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ENHANCING CORIANDER GROWTH AND YIELD VIA FOLIAR APPLICATION OF NATURAL EXTRACTS

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ABSTRACT: Recently, the shift towards safer methods of crop production has become imperative to safeguard public health, as the conventional chemical-based approaches have inflicted significant harm on public well-being and contributed to the proliferation of diseases. Coriander, a pivotal plant employed in medicinal formulations and nutritional supplements, stands out for its notable therapeutic effects. So, a field trial was conducted to evaluate the response of coriander to foliar application of various natural extracts, including seaweed extract (0.5, 1.0-, and 1.5-ml L^{-1}), licorice root extract (5, 10, and 15 g L^{-1}), and *Aloe vera* extract (5, 10, and 15%), with an additional control group without foliar application. Various parameters, including plant height (cm), branches number plant-1, fresh and dry weights (g $plant^{-1}$), chlorophyll content (SPAD), leaves N, P and K (%), umbels number $plant^{-1}$, seed yield (g $plant^{-1}$), seed index (g 1000 $seeds^{-1}$), essential oil (%), and oil yield (ml $plant^{-1}$) were determined. The results show that all natural extracts significantly enhanced coriander performance compared to the control treatment, and the values for all studied parameters increased with higher application rates of the natural extract. Generally, the most favorable outcomes were observed in plants sprayed with licorice root extract at a rate of 15 g L^{-1}, followed by those treated with licorice root extract at a rate of 10 g L^{-1}. Plants sprayed with *Aloe vera* extract at a rate of 15% ranked third, followed by those treated with *Aloe vera* extract at a rate of 10%. The least favorable outcomes were recorded in plants grown without foliar application. Conversely, the seaweed treatments were positioned at the lower ranks, just preceding the control treatment. Accordingly, to obtain the highest yield of coriander plants we must spray plants with licorice root extract at a rate of 15 g L^{-1} three times at 45, 60, and 75 days from the sowing date.

Key words: Coriander Seaweed, Licorice, *Aloe vera*, Yield.

INTRODUCTION

In contemporary agriculture, the imperative shift towards safer crop production methods is integral to preserving public health, given the adverse impact of traditional chemical-based approaches on human well-being and the propagation of diseases. The urgency to embrace safer alternatives becomes evident against this backdrop **(El-Sherpiny *et al.*, 2022).**

Coriander (Coriandrum sativum L), a pivotal plant in medicinal formulations and nutritional supplements, stands out for its noteworthy therapeutic effects, underscoring its importance in both traditional and modern applications. It is extensively distributed across diverse regions, including Egypt, India, Morocco, Central Europe, Russia, and Bangladesh. This plant is cultivated globally, for both its medicinal properties and the

extraction of seeds, which serve as spices or are processed to obtain volatile oil **(Ghatas, 2020).**

Within the realm of environmental and health considerations, researchers are actively seeking alternatives to chemical compounds used for enhancing crop productivity, especially in the cultivation of medicinal and aromatic plants, where the consequences on human health are paramount.

Seaweed extract, derived from marine algae, encompasses a rich blend of essential nutrients, trace elements, and bioactive compounds, making it a valuable resource in agriculture **(Al-Hatem, 2018 and Tursun, 2022)**.

Licorice extract, derived from the roots of *Glycyrrhiza* species, is well-known for its varied bioactive compounds. including glycyrrhizin, flavonoids, and triterpenoids, making it a valuable natural ingredient with various applications. In agriculture, licorice extract has gained recognition for its potential as a biostimulant, enhancing plant growth, and development **(El-Ghait *et al.*, 2021 and El-Sherpiny *et al.*, 2022)**.

Aloe vera extract, derived from the succulent leaves of the Aloe barbadensis miller plant, is esteemed for its rich composition of bioactive compounds, including polysaccharides, anthraquinones, and antioxidants. This extract holds significant importance in agriculture, acting as a natural growth enhancer for plants. *Aloe vera* extract is known to stimulate root development, improve nutrient absorption, and enhance plant tolerance to various environmental stressors **(Prathibha *et al.*, 2018 and Wafaa *et al.*, 2021)**.

