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Improving growth and active constituents of (*coriandrum sativum* l.) Plant using some natural stimulants under different climate conditions.

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ABSTRACT

The present study was carried out at El-Baramoon Experimental Farm, Hort. Res. Institute, Agric. Res. Center, Ministry of Agric., during the two seasons of (2013 / 2014) and (2014 / 2015) to study the effect of sowing dates (Sept., Oct., Nov., Dec. and Jan.) and foliar application of some natural stimulants (Seaweeds extract, Moringa leaf extract, Salicylic acid and Chitosan) as well as their interaction on vegetative growth, fruit yield and essential oil of coriander (*Coriandrum sativum* L.) plant. The results showed that sowing coriander seeds in October resulted in significant increase in growth characters, fruit yield and essential oil composition compared with other sowing dates in both seasons. Foliar applications of some natural stimulants (Chitosan, followed by Moringa leaf extract then Salicylic acid) significantly affected all studied parameters compared to the treatments of seaweed extract and the control plant. Moreover, the interaction treatments indicated that the highest means values for most growth characters, fruit yield and essential oil productivity were recorded from plants sown in October and sprayed with Chitosan. Delayed sowing in December and January and spraying with Moringa leaf extract gave good production at cold temperature. The G.L.C. of essential oil revealed total of 11 compounds. The main compound was linalool which constitutes 79.8 % in October sowing date with Chitosan foliar application and the sowing date in January with Moringa leaf extract application was 78.3 %.These results showed that, it is possible to produce coriander plants under different climate conditions by using some natural stimulants. Fruits yield and active constituents under early and normal sowing dates could be improved by spraying plants with chitosan foliar application, while under delayed sowing dates spraying plants with moringa leaf extract.

INTRODUCTION

Coriandrum sativum L. is an annual herb belonging to the Apiaceae family. Coriander is one of the most important introduced medicinal and aromatic crops in Egypt. The earlist medicinal uses of the plant were reported by the ancient Egyptians. Egypt occupies the second-producing country in the world (Anitescu *et al*., 1997). It is native to Mediterranean regions and cultivated for the fresh green herb which used in soups, sauces, salads, vegetable and in cooking. Their fruits are used as food ingredients as well as for production of essential oil. It has been recommended for dyspeptic complaints, loss of appetite, carminative, stomachic, rheumatism and against worms. Moreover, the essential oil and various extracts from coriander fruits possess anti-bacterial, antioxidant anti-diabetic, anti-cancerous and anti-mutagenic activities. New research studies have found that coriander helps in controlling blood sugar, cholesterol and free radical production (Dutta and Appelqvist, 1991). Egyptian agriculture is vulnerable to potential climate change. The growth and production of medicinal plants are affected by genetic and agronomic factors. Maximum yield is only obtained when an appropriate combination of these factors are provided to enhance plant growth and plant development. Changes in essential oil yield and composition have been influenced by cultivar, seeding date and environmental conditions (Gil *et al*., 2002)

Coriander (*Coriandrum sativum* L.) is one of these sensitive crops that are affected by climate change. The Sowing date is one of important factors for obtaining maximum yield in plants. Optimum temperature for germination and early growth is 20–25 ºC. Coriander seed germination and early growth are adversely affected by high temperature if the crop is sown earlier. Delay sowing reduces the plant growth and increases the incidence of diseases and pests. Coriander requires a cool and comparatively dry frost-free climate, particularly at flowering and seed formation stages. High temperature during seed formation leads to increased sterility and reduce yield. Cloudy weather at the time of flowering increases the number of aphids and diseases (Sharma and Sharma, 2012).

Kaya *et al*. (2000) mentioned that the plant height decreased with delay sowing dates. Meena *et al*. (2006) showed that *Coriandrum sativum* L. plant had more growth and yield in sowing date of October compared to sowing date of November. Another study about effects of sowing dates indicated that fruit yield, number of branches, number of umbels per plant and 1000- fruit weight were higher in sowing date of October compared to November (Sagarika *et al*., 2014).

Rashed and Darwesh (2015) compared the sowing dates in (Oct., Nov., Dec., Jan., Feb. and Mar.) on vegetative growth and flowering of coriander and found that the highest plant height, number of branches, seed yield and essential oil yield when sown in October.

There is urgent need to improve crop productivity under changed climate. A new strategy for increasing productivity of crops are using natural growth, natural stimulating compounds. These compounds prefer to be safety to the environment, inexpensive and harmless to humans. Thus, using natural stimulants such as Seaweed extract, Moringa leaf extract, Salicylic acid or Chitosan as means to alleviate the harmful effects of high or low temperature stress and to increase yield become necessity under climate changes conditions.

Seaweeds extract play role as activator of cell division, give rise to antioxidants levels for protection against adverse environmental conditions, (Smirnoff, 1995). Nasiroleslami and Safaridolatabad (2014) reported that foliar application of Seaweed increased vegetative growth of dill plants. Moringa is known as a miracle plant due to its multiple uses. Secondary metabolites isolated from this plant promote the plant growth and defense mechanisms against abiotic stresses.

