World Journal of Environmental Biosciences
Available Online at: **www.environmentaljournals.org**

Volume 15, Issue 1: 79-89

https://doi.org/10.51847/Mc9ec3nkwk

ISSN 2277- 8047

Anatomical Study of the Effect of Light Spectrum, Salicylic Acid and Micronutrients on Gerbera Inflorescences

Marwah Moyassar Hamdoon[1]*, Ammar Omar Alatrakchii[1], Asmaa Mohamad Adil[1]

[1]Department of Horticulture and Landscape Architecture, College of Agriculture and Forestry, University of Mosul, Mosul, Iraq.

ABSTRACT

This study was conducted in the fields and laboratories of the Department of Horticulture and Landscape Design/College of Agriculture and Forestry, University of Mosul. Gerbera plants were exposed to natural daylight or interference of the red and blue spectrum for four hours (one hour before sunrise and continuing one hour after, then two hours at sunset, one hour before sunset, and continuing for one hour after sunset). The plants were also sprayed with salicylic acid at 300 mg l^{-1}, and sprayed with a mixture of micronutrients, namely iron, zinc, and copper, in the form of sulfates for the three elements, at 40 mg l^{-1} for iron, zinc and at 10 mg l^{-1} for copper. Some of the morphological and anatomical characteristics of gerbera inflorescences were studied. The results showed that the diameter of the inflorescence and its vase life were not significantly affected by the studied treatments, but prolonging daylight interaction with spraying the plants with salicylic acid led to recording the highest value for the amount of water uptake, 71.86 cm^3, which was accompanied by recording the highest flowering age, 22.53 days, although it was not significant. The anatomical study indicated that prolonging daylight or spraying with salicylic acid or a mixture of micronutrients or their interaction led to a significant change in the thickness of the different components in the anatomical section of the inflorescence stalk at a distance of 5 or 30 cm below the inflorescence.

Keywords: *Spectrum type, Salicylic acid, Fertilization with microelements, Gerbera jamesonii*

Corresponding author: Marwah Moyassar Hamdoon
e-mail ✉ marwah.22agp70@student.uomosul.edu.iq
Received: 09 January 2026
Accepted: 28 March 2026

INTRODUCTION

The plant *Gerbera jamesonii* (Bolus ex Hook. F.) is a member of the Asteraceae family. It is a perennial herbaceous plant with pinnately lobed leaves and flowers in a large inflorescence, 5-12 cm in diameter, single, semi-double, or double, borne on a scape 5-40 cm long. The inflorescences come in a variety of colors (Tjia & Black, 2003). Its inflorescences are in high demand in local and international markets due to their variety of colors, size, and long vase life. Cut flowers can last for more than 14 days in a vase (Anonymous, 2009; Deepa *et al*., 2019) when proper production and handling conditions are maintained. According to global trends in floriculture, it ranks fourth among cut flowers after rose, carnation, and chrysanthemum (Dalal *et al*., 2009; Jena *et al*., 2020).

When the type of spectrum is changed, it leads to physical and phenotypic changes, technically known as photomorphogenesis, which involves the activation of several light-sensitive systems at specific wavelengths in the range of 400-500 nm for blue, 600-700 nm for red light, and 700-800 nm for infrared light (Taiz & Zeiger, 2010). The problems arising from the use of chemicals in agricultural processes have led to increased interest in finding alternative methods for regulating plant growth and improving its quality. The growth of many different plants has been manipulated by altering the wavelength ratios in the light source using spectral filters and colored plastic covers (Rajapakse *et al.,* 1999). It was observed that the ratio between the red spectrum of light and far-red (R:FR), when low, positively affects the plant, leading to stimulation of flowering processes, and when the ratio is high, the effect is negative on flowering processes, which helps to increase plant growth and productivity (Park *et al.*, 2017; Zhen & Iersel, 2017).

Marousky (1986) divided the vascular bundles in the inflorescence stalks of two gerbera kinds, Tropic Gold and Appleblossom, into large and little bundles that are found next to one another. The average length of the large bundle was 0.89 mm, while the small bundles were 0.46 mm. Compared to the bottom portion 15 cm below the inflorescence, the stalk 1 cm below the inflorescence displayed fewer vascular bundles and less cellulose and lignin. The Tropic Gold species possessed more small vascular bundles than the other variety, but both had comparable numbers of big bundles. The distribution and quantity of vascular bundles, as well as the thickness of the cell walls, which make Appleblossom more resilient to breakage after harvest, were identified as the causes of the morphological differences between the two types. Bekheta *et al.* (2008) examined the effects of pacloptrazole and selenium at different concentrations and discovered that both drugs enhanced the number of collenchyma cells and the thickness of the epidermis in the cortex, vascular tissues, and pith of gerbera inflorescences (Akdeniz *et al*., 2023; Bratt & Naimi-Akbar, 2023; Maslyakova *et al*., 2023; Al-Mubarak *et al*., 2024; Laaksonen & Virtanen, 2025; Mennitti *et al*., 2025). When compared to the control, the

treatment with selenium at 5 mgl-1 and pacloptrazole at 25 mgl-1 showed the greatest number of collenchyma cells. When pacloptrazole was administered at 50 or 100 mgl-1, the length of vascular bundles increased the most. Additionally, compared to the control, its usage alone at any of the investigated dosages or at 100 mgl-1 with selenium at 20 mgl-1 produced a 50% increase in phloem thickness. In every treatment, the thickness of the xylem and pith also increased. These structural alterations, according to the researchers, are a sign of increased inflorescence stalk mechanical strength. It explains why the treated flowers are resistant to breaking or bending (Dupuis *et al*., 2023; Suragimath *et al*., 2023; Česaitis *et al*., 2024; Essah *et al*., 2024; Hillman, 2024; Hsiao *et al*., 2024; Nyathi *et al*., 2024; Zhou *et al*., 2024; Ramirez *et al*., 2025; Yu *et al*., 2025).

When Petra *et al*. (2020) compared the anatomical structure between four Gerbera species, Aladin, Anita, Crème Eye, and Naveline, they noted that the inflorescences stalks of the different species formed epidermal cells of equal diameter and single-layered, and that the parenchyma cells under the epidermis were almost equal in diameter in all species. The central cylinder was surrounded by a ring of sclerenchyma cells (pericycle), and vascular bundles of different sizes were arranged in an alternating pattern inside it. In the apical region under the inflorescence, the pericycle appeared as a covering for the vascular bundle, while in the middle region of the inflorescence, it formed a more developed continuous ring outwards of the vascular bundles. The researchers noted that the density of sclerenchyma decreased from the middle of the stalk to the upper region under the inflorescence, in addition to the thinness of the cell walls in the apical region. The researchers also noted that the length of the vascular bundles decreased from the bottom to the top.

Salicylic acid is found in members of the plant kingdom (Raskin, 1992). It is an aromatic carboxylic acid of a phenolic nature. The studies by Asgari and Moghadam (2015) on *Gerbera jamesonii* plants showed that treatment with salicylic acid at any of the concentrations studied, namely 0.5, 1.5, and 2.5 mmol, extended the vase life by increasing the uptake of a larger quantity of preservative solution, in addition to its antioxidant effect and reduction of microbial activity at the base of the stem. Babalar *et al*. (2016) noted that the percent of curvature of the inflorescence stalk was clearly reduced as a result of treatment with salicylic acid and silicon. They pointed out that the lignin content is related to the cutting strength in the upper part of the vascular bundle, according to their histochemical study. Salicylic acid reduced the degree of curvature by increasing the thickness of the cell walls around the vascular bundle and the xylem in the stem, since the secondary cell wall is mainly composed of cellulose, hemicellulose, and lignin, to which the mechanical strength of the secondary cell walls is attributed.