Therefore, this research focuses on exploring the significance of licorice, *Aloe vera*, and algae extracts on coriander plant growth and productivity. These extracts were evaluated for their rich content of vitamins, nutrients, and antioxidants, which contribute to both plant health and environmental sustainability. Generally, the overarching goal of this research is to contribute valuable insights into the utilization of natural extracts as safe and effective alternatives in agriculture, aligning with the imperative for sustainable and health-conscious crop production practices.

MATERIALS AND METHODS

Experimental location

A field trial was executed at a private farm situated at El-Baramoon Research Farm (31°08’11.3’’N31°28’19.6’’E), Mansoura Horticulture Research Station, HRI, ARC, Egypt. during the seasons of 2020/2021 and 2021/2022.

Experimental design

The experiment was organized based on the complete randomized block design, incorporating 10 distinct treatments. These treatments included seaweed extract (0.5, 1.0, 1.5 ml L-1), licorice root extract (5, 10, 15 g L-1), and *Aloe vera* extract (5, 10, 15%). Additionally, a control group (without foliar application). Each treatment was replicated three times, and each replication comprised three plots. Within each plot, four coriander plants were cultivated.

Soil sampling

A soil sample was gathered before the sowing process at a depth ranging from 0.0 to 30.0 cm to analyze as routine work depending on the standard soil analysis methods described by **Smith and Mullins (1991)**, as their attributes are provided in Table (1).

Preparation of the studied natural extracts

The seaweed extract used in the experiment was procured from the Egyptian commercial market. Then the studied rates (0.5, 1.0, 1.5 ml L-1) were prepared. The distinctive features and properties of this seaweed extract are detailed in Table (2).

Licorice root extraction involved soaking 5, 10, and 15 g of roots (based on the respective treatments) in one liter of water at 50°C for 24 hours. The mixture was subsequently filtered, and the final volume was adjusted to one liter, following the method described by **El-Sherpiny *et al.* (2022)**. Their properties are presented in Table (3).

Table (1). Properties of the initial soil

Properties and units		Values
pH (1:2.5)		7.91
EC dSm-1 (1:5)		1.11
OM, %		1.92
Saturation, %		51.1
CaCO3,%		2.12
Mechanical analysis, %	**Coarse sand**	3.10
	Fine sand	30.8
	Silt	36.4
	Clay	29.7
Texture class		S.C.L
Available Nutrients, mgKg-1	**N**	48.3
	P	5.07
	K	237

Table (2). Properties of applied seaweed extract

Nutrients,%							Growth substances, mg L^{-1}			Vitamins, mg $100g^{-1}$	
N, %	**P, %**	**K, %**	**Fe, %**	**Zn, %**	**Ca, %**	**Si, %**	**IAA**	**Cytokinin**	**GA_3**	**Vit C**	**Vit B**
0.08	0.11	2.95	0.13	0.05	1.93	8.97	5.95	64.6	1.83	65.5	0.75

Antioxidants								
Proline (mg/100g)	**T. Phenols**	**T. Falvoinds**	**T. Alkaloids**	**T. Tannins**	**T. Carbohydrates (mg/g)**	**T. Protein**	**T. Saponin**	**T. Anthocynin**
3.00 ug	9.51	3.29	0.04	31.0	300	179	//	//

Table (3). Properties of applied extract of licorice root

Nutrients							Enzymatic antioxidants (IU min^{-1} mg^{-1} protein)		
N, %	**P, %**	**K, %**	**Fe, mg Kg^{-1}**	**Zn, %**	**Ca, %**	**Mg, %**	**Super oxide dismutase**	**Peroxidase**	**Catalase**
1.90	0.27	1.90	600	0.03	2.70	0.02	5.95	64.6	1.83

Aloe vera extract was obtained through a meticulous extraction process as described by **Liu *et al.* (2019)**. Fresh *Aloe vera* leaves were carefully harvested, and the gel from the inner leaf was extracted. The extraction involved crushing the leaves to release the gel, which was then processed to obtain a concentrated extract. Various concentrations of *Aloe vera* extract, specifically 5%, 10%, and 15% were prepared for the relevant treatments. The attributes of the *Aloe vera* extract are outlined in Table (4).