It is being rich in amino acids, ascorbats, zeatin, minerals and many other compounds. So it has several applications in agriculture and medical sciences (Hussain *et al*., 2013). Salicylic acid is naturally occurs very low amounts in plants and participates the regulation of physiological processes in plant such as stomatal closure, nutrient uptake, chlorophyll synthesis, protein synthesis, inhibition of ethylene biosynthesis, transpiration and photosynthesis (Khan *et al*., 2003). Chitosan is a natural, low toxic and inexpensive compound that environmentally friendly with various applications in agriculture, (De Alvarenga, 2011). Moreover, it has been shown to stimulate plant growth, to possess antioxidant activity, act as antitranspirant compound that has proved to be effective in many crops and to improve storability of postharvest fruits and vegetables (Mondal *et al*., 2012).

The aim of the investigation is study the effect of some natural stimulants under different sowing dates and their interaction on vegetative growth, fruits yield, essential oil production and chemical constituents of coriander (*Coriandrum sativum* L.) plants.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of El-Baramoon, Hort. Res. Station, Dakahlia Governorate, Hort. Res. Inst. Agric. Res. Center, Ministry of Agriculture, Egypt, during the two successive seasons of (2013/ 2014) and (2014/ 2015) to study the effect of sowing dates and foliar application of some natural stimulants as well as their interaction on vegetative growth, fruits yield, essential oil determinations and chemical constituents of coriander plant.

Seeds were obtained from the Medicinal and Aromatic Plants (MAP) Dept. of Hort. Res. Inst., Agric. Res. Center. Seeds were washed then soaked in tap water as control and in some natural stimulants for 12 hr. and then sown in hills at 25 cm apart. The experimental unit was 3.5 m^2 (2×1.75 m^2) every unit contained 18 hills in three rows 50 cm between rows (about 21600 plant per fed). Plants were thinned to one plant per hill when seedlings grew to a height of at least 10 cm. A light irrigation was given after one week from planting. The Physical and chemical analysis of the soil was analyzed according to Page *et al*. (1982) and presented in Table (A).

The mineral fertilizers were NPK: ammonium sulphate (20.5% N), calcium super phosphate (15.5% P_2O_5),potassium sulphate (48% K_2O) were added at rate of (143g /plot P_2O_5) during preparation of soil and (143g /plot N) and (63g/ plot K_2O) after thinning plants. The normal agricultural practices of coriander production were followed according to the recommendations of Egyptian Ministry of Agriculture.

This experiment included 25 treatments that were arranged in a split plot design with three replicates, which were the combinations between five sowing dates arranged in the main plots and five natural stimulants foliar applications treatments were randomly distributed in the sub plots.

Table (A): The physical and chemical properties of the experimental soil.

Mechanical analysis (%)		Chemical analysis (ppm)		Micro-elements (ppm)	
Soil texture	Clay loamy	Available N	38.21	Fe++	3.12
Fine san	18.3	Available P	5.53	Mn++	1.39
Silt	27.7	Available K	297	Zn++	1.27
Clay	44.80	pH	8.15	Cu++	0.46
OM	1.89	CaCO3 %	2.4	E.C.	0.62

Soluble cations and anions (meq/ 100 g soil)

Ca ++	Mg ++	Na+	K+	CO_3 -	SO_4 -
3.0	0.27	0.17	0.11	0.02	5.05

Sowing dates

1- 15th September
2- 15th October
3- 15th November
4- 15th December
5- 15th January

Natural stimulants foliar application

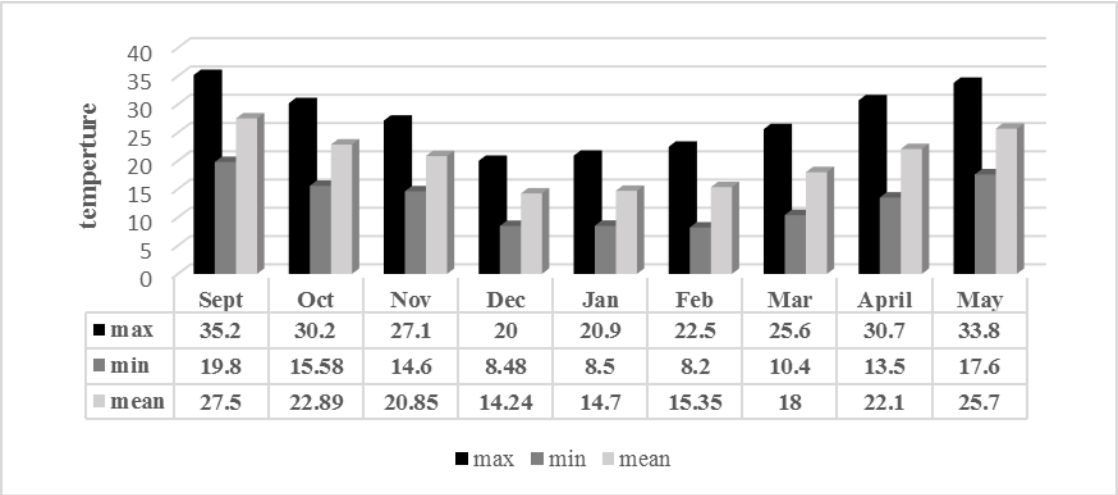
The plants were sprayed with foliar treatments three time, at 30, 45 and 60 days after sowing.

