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Response of *Schefflera actinophylla* Plants Grown under Drought to Soil Compost Addition and Foliar Application of Melatonin

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ABSTRACT

The provision of irrigation water has become crucial, especially for ornamental plants, due to Egypt's demanding water conditions. The use of inexpensive soil amendments *i.e.,* compost and the application of a newly discovered molecule "melatonin" can mitigate the negative effects of water scarcity. Therefore, this study aimed to evaluate the efficacy of combining compost with melatonin in alleviating the adverse effects of water deficit on *Schefflera actinophylla* L plants. Different irrigation regimes *i.e.,* irrigation every 5 (I_1), 7 (I_2) and 10 (I_3) days were evaluated as the main factor. The final composition of the pots, consisting of compost and sand, with options including 1:3 compost: sand mixtures v/v (C_1), 1:1 compost: sand mixtures v/v (C_2) and 3:1 compost: sand mixtures v/v (C_3) was investigated as a secondary factor. In addition, the application of melatonin by spraying at concentrations of zero (F_1) and 100 µM (F_2) was investigated as a tertiary factor. Plant performance decreased with increasing irrigation intervals. Furthermore, plants grown in pots containing 75%compost+25% sand (C_3) showed the best performance followed by the C_2 treatment and finally the C_1 treatment. Moreover, the application of melatonin led to an increase in all the growth and chemical characteristics studied, as well as in the levels of antioxidant, except for malondialdehyde, which decreased compared to the untreated plants. On another note, the plant performance was better under combined treatments of I_2xC_2 (or C_3) xF_2 than that under combined treatments of I_1xC_1xF_1. Finally, these results confirm the potential role of compost and melatonin in mitigating the adverse effects of water deficit.

Keywords: Water deficit, compost, melatonin

INTRODUCTION

The Schefflera actinophylla plant belongs to the Araliaceae family. Native to Australia, it has become a popular houseplant due to its distinctive umbrella-like foliage and adaptability to indoor conditions (Abu-Khalaf and Natsheh (2022). *Schefflera actinophylla* is favored for its aesthetic appeal, making it a popular choice for interior decoration and office spaces. Its glossy green leaves and unique growth habit have earned it a special place among plant lovers, contributing to its popularity as a decorative addition to homes and workplaces (Ahmed and Shahin (2023).

Saving irrigation water is critical for a number of reasons, including resource conservation, environmental protection, economic efficiency, food security, climate resilience, and overall sustainability. It's a shared responsibility involving farmers, policy makers, and society at large to ensure the efficient and responsible use of this precious resource in agriculture (Saad Eddin *et al.* 2023). However, it's important to note that while water conservation is essential, it must be balanced with the needs of crop production. In some cases, extreme water conservation can lead to water deficit conditions. These water deficit conditions can trigger the generation of reactive oxygen species (ROS) within plant cells, which, in turn, can cause oxidative damage to cell structures and disrupt normal cellular processes (Elsherpiny 2023). This highlights the importance of adopting water-saving practices that are both efficient and sensitive to the specific water needs of crops. Sustainable irrigation practices aim to optimize water use, by ensuring that crops receive adequate moisture without excessive water waste, thus promoting both water conservation and healthy plant growth (Moursy *et al.* 2023).

Melatonin is known for its potent antioxidant properties, effectively scavenging ROS. By reducing oxidative stress, melatonin acts as a protective shield, protecting plant cells from damage caused by drought-induced ROS (Arnao and Hernández-Ruiz 2015). The beneficial effects of melatonin can be attributed to its ability to regulate stomatal closure (Ahmad *et al.* 2023), enabling plants to balance water conservation with the maintenance of photosynthesis (Dradrach *et al.* 2022). Additionally, melatonin increases photosynthetic rates during drought conditions by protecting the photosynthetic apparatus within chloroplasts from drought-induced damage (Ahmad *et al.* 2023). Moreover, melatonin is thought to stimulate root growth and development, a key factor in facilitating plant water uptake (Khattak *et al.* 2023). A well-developed root system enables the plant to explore a larger volume of soil, thereby increasing, and its resilience to drought (Khosravi *et al.* 2023). Melatonin plays a key role in modulating the expression of genes and proteins involved in stress response pathways (Langaroudi *et al.* 2023). This includes the

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activation of genes responsible for the synthesis of protective molecules and proteins that enhance the plant's ability to cope with water deficit (Wang *et al.* 2023). Furthermore, melatonin interacts with several plant hormones, including abscisic acid (ABA), which plays a central role in the plant's response to drought stress (Yang *et al.* 2023).

On the other hand, compost enhances water retention under drought stress by improving soil structure (Shah *et al.* (2023), increasing organic matter content, reducing evaporation, promoting root growth and supporting beneficial microbial activity (Elsherpiny 2023). These combined effects make compost a valuable tool for improving the soil's ability to retain water and provide it to plants during periods of water scarcity (Paymaneh *et al.* 2023). Moreover, compost slowly releases nutrients over time as it decomposes. These nutrients include nitrogen (N), phosphorus (P), potassium (K), as well as various micronutrients (Soussani *et al.* 2023).

Therefore, the primary goals of the current research are to provide a thorough understanding of the effects of compost and melatonin on improving the performance and increasing the drought tolerance of the *Schefflera actinophylla* plant. This knowledge is important for improving ornamental plant production and developing sustainable approaches to water conservation, especially in water-scarce regions such as Egypt.

MATERIALS AND METHODS

A pot study was conducted to assess how different irrigation regimes [*i.e.,* irrigation every 5 days (I_1), 7 days (I_2) and 10 days (I_3), as the main factor], different compost ratios [*i.e.,* 1:3 compost: sand mixtures v/v (C_1), 1:1 compost: sand mixtures v/v (C_2) and 3:1 compost: sand mixtures v/v (C_3), as the secondary factor] and melatonin application[*i.e.,* zero (F_1) and 100 µM (F_2), as the tertiary factor] affect the growth performance and chemical content of *Schefflera actinophylla* cv.Compacts plants. These treatments were organized in a split-split-plot design, as each treatment was replicated five times.

