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Natural extracts elevated drought resistance in *Iris tingitana* plant

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Abstract

A study was carried out for two seasons (2020/21 and 2021/22) to examine the effects of various natural extracts individually or in combination on the drought resistance of *Iris tingitana* cv. Wedgewood. A mixture of sand and clay (1:1 v/v) was prepared as a growth media. The treatments were (0, 25, and 50 % water drought) with liquid active biostimulants (garlic and seaweed) five times intervals after two weeks from bulb germination. The results revealed that plants at different soil moisture with various biostimulants succeeded in producing flowers of the best quality. Water drought at 25% also increased chlorophyll (a & b) and carotenoids in leaves, while drought at 0% recorded the highest increase in gibberellic acid (GA_3). At 25%, vegetative growth and flower parameters were at their highest levels (GA_3). Moreover, water drought at 50 % increased abscisic acid (ABA), proline, and catalase. Additionally, increases in vegetative growth, the number of leaves, flower parameters, chlorophyll (a & b), and carotenoids in leaves were noted as a result of applying seaweed extract at a concentration of 10 mL L^{-1}; however, the best results for gibberellic acid were obtained using the highest concentration of garlic extract (500 mL L^{-1}). The interactions between treatments indicated the superiority of growing bulbs at 25 % water drought with applying seaweed extracted at 10 mL L^{-1} that improved vegetative growth and most of the flower parameters. Meanwhile, treating plants at 25 % water drought with either seaweed at 5 mL L^{-1} or garlic extract at 500 mL L^{-1} realized the highest chlorophyll (a & b), carotenoids, and gibberellic acid.

Key words: *Iris tingitana*, seaweed extract, Garlic extract, water stress

Introduction

Irises (*Iris tingitana* cv. Wedgewood) and the family Iridaceae are ornamental bulbs, and more than 300 species are known. It has flowers in various shades of blue. It has pale blue veins flowers and generally has between 1 and 2 flowers on a stem. It is native to Africa and found in Morocco, Algeria and North Africa (Trinklein, 2014).

Understanding the impact of climate change on arable land is crucial for comprehending how plants react to drought, leading to a significant constraint on plant growth. As a result, the dry and hot summer risks plant growth and survival, creating relatively intense stress conditions (Medrano *et al.*, 2009). Global climate changes will impact water availability, especially in arid and semi-arid regions. Clean, high-quality water availability will decrease, particularly in major cities (Paz *et al.*, 2018; WWAP, 2014). This, in turn, will pose challenges in maintaining verdant spaces, given that water competition will emerge as a pivotal concern.

The abundance of ornamental and potentially ornamental species presents a greater opportunity to discover genotypes capable of withstanding drought stress. Such species can be valuable in landscaping planning as they exhibit adaptations such as increased root-to-shoot ratios, reduced growth, altered leaf anatomy, and decreased total leaf area in response to water scarcity (Toscano *et al.*, 2019). Water shortage may have positive benefits on growth control. Therefore, moderate drought stress can be a helpful tool to give plants a compact habit and slower growth, both parameters required for easier landscape management (Niu *et al.*, 2007). Plant drought stress is difficult to assess because the sensitivities and response times to water deficit vary among plant species and are related to the intensity and length of the water stress. Plant response to drought stress involves the interaction of various physiological and biochemical parameters that can be exploited as markers for the identification of tolerant species (Alvarez *et al.*, 2012)

The use of extracts of certain plants referred to as bio-stimulants, botanical activators, or botanicals, such as garlic and seaweed, improves the growth of crops, especially ornamental plants (Atowa, 2013). The effects in seaweed are due to the presence of hormones (plant growth regulators), which affect plants, increased plant root growth and yield, and chlorophyll content in plants (Khan *et al.*, 2009). It observed that the value of seaweeds as fertilizers was due not only to nitrogen, phosphorus, and potash content but also to trace elements and metabolites (Pise and Sabale, 2010).

Seaweed extract attenuated the harsh effects of drought, cold, and salinity stress, which is mediated through enhanced root morphology—this improved energy storage, metabolism, water adjustments, and the build-up of proline. The enhancement and priming effects of seaweed extracts on the plant's defences against both biotic and biotic stresses can be attributed to the chemical composition of the extracts as well as their eliciting properties (Ali *et al.*, 2021).