1. Control (unsprayed).
2. Seaweeds extract (SWE) at the concentration of 0.5ml/l
3. Moringa leaf extract (MLE) at the concentration of 1:30
4. Salicylic acid (SA) at the concentration of 25 ppm.
5. Chitosan (Ch) at the concentration of 150 ppm.

A commercial seaweed extract product was used. Seaweed extract contained N (1 %), K (2.5 %), Ca (0.17 %), Mg (0.43 %), Fe (0.06 %), S (2.2 %), and Zn (0.99 ppm), Boron (3.87 ppm) alganic acids (10-12 %). 1 kg fresh moringa leaves of mature trees were collected. Leaves were washed and mixed with 1 litre distilled water by an electric blender and the decoction thereafter was filtered through a sterilized cheese cloth. The clear filtrate was stored in a refrigerator at 4°C. These extract was diluted with distilled water at a ratio 1:30 (v/v) to prepare moringa leaf extract and then sprayed directly onto plants (Nouman *et al*., 2012). A commercial salicylic acid natural was obtained from El-Gomhouria Company for chemicals and medical supplies. The solution of chitosan (2-Amino-2-deoxy-beta-D-glucosasmine) was prepared by dissolving chitosan powder in 0.5% (v/v) acetic acid.

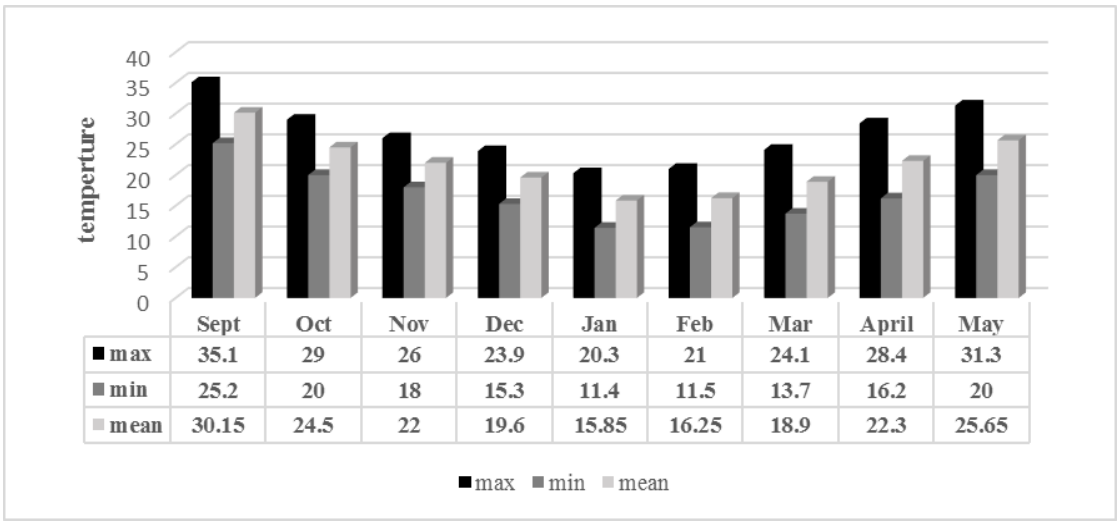
Metrological data:

Temperature records during the two growing seasons in Fig., (1 and 2) Maximum and minimum air temperature were recorded daily, and then calculated as mean / month at Mansoura weather station according to the Central Laboratory for Agricultural Climate (CLAC).



	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
max	35.2	30.2	27.1	20	20.9	22.5	25.6	30.7	33.8
min	19.8	15.58	14.6	8.48	8.5	8.2	10.4	13.5	17.6
mean	27.5	22.89	20.85	14.24	14.7	15.35	18	22.1	25.7

Fig. (1). Monthly means of air temperature (Max.,Min.and Mean)in El-Mansoura metrological station during 1st seasons (from September to May of 2013 / 2014).



	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
max	35.1	29	26	23.9	20.3	21	24.1	28.4	31.3
min	25.2	20	18	15.3	11.4	11.5	13.7	16.2	20
mean	30.15	24.5	22	19.6	15.85	16.25	18.9	22.3	25.65

Fig. (2). Monthly means of air temperature(Max.,Min.and Mean) in El-Mansoura metrological station during 2nd seasons (from September to May) of 2014 / 2015.

Data recorded were as follows:

Random samples of nine plants were taken from every experimental unit at harvest date in both seasons to evaluate the following characters.

1- Vegetative growth:

Plant height (cm)

Number of branches per plant.

Plant fresh and dry weight (g)

2- Fruits measurements:

Number of umbels /plant.

1000 fruits weight (g):

Fruits yield (g /plant) and (kg /fed)

Heat use efficiency (HUE) for seed yield: was calculated by the method suggested by Pal and Murty (2010).

3- Essential oil determination:

Oil percentage:- was determined in the dried samples (100 g) in both seasons by subjecting fruits to hydro distillation in Clevenger apparatus according to the method described by British Pharmacopoeia (2000).

