INFLUNCE OF DIFFERENT IRRIGATION INTERVALS AND ANTI-TRANSPIRATION COMPOUNDS ON PRODUCTIVITY AND CHEMICAL CONSTITUENTS OF *ECHINACEA PURPUREA* L. PLANT

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Population expansion, climate change and ineffective water management techniques exacerbate the world's serious water shortage. In addition to jeopardizing global food security, this shortfall puts millions of farmers's livelihoods in jeopardy. This study was carried out in the summer of 2022 and 2023 seasons at the Desert Research Center Experimental Station in Ras Sudr, South Sinai Governorate, Egypt. The current study aims to evaluate the effect of different irrigation intervals (2, 4 and 6 days) and anti-transpiration compound treatments (control, chitosan at 3 cm/L and green miracle at 3 cm/L) on the vegetative and flowering parameters and chemical composition of *Echinacea purpurea* L. plants. Results indicated that the irrigation interval every two days was superior to other irrigation intervals in all plant vegetative characteristics, flowering parameters and chemical composition. The plants grown with chitosan or green miracle improved all vegetative and flowering parameters and chemical composition. Green miracle treatments are superior to chitosan treatments because they have a greater effect on all studied plant characteristics. The highest growth rates, number of branches, biomass, NPK content, yield and caffeic acid derivatives of the *Echinacea purpurea* plant could be obtained by irrigation interval every two days combined with green miracle (3 cm/L). These results indicate that frequent irrigation combined with anti-transpiration compounds, especially green miracle can significantly enhance both the growth and medicinal quality of *Echinacea purpurea*.

Keywords: *Echinacea purpurea*, irrigation intervals, anti-transpiration, chitosan, green miracle

INTRODUCTION

Echinacea purpurea (L.) Moench, commonly known as purple coneflower, is a perennial herbaceous plant in the Asteraceae family, native to North America, particularly the eastern and central regions of the United States and southern Canada. *Echinacea purpurea* is highly valued for its medicinal, economic and ecological importance. *Echinacea purpurea* has gained attention due to its immune-boosting and anti-inflammatory properties, making it a crucial resource in both traditional and modern medicine. It has erect stems that can reach up to 180 cm, with ovate to lanceolate basal leaves and rough, sessile cauline leaves (Gupta et al., 2012 and Salgado-Salazar et al., 2023). The flower heads, featuring a central cone surrounded by drooping ray florets that range from light pink to deep purple, are known for their resilience and drought tolerance, making the plant suitable for various climates and soil types *Echinacea purpurea* is renowned for its immunomodulatory effects, containing active compounds such as alkamides, glycoproteins, polysaccharides and caffeic acid derivatives, which enhance immune system activity and help in preventing and treating infections like the common cold and influenza (Barnes et al., 2007; Mistríková and Vaverková, 2007; Coelho et al., 2020 and Burlou-Nagy et al., 2022). Recent studies confirm the plant's safety and efficacy, with research showing a favorable safety profile and effective pharmacokinetics of its active ingredient, chicoric acid (Jeong et al., 2024). Additionally, clinical trials have demonstrated its immune-enhancing effects in adults, supporting its use as a dietary supplement (Lee et al., 2024). Its adaptability to various soil types and climates further underscores its agricultural value (Mistríková and Vaverková, 2007).

Irrigation intervals (IRI) play a crucial role in cultivating aromatic medicinal plants, particularly in newly reclaimed areas. Ibrahim et al. (2022) found that these intervals significantly affect the chemical properties and yield of Lawsonia alba Lam, underscoring the need to optimize irrigation schedules to enhance productivity. Similarly, Asghari et al. (2023) studied the impact of salicylic acid on *Hibiscus sabdariffa* L. with irrigation intervals of 3, 5 and 7 days, revealing that different intervals significantly influenced the plant's physiological and phytochemical characteristics. Massoud et al., (2023) investigated how various stimulants and irrigation intervals affected the growth and volatile oil content of *Salvia officinalis L*., noting that irrigation every 3, 6 and 9 days resulted in different growth and oil levels. Additionally, Sharafzadeh and Zare (2011) reviewed the effects of drought stress on Lamiaceae family medicinal plants, finding that while drought stress increased essential oil percentage, it decreased shoot biomass, ultimately reducing total oil content. Finally, Abdullaevna (2024) highlighted that irrigation practices significantly influence the growth and yield of *Echinacea purpurea*; overall, these studies emphasize the importance of adjusting irrigation intervals to manage water stress and improve the quality and yield of medicinal plants.