Chemical fertilization with micronutrients is essential for plant growth, as they participate in all metabolic and cellular functions (Malewar & Ismail, 1995; Shakakibara *et al*., 2006). In the study of Sahu *et al*. (2016), they showed that spraying Gerbera plants with 0.2% concentrations of both zinc and manganese sulfates and 0.1% iron sulfate resulted in the highest values for flower stalk length (69.56 cm), flower stalk diameter (7.16 mm), inflorescence diameter (11.09 cm), and vase life 6.67 days compared to the control treatment. Pal *et al*. (2016) reported that the highest significant values for inflorescence diameter (11.64 cm), flower stalk length (54.00 cm), inflorescence stalk diameter (6.22 mm), and vase life 10.28 days were recorded when *Gerbera jamesonii* plants were sprayed with 0.2% iron and zinc sulfates each compared to the control.

The purpose of this experiment is to assess the effects of salicylic acid spraying, micronutrient fertilization, and exposure of gerbera plants to various spectrums at particular times prior to sunrise and sunset on flowering and other traits. Additionally, the effects of these treatments on the anatomical structure of the inflorescence stalk and their impact on the inflorescence's vase life will be examined.

MATERIALS AND METHODS

Between December 2024 and May 2025, the experiment was conducted in a plastic house structure at the Department of Horticulture and Landscape Design, College of Agriculture and Forestry, University of Mosul. Gerbera jamesonii plants of the Esmara variety, which are available in the horticulture field and are pink in color and have double flowers, were divided, and identical plants with three leaves were used. The experiment included a study of exposing plants to natural daylight or to interference with a red wavelength of 659 nm (intensity of 47750 lux) and a blue light wavelength of 468 nm (intensity of 1526 lux), which was obtained from diodes placed 100 cm away from the plants, for four hours (one hour before sunrise and continuing one hour after, then two hours at sunset, one hour before sunset and continuing for one hour after sunset), and spraying with salicylic acid at 300 mg l^{-1}, as well as spraying with a mixture of micronutrients, namely iron, zinc, and copper in the form of sulfates for the three elements, at a concentration of 40 mg l^{-1} for both iron and zinc, and copper was added at 10 mg l^{-1}. This was added when the plant showed signs of growth. Thus, the experiment consisted of the following treatments: The plants were placed under natural daylight, were not exposed to prolonged daylight, and were not sprayed with any of the other treatments (control) or mixed with spraying with 300 mg l^{-1} of salicylic acid, spraying with a mixture of micronutrients, or spraying with a mixture of salicylic acid and micronutrients at their concentrations above. The plants were placed under prolonged daylight for 4 hours with red and blue light, interacted without any other treatment (control), or interacted with spraying with 300 mg l^{-1} of salicylic acid, spraying with a mixture of micronutrients individually, or spraying with a combination of salicylic acid and micronutrients. The factorial experiment was conducted using a completely randomized block design with three blocks and 15 plants per treatment.

The field soil was replaced with new soil to a depth of 30 cm consisting of 3 parts new river soil and 1 part fully decomposed animal manure. The land was divided into two parts. The first part, where the plants were exposed to supplemental lighting, contained raised beds 30 cm wide and 195 cm long. The plants were planted on both sides of the raised beds in the upper third of them, with a distance of 25 cm between beds and 30 cm between plants. The plants were watered one week after planting with the fungicide Beltanol at 2.5 ml l^{-1} (AL-Taie, 2025). Maintenance operations were performed identically for all plants, including hoeing, weeding, and watering as needed. All plants were fertilized with a balanced 15:15:15 NPK fertilizer at 1 g l^{-1}, applied at a rate of 100 ml per plant every two weeks until the end of the experiment.

The plants were exposed to supplemental lighting as soon as

they showed signs of growth, and they were sprayed with micronutrients and salicylic acid at the concentrations studied, applying the solution to the foliage until it was wet, once every two months. All plants used in the experiment were also sprayed with GA_3 at 200 mg l^{-1}, and this spraying continued monthly throughout the experiment (Mahmoud, 2014). Anatomical sections were taken from the flower stalk after harvesting, the first 5 cm below the inflorescence and the second 30 cm below the inflorescence, by a sharp blade. They were then placed in FAA solution for fixation, and successive operations were performed to make fixed slides. Safranin and fast green dyes were used to stain the living and dead tissues, and then the data were recorded using a light microscope.

RESULTS AND DISCUSSION

The results in **Table 1** indicated that there were no significant differences between the inflorescence diameter and vase life traits. However, the plants that were exposed to prolonged daylight and interacted with a mixture of micronutrients (iron and zinc sulfate at 40 mg l^{-1} each and copper at 10 mg l^{-1}) had the largest inflorescence diameter, measuring 92.08 mm. This value dropped to 87.15 mm when the plants were exposed to prolonged daylight with salicylic acid at a dose of 300 mg l^{-1}, which was linked to the longest vase life value of 23.83 days. The inflorescences in the aforementioned treatment also recorded the highest amount of water uptake (71.86 cm^3), while the plants that were not exposed to prolonged daylight and interacted with the spraying of a mixture of micronutrients recorded the lowest significant values (38.5 cm^3). Flowers from plants treated with salicylic acid have generally been observed to enhance water intake even when they were not exposed to prolonged daylight.

The two treatments of salicylic acid alone, or the interaction between not being subjected to prolonged daylight, salicylic acid, and spraying with micronutrients, recorded values that did not differ significantly from the highest values for water uptake, reaching 54.02 and 53.73 cm^3. The same applies when the plants are subjected to prolonged daylight; all treatments recorded values that did not differ significantly from the highest values, except for the control treatment whose plants were subjected to prolonged daylight. The lack of significant differences in inflorescence diameter may reflect the genetic nature of this trait, which is often unresponsive to environmental changes. This was confirmed by Shammy *et al*. (2012) and Hossain *et al*. (2015), who indicated that gerbera flower traits such as inflorescence diameter are genetically controlled and less affected by external treatments compared to other biological traits (Demir & Kaya, 2023; Pinto & Sousa, 2023; Rossi *et al*., 2023; Tanaka *et al*., 2023; Abate *et al*., 2024; Al-Jassim *et al*., 2024; Csep *et al*., 2024; Karimov & Rakhimova, 2024; Lan *et al*., 2024; Prakash & Desai, 2024).

Table 1. The effect of red and blue light spectrum to prolong daylight, fertilization with some micronutrients and salicylic acid on some flower characters of *Gerbera jamesonii* var. Esmara.

Treatments		Inflorescence diameter (mm)	Vase life (day)	Holding Solution uptake (cm^{-3})
(h.)	(mgl^{-1})			
Without prolong daylight	Control	91.12 a	20.58 a	49.28 bc
	SA	90.21 a	22.05 a	54.02 a-c
	Micronut	89.41 a	21.83 a	38.5 c
	SA+ Micronut	90.11 a	22.53 a	53.73 a-c
With prolong daylight for 4 h	Control	89.37 a	22.45 a	45.70 bc
	SA	87.15 a	23.83 a	71.86 a
	Micronut	92.08 a	22.83 a	61.75 ab
	SA+ Micronut	89.01 a	22.22 a	57.04 a-c

Values sharing the same letters within each character do not differ significantly according to Duncan's Multiple Range Test at the 5% probability level.