Oil yield: was calculated by multiplying the oil % by average plant yield and expressed as volume in ml /plant. Total yield was calculated by multiplying the oil yield per plant by number of plants per feddan.

Gas Liquid Chromatography (GLC): was carried out at the Medicinal and Aromatic Dept., Horti. Res. Inst., Agric. Res. Center, Dokki, using DsChrom Gas Chromatograph equipped with a flame ionization detector for separation of essential oil constituents. Polysillphene- siloxane 30m×0.25 mmlD × 0.25 µm film. The obtained chromatogram of GLC analysis were analyzed to calculate the percentage of the main components by matching their retention time (RT) with those of authentic samples under the same conditions and the constituents of the essential oil were identified, according to Guenther and Joseph (1978).

Statistical analysis

Data of the present study was subjected to analysis of variance (ANOVA) by the general linear models (BLMS) procedure using (costat) statistical analysis system. Mean comparisons were performed

using the least significant differences (L.S.D) method at significance level of 5 % according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1- Vegetative growth characters

Effect of sowing dates

Data presented in Table (1) revealed that plant height, number of branches / plant, plant fresh and dry weights of coriander were significantly affected by different sowing dates. Date of sowing is an important management factor for coriander. Change in sowing date lead to significant change in weather microclimate and subsequently the performance of the plants. The plant height increase may be due to difference in the average air temperature during months sowing. The optimum temperature for the growth was from September to October and then gave increasing in plant height, while the low temperature was from December to January caused that the plants have not adequate opportunity for photosynthesis thus decrease in plant height. The above mentioned results followed the same trend as those obtained by Meena and Malhotra (2006), Bhadkariya *et al*. (2007), Delibaltova *et al*. (2012), Sagarika *et al*. (2014) and Moniruzzaman *et al*. (2015) on coriander, who reported that October sowing date resulted in superior vegetative growth such as plant height compared to the other sowing dates in September, December and January.

Effect of foliar application

Data clearly Table (1) illustrated that all natural stimulates; Seaweed extract (SWE), Moringa leaf extract (MLE), Salicylic acid (SA) and Chitosan (Ch) significantly increased vegetative growth characters compared to the control in the two seasons. Spraying with Chitosan caused a pronounced increase in plant height, number of branches /plant, plant fresh and dry weights in both seasons followed by Moringa leaf extract then Salicylic acid.

These results are in the same line with many researchers such as El Nagar *et al*. (2012), Mondal *et al*. (2013), EL-Sherbini (2015) and Katiyar et al., (2015) reported that the favorable effect of Chitosan might be attributed to its excelant biocompatibility, biodegradability and bioactivity. Chitosan enhanced the efficacy of plants to reduce the deterious effect of unfavorable conditions as well as plant growth. Chitosan induces mechanisms in plants against cold stresses and helps in formation of barriers that enhances plants productivity. Culver *et al*. (2012), Muhamman *et al*. (2013), Ozobia (2014) and Taha *et al*. (2015) showed that foliar application of Moringa leaf extract had significant and positive effects on all vegetative characters included number of branches/ plant compared to the control treatment. Mady (2009), Ghasemzadeh and Jaafar (2013) and Angooti and Nourafcan (2015) they noticed that foliar spray of salicylic acid had significantly effect on number of branches/ plant compared to control treatment.

Effect of the interaction

The results obtained in Table (1) show that the differences between the interaction treatments were significant in both seasons. Coriander sown at (Sept, Oct and Nov) with Chitosan (Ch) foliar application gave the tallest plants, number of branches/ plant, plant fresh and dry weight among other foliar applications in these sowing dates. On the other hand, Dec. and Jan. sowing date sprayed with Moringa leaf extract (MLE) was the tallest in these dates. Bhadkariya *et al*. (2007) compared sowing dates (Oct., Nov., and Dec.) on the growth of coriander and found that the highest plant height was at sowing in November.

Similar results were obtained by Ibrahim (2011) found that Chitosan foliar application increased plant height of onion at different sowing dates. EL-Sherbini (2015) found that Moringa leaf extract and Chitosan foliar applications increased plant height on sugar pea compared to the control but Moringa leaf extract was significantly in winter season. Antony *et al*. (2003) reported that Salicylic acid increased plant height in normal and delay sowing dates on green gram. Ghasemi *et al*. (2013) mentioned that Salicylic acid increased plant height in high temperature condition on chamomile.

2-Fruits characters

Effect of sowing dates

Data in Table (2) indicate that the seeds sown ont 15th October caused significant increase in number of umbels/ plant, 1000-fruit weight, fruit yield followed by 15th September, respectively, in both seasons than those sown in winter time. While, in the sowing dates in November, December and January the above mentioned fruits characters were decreased compared to in October or September. Reddy and Rolston (1999) found that coriander seed yield was very sensitive to sowing date. Lengthening of vegetative growth period and producing fewer branches possibly caused reduction in plant photosynthesis potential and consequently decreasing the production of reproductive organs such as umbel in plant. These results may be due to the fact that the lesser temperature rise during the growing-season would have a good impact on production by saving 60 days in season and there was a significant positive relationship between biological yield and average minimum temperature during growth period as biological yield was increased by increasing average minimum temperature. It can be said that earlier sowing increased number of reproductive units and fruit yield through lengthening growth period. Moreover, it appears that favorable environmental conditions especially light and temperature at the first sowing date allowed the plants to better use these conditions, to produce more assimilates and finally, to increase it fruit yield.