1. Experimental site

The location of this pot experiment was Al-Mansoura Agricultural Research Station, Agricultural Research Center., Egypt (31.0500°N latitude and 31.3833°E longitude). The study lasted from February 28th to October 2nd, covering both the 2022 and 2023 seasons, each of which lasted seven months.

2. Plant material

The Schefflera's leaves are typically large and compound compared to the leaves of some other indoor plants. The leaves are usually compound, consisting of several separate, twisted segments that resemble fingers. The segments can be semi-circular to oval in shape. Leaves are typically a vibrant green color, although the shade of green may vary slightly depending on soil conditions and light levels. Leaves grow progressively from the main stem of the plant, with the largest and most mature leaves at the top. The leaf surface is generally smooth and glossy, as described by Abu-Khalaf and Natsheh (2022); Ahmed and Shahin (2023).

3. Studied substances

Plant cultivar: The *Schefflera actinophylla* cv. Compacts used in this study was obtained from the private nursery located in El Qanater El Khayreya, Egypt. Similar plants with a height of 20 cm were selected and their number of compound leaves ranged from 9 to 11.

Melatonin: It was purchased from the Sigma Company (Sigma-Aldrich, St. Louis, MO, USA). A foliar spray of melatonin was prepared by dissolving melatonin in ethanol at a concentration of 10 mM and storing it at -20°C. Prior to application to the plants, this mixture was further diluted to attain a concentration of 100 µM, as described by Dradrach *et al.* (2022).

The medium used to fill the pots: Compost (field crop residues) was obtained from the Nile Compost Company, Egypt. Its characteristics are shown in Table 1. While the characteristics of the sandy soil used in this research are shown in Table 2. The analysis was carried out according to the methodology described by Dewis and Freitas (1970).

Table 1. Some characteristics of the compost used

Property	Values
EC, dSm^{-1} (1:10)	2.56
pH (1:10)	7.34
Phosphorus (P_2O_5) , %	0.42
Potassium (K_2O) , %	0.76
Organic matter ,%	50.59
Organic carbon, %	29.34
Total nitrogen, %	1.38
C:N ratio	21:1

Table 2. Some characteristics of the sand soil used

Traits and units		Values
Particles size distribution, g kg^{-1}	Sand	900
	Silt	45.0
	Clay	55.0
Texture class		Sandy
O.M,%		0.13
EC, dSm^{-1}		0.70
pH		8.00

4. Experimental set up

First, the potting medium was prepared, and then the plastic pots were filled according to the specified treatment conditions, each pot being 25 cm in diameter and 18 cm deep. After the plants were obtained from the nursery, they were transplanted into their designated plastic pots (in the last week of February). The plants were placed in a seran house, which allowed 65% shading of light. A fertilizer solution was prepared by dissolving 2.0 grams of a commercial compound known as Kristalon (19-19-19) in one liter of tap water. The NPK fertilizer was applied as a soil drench at the same rate every month until the end of the experiment. The first dose was applied 10 days after transplanting, and subsequent doses were applied at monthly intervals. The foliar application of melatonin was made 8 times, with a 15-day interval between each application until the last week of August, using a plastic atomizer, as the first application of melatonin was made in the first week of May. The application rate was 1.5 liters per pot for the melatonin treatments. Irrigation was carried out as usual for *Schefflera actinophylla* L plants until the first week of May, after which the irrigation process was carried out according to the prescribed irrigation treatments.

5. Measurements

The physical characteristics of a whole plant, leaf chemical constituents, plant pigments, antioxidants and oxidation indicators were determined on 2nd October of each season, as shown in Table 3

Table 3. Parameters, methods and references of measurements

Parameters	Methods	References
	Physical characteristics of a whole plant	
1. Plant height (cm)	Manually and visually	----------------
2. No. of leaves plant^{-1}		
3. Leaf area (cm^2 plant^{-1})		
4. Leaf fresh and dry weights (g plant^{-1})		
5. Stem fresh and dry weights (g plant^{-1})		
6. Root fresh and dry weights (g plant^{-1})		
	Plant pigments	
1. Chlorophyll a (mg g^{-1} F.W)	Spectrophotometrically	Schoefs (2005)
2. Chlorophyll b (mg g^{-1} F.W)		
3. Carotene (mg g^{-1} F.W)		
	Digestion of plant samples	
Digestion for N,P,K determenations	Using a 1:1 mixture of H_2SO4 and $HClO_4$	Peterburgski (1968)
	Nutrient elements	
Nitrogen (%)	*Via* Kjeldahl method	Harborne (1984)
Phosphorus (%)	Using spectrophotometric apparatus	
Potassium (%)	Using flame photometer apparatus	
	Biochemical traits	
Total carbohydrate,%	Using spectrophotometric apparatus	Herbert *et al.* (1971).
	Indicators of oxidation	
Malondialdehyde (MDA, µmol.g^{-1} F.W)	Spectrophotometric method	Davey *et al.* (2005)
	Antioxidative enzymes	
1. Peroxidase (POX, unit mg^{-1} protein^{-1})	Spectrophotometric method	Güneş *et al.* (2019)
2. Catalase (CAT, unit mg^{-1} protein^{-1})		

6. Statistical analysis

Statistical analysis of the data was performed using CoStat (Version 6.303, CoHort, USA, 1986). The least significant difference (LSD) test was used to to compare means, at a significance level of 0.05, following the approach described by Gomez and Gomez (1984). To further evaluate the means between treatments, the Duncan's test was used, as prescribed by Duncan (1955).

RESULTS AND DISCUSSION

1. Physical characteristics of an entire plant

The data presented in Tables 4 & 5 show the individual effect of different irrigation schedules, different compost ratios and melatonin application as well as their interaction, on various physical characteristics of Schefflera actinophylla L plants. These characteristics include plant height (cm), No. of leaves plant-1, leaf area (cm2 plant-1) (Table 4), fresh and dry leaf weights (g plant-1), fresh and dry stem weights (g plant-1), fresh and dry root weights (g plant-1) (Table 5).