The findings in **Table 2** and **Figures 1, 2** show that the various treatments under investigation altered the inflorescence's anatomical structure five centimeters below the inflorescence. The control treatment, which did not receive prolonged daylight, recorded 36 small vascular bundles. In contrast, all other treatments, whether or not they received prolonged daylight, recorded higher values of small bundles, reaching a maximum of 56 bundles when the plants received a mixture of micronutrients and were not exposed to prolonged daylight. The two treatments with fewer small bundles than the control treatment was when the plants were sprayed with salicylic acid without prolonged daylight or when sprayed with salicylic acid interacting with a mixture of micronutrients without prolonged daylight, resulting in 32 and 24 bundles, respectively. Overall, the total number of vascular bundles (large and small) decreased to 52 and 48, respectively, compared to the control treatment, which had 64 large and small vascular bundles when the plants were exposed to prolonged daylight and sprayed with salicylic acid or sprayed with salicylic acid interacting with a micronutrient mixture.

Table 2. The effect of red and blue light spectrum to prolong daylight, fertilization with some micronutrients and salicylic acid on the number of vascular bundles of *Gerbera jamesonii* var. Esmara stalk.

Treatments		5 cm below the Inflorescence.			30 cm below the Inflorescence.		
(h.)	(mgl^{-1})	Small	Large	Total	Small	Large	Total
Without Prolong daylight	Control	36	20	56	76	12	88
	SA	32	25	57	52	16	68
	Micronut	56	16	72	36	16	52
	SA & Micronut	44	12	56	52	12	64
With Prolong daylight for 4 h	Control	48	16	64	48	12	60
	SA	40	12	52	40	12	52
	Micronut	48	12	60	52	12	64
	SA & Micronut	24	24	48	40	12	52

From reviewing the table and figures above, it is noted that the number of small vascular bundles in the stalk inflorescences at a distance of 30 cm was lower in the values of all studied treatments than the value of the control treatment when plants were not subjected to prolonged daylight, which reached 76. The same applies to the total number of vascular bundles in the inflorescence stalk at a distance of 30 cm, as the values of all treatments were lower than the value recorded for the control

treatment (88 bundles in plants without prolonged daylight). It is noted that the flowers taken from plants sprayed with salicylic acid with or without prolonged daylight recorded the lowest values of 52 vascular bundles. This value was also recorded in the treatment that was sprayed with salicylic acid with a mixture of micronutrients under prolonged daylight conditions. The above figures indicate the formation of a large internal cavity in the inflorescence stalk and the protrusion of vascular bundles to the outer edge of the inflorescence stalk axis at a distance of 30 cm, while the vascular bundles occupied the entire space except for a small central core. The number of bundles or their anatomical structure did not affect the flowering age of the inflorescence, but it did affect the extent to which water could be taken up by the inflorescence stalk.

It is noted from **Table 3** and **Figures 1-3**, which show the thickness of the epidermal and cortex layers, that the thickness of these layers reached its maximum at 677.17 µm in the control treatment without prolonged daylight, at the distance of 5 cm below the inflorescence, while the values recorded for all other treatments were less than this, whether there was prolonged daylight or not; the lowest value was 491.37 µm when spraying the plants with salicylic acid without prolonged daylight. When comparing the thickness of this layer with its thickness at a distance of 30 cm below the inflorescence, the large reduction in the thickness of that layer is noted under any of the studied treatments. The length of the vascular bundles 5 cm below the inflorescence increased under any of the studied treatments compared to the control treatment when, without prolonged daylight, the maximum length of the vascular bundle reached 919.24 µm when the daylight was not prolonged and interacted with spraying the plants with micronutrients.

Table 3. The effect of the red and blue light spectrum to prolong daylight and fertilization with some micronutrients and salicylic acid on the tissue size 5 and 30 cm below the inflorescence of Gerbera jamesonii var. Esmara stalks.

Treatments		5 cm below the Inflorescence.				30 cm below the Inflorescence.			
		Tissues type and size (µm)							
(h.)	(mgl^{-1})	P	Vascul bundle length	Outer Sc	Inner Sc	P	Vascul bundle length	Outer Sc	Inner Sc
Without prolong daylight	Cont.	677.17	622.99	231.34	113.51	280.49	941.43	344.39	150
	SA	491.37	776.99	270.37	123.33	268.76	777.22	245.95	183.74
	Micronut	563.19	919.24	279.15	232.67	374.78	827.81	256.99	128.15
	SA & Micronut	552.01	765.98	249.68	151.80	268.77	831.79	300.6	144.25
With prolong. daylight for 4 h	Cont.	542.55	642.44	187.48	131.6	486.48	1000.39	353.73	207.64
	SA	596.63	841.34	258.09	216.36	365.81	811.41	317.26	141.4
	Micronut	654.50	724.22	200.62	164.70	448.24	995.11	381.34	152.95
	SA & Micronut	517.95	695.01	227.41	159.73	417.36	934.82	284.78	240.05

When comparing the lengths of the vascular bundles at distance of 5 and 30 cm, it is observed that the length of the vascular bundles increased at a distance of 30 cm under the conditions of the treatments under study, with the exception of the two values recorded from spraying the plants with micronutrients when the daylight was not prolonged and when they were sprayed with salicylic acid under conditions of prolonged daylight, which were recorded as 827.81 and 811.41 µm, respectively. The results obtained from the current study confirm that the number and size of vascular bundles in the inflorescence vary according to their location in the inflorescence, as well as their variation according to the treatments under study, while Marousky (1986) did not observe differences in the number and size of vascular bundles in the inflorescence at a distance of 15 and 30 cm below the inflorescence for the two varieties under study.

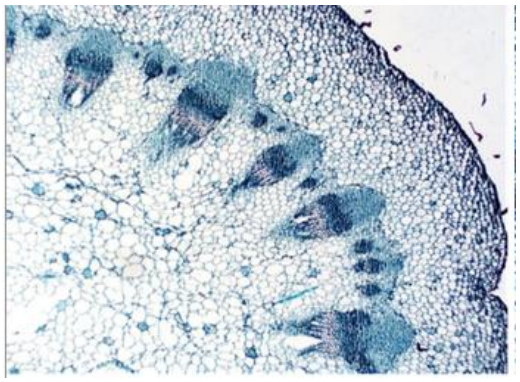
One of the observations in this study is that the pericycle (inner layer of the cortex) at a distance of 5 cm below the inflorescence appeared clearly in the control treatments with and without prolonging daylight or interacting with spraying with salicylic acid, as it began to appear as a discontinuous ring surrounding the vascular bundles and the intervascular region between the bundles **(Figures 1a, 1b, 1e, and 1f)**, while this layer appeared clearly and continuously in the inflorescence stalk at a distance of 30 cm below the inflorescence when the plants were not prolonging daylight, but it was less intense and discontinuous in the inflorescence stalks that were prolonged daylight **(Figures 2a-2d and 2e-2h)**. This is supported by what Steinitz (1983) stated, describing the upper part of the inflorescence stalk as soft and juicy, unlike its lower part.