Similar results were in line with those of Kaya *et al*. (2000), Lima *et al*. (2007), Khah (2009), Delibaltova *et al*. (2012), Sharangi and Roychowdhury (2014) and Moniruzzaman *et al*. (2015) compared sowing date in September, October, November, December and January. The results showed that early in sowing led to increase seed yield. The maximum values for fruits characters were obtained when the seeds sown in October, while the late sown crop in (December and January) recorded less seed yield.

Table (1): Effect of sowing dates , foliar application and the interaction treatments on plant height (cm), number of branches / plant, plant fresh and dry weight (g) of *Coriandrum sativum* L. plant in the two seasons (2013/2014 and 2014/2015).

Treatments		Plant height (cm)		Number of branches/ plant		Plant fresh weight (g)		Plant dry weight (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
A: Effect of sowing date									
15th September		85.40	103.27	11.20	10.80	7.60	6.72	0.35	0.32
15th October		97.27	120.47	12.73	12.80	9.61	7.98	0.67	0.49
15th November		78.73	93.87	10.60	9.27	6.74	6.75	0.32	0.31
15th December		69.47	81.20	9.53	7.87	5.19	4.21	0.28	0.29
15th January		56.33	72.67	7.47	5.67	3.70	2.89	0.24	0.23
L.S.D. at 5 %		2.06	3.72	0.35	1.29	0.83	0.74	0.009	0.025
B: Effect of foliar application									
Control		61.00	74.80	6.73	5.47	3.46	2.89	0.24	0.25
Seaweed		67.00	82.47	8.40	7.67	5.00	3.74	0.28	0.27
Moringa		82.47	103.20	11.53	11.07	8.22	6.56	0.43	0.37
Salicylic		81.87	99.67	11.07	10.20	6.88	6.49	0.34	0.35
Chitosan		94.87	111.33	13.80	12.00	9.27	8.88	0.57	0.40
L.S.D. at 5 %		1.35	4.70	0.75	0.84	0.84	0.75	0.009	0.025
C: Effect of the interaction treatments									
15th September	Con	66.00	78.67	8.00	6.67	5.27	3.18	0.29	0.28
	SWE	70.67	88.67	10.00	9.00	6.25	4.55	0.33	0.31
	MLE	82.00	105.00	11.33	11.67	7.81	6.30	0.35	0.33
	SA	97.67	116.67	12.00	11.67	8.57	7.23	0.37	0.33
	CH	110.67	127.33	14.67	15.00	10.09	12.33	0.40	0.36
15th October	Con	78.00	94.67	8.67	9.33	5.90	4.03	0.30	0.34
	SWE	85.00	104.67	10.67	11.33	7.52	5.58	0.33	0.36
	MLE	103.00	121.00	11.67	12.67	9.00	7.10	0.37	0.50
	SA	104.67	128.67	13.667	15.00	10.17	9.17	0.90	0.57
	CH	115.67	153.33	19.00	15.67	15.47	14.03	1.47	0.67
15th November	Con	61.67	78.00	7.67	5.33	3.00	3.67	0.26	0.29
	SWE	68.00	85.33	9.33	8.67	5.32	4.09	0.27	0.24
	MLE	78.33	99.00	10.33	10.00	7.47	7.08	0.32	0.34
	SA	79.00	101.67	11.67	10.33	7.84	8.83	0.35	0.35
	CH	106.67	105.33	14.00	12.00	10.05	10.09	0.39	0.36
15th December	Con	54.67	66.33	5.33	3.33	1.71	1.96	0.20	0.20
	SWE	60.67	71.33	6.67	5.67	3.60	2.35	0.25	0.25
	MLE	83.00	99.00	13.67	11.67	9.39	8.16	0.35	0.36
	SA	70.33	80.00	10.33	8.33	4.49	4.04	0.28	0.33
	CH	78.67	89.33	11.67	10.33	6.76	4.56	0.32	0.34
15th January	Con	44.67	56.33	4.00	2.67	1.44	1.62	0.18	0.16
	SWE	50.67	62.33	5.33	3.67	2.30	2.13	0.22	0.21
	MLE	66.00	92.00	10.67	9.33	7.45	4.17	0.30	0.30
	SA	57.67	71.33	7.67	5.67	3.32	3.17	0.25	0.22
	CH	62.67	81.33	9.67	7.00	4.00	3.38	0.28	0.26
L.S.D. at 5 %		3.21	4.69	1.30	1.81	1.87	1.67	0.02	0.57

Effect of foliar application

Data in Table (2) show that spraying Chitosan (Ch) increased coriander fruit characters, followed by Moringa leaf extract (MLE) compared to the untreated one in both seasons. Concerning the increase in yield from Chitosan foliar applicaton is a result of stimulation of roots, shoots, leaves, chlorophyll content and photosynthetic rate which led to the increment in the vigor growth followed by increase yield, (Gornik *et al*. 2008). The increases in fruits yield parameters might be attributed to the increase in vegetative growth characteristics, early flowering time, seed filling, number and weight of fruits. The favorable effect of Moringa leaf extract on yield might be connected with the role of plant growth regulators in improving crop growth and hence yield (Muhamman *et al*., 2013). Moreover, Emongor (2015) reported that Moringa leaf extract increased leaf area, number and leaf, chlorophyll content and that might have increased net photosynthesis resulting in more photo assimilates plant, hence higher yield.