Table (4). Properties of the applied extract of *Aloe vera*

Nutrients							Enzymatic antioxidants (IU min^{-1} mg^{-1} protein)		
N, %	**P, %**	**K, %**	**Fe, mg Kg^{-1}**	**Zn, %**	**Ca, %**	**Mg, %**	**Super oxide dismutase**	**Peroxidase**	**Catalase**
1.23	0.22	1.77	433	0.07	2.30	0.05	5.00	77.0	1.53

All extracts of Seaweed were analyzed according to **Rawe, 1966 and Shyamal *et al.*, 1990** at the Water and Soil Laboratory, Soils, Water and Environment Research Institute, Agricultural Research Center (ARC), Egypt.

Cultural practices

On the 15th of October, in both experimental seasons, the sowing of coriander seeds (at a rate of 6 kg seeds fed^{-1}) was initiated, which were sourced from the Medicinal and Aromatic Plants Department of the Horticultural Research Institute, Agricultural Research Center, Egypt. The sowing process involved placing the seeds in hills with a spacing of 30 cm between them. Once the seedlings reached 10 cm, thinning was carried out to maintain one plant per hill.

The chemical fertilizers were incorporated into the soil following the recommended doses. Ammonium nitrate (33.5% N) was applied at a rate of 90 kg N fad^{-1}. Calcium superphosphate (15.5% P2O5) was administered at a rate of 60 Kg P_2O_5 fad^{-1}. For potassium, potassium sulfate (48.5 K_2O) was utilized at a rate of 60 kg K_2O fad^{-1}. Calcium superphosphate was applied as a single dose before the planting phase during soil preparation. In contrast, ammonium sulfate and potassium sulfate were distributed in two equal doses. The initial N and K doses were introduced after thinning the plants, while the last dose was added one month after the first application. The foliar application of the investigated natural extracts was manually conducted using a hand sprayer until saturation was achieved. This application process occurred at intervals of 45, 60, and 75 days from the sowing date. For irrigation, a flood irrigation system was employed, and standard agricultural practices for coriander production were adhered to as per the recommendations of the Egyptian Ministry of Agriculture. The harvesting of plants took place in April during both investigated seasons.

Sampling and collecting data

At the flowering stage, various vegetative measurements, encompassing plant height (cm), branch number plant-1, and fresh and dry weights (g plant-1), were recorded. Simultaneously, chlorophyll content, as indicated by the SPAD readings index, was assessed at this developmental stage. Subsequently, at the flowering stage, leaf nitrogen (N), phosphorus (P), and potassium (K) percentages were determined through micro-Kjeldahl, spectrophotometer, and flame photometer analyses, respectively with the methodology outlined by **Walinga *et al.* (2013)**. Upon reaching the harvesting phase, key measurements were documented, encompassing the umbel number plant-1, seed yield (g plant-1), and seed index (g 1000 seeds-1).

Volatile oil % and components

The extraction of essential oil for each treatment in air-dried seeds was carried out through hydro-distillation for 3 hours (100 g $sample^{-1}$) using a modified Clevenger apparatus following the method outlined by **Guenther (1972)**. The Gas Chromatography–mass spectrometry (GC – MS) analysis of 2022 volatile oil samples of coriander was conducted using gas chromatography (Agilent 8890 GC System), coupled to a mass spectrometer (Agilent 5977B GC/MSD) and equipped with a HP-5MS fused silica capillary column (30 m, 0.25 mm i.d., 0.25 mm film thickness). The oven temperature was initially set at 50 °C, then programmed from 50 to 200°C at a rate of 5°C/min and from 200°C to 280°C at a rate of 10°C/min, followed by a 7-minute hold at 280°C. Helium was used as the carrier gas, flowing at a rate of 1.1 mL/min. The essential oil was dissolved in diethyl ether (20 µL essential oil / mL diethyl ether), and then 1 µL of this solution was injected into the GC with a split ratio of 1:50. The temperature of injection was 230 °C. Mass spectra in the electron impact mode (EI) were obtained at 70 eV, scanning the m/z range from 39 to 500 amu. identification of isolated peaks was performed by matching them with data from the library of mass spectra (National Institute of Standard and Technology, NIST). The relative percentage of each compound was calculated from the area of the peak corresponding to each compound). The previous (GC–MS) analysis was conducted at, Central Laboratories Network Chromatography (CLN-CE) Lab, [(Gas Chromatography-Mass spectrometer (GC Mass) unit], National Research Center, Dokki, Egypt.