The values of all the above mentioned characteristics decreased as the intervals between irrigations increased. In other words, the irrigation every 5 days (I1 treatment) was the superior for obtaining the maximum values followed by I2 treatment (irrigation every 7 days), while the lowest values were obtained when Schefflera actinophylla L plants were irrigated every 10 days (I3 treatment)

Regarding the effect of compost, the plants grown in pots containing 3:1 compost: sand mixtures v/v (C3) showed the highest values for all the above parameters followed by the C2 treatment and finally the C1 treatment.

Regarding melatonin, its application led to an increase in all the above parameters compared to untreated plants. On the other hand, plant performance was better in the combined treatments of I2xC2 (or C3) xF2 than in the combined treatments of I1xC1xF1. The same trend was observed in both seasons studied.

In general, these results confirm the potential role of compost and melatonin in mitigating the negative effects of water deficit. These results can be explained in the following way; Longer watering intervals, such as in the I3 treatment, can cause water stress in Schefflera actinophylla L plants. Water stress reduces the plant's ability to absorb nutrients and perform photosynthesis, resulting in reduced growth and overall plant health. Frequent irrigation, as in the I1 treatment, ensures consistent soil moisture, which promotes healthy root development in Schefflera actinophylla L plants. This, in turn, allows for better nutrient and water uptake, resulting in increased plant growth. Frequent irrigation helps to maintain higher transpiration rates, which can have a positive effect on leaf area and overall plant development.

Compost-rich substrates, such as C3 treatment, typically have a higher nutrient content, providing essential elements for Schefflera actinophylla L plant growth. The availability of nutrients in the substrate can improve overall plant development, including leaf area, number of leaves, and biomass. Compost can improve soil structure and water retention, ensuring adequate moisture for plant roots. This leads to better nutrient uptake and overall plant performance. Compost can encourage beneficial microbial activity in the soil, helping to mineralize nutrients and make them available to the plant.

Melatonin is known for its antioxidant properties, which can help protect plant cells from oxidative stress caused by water deficit. Reduced oxidative stress can lead to healthier and larger leaves, as well as improved biomass. Melatonin can enhance a plant's stress response mechanisms, allowing it to better cope with water deficit conditions. This can result in increased growth parameters such as plant height and leaf number. Melatonin has been shown to increase photosynthesis and chlorophyll content in plants, which can contribute to increased leaf area and overall plant vitality (Arnao and Hernández-Ruiz 2015).

The combined treatments of optimal irrigation, nutrient-rich compost, and melatonin are likely to have synergistic effects. Adequate irrigation ensures the availability of nutrients from the compost and facilitates the uptake of melatonin, leading to improved plant performance.

These scientific explanations highlight the complex interplay between irrigation, substrate composition, and melatonin in influencing the physiological and biochemical processes that control plant growth and development under water deficit conditions.

Table 4. Effect of irrigation schedules, varying compost ratios and melatonin on plant height (cm), No. of leaves plant^{-1}, leaf area (cm^2 plant^{-1}) of *Schefflera actinophylla* L plants during two consecutive seasons (2022-2023)

Treatments			Plant height, cm		No. of leaves.plant^{-1}		No. of branches plant^{-1}		Leaf area, cm^2	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor : Irrigation schedules										
I_1			68.46a	70.56a	85.39a	89.11a	14.17a	15.50a	168.49a	170.38a
I_2			65.81b	67.82b	79.28b	82.67b	13.50a	14.33b	155.13b	157.52b
I_3			58.06c	59.98c	58.33c	61.44c	9.78b	9.89c	115.74c	117.21c
LSD at 5%			1.53	1.05	1.72	1.38	1.24	0.92	2.16	2.81
Sub main factor: Varying compost ratios										
C_1			61.11c	62.98c	67.11c	70.56c	11.44c	11.89b	131.70c	133.40c
C_2			64.17b	66.14b	74.50b	77.17b	12.50b	13.28a	146.05b	147.76b
C_3			67.06a	69.24a	81.39a	85.50a	13.50a	14.56a	161.61a	163.94a
LSD at 5%			1.04	0.77	1.23	1.38	0.69	1.28	0.17	1.09
Sub-sub main factor: Melatonin applications										
F_1			63.27b	65.23b	72.19b	75.59b	12.22a	12.93b	142.14b	144.10b
F_2			64.96a	67.00a	76.48a	79.89a	12.74a	13.56a	150.77a	152.64a
LSD at 5%			1.23	0.45	1.44	1.52	N.S	0.44	1.50	1.29
Interaction										
I_1	C_1	F_1	64.73	66.74	75.67	79.00	13.00	14.00	150.25	152.03
		F_2	65.69	67.76	79.00	84.00	13.33	14.33	154.45	156.77
	C_2	F_1	66.59	68.73	80.00	83.00	13.67	15.00	157.53	158.85
		F_2	70.49	72.48	90.00	92.00	14.67	16.00	178.29	179.96
	C_3	F_1	71.23	73.23	93.00	98.00	15.00	16.67	183.05	185.75
		F_2	72.04	74.44	94.67	98.67	15.33	17.00	187.34	188.89
I_2	C_1	F_1	62.04	63.89	69.00	72.00	12.33	13.00	135.24	136.96
		F_2	62.91	64.68	71.00	74.67	12.67	13.33	142.11	143.87
	C_2	F_1	64.07	65.92	73.67	76.67	13.00	13.67	146.89	148.91
		F_2	67.74	69.66	86.00	88.00	14.00	15.00	163.23	165.55
	C_3	F_1	68.62	70.85	87.00	90.67	14.33	15.33	169.09	172.76
		F_2	69.50	71.90	89.00	94.00	14.67	15.67	174.23	177.07
I_3	C_1	F_1	54.84	56.48	53.00	55.67	8.33	8.00	100.89	102.06
		F_2	56.44	58.31	55.00	58.00	9.00	8.67	107.27	108.71
	C_2	F_1	57.32	59.31	57.67	60.67	9.67	9.67	111.99	113.51
		F_2	58.83	60.74	59.67	62.67	10.00	10.33	118.36	119.80
	C_3	F_1	59.99	61.96	60.67	64.67	10.67	11.00	124.28	126.03
		F_2	60.97	63.08	64.00	67.00	11.00	11.67	131.65	133.13
LSD at 5%			3.69	1.36	4.32	4.56	1.68	1.32	4.51	3.87