This study investigates the impact of drought and natural extracts (seaweed and garlic) individually or in combination on ornamental

Iris plants. The goal is to enhance plant growth without resorting to harmful chemical nutrients or synthetic regulators, promoting environmentally safe and clean plant cultivation.

Materials and methods

A nursery experiment was conducted during two seasons (2020/21 and 2021/22) at Horticulture Res. Inst., Agric. Res. Center and Fac. of African Postgraduate Studies, Cairo University, Egypt. It aims to study the individual or the combination of a different natural extract of garlic and seaweed to increase the drought resistance of iris plants (*I. tingitana* cv. Wedgewood).

Plant materials: Original bulbs from the nursery of Horticulture Res. Inst. (8-9 cm circumference) were selected on May 15th in both seasons. A mixture of sand and clay (1:1, v/v) was prepared as a growth media for planting.

Natural extracts preparation of garlic (*Allium sativum*): To prepare the treatment solution, 500 g of finely chopped garlic cloves were soaked in a solution of 100 mL 95% ethyl alcohol and 400 mL water for 3 hours. The mixture was then filtered and adjusted to a final volume of 1 litre, which served as the stock solution. The solution was applied via irrigation at a rate of 250 or 500 mL per litre of water, with four applications made every 15 days at 9 AM.

Seaweed extract was obtained from Soil, Water and Environment Research Institute (SWERI), which is a mixture of different types of algae and contains some amino acids and hormones. It was applied with 5 and 10 mL L^{-1} irrigation at 9 AM four times at 15-day intervals.

Experiment description: The bulbs were lifted on May 15th in both seasons. After examining and cleaning, bulbs of 8-9 cm circumference were selected and kept at room temperature of 26 - 28±3 °C from May till October. One month after planting (October 15th), the bulbs were divided into three groups for drought stress treatments (0, 25, and 50 % water drought). To assess the influence of distinct soil additives on cultivated bulbs, the experimental groups were subdivided into four distinct sets: those treated with 5 and 10 mL per liter pot of seaweed extract, as well as 250 and 500 mL per liter pot of garlic extract, alongside a control group of untreated plants. Consequently, a total of 45 pots were utilized, incorporating three levels of drought stress, five different soil additives, and three replicates for each experimental condition.

Regular agricultural practices, such as watering, weeding, etc., were carried out whenever needed. Foliar application of Kristalon (N:P:K 20:20:20) obtained from Agricultural Research Center at a rate of 1g L^{-1} was practised three times at 30-day intervals at 9 AM starting from September 15th as regular care in both seasons.

Parameters *viz.*, vegetative growth height, leaves number/plant at flowering stage, flowering date, spike stem length and diameter, fresh spike weight, fresh bulb weight, bulb circumference, bulb yield/plot, bulblet fresh weight, and bulblets yield) were recorded.

Chemical analysis

Pigment content: Determinations of chlorophyll a, b, and carotenoids in fresh leaves were carried out according to Wettstein (1957).

Free proline content: The amount of free proline (Pro) in the fresh plant was determined as reported by Ahmad *et al.* (2008) with slight adjustments.

Phytohormones: Indole acetic acid (IAA), gibberellic acid (GA_3), and abscisic acid (ABA) were analyzed using GLC (Varien Vesta, 6000). Extraction and estimation of endogenous phytohormones were carried out following the method (Ünyayar *et al.*, 1996).

Catalase: Catalase activity was determined following the method of Aebi (1984) and modified by Jaleel *et al.* (2007).

Water drought determination: A pot was filled with 1 kg of dry soil (80 °C for 48 h), then water was poured until saturation. After 24 h, the pot was weighed; the difference between the wet and dry weight means the maximum volume of water held in the soil, representing 100 % of field capacity.

Statistical analysis: The data was subjected to statistical analysis using the ASSISTAT program, and means were compared by LSD (Silva and Azevedo, 2009).