The results indicate that the outer sclerenchyma layer increased in values for all studied treatments compared to the control, reaching 231.34 µm. Similarly, when the daylight prolonged, the thickness of the sclerenchyma layer increased for all treatments compared to the control treatment, which recorded 187.48 µm. Comparing the thickness of the outer sclerenchyma layers at 5 and 30 cm, it is observed that the values recorded for the different treatments generally increased, with the exception of two values, 245.95 and 256.99 µm, recorded under the without prolonged daylight, where plants were sprayed with salicylic acid or micronutrients, respectively. Reviewing the inner sclerenchyma values at 5 cm reveals that all studied treatments recorded values higher than those recorded in the control without prolonged daylight control.

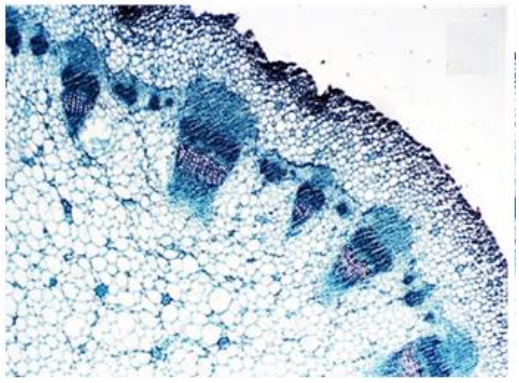
The outer phloem at a distance of 5 cm increased in all studied treatments compared to the control value without prolonged daylight, according to **Table 4**. The highest values of 161.08 µm were recorded when the daylight was prolonged and the plants were sprayed with salicylic acid. With the exception of the control treatment when daylight was prolonged, all investigated treatments showed an increase in the thickness of the xylem layer in the vascular bundle values when compared to the

control. When daylight was not prolonged, the recorded values of the total outer and inner phloem in the vascular bundle at a distance of 5 cm below the inflorescence showed that all studied treatments had higher values than the control, reaching 177.27 µm.

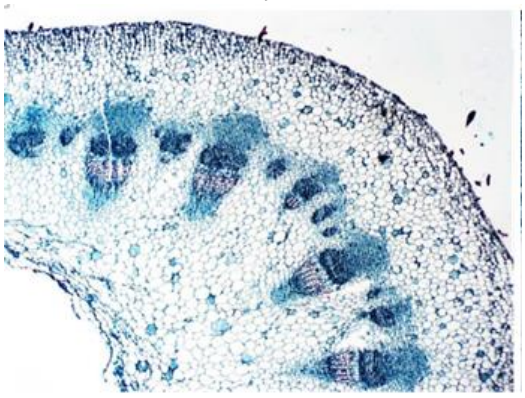
From reviewing the recorded values of the vascular bundle at a distance of 30 cm below the inflorescence, it is noted that the values of the outer phloem increased in thickness for all studied treatments compared to the control when without prolonging the daylight, except for the value recorded from the flower stalk taken from plants that were not prolonged daylight and sprayed with salicylic acid, which reached 84.27 µm.



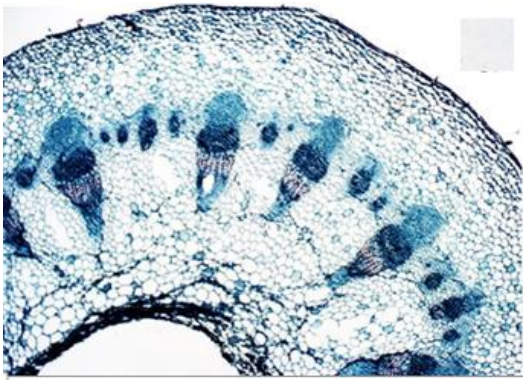
a)



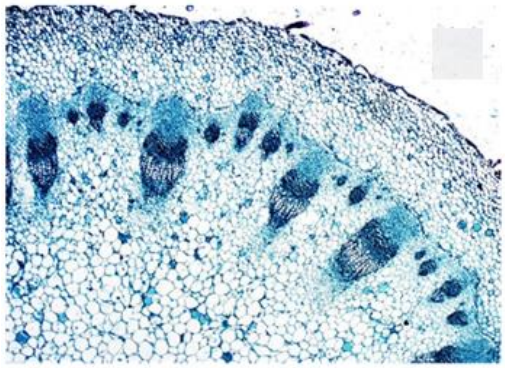
b)



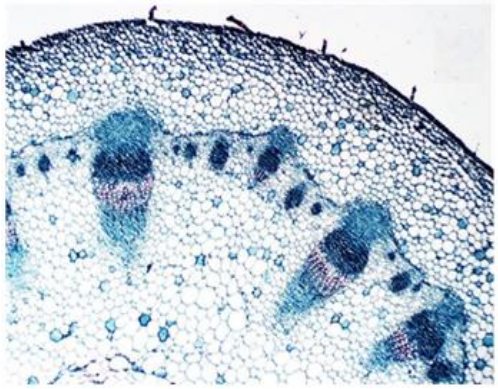
c)



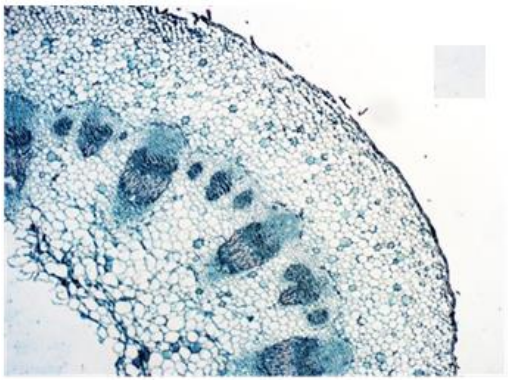
d)



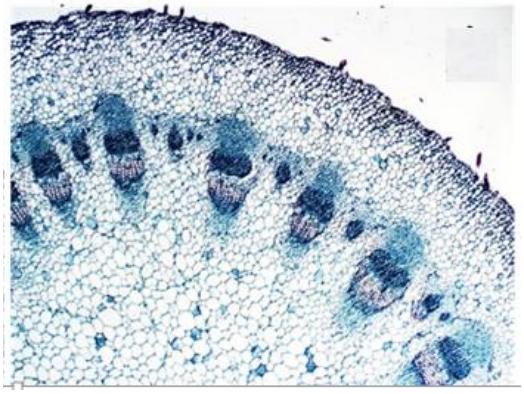
e)



f)

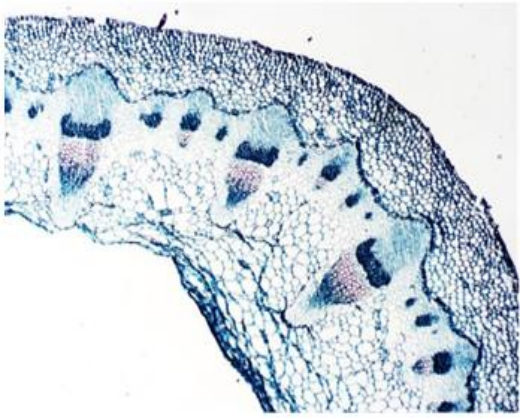


g)

