixture was obtained. Once stirred, the volume of the suspension was made up to 1 L with distilled water as required by the treatment volume. The mixture was then placed under refrigerated conditions (4-8 °C) for 12 h to ensure adequate maceration and release of the active constituent(s). After extraction, the suspension was first filtered through sterile gauze to eliminate coarse particles and then through Whatman No. 1 filter paper to get a clear aqueous extract**.**

Aliquots of 1 mL and 2 mL of the concentrated extract were transferred and each was diluted to 1 L with distilled water, and Tween-20 was added to both of these solutions at a rate of 0.05% (v/v) to aid in the uniform application of the extract on the leaf surface. The freshly prepared solutions were sprayed on the leaves of Catharanthus roseus plants. The prepared extracts were kept under refrigeration and used within 48 h to ensure the biological activity of the extracted compounds. The method adopted was aqueous maceration, which is one of the popular methods applied for the extraction of water-soluble bioactive compounds of garlic, especially sulfur-containing compounds and phenolic compounds with physiological activity in the plants (Bar *et al*., 2022)**.** Powdered roots of Glycyrrhiza glabra L. were extracted with hot water to produce an aqueous extract of licorice. In short, finely ground powder of licorice root (10 g) was prepared in 100 mL of distilled water. The suspension was placed in a water bath and kept at 60 °C for 30 minutes with continuous shaking to ensure the release of bioactive constituents into the water phase. The mixture was allowed to cool at room temperature after extraction and then filtered to get a clarified extract. The filtrate was subsequently poured into dark glass containers and refrigerated at 4 °C until use.To prepare the experimental concentrations, the mother extract was diluted with sterile distilled water to obtain concentrations of 2 mL/L and 4 mL/L by taking 2 mL and 4 mL of the mother extract

and adding them to 1 L of distilled water, respectively; the solutions were prepared immediately before use. Licorice extract has been used in numerous studies as a natural plant growth promoter, as it improves vegetative growth and physiological traits due to its content of active compounds such as glycyrrhizin and flavonoids Yousif *et al*., 2024).

Discussion of Results

Table 1: Effect of foliar spraying with garlic and licorice extracts on the growth and flowering of chrysanthemum plants

Treatment	Plant height Cm	Number of leaves (leaves/plant)	Flower diameter Mm	Flower weight (g)	Chlorophyll spad
G1L1	h 8.76	i 10.63	g 4.16	i 1.40	g 24.00
G1L2	g 10.43	h 12.63	f 4.76	h 2.26	f 27.50
G1L3	g 11.03	g 13.63	f 4.96	g 2.46	f 27.90
G2L1	f 11.66	f 14.63	e 5.76	f 2.86	e 29.10
G2L2	e 14.66	e 15.96	d 6.40	e 3.16	d 29.86
G2L3	d 16.53	d 18.63	c 6.90	d 3.43	d 30.36
G3L1	c 17.66	c 20.26	b 7.23	c 3.66	c 32.80
G3L2	b 19.33	b 22.63	a 7.66	b 3.96	b 34.03
G3L3	a 20.70	a 24.96	a 7.96	a 4.36	a 35.73

*Values with the same letters within a column do not differ significantly from each other according to Duncan's multiple range test at the 5% probability level

The effect of G3L3 was significantly better than the other treatments in all the studied traits as shown in Table (1) such that plant height increased to 20.70 cm, the number of leaves per plant increased to 24.96, the flower diameter increased to 7.96 mm, flower weight increased to 4.36 g, and chlorophyll content increased to 35.73 SPAD, indicating an improvement in the vegetative and floral growth and physiological efficiency of the plant.

The growth stimulatory effect of garlic extract on plant height and number of leaves could be due to the bioactive compounds and nutrients present in the garlic extract, which have been shown to have a positive effect on vegetative traits (Massoud, 2023; Verma *et al*., 2023). The results obtained from Taha and Aljabary (2024) also showed that the treatment with garlic extract resulted in significant enhancement of vegetative growth due to better nutrient uptake and stimulation of essential processes within the plant. The enhancement of flower size parameters (diameter and weight) is believed to be due to the application of licorice extract, which was found to contain active compounds such as glycyrrhizin and flavonoids that are identified to act as growth promoters or enhancers, hence stimulating cell division and elongation, and flower formation (Yousif, 2024; Adelah, 2024). Recent studies have also identified that the application of licorice extract promoted an increase in the floral characteristics and vegetative growth of ornamental plants (Horizon Publishing, 2025). Higher chlorophyll content (35.73 SPAD) indicates better photosynthetic efficiency, and this is consistent with Neamah (2026), who stated that extracts of plants such as licorice extract lead to an increase in chlorophyll content and photosynthetic efficiency of plants, thereby increasing the production of plant carbohydrates and dry matter, which results in an increase in plant growth and flowering. The advantage of G3L3 treatment can also be attributed to the synergistic effect between garlic and licorice extracts, which has been reported to significantly improve the vegetative growth, flowering, and productivity of plants compared to single applications of either extract, given that they work synergistically in their physiological activities (Adelah, 2024; Taha & Aljabary, 2024).

Conclusions

It was observed that the G3L3 treatment was significantly better in all the traits studied, suggesting that the interaction of garlic and licorice extracts was beneficial for vegetative and floral growth and enhanced the chlorophyll content. A synergistic effect between the two extracts was also evident, thus enhancing the efficiency of physiological processes and growth and flowering of plants.

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