These results are supported by Abdel-Mawgoud *et al*. (2010) and Javan *et al*. (2013) mentioned that spray plants with Chitosan foliar application significantly increased vegetative growth parameters included yield compared to all other treatments or the control. Nouman *et al*. (2012) and Ozobia (2014) showed that application of Moringa leaf extract as natural stimulant had positive effect on yield components compared to untreated plants.

Effect of the interaction

The interaction between sowing dates and natural stimulants on fruits characters is presented in Table (2). Sown coriander seeds in October and spraying with Chitosan (Ch) had a significant effect on number of umbels / plant, 1000-fruit weight and fruit yield respectively, in the both seasons. Sowing date in December and spraying with Moringa leaf extract

(MLE) gave the best results in above mentioned parameters.

On the other trend, sown seeds in (Sept, Oct and Nov) and sprayed with chitosan were significantly heaver in weight of 1000 seeds among other foliar applications in these dates. While, in case of (Dec and Jan) a sown seed with Moringa leaf extract was the heaviest. While, control plants which sown on 15th January gave the lightest fruits characters among different interactions in both seasons.

Table (2): Effect of sowing dates, foliar application and the interaction treatments on number of umbels/ plan t, 1000-fruit weight (g), fruits yield (g / plant and kg / fed) and heat use efficiency (HUE) of *Coriandrum sativum* L. plant in the two seasons (2013/2014 and 2014/2015).

Treatments		Number of umbels/ plant		1000- fruit weight (g)		Fruits yield (g / plant)		Fruits yield (kg / fed)		Heat use efficiency (kg /fed /deg. day)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
A: Effect of sowing date											
15th September		27.87	27.87	9.03	7.61	4.75	4.69	102.56	101.23	0.060	0.059
15th October		32.33	32.87	9.43	8.68	6.07	6.38	131.03	137.84	0.096	0.097
15th November		25.33	26.47	8.74	7.57	4.03	4.17	85.18	90.10	0.071	0.076
15th December		24.47	24.87	8.15	6.83	3.94	3.69	87.16	79.70	0.075	0.071
15th January		19.33	22.87	7.45	5.94	3.46	3.44	74.82	74.38	0.052	0.054
L.S.D. at 5 %		2.56	1.26	0.50	0.47	0.28	0.57	6.05	12.36	0.0041	0.054
B: Effect of foliar application											
Control		19.27	19.40	7.56	5.42	3.04	2.98	65.55	64.48	0.044	0.043
Seaweed		21.93	22.07	8.15	6.44	3.15	3.23	67.97	69.70	0.047	0.048
Moringa		27.33	29.33	8.94	8.27	4.91	4.60	105.98	99.42	0.075	0.077
Salicylic		26.67	29.00	8.65	7.64	4.48	5.10	96.68	110.19	0.078	0.081
Chitosan		34.13	35.13	9.55	8.85	6.69	6.45	144.56	139.46	0.110	0.110
L.S.D. at 5 %		1.50	2.19	0.46	0.23	0.34	0.49	7.40	10.86	0.0043	0.0079
C: Effect of the interaction treatments											
15th September	Con	21.67	22.67	7.58	6.25	2.91	2.89	62.93	62.50	0.034	0.033
	SWE	23.00	23.00	8.39	6.85	2.99	3.15	64.51	68.00	0.035	0.037
	MLE	25.33	25.00	9.01	7.66	3.70	3.41	79.85	73.72	0.045	0.041
	SA	28.33	32.00	9.67	7.94	5.76	6.27	124.34	135.60	0.074	0.080
	CH	41.00	36.67	10.52	9.37	8.39	7.70	181.15	166.39	0.110	0.100
15th October	Con	23.00	23.33	8.37	7.13	4.29	4.51	92.74	97.56	0.063	0.064
	SWE	25.33	27.33	8.91	8.17	4.49	5.28	96.91	113.98	0.068	0.076
	MLE	29.67	30.67	9.18	8.83	5.41	6.07	116.93	131.11	0.084	0.090
	SA	35.00	35.00	9.84	8.95	6.44	6.92	139.10	149.47	0.110	0.100
	CH	48.67	48.00	10.87	10.32	9.70	9.12	209.45	197.10	0.160	0.140
15th November	Con	20.67	19.33	7.46	5.91	2.84	2.79	61.42	60.33	0.047	0.047
	SWE	23.00	21.33	8.31	6.20	2.85	2.91	61.34	62.85	0.049	0.050
	MLE	26.33	25.67	8.99	8.14	3.45	3.43	74.52	74.23	0.061	0.060
	SA	26.33	30.67	9.11	8.39	4.22	4.50	91.15	97.34	0.077	0.085
	CH	30.33	35.33	9.84	9.18	6.36	7.21	137.45	155.73	0.120	0.140
15th December	Con	18.67	16.67	7.24	4.31	2.59	2.44	55.87	52.77	0.043	0.041
	SWE	20.33	19.67	7.67	5.87	2.70	2.49	58.25	53.78	0.046	0.043
	MLE	30.00	34.67	9.11	9.05	5.75	5.49	124.13	118.58	0.120	0.110
	SA	25.00	24.67	8.03	6.92	4.19	3.89	90.50	84.17	0.074	0.070
	CH	28.33	28.67	8.70	8.04	4.96	4.13	107.06	89.20	0.095	0.083
15th January	Con	12.33	15.00	7.13	3.54	2.54	2.28	54.79	49.24	0.033	0.031
	SWE	18.00	19.00	7.30	5.11	2.72	2.31	58.82	49.90	0.038	0.034
	MLE	25.33	30.67	8.40	7.69	4.07	4.60	87.98	99.43	0.066	0.078
	SA	18.67	22.67	6.58	6.01	3.93	3.91	84.82	84.38	0.060	0.061
	CH	22.33	27.00	7.82	7.33	4.06	4.12	87.70	88.92	0.063	0.067
L.S.D. at 5 %		3.71	4.25	0.81	0.65	0.55	0.92	11.88	19.93	0.0092	0.0017