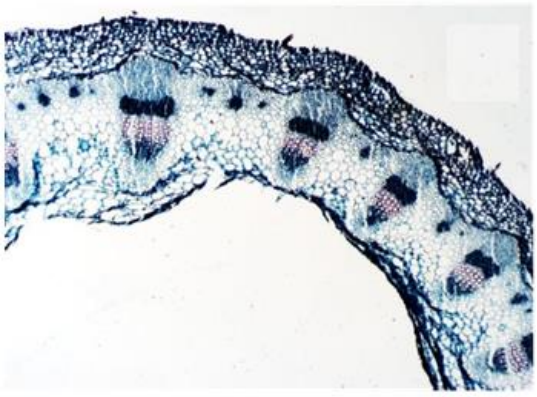


h)

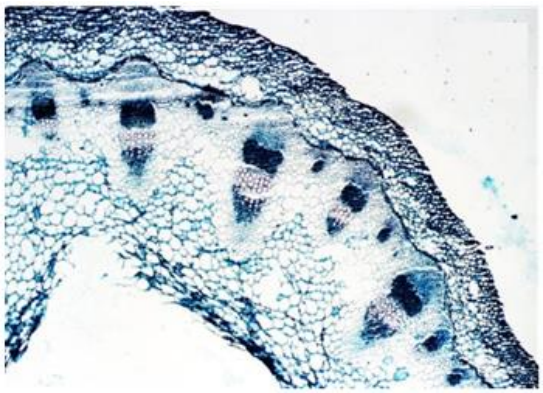
Figure 1. Anatomical sections of the inflorescence stalk of *Gerbera jamesonii* var. Esmara is 5 cm from the inflorescence disc. (a-d) Sections taken from plants not subjected to prolonged daylight. (a): Control. (b): Plants sprayed with salicylic acid. (c): Plants sprayed with a micronutrient mixture. (d): Plants sprayed with salicylic acid and a micronutrient mixture. (e-h) Sections taken from plants subjected to prolonged daylight. (e): Control. (f): Plants sprayed with salicylic acid. (g): Plants sprayed with a micronutrient mixture. (h): Plants sprayed with salicylic acid and a micronutrient mixture. Magnification: 40x



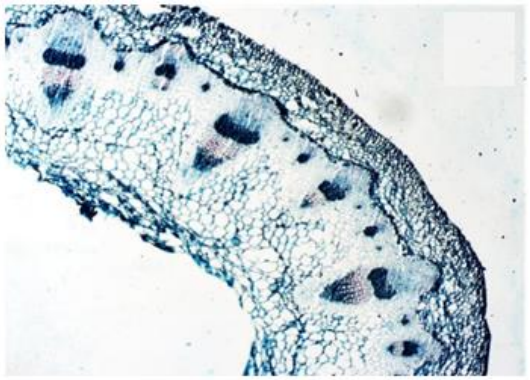
a)



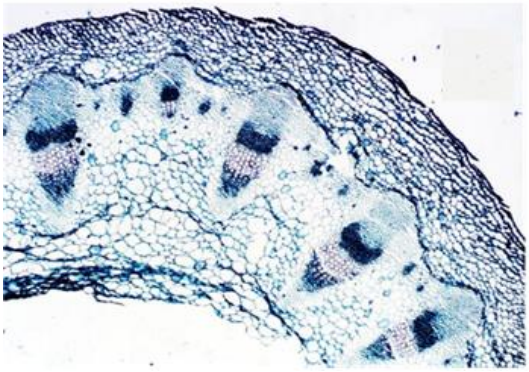
b)



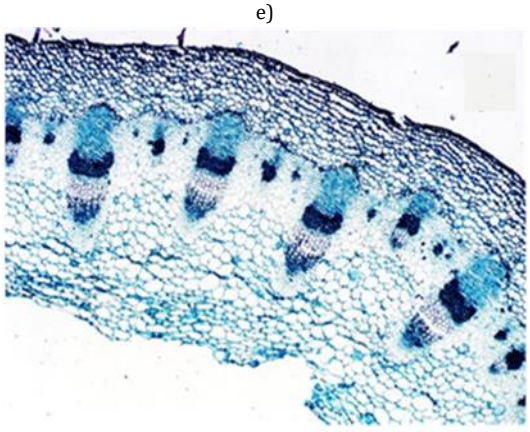
c)



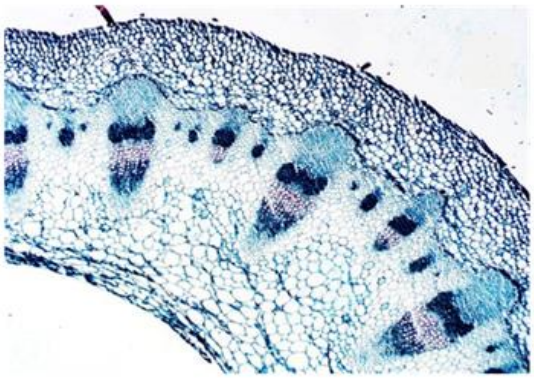
d)



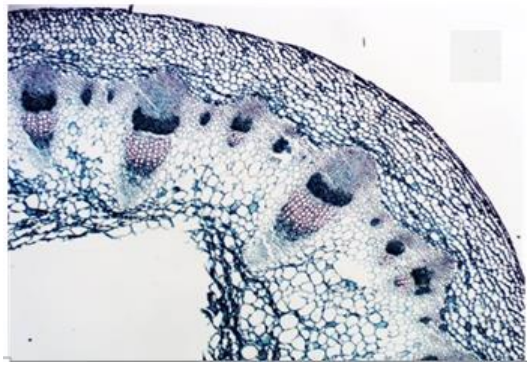
e)



f)



g)



h)

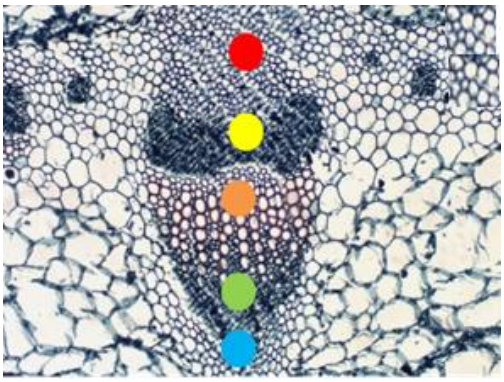
Figure 2. Anatomical sections of the inflorescence stalk of *Gerbera jamesonii* var. Esmara is 30 cm from the inflorescence disc. (a-d) Sections taken from plants not subjected to prolonged daylight. (a): Control. (b): Plants sprayed with salicylic acid. (c): Plants sprayed with a micronutrient mixture. (d): Plants sprayed with salicylic acid and a micronutrient mixture. (e-h) Sections taken from plants subjected to prolonged daylight. (e): Control. (f): Plants sprayed with salicylic acid. (g): Plants sprayed with a micronutrient mixture. (h): Plants sprayed with salicylic acid and a micronutrient mixture. Magnification: 40x

By observing the values of the inner phloem thickness, we find that any of the studied treatments, with or without light, led to a reduction in its thickness. The highest values were recorded in the control without prolonging daylight, reaching 150.87 µm, while the lowest values were recorded at 54.59 µm when prolonging daylight was combined with spraying salicylic acid. The values of the total phloem followed the same trend, as all the studied treatments led to a decrease in the total thickness of the two phloem layers. The highest values were when the photoperiod was not extended and no spraying was done with any of the studied treatments, reaching 242.81 µm.