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Since, I_1: Irrigation every 5 days; I_1: Irrigation every 7 days; I_3: Irrigation every 10; C_1: 1 compost: 3 sand (v/v); C_2: 1 compost: 1 sand (v/v); C_3: 3 compost: 1 sand (v/v); F_1: Without melatonin and F_2: Melatonin at rate of 100 µM

Table 5. Effect of irrigation schedules, varying compost ratios and melatonin on leaf fresh and dry weights (g plant^{-1}), stem fresh and dry weights (g plant^{-1}), root fresh and dry weights (g plant^{-1}) of *Schefflera actinophylla* L plants during two consecutive seasons (2022-2023)

Treatments			Leaves fresh weight		Leaves dry weight		Stem fresh weight		Stem dry weight		Root fresh weight		Root dry weight	
			(g plant^{-1})											
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor : Irrigation schedules														
I_1			100.42a	102.12a	22.19a	22.49a	33.72a	34.39a	11.53a	12.04a	23.17a	24.59a	6.63a	6.95a
I_2			89.36b	91.04b	20.73b	21.05b	31.14b	31.79b	10.60b	11.01b	22.31a	23.73b	6.25b	6.56b
I_3			59.31c	60.54c	16.52c	16.75c	23.47c	23.98c	7.59c	7.92c	20.06b	21.31c	5.16c	5.42c
LSD at 5%			0.95	3.82	0.15	0.40	0.68	0.08	0.46	0.55	1.16	0.04	0.12	0.16
Sub main factor: Varying compost ratios														
C_1			71.28c	72.51c	18.27c	18.5c0	26.23c	26.77c	8.76c	9.14c	21.02c	22.35c	5.57c	5.86c
C_2			83.10b	84.51b	19.78b	20.0b5	29.80b	30.39b	9.90b	10.31b	21.85b	23.22b	6.06b	6.36b
C_3			94.70a	96.68a	21.39a	21.74a	32.31a	33.01a	11.05a	11.52a	22.67a	24.07a	6.41a	6.73a
LSD at 5%			0.72	2.40	0.21	0.33	0.48	0.29	0.28	0.32	0.66	0.23	0.10	0.13
Sub-sub main factor: Melatonin applications														
F_1			80.07b	81.52b	19.48b	19.75a	28.59b	29.19b	9.68b	10.09b	21.68a	23.02b	5.95a	6.25a
F_2			85.99a	87.62a	20.14a	20.44a	30.30a	30.92a	10.13a	10.56a	22.01a	23.40a	6.07a	6.38a
LSD at 5%			0.65	2.26	0.15	N.S*	0.58	0.22	0.26	0.29	N.S*	0.16	N.S*	N.S*
Interaction														
I_1	C_1	F_1	85.40	86.45	20.19	20.46	30.44	31.10	10.01	10.52	22.11	23.53	6.16	6.49
		F_2	88.34	89.46	20.65	20.99	31.40	31.95	10.34	10.91	22.43	23.74	6.26	6.55
	C_2	F_1	91.47	92.93	21.09	21.31	32.19	32.89	10.63	11.05	22.55	23.96	6.47	6.78
		F_2	109.62	111.74	23.37	23.73	35.38	36.10	12.53	13.00	23.66	25.19	6.94	7.23
	C_3	F_1	112.49	114.70	23.70	24.12	36.07	36.72	12.70	13.22	24.05	25.41	6.97	7.30
		F_2	115.18	117.43	24.15	24.32	36.85	37.62	12.96	13.56	24.22	25.71	7.00	7.37
I_2	C_1	F_1	73.30	75.09	19.13	19.36	28.51	29.11	9.53	9.85	21.44	22.79	5.80	6.07
		F_2	73.31	75.04	18.54	18.78	28.02	28.57	9.12	9.44	21.21	22.66	5.58	5.91
	C_2	F_1	81.67	82.95	19.61	19.87	29.35	29.89	9.75	10.19	21.85	23.23	5.99	6.27
		F_2	97.75	99.21	21.67	21.97	32.94	33.58	11.23	11.63	22.93	24.42	6.58	6.93
	C_3	F_1	102.98	104.87	22.39	22.81	33.66	34.35	11.80	12.24	23.04	24.45	6.70	7.04
		F_2	107.14	109.07	23.03	23.54	34.39	35.22	12.16	12.69	23.37	24.86	6.83	7.16
I_3	C_1	F_1	51.16	51.96	15.74	15.86	17.16	17.56	7.05	7.35	19.71	20.93	4.92	5.19
		F_2	56.17	57.04	15.37	15.58	21.86	22.32	6.52	6.79	19.21	20.45	4.69	4.92
	C_2	F_1	58.29	59.17	16.25	16.52	23.92	24.40	7.46	7.78	19.82	21.00	5.14	5.39
		F_2	59.83	61.09	16.69	16.89	25.04	25.49	7.81	8.18	20.30	21.53	5.26	5.53
	C_3	F_1	63.84	65.53	17.23	17.45	26.00	26.71	8.23	8.58	20.54	21.89	5.41	5.70
		F_2	66.56	68.47	17.83	18.18	26.86	27.43	8.47	8.84	20.77	22.09	5.53	5.81
LSD at 5%			1.95	6.78	0.45	2.15	1.75	0.65	0.78	0.88	1.70	0.47	0.64	0.63

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Since, I_1: Irrigation every 5 days; I_1: Irrigation every 7 days; I_3: Irrigation every 10; C_1: 1 compost: 3 sand (v/v); C_2: 1 compost: 1 sand (v/v); C_3: 3 compost: 1 sand (v/v); F_1: Without melatonin and F_2: Melatonin at rate of 100 µM N.S*: Non-significant

These findings are consistent with those documented by Shah et al. (2023) and Elsherpiny (2023), who both confirmed that organic fertilizers, particularly compost, improve soil water retention and the water-holding capacity of the root zone. Additionally, the results are consistent with studies by Ahmad et al. (2023) and Dradrach et al. (2022), which confirmed that melatonin contributes to increased plant tolerance to drought. These combined studies provide further support for the beneficial effects of compost and melatonin in mitigating the effects of water deficit on plant growth and performance.