Anti-transpiration are compounds that decrease the transpiration rate in plants by reducing the size and number of stomata, thus helping plants cope with water stress (Mphande et al., 2023). Research shows that 95-98 % of a plant's absorbed water is lost through transpiration, making these compounds vital for improving water use efficiency and plant growth, especially in water-scarce conditions (Prakash and Ramachandran, 2000 and Mphande et al., 2020). Studies have demonstrated that applying anti-transpiration, such as potassium silicate and glycerol, can reduce irrigation needs by up to 20 % while enhancing growth and yield in crops like bananas (Abdel Gawad, 2015). Their commercial application is significant in agriculture for minimizing water loss, improving plant water status, and increasing drought tolerance (Bistgani et al., 2024 and Mphande et al., 2024). Further findings indicate that anti-transpiration can maintain higher water content in plant tissues, leading to better growth and fruit quality, as seen in grapevines treated with di-1-p-menthene (Fahey and Rogiers, 2019 and Das and Kosser, 2023). Additionally, they have been shown to enhance drought tolerance in wheat by lowering transpiration rates and abscisic acid levels (Mphande et al., 2024).

Chitosan, a biopolymer derived from chitin (Ramadan and El Mesairy, 2015), has emerged as an effective anti-transpiration agent in agriculture due to its ability to form a protective film on plant surfaces, thus reducing water loss through transpiration. Recent studies have demonstrated its efficacy in improving plant water retention and stress tolerance without adversely affecting photosynthesis (Kumar et al., 2020). Additionally, chitosan's antimicrobial properties offer added benefits in protecting crops from pathogens. This natural and biodegradable compound is gaining popularity as a sustainable solution for enhancing plant resilience under drought conditions (Yang et al., 2016 and Hao et al., 2023).

Green miracle is a new agricultural product designed to improve plant growth and resilience against environmental stresses. It uses a formulation based on long-chain fatty alcohols and supplemented with amino acids and peptides to operate as a non-toxic anti-transpiration and surfactant. Because of its special composition, green miracle is able to control stomatal movement, which lowers transpiration rates by about 35-40 % while preserving photosynthesis and minimizing water loss. Studies have shown that its application can significantly improve the nutritional quality of crops, as evidenced by increased nitrogen, phosphorus, and potassium content in treated plants compared to controls (Abdel Gawad, 2015). Its effectiveness has been demonstrated across various crops, promoting not only higher yields but also better quality produce (El-Gioushy et al., 2017; Khandagale et al., 2020 and Fahmy, 2023). This study aimed to investigate the effect of irrigation intervals and anti-transpiration compounds on vegetative growth, flowering parameters and chemical composition of the *Echinacea purpurea* plant.

MATERIALS AND METHODS

1. Site Description, Plant Materials, Experimental Layout and Treatments

Two field experiments were carried out at the Experimental Station of Desert Research Center in Ras Sudr, South Sinai Governorate, Egypt (29°37'28.0"N 32°42'46.0"E), during growing summer seasons 2022 and 2023 to evaluate the effect of different irrigation intervals and anti-transpiration compounds on growth characteristics, flowering parameters and chemical constituents of *Echinacea purpurea* plants. The soil of the cultivation location was saline and calcareous with a sandy loam texture, its pH is 7.4, its EC is 4.65 mS cm^{-1}, and its $CaCO_3$ concentration is 54.21%. Physical and chemical analyses of the soil were determined according to Burt (2004). The seeds were obtained from the mature plants of *Echinacea purpurea* cultivated in a private farm in Qaliubiya Governate, Egypt. The seeds were planted in seedling trays, lightly covered and kept in a polyethylene greenhouse until they germinated. Once the seedlings reached a height of 8-10 cm with 5-6 leaves, they were transplanted into the open field on 15th March in both seasons. The distance between rows was 50 cm and 20 cm between hills. The soil was directly irrigated to provide suitable moisture for growth to a month before the irrigation intervals were began. All the recommended cultural practices for growing *Echinacea purpurea* plants in Egypt were followed. The plants were cut twice the first one was on 15th July and the second one on 20th October. Plants were irrigated with saline water (2300 ppm) using a drip irrigation system with drippers (2.0 liter/hour/hill). Drippers were set up at 2.0 liter/hour/plant for just two hour every irrigation time. The layout of this experiment was a factorial experiment in a split-plot design; the main plots devoted to irrigation intervals, while the sub-plots occupied the anti-transpiration treatments with three replicates, each treatment contained 10 plants.