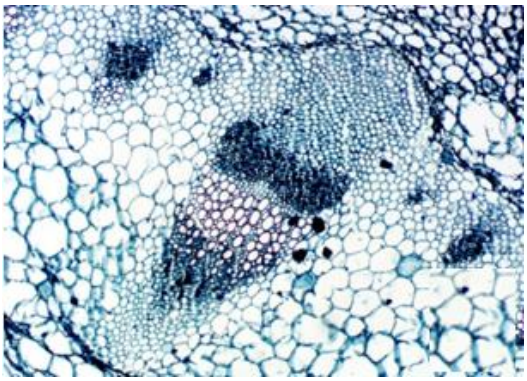
The total phloem thickness decreased to the lowest values of 152.10 µm when prolonging daylight and sprayed with salicylic acid. On the other hand, spraying with salicylic acid alone or in combination with micronutrients, with or without prolonging daylight, led to a significant decrease in the amount of wood in the vascular bundle in sections 30 cm below the inflorescence, compared to the two control treatments with or without prolonging daylight. The greater water uptake by inflorescences when plants are treated with salicylic acid may be explained by the fact that salicylic acid is one of the internal signals that play an important role in plant defenses, as it is necessary for both basic resistance against pathogens and the induced defense mechanism known as acquired systemic resistance, which confers resistance against a wide range of pathogens (Chaturvedi & Shah, 2007). Maybe this allows the xylem to remain open.

Table 4. The effect of the red and blue light spectrum to prolong daylight and fertilization with some micronutrients and salicylic acid on the vascular bundle component size 5 and 30 cm below the inflorescence of *Gerbera jamesonii* var. Esmara stalks.

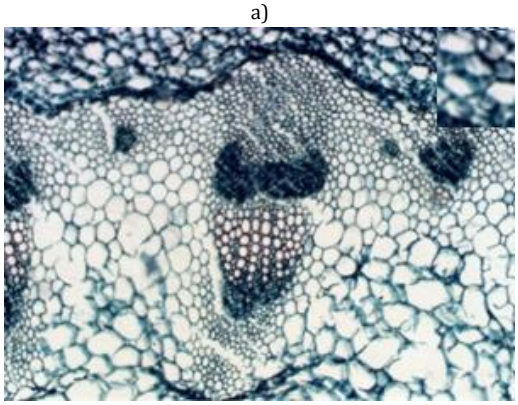
Treatments		5 cm below the Inflorescence.				30 cm below the Inflorescence.			
		Tissues type and size (µm)							
(h.)	(mgl^{-1})	Outer phloem	Xylem	Inner phloem	Total phloem	Outer phloem	Xylem	Inner phloem	Total phloem
Without prolong daylight	Cont.	110.56	100.87	66.71	177.27	91.94	204.23	150.87	242.81
	SA	146.40	123.58	113.31	259.71	84.27	154.36	108.9	193.17
	Micronut	125.45	163.47	118.50	243.95	153.36	210.48	78.83	232.19
	SA & Micronut	144.95	151.36	68.19	213.14	114.88	156.81	115.25	230.13
With prolong daylight for 4 h	Cont.	158.65	95.08	69.63	228.28	117.79	224.76	96.47	214.26
	SA	161.08	148.25	57.56	218.64	97.51	200.65	54.59	152.10
	Micronut	138.05	168.04	52.81	190.86	133.62	254.34	72.86	206.48
	SA & Micronut	138.8	101.62	67.45	206.25	113.58	216.15	80.26	193.84



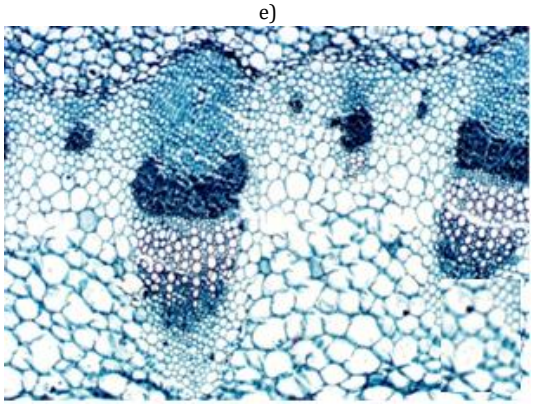
a)



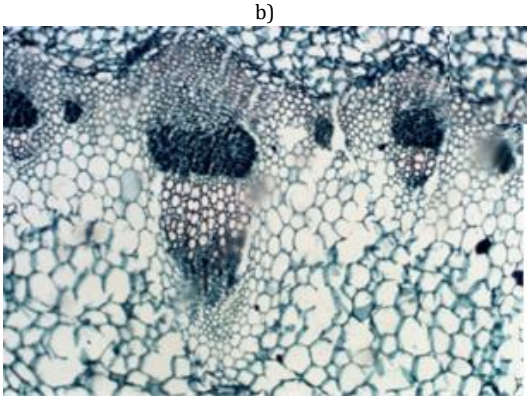
e)



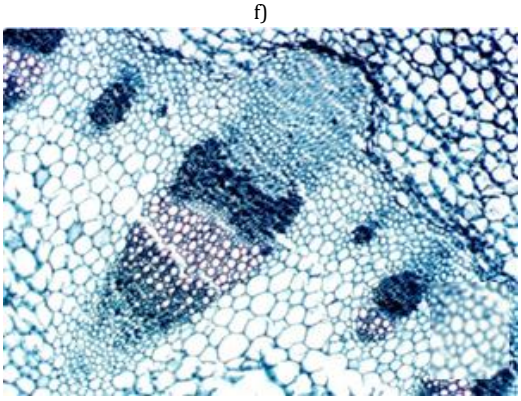
b)



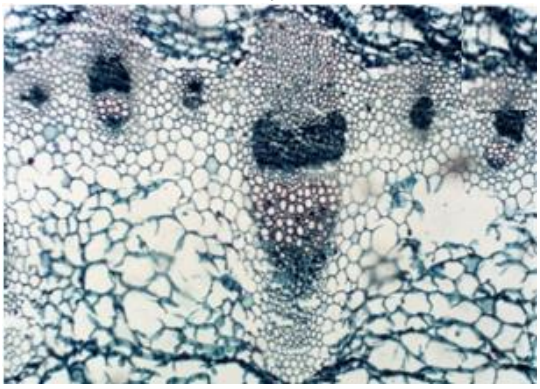
f)



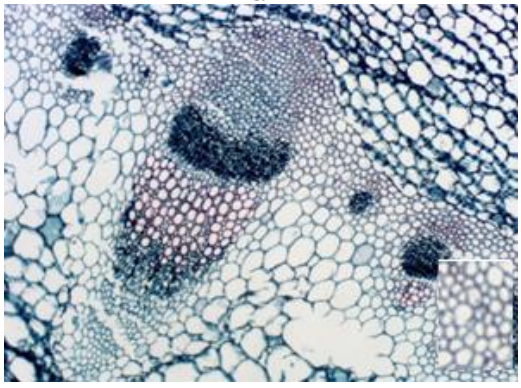
c)



g)



d)



h)

Figure 3. Anatomical sections of the large vascular bundles of *Gerbera jamesonii* var. Esmara is 30 cm from the inflorescence disc. (a-d) Sections taken from plants not subjected to photoperiod extension. (a): Control (b): Plants

sprayed with salicylic acid. (c): Plants sprayed with a micronutrient mixture. (d): Plants sprayed with salicylic acid and a micronutrient mixture. (e-h) Sections taken from plants subjected to red and blue spectral photoperiod extension for 4 hours. (e): Control. (f): Plants sprayed with salicylic acid. (g): Plants sprayed with a micronutrient mixture. (h): Plants sprayed with salicylic acid and a micronutrient mixture. Magnification: 40x. Red circle=Outer Sclerenchyma, Yellow circle=Outer phloem, Orange circle=Xylem, Green circle=Inner Phloem, Blue circle=Inner Sclerenchyma

CONCLUSION

The anatomical study indicated that prolonging daylight or spraying with salicylic acid or a mixture of micronutrients or their interaction led to a significant change in the thickness of the different components in the anatomical section of the inflorescence stalk at a distance of 5 or 30 cm below the inflorescence.