2. Chemical contents

The data also show that different irrigation schedules, different compost ratios, and the application of melatonin have a significant effect on the pigments of *Schefflera actinophylla* L plants, including chlorophyll a & b (mg g^{-1} F.W), carotene (mg g^{-1} F.W) (Table 6) as well as leaf chemical content of nitrogen, phosphorus, potassium, carbohydrate content (%) (Table 7) in the leaves. The data show that the irrigation every 5 days (I_1 treatment) was the best for obtaining the maximum values of all the above mentioned traits. It was followed by the I_2 treatment (irrigation every 7 days), and finally by the I_3 treatment (irrigation every 10 days). These results indicate that the frequency of irrigation plays a key role in shaping the pigment content and chemical composition of the leaves of *Schefflera actinophylla* L plants. Higher irrigation frequency, as exemplified by the I_1 treatment, seems to enhance the accumulation of pigments and the nutrient content within the leaves of *Schefflera actinophylla* L plants.

Regarding the compost treatments, the plants grown in pots containing 3:1 compost: sand mixtures v/v (C_3) showed the highest values for chlorophyll a & b (mg g^{-1} F.W.), carotene (mg g^{-1} F.W.) (Table 6) as well as leaf chemical content of nitrogen, phosphorus, potassium, carbohydrate content (%) (Table 7). This was followed by the C_2 treatment and finally the C1 treatment.

Concerning the compost treatments, the plants that were grown in pots filled with a mixture of compost and sand at ratio of 3:1 v/v (C_3 treatment) showed the highest values for chlorophyll a & b (mg g^{-1} F.W), carotene (mg g^{-1} F.W) (Table 6) as well as leaf chemical content of nitrogen, phosphorus, potassium, carbohydrates content (%) (Table 7). After the C_3 treatment in terms of these parameters, the C_2 treatment showed intermediate values, and the C_1 treatment gave the lowest values.

These results suggest that the organic-rich C_3 compost treatment provides optimal conditions for improving plant pigment content and nutrient composition. The higher organic content in this treatment is likely to contribute to improved nutrient availability, which in turn promotes chlorophyll synthesis and overall leaf chemistry, including nitrogen, phosphorus, potassium, and carbohydrates.

Regarding melatonin, its application resulted in an increase in the values of chlorophyll a & b (mg g^{-1} F.W.), carotene (mg g^{-1} F.W.) (Table 6) as well as leaf chemical content of nitrogen, phosphorus, potassium, carbohydrate content (%) (Table 7) compared to untreated plants.

In relation to melatonin, its application resulted in an increase in the values for chlorophyll a & b (mg g^{-1} F.W), carotene (mg g^{-1} F.W) (Table 6). Additionally, the application of melatonin led to an increase in the chemical content of the leaves in terms of nitrogen, phosphorus, potassium, and carbohydrate content (%) (Table 7), when compared to the plants that were not treated.

Table 6. Effect of irrigation schedules, varying compost ratios and melatonin on chlorophyll a & b (mg g^{-1} F.W) and carotene (mg g^{-1} F.W) contents in leaves of *Schefflera actinophylla* L plants during two consecutive seasons (2022-2023)

Treatments			**Chlorophyll a**		**Chlorophyll b**		**Carotene**	
			(mg g^{-1} F.W)					
			1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Main factor : Irrigation schedules								
I_1			1.028a	1.080a	0.632a	0.658a	0.516a	0.532a
I_2			0.992b	1.042b	0.619b	0.643a	0.501b	0.517b
I_3			0.896c	0.940c	0.583c	0.607b	0.464c	0.479c
LSD at 5%			0.011	0.009	0.012	0.015	0.004	0.014
Sub main factor: Varying compost ratios								
C_1			0.935c	0.983c	0.596c	0.620c	0.479c	0.493c
C_2			0.973b	1.021b	0.611b	0.636b	0.494b	0.509b
C_3			1.008a	1.059a	0.626a	0.652a	0.509a	0.525a
LSD at 5%			0.010	0.010	0.007	0.010	0.005	0.010
Sub-sub main factor: Melatonin applications								
F_1			0.962b	1.010b	0.607b	0.631a	0.490b	0.505a
F_2			0.983a	1.032a	0.615a	0.641a	0.498a	0.514a
LSD at 5%			0.006	0.008	0.002	N.S	0.002	N.S
Interaction								
I_1	C_1	F_1	0.980	1.034	0.612	0.637	0.498	0.513
		F_2	0.994	1.043	0.618	0.644	0.503	0.519
	C_2	F_1	1.008	1.057	0.621	0.647	0.507	0.522
		F_2	1.051	1.103	0.641	0.669	0.526	0.541
	C_3	F_1	1.064	1.117	0.648	0.673	0.529	0.543
		F_2	1.073	1.129	0.651	0.681	0.534	0.550
I_2	C_1	F_1	0.937	0.981	0.603	0.628	0.482	0.496
		F_2	0.956	1.010	0.606	0.630	0.486	0.500
	C_2	F_1	0.969	1.019	0.610	0.634	0.492	0.506
		F_2	1.018	1.069	0.626	0.650	0.511	0.525
	C_3	F_1	1.031	1.079	0.632	0.657	0.517	0.533
		F_2	1.043	1.096	0.637	0.662	0.521	0.539
I_3	C_1	F_1	0.863	0.906	0.563	0.585	0.448	0.460
		F_2	0.882	0.924	0.575	0.599	0.456	0.471
	C_2	F_1	0.892	0.933	0.582	0.607	0.463	0.478
		F_2	0.898	0.944	0.588	0.612	0.468	0.482
	C_3	F_1	0.912	0.960	0.591	0.615	0.474	0.488
		F_2	0.927	0.972	0.598	0.622	0.477	0.494
LSD at 5%			0.018	0.023	0.007	0.036	0.006	0.037