Results

Effect of different water drought and soil additives on vegetative growth: Data (Table 1) revealed the superiority of growing bulbs at 25 % water drought that elevates vegetative

Table 1. Effect of water drought, natural extract fertilization, and their interaction on plant height (cm) and Leaves number/ plant of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022)

Soil additive (A)	Water drought (B)															
	Plant height (cm)								Leaves number/ plant							
	1st season				2nd season				1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	79.11	76.07	72.08	75.75	81.3	78.21	74.1	77.87	3.3	4.3	3.2	3.6	3.5	4.5	3.4	3.8
5 mL L^{-1} SW	87.12	88.2	82.34	85.89	88.21	90.52	84.43	87.72	4.5	5.4	4.2	4.7	4.8	5.7	4.6	5
10 mL L^{-1} SW	94.14	95.4	89.33	92.96	96.28	97.55	91.5	95.11	5.6	6.2	5.3	5.7	5.8	6.7	5.5	6
250 mL L^{-1} GAR	88.22	90.63	86.36	88.27	90.22	92.43	87.4	90.02	4.4	5.7	4.2	4.8	4.6	5.9	4.4	4.9
500 mL L^{-1} GAR	86.29	87.52	83.31	85.63	87.18	89.46	85.23	87.29	4.6	5.5	5.3	5.1	4.8	5.7	5.5	5.3
Mean	86.98	87.57	82.68		88.64	89.63	84.73		4.5	5.4	4.4		4.7	5.8	4.7	
*LSD at 0.05																
A				2.388				2.892				N.S				N.S
B				3.258				3.566				N.S				N.S
A×B				5.247				5.459				N.S				N.S

growth (height) at a flowering time followed by 0 and 50 % water drought during both seasons.

Treating plants with seaweed extract at 10 mL L^{-1} achieved the highest increase in vegetative growth height, followed by plants treated with the highest garlic extract 250 mL L^{-1} and the least one was noticed for untreated bulbs during both seasons. The interactions among soil additives and field capacity realized the prevalence of growing bulbs at 25 % water drought by applying 10 mL L^{-1} seaweed extract. This treatment elevated the vegetative growth height at the flowering time, giving the highest values in both seasons. On the contrary, undesirable effects were recorded on such traits in the bulbs planted at 0 or 50 % water drought with the highest concentration of seaweed extract 10 mL L^{-1}. On the other hand, number of leaves per plant was insignificantly affected by the different water drought, seaweed extract levels and interaction treatments during both seasons.

Effect of different water drought and soil additives on flowering: Water drought at 25 % increased the time required from planting bulbs to flowering compared 0 or 50 % water drought with a significant effect during both seasons (Tables 2 and 3). However, such a result caused a pronounced prolongation in the flowering season. On the other side, applying seaweed extract at 10 mL L^{-1} significantly induced flowering earlier than the control in both seasons.

On the other hand, marked influences were detected in the time required for flowering due to the interactions. The earliest flowering was obtained from plants grown in a water drought of 25 % with seaweed extract 10 mL L^{-1}. Meanwhile, plants grown in field capacity with seaweed extract prolonged the time required for flowering.

Improved results in most cases were scored on some flowering traits (Tables 2 and 3) due to water drought of 25 % in plantation; it elevated flowering date, spike stem length, spike stem diameter, and fresh weight of cut spike than that gained from other water drought used in cultivation.

The effect of seaweed extract is evident from data presented in Tables 2 and 3 and indicates the superiority of applying seaweed extract at 10 mL L^{-1} for improving most flower traits in both seasons. This treatment caused a clear increment in flowering date, spike stem length, spike stem diameter, and fresh weight of the cut spike followed by garlic extract 500 mL L^{-1}.

Numerous studies have underscored the substantial impact of seaweed extract on various flower traits. In support of these findings. Furthermore, insightful interactions demonstrated the efficacy of introducing a 25% water drought in plantations while applying seaweed extract at 10 mL L^{-1}, positively influencing multiple flower parameters. This treatment not only advanced the flowering date but also enhanced spike stem length and diameter.

Conversely, the utilization of garlic extract at a concentration of 500 mL L^{-1}, coupled with plants exposed to a 25% water drought, resulted in a notable increase in the fresh weight of the cut spike. These findings highlight the nuanced effects of different extracts and environmental conditions on flower characteristics, providing valuable insights for optimizing cultivation practices.

Chemical constituents

Pigment content in leaves: Different trends in leaf pigment content were observed as a result of different water droughts conditions. At water drought (25%) in both seasons higher chlorophyll accumulation in leaves was observed. In terms of the effect of seaweed extract, data shown in (Table 4) demonstrate the advantage of using the highest seaweed extract (10 mL L^{-1}) for increasing chlorophyll accumulation in leaves in both seasons.