ACKNOWLEDGMENTS: The authors would like to thank the University of Mosul / College of Agriculture and Forestry for its provided facilities in this research.

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

REFERENCES

Abate, Y., Tsegaye, S., Alemayehu, H., & Tesema, B. (2025). Personalized management of palbociclib and ribociclib using TDM, pharmacogenetics, and drug–drug interaction assessment: A clinical case series. *Specialty Journal of Pharmacognosy, Phytochemistry and Biotechnology, 5*, 126–138. doi:10.51847/BZzcGOdTvs

Akdeniz, D., Yardımcı, A., & Kavukcu, O. (2023). Medical futility in end-of-life care: Exploring ethical decision-making practices among Turkish physicians – A qualitative study. *Asian Journal of Ethics in Health and Medicine, 3*, 17–25. doi:10.51847/OTwRe560gm

Al-Jassim, R., Al-Khalifa, N., & Fadel, E. (2024). Evaluating the efficacy of surgery with complementary radiofrequency ablation in intermediate-stage hepatocellular carcinoma. *Asian Journal of Current Research in Clinical Cancer, 4*(1), 51–60. doi:10.51847/o0zaWPmALB

Al-Mubarak, A. M., Alkhaldi, F. A., Alghamdi, A. A., Almahmoud, M. A., & Alghamdi, F. A. (2024). Awareness and clinical competency of dental students in crown lengthening procedures. *Asian Journal of Periodontics and Orthodontics, 4*, 42–51. doi:10.51847/r5cLVpz1UT

Al-Taei, H. H. (2025). Scientific consultation, Department of Plant Protection, College of Agriculture and Forestry, University of Mosul, Iraq.

Anonymous. (2009). *Plants Rescue, Gerbera jamesonii*. Pyrmont, NSW, Australia. Email: sales@plantsrescue.com, pp. 1–3.

Asgari, M., & Moghaddam, A. R. L. (2015). Comparison of different salicylic acid application ways as a preservative on postharvest life of gerbera cut flowers. *Agricultural Communications, 3*(4), 1–8.

Babalar, M., Edrisi, B., & Naderi, R. (2016). Evaluation of the mechanical strength of gerbera flower stem in response to silicon and salicylic acid application. *Journal of Ornamental Plants, 6*(3), 163–171.

Bekheta, M. A., Abbas, S., El-Kobisy, O. S., & Mahgoub, M. H. (2008). Influence of selenium and paclobutrazole on growth, metabolic activities and anatomical characters of *Gerbera jamesonii* L. *Australian Journal of Basic and Applied Sciences, 2*(4), 1284–1297.

Bratt, A., & Naimi-Akbar, A. (2023). A comparative study of ethical issues in the Egyptian clinical research law. *Asian Journal of Ethics in Health and Medicine, 3*, 66–80. doi:10.51847/mjnPnkn27U

Česaitis, L., Jonušas, R., Latakas, D., Janužis, G., & Razukevičius, D. (2024). A comprehensive review on the efficacy of amoxicillin, amoxiclav, and chlorhexidine as prophylactic measures following tooth extraction. *Journal of Current Research in Oral Surgery, 4*, 32–40. doi:10.51847/0zwmDoY3YU

Chaturvedi, R., & Shah, J. (2007). Salicylic acid in plant disease resistance. In S. Hayat & A. Ahmad (Eds.), *Salicylic acid: A plant hormone* (pp. 335–370). Springer.

Csep, A. N., Voiţă-Mekereş, F., Tudoran, C., & Manole, F. (2024). Understanding and managing polypharmacy in the aging population. *Annals of Pharmacy Practice and Pharmacotherapy, 4*, 17–23. doi:10.51847/VdKr0egSln

Dalal, S. R., Somavanshi, A. V., & Karale, G. D. (2009). Effect of gibberellic acid on growth, flowering, yield and quality of gerbera under polyhouse conditions. *International Journal of Agricultural Sciences, 5*(2), 355–356.

Deepa, M. S., Sudarshan, G. K., & Keerthishankar, K. (2019). Evaluation of gerbera (*Gerbera jamesonii*) cultivars for growth, flowering and yield under different growing structure. *International Journal of Chemical Studies, 7*(1), 1138–1140.

Demir, B., & Kaya, S. (2023). Budgetary participation and leadership style effects on managerial performance: The mediating role of organizational commitment in Indonesian public sector offices. *Annals of Organizational Culture, Leadership and External Engagement Journal, 4*, 82–96. doi:10.51847/JVeRT96uGe

Dupuis, M. L., Bernard, C. H., & Martin, S. R. (2023). Current status and faculty perspectives on tobacco cessation training in U.S. pharmacy programs. *Annals of Pharmacy Education, Safety and Public Health Advocacy, 3*, 155–161. doi:10.51847/O0qyln5KHB

Essah, A., Igboemeka, C., & Hailemeskel, B. (2024). Exploring gabapentin as a treatment for pruritus: A survey of student perspectives. *Annals of Pharmacy Education, Safety and Public Health Advocacy, 4*, 1–6. doi:10.51847/h8xgEJE3NE

Hillman, T. (2024). A predictive approach for determining the optimal anti-CCR5 monoclonal antibody. *Interdisciplinary Research in Medical Sciences Specialty, 4*(1), 11–22. doi:10.51847/jVJ3mRs3yR

Hossain, S., Jolly, S. N., Parvin, S., Mehraj, H., & Uddin, A. F. M. J. (2015). Performance on growth and flowering of sixteen

hybrid gerbera cultivars. *International Journal of Business and Social Science Research, 3*(2), 87–92.

Hsiao, F. H., Chen, P. L., Ho, C. C., Ho, R. T. H., Lai, Y. M., & Wu, J. L. (2024). Exploring the impact of cognitive-behavioral therapy on anxiety disorders in children and adolescents. *International Journal of Social Psychology Aspects of Healthcare, 4*, 26–31. doi:10.51847/jcgvRFfQPM

Jena, L., Pattnaik, S., & Sahu, S. (2020). Impact of foliar application of Multiplex General Liquid on yield and yield attributing traits of *Gerbera jamesonii* L. growing under protection. *Journal of Pharmacognosy and Phytochemistry, 9*(5), 1057–1060.