The experimental treatments

A. Irrigation intervals (IRI): three irrigation intervals were used, namely IRI2 (2 days), IRI4 (4 days) and IRI6 (6 days). Irrigation intervals treatments were started after 30 days of transplanting.

B. Anti-transpiration compounds: two anti-transpiration compounds were used, chitosan (3 cm/L) and green miracle (3 cm/L) (El-Gioushy et al., 2017). Spraying treatments were done twice: the first time started a month after the transplanting, and the second time, four weeks after the first cut. In the meantime, tap water was sprayed on the control group at the times above; all spraying treatments were carried out in the early morning using a two-liter hand pressure sprayer.

2. Plant Measurements

2.1. Vegetative parameters

Random samples of five plants were taken at the beginning of flowering from plants of each plot to measure vegetative growth parameters, i.e., plant height, branches number/plant, fresh weight of herb/plant and dry weight of herb/plant.

2.2. Flowering parameters

At flowering stage, number of flowering heads/plant, fresh weight of flowering heads/plant and dry weight of flowering heads/plant were recorded.

2.3. Chemical composition

The N, P and K contents were determined in the dried leaves at the flowering stage according to A.O.A.C. (1970), Murphy and Riley (1962) and Cottenie et al. (1982), respectively. In addition, the determination of total alkamides was quantitatively determined in *Echinacea purpurea* aerial parts in the second cut of the 2023 season using High Performance Liquid Chromatography (HPLC) according to Bauer and Remiger (1989), while the total caffeic acid derivatives content (mg/g dry weight) was determined using a spectrophotometer according to A.O.A.C. (1980).

3. Statistical Analysis

The means of all obtained data as an average of the two cuts from the studied factors were subjected to analyses of variance (ANOVA). For means' comparison, the L.S.D. test was used to compare means at the 0.05% level using the MSTAT-C statistical software package according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

1. Vegetative Growth Parameters

Results revealed that the *Echinacea purpurea* growth parameters were significantly affected by irrigation intervals (IRI) and the application of anti-transpiration compounds (Table 1). In both seasons, IRI2 gave the highest values of plant height, number of branches, and fresh and dry weight of the herb per plant. Concerning anti-transpiration, chitosan and green miracle treatments significantly affected all growth parameters in both seasons. The most effective treatment for enhancing the plant height, number of branches, and fresh and dry weight of the herb was a green miracle (3 cm/L) treatment. As for the interaction between irrigation intervals and anti-transpiration treatments, generally, the most vigorous plants were those irrigated with IRI2 and received the green miracle (3 cm/L) treatment in both seasons. The differences among treatments were significant in both seasons.

2. Flowering Parameters

The number of flowering heads and fresh and dry weight of flowering heads per plant of each treatment are presented in Table (2). The number of flowering heads and fresh and dry weight of flowering heads per plant showed highly significant differences with irrigation intervals and anti-transpiration compound treatments. The values of number of flowering heads and fresh and dry weight of flowering heads per plant were higher under IRI2 compared to other irrigation intervals (IRI4 and IRI6) in both seasons. The exogenous

application of anti-transpiration compounds (chitosan and green miracle at 3 cm/L) resulted in a significant increase in the number of flowering heads and the fresh and dry weight of flowering heads. The application green miracle (3 cm/L) exhibited the highest values followed by chitosan (3 cm/L) in comparison with untreated plants in both seasons. The interaction between irrigation intervals and anti-transpiration compounds applications indicated that the IRI2 combined with green miracle (3 cm/L) recorded the highest number of flowering heads and fresh and dry weight of flowering heads per plant in both seasons.

Table (1). Effect of irrigation intervals and anti-transpiration compounds on plant height, number of branches /plant, fresh weight of herb/plant and dry weight of herb/plant of *Echinacea purpurea* L. plant as an average of the two cuts during 2022 and 2023 seasons.