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Since, I_1: Irrigation every 5 days; I_1: Irrigation every 7 days; I_3: Irrigation every 10; C_1: 1 compost: 3 sand (v/v); C_2: 1 compost: 1 sand (v/v); C_3: 3 compost: 1 sand (v/v); F_1: Without melatonin and F_2: Melatonin at rate of 100 µM

N.S*: Non-significant

This shows that melatonin plays a positive role in improving the pigment content and nutrient composition of the plant. The antioxidant properties of Melatonin are likely to contribute to the reduction of oxidative stress, which may lead to improved chlorophyll synthesis and pigment accumulation. Furthermore, melatonin may influence nutrient uptake and utilization, leading to higher levels of nitrogen, phosphorus, potassium, and carbohydrates in the leaves, ultimately promoting plant growth and stress tolerance. In summary, the effects of melatonin on plant drought tolerance are diverse. It acts as an antioxidant, regulates stomatal behavior, maintains photosynthesis, enhances root development, improves stress signalling, and interacts with plant hormones. Together, these mechanisms contribute to improved drought tolerance in melatonin-treated plants, making it a promising tool for mitigating the adverse effects of drought stress (Ahmad *et al.* 2023).

On the other hand, the plant performance in the combined treatments of I_2xC_2 (or C_3) xF_2 was better than that in the combined treatments of $I_1xC_1xF_1$. The same trend was observed in both seasons studied. The same pattern or trend was observed in both of the seasons studied. These results are consistent with those reported by Dradrach *et al.* (2022); Shah *et al.* (2023) and Elsherpiny (2023).

Table 7. Effect of irrigation schedules, varying compost ratios and melatonin on the leaf chemical content of nitrogen, phosphorus, potassium, and carbohydrate content (%) in leaves of *Schefflera actinophylla* L plants during two consecutive seasons (2022-2023)

Treatments			N		P		K		Carbohydrates	
			(%)							
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor : Irrigation schedules										
I_1			3.36a	3.51a	0.525a	0.534a	2.17a	2.27a	27.25a	27.92c
I_2			3.22b	3.35b	0.510b	0.519b	1.97b	2.05b	26.38b	27.09b
I_3			2.88c	3.00c	0.470c	0.479c	1.76c	1.83c	24.06c	24.69a
LSD at 5%			0.08	0.05	0.002	0.010	0.10	0.09	0.37	0.28
Sub main factor: Varying compost ratios										
C_1			3.02c	3.14c	0.486c	0.495c	1.88b	1.96b	25.03c	25.68c
C_2			3.16b	3.29b	0.501b	0.509b	1.91b	1.99b	25.94b	26.62b
C_3			3.29a	3.42a	0.518a	0.528a	2.11a	2.21a	26.73a	27.41a
LSD at 5%			0.05	0.05	0.006	0.006	0.06	0.06	0.42	0.24
Sub-sub main factor: Melatonin applications										
F_1			3.12b	3.24b	0.498b	0.506b	1.90b	1.99b	25.66a	26.36b
F_2			3.19a	3.32a	0.506a	0.515a	2.03a	2.12a	26.14a	26.77a
LSD at 5%			0.06	0.07	0.003	0.009	0.05	0.05	N.S	0.1
Interaction										
I_1	C_1	F_1	3.20	3.32	0.505	0.512	2.00	2.09	26.21	26.91
		F_2	3.24	3.38	0.507	0.518	2.05	2.15	26.56	27.25
	C_2	F_1	3.29	3.44	0.514	0.521	2.09	2.19	26.71	27.46
		F_2	3.46	3.60	0.536	0.544	2.27	2.36	27.71	28.40
	C_3	F_1	3.48	3.62	0.543	0.552	2.30	2.41	28.02	28.58
		F_2	3.51	3.67	0.548	0.557	2.33	2.45	28.29	28.92
I_2	C_1	F_1	3.03	3.16	0.490	0.499	1.92	2.01	25.02	25.77
		F_2	3.05	3.17	0.495	0.503	1.96	2.04	25.33	25.92
	C_2	F_1	3.12	3.23	0.500	0.510	1.40	1.45	25.94	26.71
		F_2	3.33	3.46	0.519	0.526	2.14	2.22	27.06	27.64
	C_3	F_1	3.37	3.49	0.526	0.534	2.18	2.29	27.35	28.19
		F_2	3.42	3.56	0.530	0.540	2.20	2.29	27.57	28.28
I_3	C_1	F_1	2.76	2.88	0.456	0.463	1.62	1.69	23.35	23.94
		F_2	2.83	2.95	0.463	0.471	1.71	1.78	23.68	24.27
	C_2	F_1	2.86	2.99	0.467	0.471	1.77	1.84	23.88	24.53
		F_2	2.90	3.02	0.472	0.483	1.78	1.86	24.33	24.96
	C_3	F_1	2.96	3.07	0.478	0.490	1.81	1.90	24.44	25.18
		F_2	3.00	3.12	0.483	0.495	1.85	1.92	24.70	25.28
LSD at 5%			0.18	0.20	0.008	0.028	0.16	0.14	1.54	0.45

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Since, I_1: Irrigation every 5 days; I_1: Irrigation every 7 days; I_3: Irrigation every 10; C_1: 1 compost: 3 sand (v/v); C_2: 1 compost: 1 sand (v/v); C_3: 3 compost: 1 sand (v/v); F_1: Without melatonin and F_2: Melatonin at rate of 100 µM N.S*: Non-significant