Statistical analysis

Statistical analysis of variance (ANOVA) was performed on the collected data using **CoStat (Version 6.303, Co Hort, USA, 1998–2004)**. Mean comparisons were carried out using the Least Significant Differences (L.S.D) method at a significance level of 5%, following the approach outlined by **Gomez and Gomez (1984)**.

RESULTS AND DISCUSSION

Growth Criteria

Data in Table (5) show the impact of seaweed, licorice, and extracts at different rates as a foliar application on the growth parameters of coriander plants, including plant height (cm), branch number plant-1, fresh and dry weights (g plant-1) during the two successive seasons of 20/2021 and 21/2022. The results show that all-natural extracts significantly enhanced coriander growth performance compared to the control treatment. Under each extract type, the values for all studied growth parameters increased with higher application rates of the natural extract. Generally, the highest values were observed in plants that were sprayed with licorice root extract at a rate of 15 g L^{-1} followed by those sprayed with licorice root extract at a rate of 10 g L^{-1}. Generally, the most favorable outcomes were observed in plants sprayed with licorice root extract at a rate of 15 g L^{-1}, followed by those treated with licorice root extract at a rate of 10 g L^{-1}. Plants sprayed with *Aloe vera* extract at a rate of 15% ranked third, followed by those treated with *Aloe vera* extract at a rate of 10%. The least favorable outcomes were recorded in plants grown without foliar application. On the other hand, the seaweed treatments were positioned at the lower ranks, just preceding the control treatment. The same trend was found for both studied seasons.

Table (5). Effect of seaweed, licorice, and extracts as a foliar application on the growth parameters of coriander plants during the two successive seasons (2020/2021&2021/2022)

Parameters / Treatments	Plant height, cm		Branches number plant^{-1}		Fresh weight, g plant^{-1}		Dry weight, g plant^{-1}	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control (without foliar application)	60.07g	63.19g	8.75g	10.50f	85.63i	92.91i	8.11h	8.05i
Seaweed extract (0.5 ml L^{-1})	61.27g	65.09f	10.00fg	11.25f	91.33h	103.91h	8.03h	8.59h
Seaweed extract (1.0 ml L^{-1})	66.47f	67.79e	11.00ef	12.00ef	100.53g	111.61g	9.30g	10.00g
Seaweed extract (1.5 ml L^{-1})	75.17d	81.89c	15.00cd	17.00c	156.33d	173.51d	15.60e	16.69d
Licorice root extract (5 g L^{-1})	71.87e	80.59c	14.00d	15.00d	151.33e	163.51e	15.40e	15.74e
Licorice root extract (10 g L^{-1})	80.27ab	84.89ab	18.00a	19.00ab	180.73b	207.36a	19.60b	21.59b
Licorice root extract (15 g L^{-1})	82.47a	85.89a	19.25a	19.75a	186.93a	209.41a	21.40a	23.29a
***Aloe vera* extract (5%)**	69.77e	69.79d	12.00e	13.00e	118.13f	116.51f	10.79f	10.59f
***Aloe vera* extract (10%)**	77.17cd	83.89ab	16.00bc	17.25c	164.63c	183.31c	18.11d	20.29c
***Aloe vera* extract (15%)**	78.67bc	85.09ab	17.50ab	18.00bc	180.63b	199.61b	19.11c	21.19b
LSD at 5%	2.29	1.90	1.85	1.69	2.40	2.12	0.42	0.52

Means within a column labeled with a different letter(s) is statistically different at a 0.05 level