Treatments		Plant height (cm)		Number of branches/plant		Fresh weight of herb/plant (g)		Dry weight of herb/plant (g)	
IRI	**A-T**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
	Without	71.63	73.04	11.67	12.00	197.20	200.40	35.02	35.59
IRI2	Chitosan	74.93	75.84	12.33	13.33	208.90	212.00	38.17	39.05
	Green miracle	79.97	81.20	14.00	14.33	218.50	222.20	38.57	39.31
Mean		75.51	76.69	12.67	13.22	208.20	211.50	37.25	37.99
	Without	60.83	61.81	10.67	10.33	165.50	168.40	29.47	30.03
IRI4	Chitosan	63.30	64.34	11.00	11.00	173.00	176.30	31.03	31.65
	Green miracle	67.10	68.18	12.00	12.33	186.00	189.50	33.87	34.43
Mean		63.74	64.78	11.22	11.22	174.83	178.07	31.46	32.04
	Without	52.67	53.52	9.67	10.00	131.60	132.30	25.40	25.88
IRI6	Chitosan	55.87	56.90	10.67	11.33	144.70	147.00	27.90	28.43
	Green miracle	59.30	60.37	11.67	12.00	159.30	162.10	30.23	29.93
Mean		55.94	56.93	10.67	11.11	145.20	147.13	27.84	28.08
Means of A-T									
	Without	61.71	62.79	10.67	10.78	164.80	167.00	29.97	30.50
	Chitosan	64.70	65.69	11.33	11.89	175.50	178.40	32.37	33.04
	Green miracle	68.79	69.91	12.56	12.89	187.90	191.30	34.22	34.56
LSD at 0.05									
	IRI	1.46	1.06	1.10	1.54	8.29	8.81	1.89	2.01
	A-T	1.76	1.88	0.79	0.93	5.23	4.80	1.11	1.11
	IRI × A-T	3.06	3.25	1.37	1.60	9.06	8.31	1.91	1.92

IRI: Irrigation intervals, IRI2: irrigation every 2 days, IRI4: irrigation every 4 days, IRI6: irrigation every 6 days, A-T: Anti-transpiration compounds.

Data in Table (2) indicate that the IRI2 interval consistently yielded the highest number and weight of flowering heads compared with the other irrigation intervals, this indicates that frequent irrigation supports more prolific flowering. The number of flowering heads and the fresh and dry weights of flowering heads were notably superior with the green miracle treatment. The combination of green miracle with IRI2 proved to be the most

effective in promoting both vegetative and reproductive growth, making IRI2 the optimal irrigation interval for maximizing growth and flowering traits in *Echinacea purpurea*. This result is consistent with other research emphasizing the impact of irrigation intervals on crop performance has been well documented Al-Jeboori et al. (2017) and Mahmoud et al. (2023) highlight how more frequent irrigation significantly enhances the growth and yield of medicinal and aromatic plants by ensuring adequate water supply. Additional support comes from the work of Paraskevopoulou et al. (2020), who found that regular irrigation schedules were essential for maintaining high productivity in drought-sensitive crops.

Table (2). Effect of irrigation intervals and anti-transpiration compounds on number of flowering heads/plant, fresh weight of flowering heads/plant and dry weight of flowering heads/plant of *Echinacea purpurea* L. plant as an average of the two cuts during 2022 and 2023 seasons.

Treatments		Number of flowering heads/plant		Fresh weight of flowering heads/plant (g)		Dry weight of flowering heads/plant (g)	
IRI	**A-T**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
IRI2	Without	16.00	16.33	80.11	81.44	14.28	14.57
	Chitosan	17.67	18.00	85.15	86.70	14.66	14.96
	Green miracle	19.00	19.33	88.52	90.07	15.94	16.26
Mean		17.56	17.89	84.59	86.07	14.96	15.26
IRI4	Without	13.33	13.67	75.44	76.84	13.43	13.70
	Chitosan	14.67	15.00	78.29	79.84	14.07	14.35
	Green miracle	15.33	15.67	79.37	80.93	14.46	14.75
Mean		14.44	14.78	77.70	79.20	13.99	14.27
IRI6	Without	8.67	9.33	63.96	65.17	11.51	11.74
	Chitosan	10.00	10.33	67.07	68.56	11.95	12.19
	Green miracle	11.33	11.67	70.32	71.75	12.62	12.87
Mean		10.00	10.44	67.12	68.49	12.03	12.27
Means of A-T							
	Without	12.67	13.11	73.17	74.48	13.08	13.34
	Chitosan	14.11	14.45	76.84	78.37	13.56	13.83
	Green miracle	15.22	15.56	79.40	80.91	14.34	14.63
LSD at 0.05							
	IRI	0.62	0.81	2.35	2.36	0.58	0.59
	A-T	0.92	1.07	1.66	1.76	0.41	0.42
	IRI × A-T	1.59	1.85	2.87	3.04	0.72	0.73