3. Indicators of oxidation and antioxidant enzymes

The data presented in Table 8 show the effect of the treatments studied on the indicators of oxidation [malondialdehyde (MDA, µmol. g^{-1} F.W)] and antioxidant enzymes [*i.e.*, peroxidase (POX, unit mg^{-1} $protein^{-1}$) and catalase (CAT, unit mg^{-1} $protein^{-1}$)] in *the* leaves of *Schefflera actinophylla* L plants. The data show that the highest values of MDA, POX and CAT were obtained when *Schefflera actinophylla* L. plants were subjected to the irrigation schedule of every 10 days (I_3 treatment), followed by those irrigated every 7 days (I_2 treatment). In contrast, the conventional irrigation treatment (I_1 treatment) resulted in the lowest levels for MDA, POX, and CAT. These results suggest that less frequent irrigation, as seen in the I_3 and I_2 treatments, induced oxidative stress in the plants, leading to higher levels of MDA, an indicator of lipid peroxidation. In response to this stress, the plants increased the activity of antioxidant enzymes, such as POX and CAT, as a defense mechanism. On the other hand, the I1 treatment, characterized by more frequent irrigation, maintained lower levels of oxidative stress, resulting in reduced MDA and lower activity of antioxidant enzymes.

The plants that were grown in pots filled with a mixture of compost and sand in a ratio of 3:1 v/v (C_3 treatment) showed the highest values for peroxidase (POX) and catalase (CAT) activity. Following the C_3 treatment in terms of these enzyme activities, the C_2 treatment showed intermediate values, and the C_1 treatment resulted in the lowest activity levels for both POX and CAT. Conversely, for malondialdehyde (MDA) levels, the highest values were recorded in the C_1 treatment, followed by the C_2 treatment, and the lowest MDA levels were observed in the C_3 treatment.These results suggest that the C_3 treatment, which contains a higher proportion of compost, increases the activity of antioxidant enzymes (POX and CAT), probably in response to potential oxidative stress. This suggests that the plants are better equipped to combat oxidative damage when grown in a substrate rich in organic matter. Conversely, the C_1 treatment, with a lower compost ratio, appears to result in higher oxidative stress, as evidenced by elevated MDA levels, which is indicative of lipid peroxidation.

Furthermore, the application of melatonin resulted in an increase in the levels of peroxidase (POX) and catalase (CAT) when compared to untreated plants. Conversely, malondialdehyde (MDA) levels decreased in melatonin-treated plants as compared to untreated plants. These observations suggest that melatonin has a positive effect on the plant's antioxidant defense mechanisms. It increases the activity of antioxidant enzymes (POX and CAT), which are involved in reducing oxidative stress by neutralizing harmful reactive oxygen species (ROS). As a result, the levels of MDA, an indicator of lipid peroxidation and oxidative damage, are reduced in melatonin-treated plants, indicating improved protection against oxidative stress.

Table 8. Effect of irrigation schedules, varying compost ratios and melatonin on malondialdehyde (MDA, µmol. g^{-1} F.W), peroxidase (POX, unit mg^{-1} protein^{-1}) and catalyse (CAT, unit mg^{-1} protein^{-1}) content in leaves of *Schefflera actinophylla* L plants during two consecutive seasons (2022-2023)

Treatments			MDA, µmol.g^{-1} F.W		POX, unit mg^{-1} protein^{-1}		CAT, unit mg^{-1} protein^{-1}	
			1st	2nd	1st	2nd	1st	2nd
Main factor : Irrigation schedules								
I_1			8.54c	8.90c	0.349c	0.366c	0.030c	0.032c
I_2			9.74b	10.13b	0.398b	0.417b	0.048b	0.053b
I_3			11.62a	12.10a	0.472a	0.495a	0.080a	0.086a
LSD at 5%			0.09	0.10	0.005	0.008	0.001	0.003
Sub main factor: Varying compost ratios								
C_1			10.42a	10.84a	0.425a	0.445a	0.062a	0.067a
C_2			10.00b	10.40b	0.406b	0.427b	0.052b	0.057b
C_3			9.49c	9.89c	0.387c	0.406c	0.044c	0.048c
LSD at 5%			0.06	0.16	0.004	0.004	0.001	0.002
Sub-sub main factor: Melatonin applications								
F_1			10.09a	10.51a	0.402b	0.422b	0.050b	0.054b
F_2			9.84b	10.24a	0.411a	0.431a	0.055a	0.060a
LSD at 5%			0.09	N.S	0.003	0.002	0.001	0.002
Interaction								
I_1	C_1	F_1	8.85	9.22	0.355	0.372	0.036	0.039
		F_2	8.66	9.01	0.362	0.379	0.038	0.040
	C_2	F_1	8.57	8.97	0.348	0.366	0.026	0.028
		F_2	8.53	8.86	0.350	0.368	0.033	0.037
	C_3	F_1	8.37	8.71	0.338	0.354	0.021	0.023
		F_2	8.24	8.63	0.340	0.359	0.024	0.027
I_2	C_1	F_1	10.27	10.69	0.418	0.440	0.056	0.061
		F_2	10.02	10.40	0.429	0.450	0.059	0.064
	C_2	F_1	9.94	10.34	0.389	0.407	0.045	0.048
		F_2	9.80	10.14	0.406	0.427	0.052	0.057
	C_3	F_1	9.29	9.69	0.369	0.387	0.039	0.041
		F_2	9.14	9.51	0.378	0.395	0.040	0.044
I_3	C_1	F_1	12.63	13.11	0.489	0.511	0.089	0.096
		F_2	12.08	12.62	0.496	0.520	0.092	0.099
	C_2	F_1	11.57	12.05	0.467	0.492	0.076	0.082
		F_2	11.57	12.06	0.480	0.503	0.082	0.089
	C_3	F_1	11.35	11.83	0.444	0.466	0.066	0.071
		F_2	10.52	10.95	0.456	0.478	0.072	0.079
LSD at 5%			0.23	1.01	0.008	0.007	0.003	0.006