Karimov, D., & Rakhimova, N. (2024). The impact of socially responsible human resource management on employee innovation performance: Exploring the roles of person–organization fit, work engagement, and individualism orientation. *Annals of Organizational Culture, Leadership and External Engagement Journal, 5*, 132–146. doi:10.51847/xJBYUl9BqH

Laaksonen, O. J., & Virtanen, M. P. (2025). Role of m^6A RNA methylation in mediating resistance to chemotherapy and immunotherapy in cancer. *Archives of International Journal of Cancer and Allied Sciences, 5*(1), 75–98. doi:10.51847/9lbgiSgyyw

Lan, N. T., Duc, T. M., & Anh, P. H. (2024). Comparison of chicory–fumitory syrup and megestrol for the management of hot flashes in prostate cancer patients undergoing androgen deprivation therapy. *Specialty Journal of Pharmacognosy, Phytochemistry and Biotechnology, 4*, 264–275. doi:10.51847/z0Yjxkddqs

Mahmood, A. T. (2014). Effect of gibberellic acid, mineral fertilizer on growth and flowering of two cultivars of *Gerbera jamesonii*. M.Sc. Thesis, Department of Horticulture Science and Landscape Design, College of Agriculture and Forestry, University of Mosul, Iraq.

Malewar, G. U., & Ismail, S. (1995). Iron research and agricultural production. In H. L. S. Tandon (Ed.), *Micronutrient research and agricultural production* (pp. 57–82). India Fertiliser Development and Consultation Organisation.

Marousky, F. J. (1986). Vascular structure of the gerbera scape. *Acta Horticulturae, 181*, 399–406.

Maslyakova, A. R., Magomedova, S. A., Romantsov, I. N., Nurbagandov, S. M., Bulovin, M. N., & Podobin, O. R. (2023). Evaluation of the anticancer potential of selenium nanoparticles. *Archives of International Journal of Cancer and Allied Sciences, 3*(2), 41–47. doi:10.51847/POXX7HfEZo

Mennitti, C., Paolucci, S., Russo, A., & Stellini, E. (2025). Unexpected hemostatic complications during dental implant and mini-screw therapy in von Willebrand disease: Case report. *Asian Journal of Periodontics and Orthodontics, 5*, 96–103. doi:10.51847/BSQvnauZim

Nyathi, C., Mutsvangwa, T., & Ncube, B. (2024). Influence of traditional Chinese medicine treatment duration on survival in patients with primary liver cancer: Evidence from real-world data. *Interdisciplinary Research in Medical Sciences Specialty, 4*(2), 149–161. doi:10.51847/aog7YpaPPu

Pal, S., Barad, A. V., Singh, A. K., Khadda, B. S., & Kumar, D. (2016). Effect of foliar application of Fe and Zn on growth, flowering and yield of gerbera (*Gerbera jamesonii*) under protected condition. *Indian Journal of Agricultural Sciences, 86*(3), 394–398.

Park, Y., Runkle, E. S., & Botany, E. (2017). Far-red radiation promotes growth of seedlings by increasing leaf expansion and whole-plant net assimilation. *Plant Physiology, 136*, 41–49.

Petra, S. A., Georgescu, M. I., Manescu, C. R., Toma, F., Padure, I. M., Savulescu, E., & Dobrescu, E. (2020). Flowering phenology, stalk anatomy and vase life of four cultivars of *Gerbera hybrida*. *Romanian Biotechnological Letters, 25*(3), 1635–1640. doi:10.25083/rbl/25.3/1635.1640

Pinto, R., & Sousa, A. (2023). Role of OmpH in Cec4-mediated reduction of *Acinetobacter baumannii* biofilm. *Pharmaceutical Sciences and Drug Design, 3*, 210–223. doi:10.51847/AFVSVjF1Kp

Prakash, A., & Desai, N. (2024). Network pharmacology-guided and experimental insights into the therapeutic effects of Sancao Yuyang decoction on oral mucositis. *Pharmaceutical Sciences and Drug Design, 4*, 63–81. doi:10.51847/Ey0Zr9qcrb

Rajapakse, N. C., Young, R. E., McMahon, M. J., & Oi, R. (1999). Plant height control photoselective filters: Current status and future prospects. *HortTechnology, 9*, 618–624.

Ramirez, J. C., Hernandez, L. A., Torres, D. M., Salazar, A. F., Gutierrez, O. D., & Cardenas, F. A. (2025). Persistent gaps in the hypertension care cascade: Prevalence and inequality among older adults in Mexico. *Journal of Medical Sciences Interdisciplinary Research, 5*(2), 50–64. doi:10.51847/59aGMRkA4K

Raskin, I. (1992). Role of salicylic acid in plants. *Annual Review of Plant Physiology and Plant Molecular Biology, 43*, 439–463.

Rossi, M., Bianchi, G., & Ferrari, L. (2023). Unbiased genomic profiling by whole genome sequencing enhances precision oncology for sarcoma patients. *Asian Journal of Current Research in Clinical Cancer, 3*(1), 96–104. doi:10.51847/H8ryt4Gl2l

Sahu, M. K., Tirkey, T., Sharma, G., Tiwari, A., & Kushra, T. (2016). Effect of foliar application of micronutrients on growth and flower production of gerbera under protected condition. *Journal of Pure and Applied Microbiology, 10*(4), 3099–3103.

Shakakibara, H., Takei, K., & Hirose, N. (2006). Interactions between nitrogen and cytokinin in the regulation of metabolism and development. *Trends in Plant Science, 11*(9), 440–448.

Shammy, F. H., Das, C., Islam, M. D., & Uddin, A. (2012). Growth and flowering characteristics of two potted gerbera (*Gerbera jamesonii* L.) varieties. *Journal of Experimental Biosciences, 3*(1), 33–36.

Steinitz, B. (1983). The influence of sucrose and silver ions on dry weight, fiber and lignin contents, and stability of cut gerbera flower stalks. *Gartenbauwissenschaft, 48*(2), 67–71.

Suragimath, G., Ashwinirani, S., & Shetgaonkar, K. A. (2023). Exploring secondary school teachers' knowledge, awareness, and practices regarding periodontal disease. *International Journal of Social Psychology Aspects of Healthcare, 3*, 34–39. doi:10.51847/qKN7RLvjfF

Taiz, L., & Zeiger, E. (2010). *Plant physiology* (4th ed.). Sinauer Associates, Inc.

Tanaka, H., Yamamoto, K., & Saito, M. (2023). Standard procedures vs. real-world practice: Exploring variations in clinical prescription checks in English community pharmacies—A multi-method investigation. *Annals of Pharmacy Practice and Pharmacotherapy, 3*, 243–252. doi:10.51847/lIk67gyV9S

Tjia, B., & Black, R. J. (2003). Gerbera for Florida. *University of Florida IFAS Extension Circular, 527*, 1–3.

Yu, M., Ma, Y., Han, F., & Gao, X. (2025). Effectiveness of mandibular advancement splint in treating obstructive sleep apnea: A systematic review. *Journal of Current Research in Oral Surgery, 5*, 25–32. doi:10.51847/AInSXrD9rc

Zhen, S., & Iersel, M. W. (2017). Far-red light is needed for efficient photochemistry and photosynthesis. *Journal of Plant Physiology, 209*, 115–122.

Zhou, Y., Peng, S., Wang, H., Cai, X., & Wang, Q. (2024). Pharmacogenomic strategies in Alzheimer's disease: An in-depth review. *Journal of Medical Sciences Interdisciplinary Research, 4*(1), 15–21. doi:10.51847/q8JX01Pn0m