Seasonal variation in Photosynthetic Pigments, Phytohormones, and phenols of Teucrium Polium L. Growing in Wadi Halazien, Egypt

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ABSTRACT

Teucrium polium L. known popularly as felty germander, is a perennial plant that grows in the dry climate of the Mediterranean region. It's a seasonal dimorphic plant, and it appears quite different in the winter than it does in the summer. The plant's apparent seasonal transformation reflects its adaptability to the stressful climatic conditions prevailing in winter or summer. Thus, this study aimed to investigate the effect of seasonal changes on photosynthetic pigments, phytohormones, and phenols of *Teucrium polium* L. that grows in Egypt. Results showed that the content of chlorophyll was significantly decreased in summer, while the content of carotenoids were significantly increased with stress. Production of some organic compounds was significantly affected by seasons and significantly increased under stress conditions in the summer. In conclusion, the tolerance of *Teucrium polium* L. to stress conditions was closely associated with the production of organic compounds, such as carbohydrates, proline, and phenolic compounds. Total carbohydrates and proline were the main active components in the osmotic potential (Ψs) in *Teucrium polium* L. In the dry season, *Teucrium polium* L. exhibited the accumulation of Abscisic acid (ABA), which may alleviate the inhibitory effect of salinity on photosynthesis. Higher values of phenols, carotenoids, and proline under stress conditions may improve tolerance of *Teucrium polium* L. to oxidative stress and help in scavenging the free radicals under stress conditions. Further studies are recommended to investigate the possibility of increasing the resistance of economic crops to drought and/or salinity stress by increasing the synthesis of osmotically active solutes through genetic engineering techniques.

Keywords: Phytohormones, phenolic compounds, proline, stress, Teucrium polium.

INTRODUCTION

The Mediterranean Basin was considered a hotspot region of global biodiversity (Cuttelod *et al.*, 2009). There is a great number of flowering plants that grow in this region due to the variation in habitat and climatic conditions (Médail, 2017). Although the soil in this region is classified as poor soil with low fertility, Mediterranean plants could survive in different ecological conditions.

Many plants when are stressed by drought, they exhibit different responses to improve the uptake of water. The early response to stress conditions includes the closure of stomata, a decrease in vegetative growth, and a photosynthetic rate (Lawlor and Tezara, 2009 and Chaves *et al.*, 2009). The most adaptive mechanism in desert plants to withdraw water from the soil is an osmotic adjustment, which helps to maintain plant water potential lower than the surrounding medium**.** Osmotic adjustment helps maintain cell swelling by accumulating solutes that help in reducing the negative effects of water stress in most of the phenological stages of crop growth. (Subbarao *et al.*, 2000). Mediterranean plants are often exposed to varying soil conditions, as a result of the drying of the soil in hot summers and it's re-wetting in moist winters.

The genus *Teucrium* belongs to the family of Lamiaceae. This family is well represented in the Mediterranean area and in Britain It includes 200 genera and 3300 species: aromatic, annual, or perennial herbs or under shrubs (Evans, 2009). Species of the genus *Teucrium* are rich in essential oils, saponins, sterols, phenols, flavonoids, alkaloids (Karamanoli *et al.*, 2000), and fatty acids (Bakari *et al.*, 2015). These compounds have been known for their effects on plant defense activities (Harborne *et al.*, 1986).

Teucrium polium is a seasonally dimorphic plant, which appears quite differently in winter and summer (Djabou *et al.*, 2012). The apparent seasonal transformation of the plant reflects its adaptation to the stressful climatic conditions prevailing in winter or summer. Investigating the adaptation mechanism of naturally adapted plants can help identify metabolic products associated with improved performance under drought stress. Therefore, this study aimed to investigate the effect of seasonal changes on photosynthetic pigments, phytohormones, and phenols of *Teucrium polium* L. growing in wadi Halazien, Egypt.

MATERIALS AND METHODS

Materials

Plant material

Arial parts of the *Teucrium polium* L. plant were collected from Wadi Halazien, Northwest coast at Matrouh Governorate, Egypt in February and July 2016. In the herbarium of Desert Research Center, the plant was authenticated and identified.