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Since, I_1: Irrigation every 5 days; I_1: Irrigation every 7 days; I_3: Irrigation every 10; C_1: 1 compost: 3 sand (v/v); C_2: 1 compost: 1 sand (v/v); C_3: 3 compost: 1 sand (v/v); F_1: Without melatonin and F_2: Melatonin at rate of 100 µM N.S*: Non-significant

Regarding the interaction effect, the plant performance was better in the combined treatments of I_2xC_2 (or C_3) xF_2 than in the combined treatments of $I_1xC_1xF_1$. The same pattern was observed for both seasons studied. These results are consistent with those of Arnao and Hernández-Ruiz (2015); Ahmad *et al.* (2023); Dradrach *et al.* (2022); Shah *et al.* (2023); Elsherpiny (2023).

CONCLUSION

This study underscores the critical importance of addressing water scarcity challenges, especially in the context of ornamental plant cultivation in Egypt. The findings reveal several key points:

1. The performance of *Schefflera actinophylla* L plants is adversely affected as the intervals between irrigation increase, highlighting the serious impact of water scarcity on plant growth and health.
2. The combination of compost and melatonin shows promise in mitigating the adverse effects of water deficit. In particular, the treatment with 3:1 compost: sand mixtures v/v (C_3) proves to be highly effective, resulting in the best plant growth and physiological responses.
3. The application of melatonin by spraying at a concentration of 100 µM significantly improves various growth parameters, chemical characteristics, and antioxidant levels, thus contributing to improved plant resistance to water deficitconditions.
4. To save irrigation water, the combination of a 7-day irrigation interval (I_2) with a pot composition of 3:1 compost: sand mixtures v/v (C_3), together with melatonin application at 100 µM (F_2), emerged as the most favorable treatment regimen for *Schefflera actinophylla* L plants.

RECOMMENDATIONS

Based on the results of the study, the following recommendations are proposed:

1. Given the observed decline in plant performance with extended irrigation intervals, it is critical to implement efficient water management practices. Consideration should be given to scheduling regular and consistent irrigation to meet the water needs of ornamental plants.
2. The use of compost, especially at higher ratios such as 3:1 compost: sand mixtures v/v (C_3), should be encouraged in Shefflera plant cultivation. Compost improves soil structure, nutrient and water retention, and overall plant health.
3. The incorporation of melatonin into cultivation practices, particularly at a concentration of 100 µM, is recommended to enhance plant growth of Shefflera and improve tolerance to water deficit conditions. Further research can explore optimal application methods and timing.
4. In the face of ongoing water scarcity challenges, ornamental plant growers should consider adapting their cultivation techniques to align with more sustainable and water-efficient practices. This may include the use of drought-tolerant plant varieties and advanced irrigation technologies.
5. Ongoing research is needed to explore the long-term effects of compost and melatonin applications on different ornamental plant species. Additionally, research into the economic feasibility of these treatments and their scalability in commercial settings is essential.

By implementing these recommendations, ornamental horticulture in Egypt can become more resilient to water scarcity, and ensure the sustainability of this vital industry.

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استجابة نباتات الشفليرا النامية تحت ظروف العجز المائي للإضافات الأرضية للكمبوست والرش الورقي للميلاتونين

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الملخص

أصبح توفير مياه الري أمرًا بالغ الأهمية وخاصة عندما نتحدث عن نباتات الزينة، نتيجة للظروف المائية الصعبة في مصر. إن استخدام التعديلات الأرضية الفعّالة منخفضة التكلفة، مثل الكمبوست، واستخدام جزيء "الميلاتونين" المكتشف حديثًا، يمكن أن يخفف من الآثار الضارة لندرة المياه. ولذلك هدفت هذه الدراسة إلى تقييم مدى فعالية دمج الكمبوست مع الميلاتونين في التخفيف من الآثار الضارة للعجز المائي على نبات الشفليرا. تم تقييم فترات ري مختلفة والتي كانت كما يلي، الري كل 5 أيام (I_1)، 7 أيام (I_2)، 10 أيام (I_3)، كعامل رئيسي. أيضاً تم دراسة التركيبة النهائية لبيئة النمو داخل لأصيص، التي تتضمن الكمبوست والرمل، مع خيارات تشمل خليط من الكمبوست والرمل بنسبه 3:1 (حجم /حجم) (C_1)، وخليط من الكمبوست والرمل بنسبه 1:1 (حجم /حجم) (C_2)، وخليط من الكمبوست والرمل بنسبه 1:3 (حجم /حجم) (C_3)، كعامل منشق اول. بالإضافة إلى ذلك، تم دراسة رش الميلاتونين بتركيزات صفر (F_1) و100 ميكرومول (F_2) كعامل منشق ثاني. شهد أداء النباتات انخفاضًا مع زيادة فترات الري. علاوة على ذلك، أظهرت النباتات النامية بالأصص التي تحتوي على خليط من الكمبوست والرمل بنسبه 1:3 (حجم /حجم) (C_3) افضل اداء، تليها معاملة C_2، وأخيرًا C_1. علاوة على ذلك، أدى رش الميلاتونين إلى زيادة في جميع الصفات المدروسة من حيث النمو والخصائص الكيميائية، ومستويات مضادات الأكسدة، باستثناء المالونديالدهيد، الذي انخفض مقارنة بالنباتات غير المعاملة. وفي سياق مختلف، أظهر أداء النباتات تحت المعاملة المشتركة F_2 x(C_3 أو C_2) x I_2 تحسنًا أفضل من الأداء تحت المعاملة المشتركة F_1xC_1x I_1. وأخيرا، تؤكد هذه النتائج الدور المحتمل للكمبوست والميلاتونين في التخفيف من التأثيرات الضارة لندرة المياه.