The heat use efficiency(HUE) for seed(kg seed/deg. day)
Effect of sowing dates

Data presented in Table (2) show that heat use efficiency (HUE) for seed as affected by five different coriander sowing dates (Sept, Oct, Nov, Dec and Jan). It is obviously from these data that heat use efficiency (HUE) for seed decreased in the sowing dates on 15th November, 15th December and 15th January compared to in October.

The maximum HUE for seed (0.096 and 0.097 kg seed/fed/deg) obtained from the sowing date on 15th October, in both seasons significantly increased than another sowing dates. While, the minimum HUE for seed was at 15th January (0.052 and 0.054 kg seed/fed/deg) respectively, in the first and second seasons than other sowing dates.

Pal and Murty (2010) and Fayed *et al*. (2015) mentioned that the maximum HUE for wheat seed obtained from the sowing date in October compared other sowing dates. Moniruzzaman *et al*. (2015) mentioned that the maximum HUE for coriander seed obtained from the sowing date at November compared December sowing date. These results may be due to

sowing dates on 15th October gave the highest seed yield and higher accumulation temperature to harvest and with decrease seed yield and accumulation temperature decreasing heat use efficiency (HUE). Increasing yield under foliar application of Salicylic acid could be ascribed to the well-known roles on photosynthetic parameters and plant water relations. Hesami *et al*. (2012) mentioned that spraying salicylic acid (SA) significantly increased 1000 seed weight and coriander seed yield compared with untreated plants.

Effect of foliar application

Concerning The heat use efficiency (HUE) for seed as affected by different types of natural stimulates foliar applications (Seaweed, Moringa leaf extract, Salicylic acid and Chitosan), data presented in Table (2) showed that coriander plants sprayed with Chitosan gave the maximum HUE for seed (0.11 and 0.11 kg seed /fed /deg) followed by Salicylic acid (0.081 and 0.078 kg seed /fed /deg) respectively, in the both seasons compared with the other foliar application separately. The minimum HUE for seed obtained from untreated plants (control).

Effect of the interaction

Data in Table (2) showed the effect of the dual interaction between (sowing dates x foliar applications) on the heat use efficiency (HUE) for seed of coriander. It is clearly from the previous data that the (HUE) for seed significantly affected by the interaction treatments. It is clearly from the previous data that the heat use efficiency (HUE) for seed significantly affected by the interaction treatments.

The presented analyzed data indicated that sowing date at 15th October and sprayed with Chitosan gave the maximum of heat use efficiency (HUE) (0.16 and 0.14 kg seed /fed /deg)**.** While, the minimum of heat use efficiency (HUE) was sowing date on 15th January with seaweed foliar application (0.038 and 0.034 kg seed /fed /deg) and the control plants (0.033 and 0.031 kg seed /fed /deg**)** respectively, among different interactions in both seasons. On the other trend in case of (Sept, Oct and Nov) sown seeds with chitosan foliar application plants were significantly higher in heat use efficiency among other foliar applications. While, is highest in case of (Dec and Jan) sowing seed with Moringa leaf extract foliar application.

3-Essential oil productivity

Effect of sowing dates

Data presented in Table (3) reveal that harvest season and plant development had significant effect on essential oil productivity and influenced by the five sowing dates. However, in the two seasons, sown coriander on 15th October had the highest essential oil percentage (1.32 and 1.18 %) and oil yield (0.083 and 0.078 ml / plant) and (1.79 and 1.69 L / fed), while sowing date on 15th January gave the lowest essential oil percentage (0.65 and 0.57 %), oil yield (0.024 and 0.021 ml / plant) and (0.52 and 0.45 L / fed) respectively. The increment in essential oil percent may be due to the fact that sowing date is an important management factor for almost all seed spices including coriander. Change in sowing time leads to significant change in weather microclimate and subsequently the performance of the crop. In addition, the physical environment has profound influence on growth, biomass partitioning and ultimately the yield of coriander.Time of sowing controls the crop phonological development along with efficient conversion of biomass into economic yield (Khichar and Niwas, 2006).