IRI: Irrigation intervals, IRI2: irrigation every 2 days, IRI4: irrigation every 4 days, IRI6: irrigation every 6 days, A-T: Anti-transpiration compounds.

The function of anti-transpiration in enhancing plant water use efficiency and stimulating growth in water-limited environments has been shown in many studies, Kocięcka et al. (2023) and Rida and El-Gedawey (2022) demonstrated that anti-transpiration could enhance the growth and yield of various plants by minimizing transpiration and maintaining higher tissue water content under drought stress. Similar results were reported by Abdullah et al. (2015) and Morsy and Mehanna (2022), who found that anti-transpiration improved the physiological performance and productivity of various crops under water deficit conditions. Irrigation intervals had a pronounced impact on the growth and flowering of *Echinacea purpurea* plants irrigated every two days exhibited the greatest plant height, number of branches, fresh and dry weight of herb, and number and weight of flowering heads. This is likely due to the continuous availability of water, which supports cell expansion, photosynthesis and nutrient transport, all of which are crucial for optimal plant growth and reproductive success.

3. Chemical Composition

Data in Table (3) reveal that the different irrigation interval treatments significantly influence the plant content of N, P, K and caffeic acid derivatives. The maximum plant percentage of N, P, K and caffeic acid derivatives was observed in the treatment of IRI2 in both seasons. Applying anti-transpiration compounds (chitosan and green miracle) led to a significant increase in N, P, K and caffeic acid derivatives contents in plants (Table 3).

In general, the highest and lowest N, P, K and caffeic acid derivatives values were obtained by the application of green miracle (3 cm/L) and no application (control), respectively, in both seasons. The effect of interaction between irrigation intervals and anti-transpiration compounds indicated that the highest values of a mineral percent of plant (N, P and K), and caffeic acid derivatives were obtained from IRI2 combined with green miracle (3 cm/L) in both seasons. The differences among treatments were significant in both growing seasons.

Treatment resulted in higher concentrations of N, P and K as well as caffeic acid derivatives compared to chitosan and the control treatment. This suggests that green miracle not only enhances plant growth but also improves nutrient uptake and the synthesis of secondary metabolites, which are essential for the medicinal properties of *Echinacea purpurea*. The results also show that frequent irrigation (IRI2) raises the amounts of N, P, K and caffeic acid derivatives in *Echinacea purpurea* by a large amount. Regarding the interaction between irrigation intervals and anti-transpiration, the best treatment was the combination of green miracle and IRI2 which resulted in the height values of previous parameters.

The continuous availability of water plays a crucial role in supporting nutrient solubilization and transport, providing the necessary conditions for optimal enzymatic activity involved in secondary metabolite synthesis, so the IRI2 treatment was the optimal irrigation treatment. These findings are consistent with other studies by Hassan et al. (2013) and Rioba et al. (2015) which

indicate that frequent irrigation is critical for maintaining high nutrient levels and promoting the synthesis of bioactive compounds in medicinal plants. Additionally, Haddou et al. (2023) demonstrated that optimal irrigation management could significantly enhance the accumulation of key metabolites in *Mentha piperita* plants, contributing to their medicinal value. The interaction between green miracle and IRI2 yielded the highest levels of N, P, K and caffeic acid derivatives, indicating a synergistic effect. This combination not only ensures optimal water availability but also enhances nutrient absorption and secondary metabolite production, leading to a higher medicinal quality of *Echinacea purpurea*.