Reagents and chemicals

Reagents and chemicals that used in this study were ethanol, methanol, acetone, NaOH, HCl (ADWIC, Egypt), sulfosalicylic acid (Techno Pharm Chem, India), Folin reagent (Alpha Chemica, India), Gallic acid, quercetin and ascorbic acid (Sigma-Aldrich, Germany).

Ecological studies

Climatic Factors:

The Meteorological data of temperature and rainfall were obtained from the Applied Agricultural Meteorological Laboratory, Desert Research Center (DRC) during the study period.

Soil analysis:

Soil samples were collected from two depths (0-20 cm) and (20-40 cm) in Wadi Halazien. The physical properties of soil including electrical conductivity (EC) and pH of the soil-water suspension (1:2.5) were determined according to (Gee and Bauder, 1986). The contents of Na and K in the soil solution were measured using a flame photometer (Jenway, PFP-7), while Chloride (Cl) content was determined acceding to (Jackson, 1967). The concentrations of carbonate (CO_3) and bicarbonate ions (HCO_3), magnesium (Mg), and calcium (Ca) in the soil solution were determined according to (Rowell, 1994).

Physiological studies

Plant water content

The percentage of plant water content (WC) was estimated according to the method described by (Rybak-Chmielewska, 2003).

$$\text{Plant water content (\%)} = \frac{\text{Fresh wt.} - \text{Dry wt.}}{\text{Dry wt.}} \times 100$$

Determination of inorganic (ash) and organic matters

A known weight of the dried sample (2g) was weighed in a porcelain crucible and placed in a temperature-controlled muffle furnace at 550°C for 6 hrs. until a constant weight was obtained. The percentage of ash was calculated on a dry weight basis according to (Momin and Kadam 2011) then Organic matter and Ash contents were calculated according to the following equations:

The organic matter content = (wt. of crucible + plant sample) - (wt. of the crucible + plant ash)

$$\text{The organic matter (\%)} = \frac{\text{wt. of organic matter}}{\text{wt. of dry plant}} \times 100$$

Ash content = (wt. of crucible + plant ash) – wt. of empty crucible

$$\text{Ash (\%)} = \frac{\text{wt. of ash}}{\text{wt. of dry plant}} \times 100$$

Determination of photosynthesis pigments

The concentrations of chlorophyll-a (Chl.a), chlorophyll-b (Chl.b), and carotenoids were determined according to (Sumanta *et al.*, 2014). Half gram of fresh leaf was homogenized with 10 ml of 80% Acetone and then centrifuged for 15 min at 10,000 rpm at 40°C.4.5 ml of solvent that was mixed with 0.5ml of the resulting supernatant. Absorbance was read at 663, 644, and 452.5 nm using (Unicam UV300 spectrophotometer). The content of Chlorophyll-a, Chlorophyll-b, and Carotenoids were calculated according to the following equations:

$$\text{Chl.a} = 12.25\ A663.2 - 2.79\ A646.8$$

$$\text{Chl.b} = 21.5\ A646.8 - 5.1\ A663.2$$

$$C\ (x+c) = (1000A470 - 1.82\ \text{Chl.a} - 85.02\ \text{Chl.b}) / 198$$

Where: A = Absorbance, Chl.a = chlorophyll a, Chl.b = chlorophyll b, and C (x+c) = carotenoids. The results were expressed as (μg/g).

Plant Chemical Analysis

Preparation of samples

The aerial parts of plant samples were dried in the oven at 60 °C and ground to a fine powder, then subjected to chemical analyses.

Mineral Analysis

The dried samples (0.5g) were digested with 10ml concentrated sulfuric acid and 2-4 ml of perchloric acid. The mixture was heated until the mixture become clear. The solution was allowed to cool, then diluted with distilled water to 100ml and used for mineral analysis (Baker and Smith, 1974). The contents of Ca, Mg, K, and Na in this solution were determined according to (Rowell, 1994). Whereas the contents of P and Cl were determined in the ashed powder, that resulted from ashing the dry plant in porcelain crucibles for 4-6 hours in a muffle furnace at 550, part of ashed powder was used to measure the content of phosphorus by using phosphomolybdate methods (Rowell, 1994). While the other part was used to measure chloride content according to (Jackson and Thomas, 1960). The nitrogen (N) content of the sample was determined according to (Kjeldahl, 1983) and crude protein was calculated by multiplying the total content of nitrogen with the traditional conversion factor of 6.25 (James, 1995).