The superiority of licorice root extract in promoting robust growth in coriander plants can be attributed to its rich composition of bioactive compounds, including glycyrrhizin, flavonoids, and triterpenoids. These compounds are known to have various physiological effects on plants, influencing processes such as seed germination, root development, and nutrient uptake. Licorice root extract contains substances that act as natural growth regulators, stimulating cell division and elongation, leading to enhanced plant height and branching. Additionally, the extract's bioactive components may contribute to improved stress tolerance and overall resilience in coriander plants. The dose-dependent response observed, with the highest values recorded at a rate of 15 g L^{-1}, suggests that licorice root extract's effectiveness is influenced by the concentration of its bioactive compounds. At higher concentrations, the extract may provide an optimal balance of growth-promoting substances, leading to the observed superior performance in coriander growth parameters **(El-Ghait *et al.*, 2021 and El-Sherpiny *et al.*, 2022)**.

The superior performance of *Aloe vera* extract in promoting robust growth in coriander plants can be attributed to the unique composition of bioactive compounds present in the extract. *Aloe vera* is renowned for containing polysaccharides, anthraquinones, vitamins, and antioxidants, which collectively contribute to its remarkable properties. In the context of coriander growth, *Aloe vera* extract is known to stimulate root development, improve water and nutrient absorption, and enhance the plant's overall stress tolerance. The effectiveness of *Aloe vera* extract, especially at the 15% application rate, suggests that the concentration of these beneficial compounds plays a crucial role in influencing coriander growth parameters. The polysaccharides in *Aloe vera* are known to have a positive impact on cell division and elongation, contributing to increased plant height and branching (Prathibha et al., 2018). The extract's antioxidant content may play a role in protecting the plant from oxidative stress, ensuring healthier growth. *Aloe vera* extract's positive effects extend beyond direct growth stimulation. Its water-retaining properties can enhance soil moisture retention, particularly beneficial in arid conditions or during periods of water scarcity. Additionally, the extract may foster beneficial interactions with soil microorganisms, further supporting nutrient availability and uptake by coriander plants **(Wafaa *et al.*, 2021)**.

While the data presented in Table 5 indicate that seaweed extract exhibited comparatively lower growth parameters for coriander plants, it's important to consider the potential benefits it may provide in other aspects of plant development and health. Seaweed extracts are known to contain a wide array of bioactive compounds, including cytokinins, auxins, and various micronutrients. The positive impact of seaweed extract may not be as pronounced in terms of plant height, branches number per plant, and fresh and dry weights, but it could contribute significantly to other aspects of plant physiology (Al-Hatem, 2018). Seaweed extracts are often valued for their role in improving stress tolerance, enhancing root development, and promoting nutrient absorption. These benefits may not manifest prominently in the measured growth parameters but could play a crucial role in the long-term health and resilience of coriander plants, especially under challenging environmental conditions. The observed lower ranking of seaweed extract in terms of growth parameters may be due to variations in the concentration and composition of bioactive compounds or a dose-response relationship that differs from licorice root and *Aloe vera* extracts. It's essential to consider the specific needs of coriander plants and the environmental conditions under which they were cultivated to better understand the nuances of seaweed extract's effectiveness **(Tursun, 2022)**.

Photosynthetic pigments and leaves chemical composition

Data organized in Table (6) reveal the profound impact of foliar applications of seaweed, licorice, and *Aloe vera* extracts at various rates on the chlorophyll pigment (SPAD) and leaves chemical composition (N, P, and K %) of coriander plants across two consecutive seasons (2020/2021 and 2021/2022). The results demonstrate a significant elevation in the values of chlorophyll pigment (SPAD) and leaves'

chemical composition (N, P, K %) in coriander plants treated with natural extracts compared to the control treatment. under each extract type, there is a discernible trend where the values of chlorophyll, N, P, K increase with higher application rates of the respective natural extract.