Table (3). Effect of irrigation intervals and anti-transpiration compounds on N, P, K content and caffeic acid derivatives of *Echinacea purpurea* L. plant as an average of the two cuts during 2022 and 2023 seasons.

Treatments		N (%)		P (%)		K (%)		Caffeic acid derivatives (mg/g dry weight)	
IRI	**A-T**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
	Without	1.98	2.05	0.740	0.756	1.53	1.58	8.79	8.96
IRI2	Chitosan	2.17	2.25	0.802	0.826	1.68	1.71	9.10	9.25
	Green miracle	2.26	2.33	0.873	0.895	1.72	1.76	10.13	10.30
Mean		2.14	2.21	0.805	0.826	1.64	1.68	9.34	9.51
	Without	1.80	1.83	0.632	0.646	1.46	1.52	7.85	8.00
IRI4	Chitosan	1.86	1.91	0.673	0.690	1.58	1.60	8.17	8.32
	Green miracle	1.91	1.96	0.733	0.750	1.64	1.66	8.46	8.60
Mean		1.86	1.90	0.679	0.695	1.56	1.59	8.16	8.31
	Without	1.64	1.66	0.547	0.560	1.09	1.09	6.88	7.11
IRI6	Chitosan	1.71	1.76	0.613	0.625	1.25	1.27	7.12	7.28
	Green miracle	1.80	1.86	0.637	0.654	1.39	1.43	7.44	7.61
Mean		1.72	1.76	0.599	0.613	1.24	1.26	7.15	7.33
Means of A-T									
	Without	1.81	1.85	0.639	0.654	1.36	1.39	7.84	8.02
	Chitosan	1.91	1.97	0.696	0.713	1.50	1.53	8.13	8.28
	Green miracle	1.99	2.05	0.748	0.766	1.58	1.62	8.68	8.84
LSD at 0.05									
	IRI	0.10	0.07	0.001	0.041	0.06	0.07	0.27	0.28
	A-T	0.03	0.03	0.032	0.032	0.06	0.06	0.26	0.28
	IRI × A-T	0.06	0.06	0.056	0.056	0.10	0.10	0.44	0.49

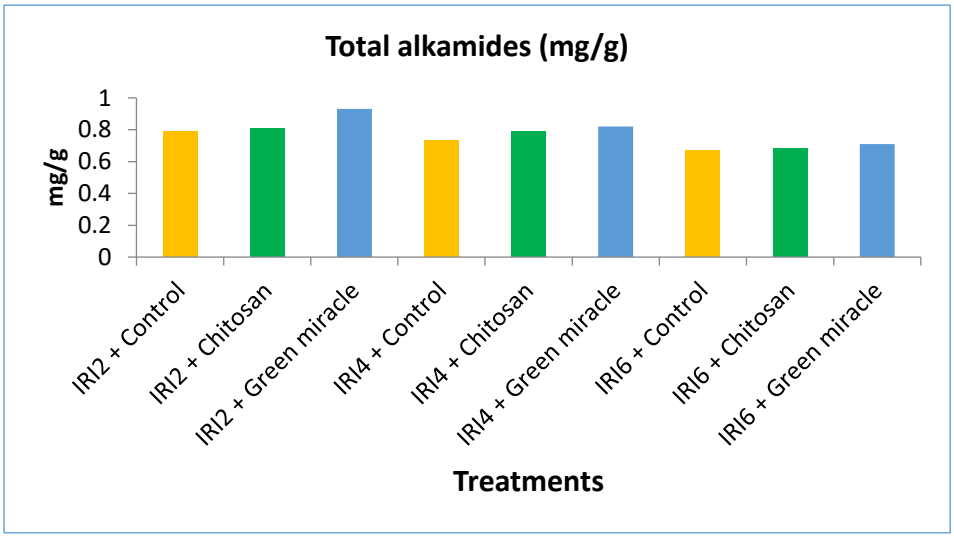
IRI: Irrigation intervals, IRI2: irrigation every 2 days, IRI4: irrigation every 4 days, IRI6: irrigation every 6 days, A-T: Anti-transpiration compounds.

The ability of green miracle to improve nutrient uptake may be due to its moisture retention capabilities, which facilitate the movement of nutrients into the plant's root system. Similarly, studies by Abou Dahab et al. (2010), Safaei et al. (2014), Kumar et al. (2020) and Kocięcka et al. (2023) showed

that anti-transpiration could enhance nutrient absorption and secondary metabolite production in drought-stressed plants.