Determination of total Carbohydrates

The total carbohydrates content was determined according to phenol–sulfuric acid assay (Buysse and Merck, 1993). 0.3 gm of plant powder was dissolved in 10ml of 3%HCl to extract total carbohydrates and heated for a period of 2-5 hrs at 100 ˚C in a sealed tube. Glucose was used as standard.

Determination of free proline

The proline content was determined according to (Bates et al., 1973). A known weight of dried samples (0.5gm) was homogenized in 10 ml of 30% sulfosalicylic acid, the homogenate was centrifuged and the supernatant was combined. Two ml of the filtrate was mixed with an equal volume of acetic acid ninhydrin reagent and incubated for 1hour at 100 °C. The reaction was stopped by incubating the tube in an ice bath and extracted with 4ml toluene. After 50min the light absorption of the toluene phase was estimated at 520nm. Proline concentration was determined using a standard curve of L-proline.

Determination of plant phytohormones

The plant hormones: gibberellic acid (GA), indole acidic acid (IAA), abscisic acid (ABA), and Zeatin were determined by reversed-phase high-performance liquid chromatography (HPLC) (Kelen *et al.,* 2004).

Extraction procedure

Ten grams of fresh plant sample were homogenized in 70% methanol and stirred at 4°C overnight. The extract was filtered and evaporated under a vacuum. 0.1M phosphate buffer was used to adjust the aqueous phase pH was adjusted to 8.5 and partitioned twice using ethyl acetate. The phase of ethyl acetate was discarded, and the aqueous phase pH was adjusted to 2.5 using 1N hydrochloric acid (HCl). The extract of phytohormones was partitioned three times with diethyl ether. Then the phase of diethyl ether was dried under vacuum, then dissolved in 1 ml methanol, and stored at 4 °C for further analysis. The extracted phytohormones were analyzed by HPLC (Shimadzu) on reverse phase C18 column (250 x 4.60mm) at the temperature of 25 °C. Separation and quantitation were carried out with a mobile phase of acetonitrile: water (26: 74) and 30mM phosphoric acid. The pH was adjusted to 4 using 1N sodium hydroxide acid. A constant flow rate of 0.4 mL/min was used for analyte separation and the elution of the phytohormones at 208, 265, 270, and 280 nm (Kelen *et al.,* 2004).

Determination of total phenolic content

The content of total phenolics was determined using the Folin–Ciocalteu method as described by (Attard, 2013). Phenolic compounds were extracted by dissolving 2 grams of plant sample in 100ml of 80% ethanol. In a 96-well microplate, 10 µL of the sample was mixed with 100 µL of (1:10) diluted reagent of Folin-Ciocalteu and kept in dark for 20 minutes after adding 80 µL of 4 N Na_2CO_3. At the end of incubation time, the absorbance of the blue complex color was measured at 630 nm. The results were expressed as milligrams gallic acid equivalent per gram dry weight (mg GAE/g DW).

Statistical analysis

The statistical differences among means were conducted in triplicates. SPSS software (19.0, SPSS Inc. Chicago, IL, USA) was used to analyze the data. Duncan's test (at 5% level of probability, $p < 0.05$) was used to evaluate the statistical differences among means.

RESULTS AND DISCUSSIONS

Plant description

Teucrium polium L. Fig.1, is a shrublets with racemose or head-like terminal inflorescences and small leaves. Corolla white, pale mauve, or greenish-yellow, with all the 5 lobes joined into a lower limb. Stem white-felty, but shrubby only at base, branches softer herbaceous, leaves typically revolute-margined, heads 10-15 mm. across. plant continuing to live from year to year; here in the sense of herbaceous plants (perennial). Distributed in the mountains, hills, and deserts of the Mediterranean regions and considered one of the most useful traditional medicinal plants in Egypt, Palestine, and other Middle Eastern countries (Tackholm, 1974).

Description of the study area and climatic data

Wadi Halazien is a rocky wadi located at the Northwest coast of Matrouh Governorate, Egypt at a distance of about 40 km west of Matrouh city at latitudes of 31° 25' 21'' N and longitudes of 26° 51' 43'' E. Egypt's northern coast region extends around 1000 kilometers along the Mediterranean Sea and 30 kilometers inland (Tilbury, 1995) and highly variable environmental conditions from extremely low to high temperatures. These episodic variations in temperature significantly affect the medicinal properties of the plants. The distribution of main annual rainfall in Egypt shows a maximum rate over the Mediterranean coast with a rapid decrease toward the south.