In terms of interactions, the data show that different trends in constituents (chlorophyll a, b and carotenoids) were observed as a result of interactions between the various factors studied in this regard. The highest chlorophyll a accumulation in leaves were obtained after treating plants grown in 25% water drought with either seaweed extract at 10 mL L^{-1}or garlic extract at 250 mL L^{-1}.

In contrast, insignificant effects on chlorophyll b and carotenoids were observed in treatments with natural extracts, water drought, or interactions between different water drought and seaweed extract levels in both seasons (Tables 4 and 5).

Gibberellic acid and abscisic acid content in leaves (mg/g f.w.): It is evident from the data that growing plants at a water drought

Table 2. Effect of water drought, natural extract fertilization, and their interaction on number of days to flowering and spike stem length (cm) of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022)

Soil additive (A)	Water drought (B)															
	Number of days to flowering								Spike stem length (cm)							
	1st season				2nd season				1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	142.00	141.60	142.30	142.00	145.30	144.10	146.20	145.20	52.12	49.05	45.02	48.73	53.21	50.15	46.10	49.82
5 mL L^{-1} SW	135.00	133.60	139.00	135.90	138.20	136.20	144.70	139.70	60.18	62.31	54.18	58.89	61.22	63.50	55.30	60.00
10 mL L^{-1} SW	131.30	129.60	136.00	132.30	132.50	131.30	140.50	134.70	64.33	65.50	59.20	63.01	65.52	66.76	60.42	64.23
250 mL L^{-1} GAR	134.00	134.30	138.10	135.50	138.50	135.80	142.10	138.80	62.61	63.22	57.28	61.04	63.70	64.50	58.47	62.22
500 mL L^{-1} GAR	132.00	130.20	137.70	133.30	137.70	134.50	141.30	137.90	58.23	60.20	56.33	58.25	59.40	61.43	57.53	59.45
Mean	134.80	133.90	138.60		138.40	136.40	143.00		59.59	60.06	54.40		60.61	61.27	55.56	
*LSD at 0.05																
A				2.37				2.56				1.52				1.73
B				3.58				3.80				1.84				2.02
A×B				5.66				6.05				3.06				3.55

Table 3. Effect of water drought, natural extract fertilization, and their interaction on spike stem diameter (mm) and fresh weight of cut spike (g) of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022)

Soil additive (A)	Water drought (B)															
	Spike stem diameter (mm)								Fresh weight of cut spike (g)							
	1st season				2nd season				1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	0.67	0.65	0.63	0.65	0.7	0.67	0.64	0.67	25.3	24.11	22.8	24.07	26.11	25.08	24.1	25.1
5 mL L^{-1} SW	0.70	0.72	0.71	0.71	0.72	0.74	0.73	0.73	26.12	27.7	24.9	26.24	27.30	28.3	26.5	27.37
10 mL L^{-1} SW	0.84	0.86	0.76	0.82	0.86	0.88	0.78	0.84	27.82	33.52	28.07	29.8	29.11	35.18	30.12	31.69
250 mL L^{-1} GAR	0.71	0.78	0.75	0.75	0.73	0.8	0.77	0.77	28.53	34.25	26.3	29.69	30.48	36.31	31.27	31.47
500 mL L^{-1} GAR	0.68	0.75	0.73	0.72	0.71	0.77	0.75	0.74	30.84	36.16	31.42	32.81	32.37	38.25	33.21	34.61
Mean	0.73	0.75	0.72		0.74	0.77	0.73		27.72	31.15	26.7		29.27	32.63	29.04	
*LSD at 0.05																
A				N.S				N.S				1.33				1.63
B				N.S				N.S				1.56				1.89
A×B				N.S				N.S				3.34				3.75

Table 4. Effect of water drought, natural extract fertilization, and their interaction on chlorophyll a and b number/ plant of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022)