Specifically, licorice root extract emerges as the most influential, with the highest values consistently recorded at a rate of 15 g L-1, closely followed by the 10 g L-1 rate, indicating a dose-dependent response. *Aloe vera* extract, while ranking third after licorice root extract treatments, still exhibits favorable outcomes, especially at the 15% application rate. Conversely, seaweed treatments, positioned at lower ranks, demonstrate comparatively lower values for chlorophyll and leaves chemical composition, placing them just preceding the control group. Consistent patterns were observed across both investigated seasons. The obtained results underscore the scientific reasons behind the enhanced chlorophyll levels and improved leaves' chemical composition in coriander plants. The bioactive compounds in licorice root and *Aloe vera* extracts, at higher concentrations, likely contribute to increased chlorophyll synthesis, nutrient absorption, and overall plant health. In contrast, while seaweed extracts may have positive effects, their impact on chlorophyll and leaves chemical composition appears to be less pronounced, emphasizing the varying efficacy of different natural extracts in influencing these physiological parameters. The obtained results are in harmony with those of **Al-Hatem (2018); Prathibha *et al.* (2018) and El-Ghait *et al.* (2021)**.

Table (6). Effect of seaweed, licorice and extracts as a foliar application on the chlorophyll pigment and leaves chemical composition of coriander plants during the two successive seasons (2020/2021&2021/2022)

Parameters / Treatments	Total chlorophyll, SPAD reading		N, %		P, %		K, %	
	1st season	2nd season	1st season	2nd season	1st season	2nd Season	1st season	2nd season
Control (without foliar application)	8.92h	9.10h	2.94h	3.14i	0.366h	0.377i	3.81f	3.83g
Seaweed extract (0.5 ml L^{-1})	8.97h	9.11h	3.04g	3.23h	0.375gh	0.387h	3.91f	4.02g
Seaweed extract (1.0 ml L^{-1})	9.79g	9.49g	3.18f	3.34g	0.387g	0.400g	4.07e	4.28f
Seaweed extract (1.5 ml L^{-1})	10.79e	10.84e	3.58d	3.62e	0.423de	0.435d	4.46c	4.59d
Licorice root extract (5 g L^{-1})	10.19f	10.90e	3.43e	3.52f	0.412ef	0.425e	4.44c	4.52e
Licorice root extract (10 g L^{-1})	14.26b	13.99b	3.94b	3.95b	0.440bc	0.456b	4.82a	4.86b
Licorice root extract (15 g L^{-1})	14.58a	14.7a	4.04a	4.14a	0.457a	0.465a	4.91a	5.02a
***Aloe vera* extract (5%)**	10.09f	10.19f	3.45e	3.38g	0.405f	0.415f	4.21d	4.32f
***Aloe vera* extract (10%)**	10.99d	11.29d	3.64d	3.72d	0.431cd	0.445c	4.53c	4.62d
***Aloe vera* extract (15%)**	13.60c	13.59c	3.83c	3.84c	0.453ab	0.455b	4.68b	4.72c
LSD at 5%	0.15	0.07	0.06	0.06	0.014	0.008	0.13	0.02

Means within a column labeled with a different letter(s) is statistically different at a 0.05 level

Yield measurements

Table (7) data illustrates the impact of the investigated treatments on the yield characteristics of coriander plants, including umbels number $plant^{-1}$, seed yield (g $plant^{-1}$), seed index (g 1000 $seeds^{-1}$), essential oil (%), and oil yield (ml $plant^{-1}$) during the two successive seasons of 20/2021 and 21/2022. The findings distinctly reveal that all-natural extracts significantly elevated the yield traits of

coriander compared to the control treatment. Within each extract type, there is a consistent pattern of increased values for all studied yield traits with higher application rates of the respective natural extract. Specifically, licorice root extract stands out as the most influential, with the highest values consistently observed at a rate of 15 g L^{-1}, closely followed by the 10 g L^{-1} rate. This dose-dependent response highlights the potency of the licorice root extract in enhancing umbels number plant-1, seed yield (g $plant^{-1}$), seed index (g 1000 $seeds^{-1}$), essential oil (%) and oil yield (ml $plant^{-1}$). *Aloe vera* extract, while ranking third after licorice root extract treatments, still exhibits favorable outcomes, particularly at the 15% application rate. In contrast, seaweed treatments occupy lower ranks, demonstrating comparatively lower values for yield traits, just preceding the control group. The same trend was observed in both seasons.