As shown in table 1 average annual rainfall was 150 mm/year. The dry period extended to six months (from April to September). The driest month is July. There is 0 mm of precipitation in July. Most precipitation falls in January, with an average of 36 mm. The average high temperature during winter fluctuated between 18-20 °C, the average temperature is 13.1 °C in January. The highest average temperature of 25.3 °C was recorded in August, as it is considered the warmest month.

Soil physical and chemical properties

Physicochemical characters of Wadi Halazein soils were represented in table 2. The soil texture was loamy sand in the first depth (0-20 cm) and loam in the second depth (20-40 cm). The percentages of sand, silt, and clay in the first depth were (80.63 %, 16.67 %, and 2.70 %, respectively), while in the second depth, their percentages were 46.45 %, 41.30 %, and 12.25 %, respectively. The percentage of soil moisture content at first depth was 5.65 % in the winter season and 2.80% in the summer season and slightly increased to 6.25% and 3.56%, respectively.

The high content of soil moisture in the second depth may be due to the high value of rainfall during winter and high water-holding capacities as a result of high silt and clay contents.

As shown in table 3, the pH values fluctuated in the basic range. Generally, no significant differences in soil pH due to depth changes were noticed. The lowest pH value of (8.44) was recorded in the second depth and the highest value of (8.80) in the first depth. Electric conductivity values were (1.02 dsm and 3.36 ds/m) in first and second depths, respectively. The highest values of calcium (4.85 meq^{-1}), magnesium (5.15 meq^{-1}), and sodium (21.84 meq^{-1}) were detected in the second depth when compared with the first depth, while the highest value of potassium was in the first depth. The content of bicarbonate was 1.94 and 1.60 meq^{-1}, while the percentage of total calcium carbonate ($CaCO_3$) was 26.75% in the first depth and 27.50% in the second depth. The presence of high percentages of silt and clay particles makes carbonate more active, which may cause a decrease in the availability of phosphorus, manganese, copper, and zinc (Moore, 2004).

According to (Poodeh and Mojri, 2012), the presence of an excessive amount of salts resulted in salinity, the salts that cause salinity are generally chloride, sodium, calcium, and magnesium. These salts affect plant growth by decreasing the osmotic potential of soil, which leads to a decrease in plant water uptake.

Effect of season on photosynthetic pigments

As shown in table 4 and Fig.2, under stress conditions in the summer season, the content of Chl.a was decreased significantly ($p<0.05$) from 82.43±2.37 to 65.41±0.62 μg/g in winter, While Chl.b content was not significantly affected by seasons. In contrast, the content of carotenoids differed significantly between seasons, with its value tending to increase significantly due to stress. The ability of *Teucrium polium* L to maintain a high content of carotenoid gives the plant a competitive trait that makes it more adaptable to the desert environment, due to the capacity of carotenoid to quenching of O_2 and peroxyl radicals (Demmig–Adams, 1996), which helps protecting from photo-oxidative damage during environmental stresses. Whereas the ratio of Chl.a to Chl.b was slightly decreased under stress conditions, the reduction in chlorophyll a/b under drought stress was also reported in some plants like tomato plants, wheat, and sunflower (Ghorbanli et al., 2013; Pastori and Trippi, 1993 and Synerri et al., 1993).

Effect of season on plant water content, ash, and organic matter contents

As shown in table 5 and Fig.3, the plant water content was significantly higher ($p < 0.05$) in winter when compared with summer, as its value was 41.77±0.44 g/100g in winter, while in summer it was 25.79±2.26 g/100g. Reducing the water content is the first effect of drought on plants (Farooq et al., 2009), which causes a reduction in the leaf water potential and close of stomata (Arbona et al., 2013 and Sapeta *et al.*, 2013).

Ash content was significantly higher ($p < 0.05$) in the winter sample when compared with the summer sample, its value was 33.44±3.50 g/100g in winter and decreased to 22.67 ±2.19 g/100g in summer. Whereas the content of organic matter was significantly higher ($p < 0.05$) in the summer sample when compared with the winter sample.