Soil additive (A)	Water drought (B)															
	Chlorophyll a								Chlorophyll b							
	1st season				2nd season				1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	0.43	0.42	0.35	0.40	0.50	0.48	0.42	0.47	0.22	0.21	0.19	0.20	0.25	0.23	0.22	0.23
5 mL L^{-1} SW	0.69	0.82	0.49	0.67	0.80	0.87	0.54	0.87	0.34	0.47	0.33	0.38	0.38	0.50	0.37	0.42
10 mL L^{-1} SW	0.75	0.93	0.74	0.81	0.74	0.98	0.80	0.72	0.33	0.35	0.25	0.31	0.37	0.41	0.38	0.39
250 mL L^{-1} GAR	0.78	0.84	0.56	0.73	0.82	0.90	0.61	0.78	0.28	0.30	0.26	0.28	0.32	0.34	0.30	0.32
500 mL L^{-1} GAR	0.74	0.59	0.46	0.60	0.79	0.64	0.52	0.65	0.24	0.38	0.23	0.29	0.29	0.43	0.28	0.33
Mean	0.68	0.72	0.52		0.73	0.77	0.58		0.28	0.34	0.25		0.32	0.38	0.31	
*LSD at 0.05																
A				0.135				0.15				N.S				N.S
B				0.252				0.278				N.S				N.S
A×B				0.309				0.351				N.S				N.S

Table 5. Effect of water drought, natural extract fertilization and their interaction on carotenoids of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022)

Soil additive (A)	Water drought (B)							
	Carotenoids							
	1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	0.37	0.35	0.33	0.35	0.41	0.39	0.37	0.39
5 mL L^{-1} SW	0.63	0.62	0.89	0.71	0.67	0.66	0.93	0.75
10 mL L^{-1} SW	0.60	0.74	0.49	0.63	0.65	0.78	0.54	0.66
250 mL L^{-1} GAR	0.64	0.72	0.47	0.61	0.68	0.76	0.53	0.65
500 mL L^{-1} GAR	0.68	0.88	0.45	0.67	0.73	0.90	0.50	0.71
Mean	0.58	0.66	0.53		0.63	0.70	0.57	
*LSD at 0.05								
A				N.S				N.S
B				N.S				N.S
A×B				N.S				N.S

of 0 % gave rise to the highest GA_3 content in both seasons (Table 6). ABA content was significantly affected by the different water droughts 50 % used. On the other hand, GA_3 was significantly affected by garlic extract 500 mL L^{-1}. Untreated plants insignificantly increased ABA. On the other hand, the interactions revealed the favourable combined effect between either water drought of 0 or 25 % and seaweed extract treatment at 10 mL L^{-1} for raising GA_3 content in both seasons. Water drought of 50 % with seaweed extract at 5 mL L^{-1} increased ABA.

Proline and catalase content in leaves (mg/g f.w.): It is evident from the data (Table 7) that growing plants at a water drought of 50 % gave rise to the highest proline and catalase contents in both seasons. On the other hand, proline and catalase contents were significantly affected by the seaweed extracts 10 mL L^{-1}. On the other hand, the interactions revealed the favourable combined effect at water drought of 50 % and either seaweed extract

Table 6. Effect of water drought, natural extract fertilization, and their interaction on GA_3 and ABA of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022

Soil additive (A)	Water drought (B)															
	GA_3								ABA							
	1st season				2nd season				1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	4.688	3.449	2.425	3.521	4.719	3.517	2.411	3.549	0.921	1.035	1.181	1.107	0.848	1.051	1.177	1.025
5 mL L^{-1} SW	3.306	2.849	2.563	2.906	3.325	2.879	2.581	2.928	1.023	1.11	1.289	1.246	1.021	1.108	1.18	1.103
10 mL L^{-1} SW	5.006	4.839	4.073	4.639	5.203	5.012	4.054	4.69	0.911	0.901	1.079	0.964	0.916	0.909	1.073	0.966
250 mL L^{-1} GAR	3.552	2.905	2.866	3.108	3.679	3.077	2.895	3.117	0.913	0.91	0.903	0.908	0.911	0.911	0.907	0.91
500 mL L^{-1} GAR	5.206	5.224	4.215	4.882	5.287	5.299	4.261	4.949	0.91	0.867	0.907	0.895	0.912	0.902	0.905	0.906
Mean	4.352	3.853	3.229		4.343	3.937	3.2		0.936	0.965	1.172		0.862	0.976	1.208	
*LSD at 0.05																
A				0.425				0.47				0.521				0.608
B				0.912				0.952				0.802				0.878
A×B				1.423				1.514				1.165				1.388