4. Total Alkamides

Data in Fig. (1) indicate that the green miracle treatment consistently produced the highest total alkamides across all irrigation intervals, with values of 0.93 mg/g at IRI 2. While chitosan also contributed positively to total alkamides levels, its effectiveness was slightly lower than that of green miracle, with maximum values of 0.81 mg/g at IRI 2. In contrast, the control treatment showed the lowest concentrations, particularly at IRI 6 with only 0.67 mg/g, highlighting the potential benefits of utilizing anti-transpiration compounds. Overall, these findings suggest that optimizing irrigation intervals and incorporating anti-transpiration treatments can significantly enhance the phytochemical profile of *Echinacea purpurea*.



IRI2: irrigation every 2 days, IRI4: irrigation every 4 days, IRI6: irrigation every 6 days

Fig. (1). Effect of irrigation intervals and anti-transpiration compounds interaction treatments on total alkamides in dry aerial parts (mg/g dry weight) of *Echinacea purpurea* L. in the 2nd cut of the 2023 season.

CONCLUSION

In the present study, the effects of irrigation intervals and anti-transpiration compounds on *Echinacea purpurea* were investigated, and the results were examined regarding different vegetative parameters, flowering parameters and chemical composition. The foliar application of anti-transpiration compounds enhanced the tolerance of plants to water deficiency especially green miracle. The combination of irrigation interval every two days and green miracle was identified as the optimal treatment for maximizing growth, reproductive success

and nutrient content in *Echinacea purpurea*. This approach not only improves yield but also enhances the medicinal properties of the plant, making it highly recommended for cultivation in similar environments. The study emphasizes the importance of optimized irrigation and the use of anti-transpiration compounds for high-quality agricultural production of *Echinacea purpurea*.

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تأثير فترات الري المختلفة والمركبات المضادة للنتح في الإنتاجية والمكونات الكيميائية لنبات الإشناسيا

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إن التوسع السكاني وتغير المناخ وتقنيات إدارة المياه غير الفعالة تؤدي إلى تفاقم النقص الخطير في المياه في العالم، بالإضافة إلى تهديد الأمن الغذائي العالمي، هذا النقص يعرض سبل معيشة ملايين المزارعين حول العالم للخطر. أجريت هذه الدراسة خلال المواسم الصيفية لعام ٢٠٢٢ و٢٠٢٣ في محطة التجارب التابعة لمركز بحوث الصحراء في رأس سدر، محافظة جنوب سيناء، مصر. تهدف الدراسة الحالية إلى تقييم تأثير فترات الري المختلفة (٢، ٤ و٦ أيام) ومعاملات المركبات المضادة للنتح (الكنترول، الشيتوزان بتركيز ٣ سم^{٣}/لتر والجرين ميراكل بتركيز ٣ سم^{٣}/لتر) على الصفات الخضرية والزهرية والتركيب الكيميائي لنبات الإشناسيا (*Echinacea purpurea* L.). أشارت النتائج إلى أن فترة الري كل يومين كانت متفوقة على الفترات الأخرى في جميع صفات النبات الخضرية والزهرية والتركيب الكيميائي. كما أظهرت النباتات المعاملة بالشيتوزان أو الجرين ميراكل تحسنًا في جميع الصفات الخضرية والزهرية والتركيب الكيميائي، كانت معاملات الجرين ميراكل متفوقة على معاملات الشيتوزان بسبب تأثيرها الأكبر على جميع الخصائص المدروسة للنبات. يمكن الحصول على أعلى صفات للنمو، عدد الفروع، الكتلة الحيوية، محتوى العناصر الغذائية (نتروجين، فسفور وبوتاسيوم)، المحصول ومشتقات حامض الكافيين لنبات الإشناسيا من خلال الري كل يومين مع استخدام الجرين ميراكل (بتركيز ٣ سم^{٣}/لتر). تشير هذه النتائج إلى أن الري المتكرر بالتزامن مع المركبات المضادة للنتح، وخاصة الجرين ميراكل، يمكن أن يعزز بشكل كبير كل من النمو والجودة الطبية لنبات الإشناسيا.