Effect of season on the content of Minerals

As shown in table 6 the contents of nitrogen, potassium, calcium, and magnesium were significantly different between seasons ($p < 0.05$), their values were significantly lowered in the dry season, while the contents of phosphorus, sodium, and chloride were not significantly affected by seasonal variation. These results are agreed with (Akhtar and Nazir, 2013), who reported that water deficiency affects the content of plants from minerals and the homeostasis of ions in plant cells. Similarly, (Aroca, 2012), found that drought stress limits the availability of total nutrients in the soil, reduces the roots nutrient uptake, and consequently reduces their concentrations in plant tissues. The significant decrease in K^+, $Ca^{2+,}$ and Mg^{2+} *Teucrium polium* L. could be attributed to the high proportion of silt and clay in the root-associated soil particles in the rhizosphere, which increased the activity of calcium carbonate and reduced the absorption of nutrients.

Effect of season on the contents of total carbohydrates, protein, and proline

The obtained results from table 7 indicated that the content of total carbohydrates content was significantly different between seasons ($p < 0.05$). Its values were 24.21±0.98 g/100g in winter and increased significantly to 32.89±2.47 g/100g in the summer season. The high contents of total carbohydrates in plants under stress conditions may assist in the maintenance of turgor and help to enhance drought tolerance as reported by (Sayed *et al.*, 2013). The main role of carbohydrates in stress relief includes osmoprotectant, carbon storage, and scavenging of reactive oxygen species (Gupta and Huang, 2014).

The content of protein also showed a significant difference between seasons, its value was decreased significantly by stress. Decreased rate of protein synthesis with stress has been reported by others (Vyas *et al.*, 1996; Al-Jebory, 2012), which is one of the essential metabolic processes that may affect tolerance to water stress (Jiang and Huang, 2002). According to (Farooq *et al.*, 2009), the quantity and quality of plant proteins were significantly affected by drought stress. Due to the suppression of their synthesis and the changes in gene expression under stress conditions (Bernacchia and Furini, 2004).

Similarly, the content of proline was significantly different between seasons ($p < 0.05$). Proline content showed a significant increase in the dry season, its value was increased significantly from (3.67±0.34) in winter to (6.02±0.35 mg/g DW) in the dry season. The results of this study agree with other investigations (Behnamnia et al., 2009; Zhang et al., 2006). Several studies have reported the accumulation of proline in plants under stress conditions as a primary defense response to maintain osmotic balance in the cell (Mansour *et al.*, 2005; Desingh and Kanagarai, 2007) as reported in *Pennisetum glaucum* (Sneha et al.,2013), *Triticum aestivum* (Tammam et al., 2008) and in olive cultivars (*Olea europea* L.) (Bacelar et al., 2009).

Treatment of rice seeds with 1 mM proline improved the growth of their seedlings during salt stress (Deivanai *et al.*, 2011). It also enhanced the tolerance for salt in olive by improving the activity of some antioxidant enzymes, photosynthetic activity, and growth of plants as well as maintaining the water uptake under salinity conditions (Ben Ahmed *et al.*, 2010). Similarly, the tolerance for salt in *Nicotiana tabacum* has been improved by increasing the activity of enzymes involved in the antioxidant defense system (Hoque *et al.*, 2008).

The intracellular proline not only acts as a compatible osmolyte but also serves as a source of organic carbon, nitrogen, and energy during stress recovery (Sairam and Tyagi, 2004). Moreover, it is accumulated in the cytosol and chloroplasts which may contribute to protecting proteins, membranes, and enzymes from stress. It may also contribute to the alleviation of cytoplasmic acidosis necessary to maintain the $NADP^+$/NADPH ratio (Hoque *et al.*, 2008).

The higher accumulation of total carbohydrates and proline in the dry season could have been one of the important factors in the adaptation of *Teucrium polium* L to stress conditions.