From Tables (6 and 7), it seems that growth, seed yield and volatile oil yield characterization of coriander were significantly increased with the different extracts (Seaweed, Licorice root and *Aloe vera*) concentrations and their constituents (Tables 2, 3 and 4). Such synergistic effects of seaweed extract on growth, seed yield and volatile oil yield characterization on dill were reported by El-Gamal and Ahmed (2016). The scientific rationale behind these results lies in the bioactive compounds present in licorice root and *Aloe vera* extracts, which, at higher concentrations, likely contribute to increased reproductive and oil-producing capacities in coriander plants. Conversely, while seaweed extracts may have positive effects, their impact on yield traits appears to be less pronounced, underscoring the varying efficacy of different natural extracts in influencing these crucial aspects of coriander productivity. The findings obtained in this study align with the results reported by **Wafaa *et al.* (2021); El-Sherpiny *et al.* (2022) and Tursun (2022)**.

Table (7). Effect of seaweed, licorice and extracts as a foliar application on the fruit measurements of coriander plants during the two successive seasons (2020/2021&2021/2022)

Parameters / Treatments	Umbels number plant-1		Seed yield, g plant-1		Seed index, g 1000 seeds-1		Essential oil, %		Oil yield, ml plant-1	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season	1st season	2nd season
Control (without foliar application)	27.00g	30.00e	40.97j	42.28j	11.22f	11.78g	1.10g	1.11f	0.451h	0.478g
Seaweed extract (0.5 ml L-1)	31.00fg	33.00e	44.17i	43.17i	11.27f	11.77g	1.16fg	1.14ef	0.554g	0.526f
Seaweed extract (1.0 ml L-1)	34.00ef	33.00e	45.97h	44.27h	11.47ef	12.47f	1.18ef	1.16ef	0.560g	0.540ef
Seaweed extract (1.5 ml L-1)	45.00cd	43.00d	56.50e	53.97e	12.07cd	13.37d	1.25cde	1.25bcd	0.628e	0.729c
Licorice root extract (5 g L-1)	40.00de	41.00d	54.97f	50.97f	11.87de	12.77e	1.21def	1.22cde	0.575f	0.622d
Licorice root extract (10 g L-1)	53.00ab	58.00ab	64.87b	65.27b	13.47b	14.77a	1.33ab	1.32ab	0.797b	0.815b
Licorice root extract (15 g L-1)	57.00a	59.00a	68.50a	66.87a	14.77a	14.78a	1.37a	1.35a	0.838a	0.884a
***Aloe vera* extract (5%)**	35.00ef	39.00d	49.47g	45.27g	11.77de	12.57ef	1.19def	1.19def	0.565fg	0.553e
***Aloe vera* extract (10%)**	42.00d	51.00c	60.50d	56.77d	12.37c	13.87c	1.26bcd	1.28abc	0.649d	0.744c
***Aloe vera* extract (15%)**	50.00bc	54.00bc	63.50c	61.77c	12.47c	14.17b	1.29bc	1.31ab	0.773c	0.796b
LSD at 5%	6.41	4.52	1.19	0.29	0.44	0.24	0.07	0.09	0.012	0.026

Means within a column labeled with a different letter(s) is statistically different at a 0.05 level.

Volatile Oil Composition

The profile of the essential oil of the harvested and air-dried coriander fruits is detailed in Table (8). Overall, 23 components were identified that characterized 93.02 to 99.33 % of the oil components. Linalool component was found to be the dominant in the volatile oil (50.21 – 53.90%). Other coriander volatile oil main components were α-Pinene (5.87– 9.33%), followed by γ-Terpinene (3.11– 8.76%), Geranyl acetate (1.03– 6.51%), limonene (2.19– 5.88%), Geraniol (2.87– 5.42%), Camphor (3.76 – 5.01%) and p-cymene (3.31 – 3.65%).

The maximum content of linalool (53.90%) was obtained from samples of plants sprayed with Licorice root 15 g L^{-1} while the low content (50.21%) was obtained from untreated pants. It is noticed that linalool and oxygenated components percentages increased with the different extracts (Seaweed, Licorice root and *Aloe vera*) and their constituents (Tables 2, 3 and 4).