Table 7. Effect of field capacity, natural extract fertilization, and their interaction on proline and catalase of *Iris tingitana* cv. Wedgewood during the two seasons (2020/2021 and 2021/2022)

Soil additive (A)	Water drought (B)															
	Proline								Catalase							
	1st season				2nd season				1st season				2nd season			
	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean	0%	25%	50%	Mean
Control	9.10	8.82	9.65	9.19	8.77	8.63	9.54	8.98	42.50	40.41	44.80	42.57	41.22	39.79	45.10	42.03
5 mL L^{-1} SW	9.52	10.05	11.31	10.29	9.49	10.04	11.49	10.34	46.11	48.20	50.43	48.25	45.09	48.30	50.38	47.92
10 mL L^{-1} SW	9.87	10.71	12.61	11.07	8.58	10.86	12.55	10.70	48.70	54.77	58.29	53.92	44.91	52.80	56.30	51.34
250 mL L^{-1} GAR	9.72	10.61	11.98	10.77	9.26	10.57	12.26	10.69	49.31	51.90	55.11	52.11	49.27	49.88	52.80	50.65
500 mL L^{-1} GAR	9.46	9.55	10.88	9.96	9.58	9.54	10.79	9.97	44.10	45.10	50.77	46.66	44.20	43.08	51.66	46.31
Mean	9.54	9.95	11.29		9.13	9.93	11.33		46.14	48.08	51.88		44.94	46.77	51.25	
*LSD at 0.05																
A				0.56				0.61				3.28				3.60
B				0.86				0.92				5.05				5.42

treatment of 10 mL L^{-1} or garlic extract 250 mL L^{-1} for raising proline and catalase contents in both seasons.

Discussion

The ability of the natural extracts to resist water drought was investigated in the study, as it was discovered that the plant tolerates water drought up to a certain point, after which it begins to deteriorate. Atif Riaz *et al.* (2013) found in *Tagetes erecta* that 70 % field capacity is acceptable to maintain plant quality to plant height. Toscano *et al.* (2018) recorded a favourable effect of using 50 % field capacity in the plantation of *Lantana* and *Ligustrum sp.* They applied 25, 50, 75 and 100 % field capacity and realized a reduction in vegetative growth at 25 and 50 % field capacity. Therefore, natural seaweed and garlic extract balance the harmful effect of water stress on plants, which has been found to increase plant resistance and sometimes growth and flowering parameters with specific concentrations. According to Kularathne *et al.* (2021), the application of seaweed extract resulted in increased growth of *Begonia* sp. and improved plant height and quality of *Polyanthas gracilis* and *Narcissus tazetta*. Similarly, Al-Saad (2020) observed that the addition of 2 g of seaweed extract (*Ascophyllum nodosum*) to the soil significantly affected all parameters in the *Gladiolus* hybrid, resulting in improved vegetative growth and flowering. Attia *et al.* (2020) also obtained positive results in *Hedychium coronarium* with the application of seaweed extract, indicating its potential as a growth enhancer. The chemical constituents present in leaves, such as chlorophyll a, b, and carotenoids, were studied in the context of interaction treatments involving a 25% water drought and seaweed extract at 10 mL L^{-1}. However, proline and catalase exhibited a similar interaction pattern, albeit with a subtle distinction: the highest recorded results were observed when subjected to a 50% water drought, as documented by Dghim et al. (2018) for *Periploca angustifolia*.

Treatments involving GA_3 without water drought and seaweed extract at 10 mL L^{-1}, as well as ABA treatment with a 50% water drought and seaweed extract at 5 mL L^{-1}, demonstrated increased levels of these chemical constituents in leaves.

The investigation unveiled that the application of seaweed extracts at a concentration of 10 mL L^{-1}, administered as soil drenches five times at 15-day intervals from two weeks post-bulb germination to the onset of flowering, significantly enhanced both vegetative growth and flower parameters in *I. tingitana* cv. Wedgewood plants subjected to a 25% water drought. Similarly, the utilization of garlic extract at a concentration of 500 mL L^{-1}, applied as soil drenches five times at 15-day intervals during the same period, led to notable improvements in overall plant traits.

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