Effect of season on the content of phytohormones

As shown in (Table 8), the content of growth-promoting hormones, gibberellic acid (GA_3), indole acetic acid (IAA), and zeatin reached the maximum values of (5.29, 2.68, and 1.98 μg /g respectively) in the wet season, while the concentration of stress hormone, ABA reached the maximum value of (1.30 μg /g) in the summer season. The decrease in the concentration of IAA and increase in ABA concentration may be due to the plants being exposed to drought stress, as the drought period was extended to four months. Abscisic acid (ABA) is one of the most potent hormones in the plant's response to drought stress. After plants are exposed to drought, ABA is synthesized in the roots and transmitted to shoots, especially leaves Moreover, water stress stimulates ABA formation in chloroplasts (Bhargava and Sawant, 2013). The same effects of environmental stresses on the concentration of auxin, cytokinin, and abscisic acid have been reported in rice plants (Nilsen and Orcutt, 1996) and soybean (Dong *et al.*, 2019). Salinity and water deficit increased ABA production in shoot and root, the accumulation of ABA can alleviate the inhibitory effect of salinity on photosynthesis, growth. The positive relationship between ABA accumulation and salinity tolerance has been partially attributed to the accumulation of compatible solutes, such as proline and sugars, in cell vacuoles (Gupta and Huang, 2014). (Heidari and Moaveni, 2009) found a close correlation between the accumulation of proline and ABA in different species of *Zea mays* under drought stress.

Effect of season on the total phenolic compounds

As shown in (Table 9), the content of total phenolic compounds was significantly different between seasons. Its value was significantly increased from 14.03±0.33 in winter to 17.22±1.04 (mg GA/g DW) in the dry season. It is generally known that phenolic compounds act as a protective substance against the negative effects of stress. As they can scavenge reactive oxygen and free radicals. (Caillet *et al.*, 2006; Amarowicz and Weidner 2009). Moreover, they can form complexes with the metals which catalyzed oxygenation reaction and cause the inhibition of the activity of oxidizing enzymes (Sokół-Łętowska 1997).

CONCLUSION

A naturally adapted *Teucrium polium* L. growing in the semi-arid Mediterranean coastal area of Marsa Matrouh was studied for its adaptive mechanism and effect of seasonal variation on photosynthetic pigment, phytohormones, minerals, phenolic acid, total carbohydrates, and proline.

The obtained results indicated that the contents of photosynthetic pigments, phytohormones, and total phenolic compounds were significantly affected by seasonal variation in climatic conditions. The content of carotenoid was significantly increased in the dry season, while the content of Chl . was significantly decreased by stress.

The depletion of soil fertility in the Mediterranean region and high proportions of silt and clay in the root-associated soil particles in the rhizosphere increased the activity of calcium carbonate and reduced the absorption of nutrients, thus lowering the mineral content of *Teucrium polium* L.

The obtained results showed that the stress conditions in the dry season caused an increase in the total carbohydrate and proline content in *Teucrium polium* L., which may act in osmotic adjustment. The production of ABA was increased in the dry season; the accumulation of ABA can mitigate the inhibitory effect of salinity on photosynthesis, growth. The positive relationship between ABA accumulation and stress tolerance has been partially attributed to the accumulation of compatible solutes, such as proline and sugars, in cell vacuoles

Teucrium polium L. could tolerate the period of water stress through the production of compatible osmolytes, such as carbohydrates and proline to decrease osmotic potential and maintain the uptake of water.

Higher values of phenols, carotenoids, and proline under stress conditions may be responsible for the improved tolerance of *Teucrium polium* L. to oxidative stress, reduced levels of free radicals, and protection of plant tissues from their harmful effects.

Further studies are recommended to investigate the possibility of increasing the resistance of economic crops to drought and/or salinity stress by increasing the synthesis of osmotically active solutes. Through genetic engineering techniques.

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Table 1. Climatic data.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Avg.Temp. (°C)	13.10	13.60	15.40	17.90	20.00	23.10	24.80	25.30	24.80	22.50	19.20	15.40
Min.Temp. (°C)	8.40	8.90	10.60	13.30	16.00	19.40	21.80	22.30	21.10	18.20	14.40	16.60
Max.Temp.(°C)	17.90	18.40	20.20	22.50	24.10	26.90	28.50	28.40	28.50	26.90	24.00	20.20
Rainfall (mm)	36.00	23.00	12.00	2.00	2.00	1.00	0.00	1.00	2.00	14.00	23.00	34.00

Table 2. Soil physical properties of Wadi Halazien.