The γ-Terpinene component, Geranyl acetate, Camphor and p-cymene took the same trend of linalool trend, meanwhile, α-Pinene and limonene took an inverse trend to reach their highest values in control plant samples (9.33 and 5.88%, respectively).

Similar to our results profile, the other reports of authors with linalool as the main component like **El-Gamal *et. al.*, 2020a, and Khater *et al.*, 2022** working on coriander. The linalool terpene alcohol compound corresponds with the greater value of coriander oil and possesses sedative, anti-inflammatory, and antimicrobial qualities **(Nurzyńska-Wierdak, 2013)**.

Table (8). Coriander volatile oil components and their percentages of the most effective applications of natural extracts (Seaweed, Licorice root and *Aloe vera*) samples and control treatment in the 2022 season

ID	Treatments / Components	Control		Seaweed 1.5 ml L-1		Licorice root 15 g L-1		*Aloe vera* 15%	
		RT	Area%	RT	Area%	RT	Area%	RT	Area%
1	α-Pinene	5.93	9.33	5.91	5.99	5.94	6.03	5.90	5.87
2	Camphene	6.26	0.79	6.24	0.60	6.21	0.63	6.25	0.61
3	β-Pinene	6.86	0.51	6.81	0.54	6.84	0.52	6.73	0.56
4	β-Myrcene	6.89	0.72	7.10	0.65	7.12	0.62	7.11	0.58
5	p-Cymene	7.10	0.76	7.84	3.31	7.90	3.65	7.91	3.39
6	D-Limonene	7.89	5.88	8.01	2.19	8.05	2.21	8.02	2.25
7	γ-Terpinene	8.01	3.11	8.52	8.28	8.71	8.76	8.68	8.41
8	Terpinolene	8.61	0.68	9.45	0.67	9.41	0.67	9.39	0.67
9	Linalool	9.21	50.21	9.59	52.81	9.51	53.9	9.50	52.00
10	Nonanal	9.56	1.61	9.72	0.38	9.75	0.41	9.74	0.55
11	(+)-Camphor	10.71	3.76	10.81	5.01	10.82	4.38	10.79	4.76
12	α-Terpineol	11.45	0.49	11.85	0.41	11.82	0.45	11.87	0.48
13	Anethole	12.01	2.38	12.03	0.39	12.00	0.47	12.02	0.33
14	Decanal	12.11	2.04	12.13	1.15	12.11	1.11	12.12	1.16
15	Cuminaldehyde	13.08	1.1	13.04	0.77	13.02	0.81	13.01	0.68
16	Carvone	16.11	0.87	13.12	0.89	13.17	0.97	13.15	0.95
17	Geraniol	17.82	5.42	13.19	2.90	13.21	2.87	13.25	2.91
18	2(E)-Decenal	19.69	1.35	13.41	0.53	13.45	0.44	13.44	0.50
19	cis-p-Propenylanisole	--	--	14.03	0.71	14.05	0.69	14.02	0.74
20	Geranyl acetate	--	1.03	16.10	6.27	16.13	6.51	16.14	6.48
21	2-Dodecenal	23.64	0.98	17.51	1.21	17.83	1.3	17.79	1.27
22	Myristic acid	--	--	23.52	1.29	23.51	1.32	23.55	1.35
23	Palmitic acid	--	--	26.03	0.58	26.11	0.61	26.07	0.63
Total identified components %		93.02		97.53		99.33		97.13	

RT: retention time (min), Area%: component percentage

CONCLUSION & RECOMMENDATION

According to the obtained results, it can be deduced that foliar application of natural extracts, including licorice root and *Aloe vera* substantially enhanced coriander performance across various parameters compared to the control treatment. Notably, licorice root extract at a rate of 15 g L-1 demonstrated the most favorable outcomes, emphasizing its potential as a promising natural enhancer for coriander cultivation. In contrast, seaweed treatments exhibited comparatively lower efficacy. As a recommendation, incorporating licorice root extract at optimal concentrations in coriander cultivation practices can serve as a sustainable and beneficial approach, contributing to both plant health and overall agricultural sustainability.

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RESEARCH ARTICLE

Enhancing Coriander Growth and Yield Via Foliar Application of Natural Extracts

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