Soil depth (cm)	Soil Particles Distribution			Soil Texture Class	Soil moisture content (%)	
	Sand (%)	Silt (%)	Clay (%)		Winter	Summer
0-20	80.63	16.67	2.70	Loamy sand	5.65	2.80
20-40	46.45	41.30	12.25	Loam	6.25	3.56

Table 3. Soil chemical properties of Wadi Halazien.

Soil depth (cm)	pH 1:2.5	EC dS/m	Cation(milliequivalent/Liter)				Anion(milliequivalent/Liter)			$CaCO_3$%
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	CO_3	HCO_3^{-}	
0-20	8.80	1.02	3.25	1.85	4.03	0.91	3.90	Traces	1.94	26.75
20-40	8.44	3.30	4.85	5.15	21.84	0.39	24.90	Traces	1.60	27.50

Table 4. Content of photosynthetic pigments in *Teucrium polium* L.

Season	Chlorophyll a (μg/g)	Chlorophyll b (μg/g)	Carotenoids (μg/g)	Chl a/Chl b
Winter	82.43±2.37[a]	34.03±3.17[a]	11.39±1.57[b]	2.43±0.24[a]
Summer	65.41±0.62[b]	32.71±1.50[a]	18.04±0.90[a]	2.00±0.10[a]

Results are expressed as mean ± SD (n = 3), Mean within a column followed by different letters are significantly different ($p < 0.05$).

Table 5. Plant water content, ash, and organic matter contents in *Teucrium polium* L.

Season	Plant water content (g/100g)	Ash (g/100g)	Organic matter (g/100g)
Winter	41.77 ±0.44[a]	33.44 ±3.50 [a]	66.56 ±3.50 [b]
Summer	25.79 ±2.26[b]	22.67±2.19 [b]	77.33 ±2.19 [a]

Results are expressed as mean ± SD (n = 3), Mean within a column followed by different letters are significantly different ($p < 0.05$).

Table 6. The content of Minerals in *Teucrium polium* L.

Seasons	N (g/100g)	P (g/100g)	K^+ (g/100g)	Ca^{++} (g/100g)	Mg^{++} (g/100g)	Na^+ (g/100g)	Cl^- (g/100g)
Winter	1.25 ±0.03[a]	0.14 ±0.02[a]	1.76 ±0.02[a]	1.56 ±0.03[a]	0.57 ±0.02 [a]	0.12 ±0.01 [a]	0.24 ±0.02 [a]
Summer	0.65 ±0.01[b]	0.10 ±0.01[a]	0.82 ±0.02[b]	1.43 ±0.04[b]	0.51 ±0.02[b]	0.14 ±0.02 [a]	0.25 ±0.02 [a]

Results are expressed as mean ± SD (n = 3), Mean within a column followed by different letters are significantly different ($p < 0.05$).

Table 7. The contents of total carbohydrates, protein, and proline in *Teucrium polium* L.

Seasons	Total carbohydrates (g/100g)	Protein (g/100g)	Proline (mg /g DW)
Winter	24.21 ±0.98[b]	7.83 ±0.21 [a]	3.67 ±0.34 [b]
Summer	32.89 ±2.47[a]	4.08 ±0.09 [b]	6.02 ±0.35 [a]

Results are expressed as mean ± SD (n = 3), Mean within a column followed by different letters are significantly different ($p < 0.05$).

Table 8. The content of phytohormones in *Teucrium polium* L.

Seasons	GA_3 (μg/g)	IAA (μg /g)	ABA (μg /g)	Zeatin (μg /g)
Winter	5.29	2.68	1.15	1.98
Summer	4.98	2.21	1.30	1.79

Table 9. The content of total phenolics in *Teucrium polium* L.

Seasons	Total phenolics (mg GA/g DW)
Winter	14.03±0.33[b]
Summer	17.22±1.04[a]

Results are expressed as mean ± SD (n = 3), Mean within a column followed by different letters are significantly different ($p < 0.05$).

Figure1. Teucrium polium L. (Djabou., 2012)

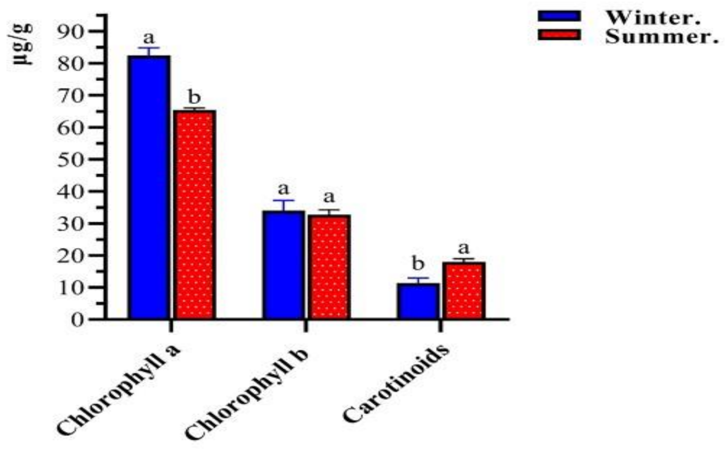

Figure 2: Content of photosynthetic pigments in *Teucrium polium* L.

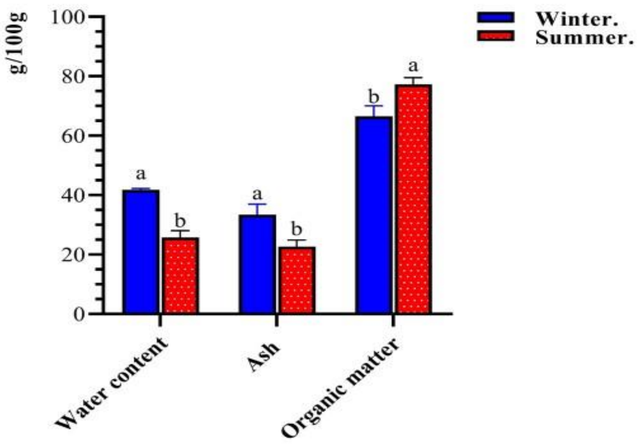

Figure 3: Plant water content, ash, and organic matter contents in *Teucrium polium* L.

التغيرات الموسمية في صبغات البناء الضوئي والهرمونات النباتية والفينولات في نبات الجعدة النامي في وادي حلازين بمصر.

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الملخص

الجعدة نبات معمر ينمو في المناخ الجاف لمنطقة البحر الأبيض المتوسط. إنه نبات ثنائي الشكل موسمي ، والذي يظهر بشكل مختلف تمامًا في الشتاء والصيف. يعكس التحول الموسمي الظاهر للنبات تكيفه مع الظروف المناخية المجهدة السائدة في الشتاء أو الصيف. لذلك هدفت هذه الدراسة إلى معرفة تأثير التغيرات الموسمية على أصباغ التمثيل الضوئي والهرمونات النباتية والفينولات لنبات الجعدة النامي في وادي حلازين ، بمصر. أشارت النتائج إلى أن محتوى الكلوروفيل أ انخفض معنويا في موسم الجفاف ، بينما زاد محتوى الكاروتينات معنويا مع الإجهاد. تأثر إنتاج بعض المركبات العضوية معنوياً بالموسم وزاد معنوياً تحت ظروف الإجهاد في موسم الصيف. في الختام ، ارتبط تحمل الجعدة لظروف الإجهاد ارتباطًا وثيقًا بإنتاج المركبات العضوية ، مثل الكربوهيدرات والبرولين والمركبات الفينولية. كانت الكربوهيدرات الكلية والبرولين هي المركبات النشطة الرئيسية في ضبط الاسموزية في نبات الجعدة. في موسم الجفاف ، أظهرت النتائج تراكم حامض الابسيسيك ، والذي قد يخفف من التأثير المثبط للملوحة على التمثيل الضوئي. قد تؤدي القيم الأعلى من الفينولات والكاروتينات والبرولين في ظل ظروف الإجهاد إلى تحسين تحمل الجعدة لظروف الإجهاد التأكسدي وتساعد في تنظيف الجذور الحرة تحت ظروف الإجهاد. يوصى بإجراء مزيد من الدراسات للتحقيق في إمكانية زيادة مقاومة المحاصيل الاقتصادية للجفاف و / أو إجهاد الملوحة عن طريق زيادة تخليق المواد المذابة النشطة في ضبط الاسموزية من خلال تقنيات الهندسة الوراثية.

الكلمات الاسترشادية: الهرمونات النباتية، الفينولات، البرولين، الجفاف، نبات الجعدة.