These results are in accordance with those obtained by Kaya *et al*. (2000) on coriander, reported that the highest essential oil % and yield were decreased with delay sowing dates, while the effect of sowing date was insignificant on essential oil content. Naghera *et al*. (2000) showed that the sown coriander in October recorded the highest values of oil content. Rashed and Darwesh (2015) compared the sowing dates in (Oct., Nov., Dec., Jan., Feb. and Mar.) and found that the highest essential oil % and yield was at sown in October.

Effect of foliar application

Data in the same Table clearly demonstrate that all foliar sprays of bio-stimulants were significantly differed in their effect on essential oil percentage and yield in the two seasons. Plants sprayed with Chitosan produced the highest essential percentage (1.27 and 1.23 %) and oil yield (0.089 and 0.085 ml/ plant) and (1.93 and 1.83 L/ fed), respectively, in the both seasons. The increment in essential oil yield might be due to the increase in vegetative growth, fruit yield / plant nutrients uptake or changes in size of vittae in fruits .

Effect of the interaction

The effect of dual interaction between different sowing dates (Sept, Oct, Nov, Dec and Jan) and bio-stimulants (SWE, MLE, SA and Ch) on essential oil % and yield is shown in Table (3). Data reveal that seeds sown on 15th October and sprayed with Chitosan (Ch) produced the highest essential oil percent (1.60 and 1.52 %), oil yield (0.16 and 0.13 ml /plant) and (3.35 and 3.00 L /fed), respectively, in the both seasons. The effect of the interaction between sowing date (Sept, Oct and Nov) and foliar application of Chitosan (Ch) resulted in highest value of essential oil percentage. While, in case of winter sowing date (Dec and Jan) foliar application of Moringa leaf extract (MLE) resulted in highest value of essential oil percentage. Biertumpfel and Graf (2006) concluded that the highest value of oil yield and earlier harvest obtained from autumn sowing compared to spring sowing.

4- Essential oil constituents (%)

Data presented in Table (4) and illustrated in Fig. (3, 4 and 5) gave the different components separated and identified from coriander oil samples produced from plant sown in Sept., Oct. and Jan. G.L.C. chromatograms revealed and identified a total of 11 compounds are α-pinne, myrcene, β-pinene, phyllandrene, p-cymene, linalool, geraniol, terpinene-4-ol, borneol, linalyl acetate and geranyl acetate. The highest value of the main components (linalool produced from the sowing date in October and treated with Chitosan (%79.8), but sowing date in September with Chitosan gave (77.7 %). While, seeds sown in January and plants treated with Moringa leaf extract (MLE) produced 78.27 % of the major components (linalool) compared with the other treatments.

Table (3): Effect of sowing dates, foliar application and the interaction treatments on essential oil (%) and oil yield (ml /plant and L /fed) of *Coriandrum sativum* L. plant in the two seasons (2013/2014 and 2014/2015).

Treatments		Essential oil (%)		Essential oil yield (ml / plant)		Essential oil yield (L / fed)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
A: Effect of sowing date							
15th September		0.99	0.98	0.050	0.049	1.08	1.08
15th October		1.32	1.18	0.083	0.078	1.79	1.69
15th November		1.28	1.12	0.051	0.049	1.11	1.06
15th December		1.13	1.07	0.047	0.041	1.02	0.90
15th January		0.65	0.57	0.024	0.021	0.52	0.45
L.S.D. at 5 %		0.40	0.05	0.004	0.007	0.09	0.16
B: Effect of foliar application							
Control		0.89	0.80	0.028	0.025	0.61	0.54
Seaweed		0.97	0.83	0.031	0.028	0.68	0.60
Moringa		1.21	1.11	0.055	0.052	1.18	1.13
Salicylic		1.04	0.96	0.052	0.050	1.12	1.08
Chitosan		1.27	1.23	0.089	0.085	1.93	1.83
L.S.D. at 5 %		0.025	0.047	0.004	0.007	0.08	0.14
C: Effect of the interaction treatments							
15th September	Con	1.00	0.90	0.02	0.02	0.47	0.45
	SWE	1.13	0.91	0.03	0.03	0.50	0.52
	MLE	1.32	1.31	0.05	0.04	0.98	0.81
	SA	1.00	1.07	0.06	0.06	1.18	1.26
	CH	1.26	1.40	0.11	0.11	2.28	2.33
15th October	Con	1.21	1.00	0.05	0.05	1.13	0.96
	SWE	1.22	1.03	0.06	0.05	1.19	1.14
	MLE	1.32	1.28	0.07	0.08	1.54	1.67
	SA	1.25	1.13	0.08	0.08	1.74	1.68
	CH	1.60	1.52	0.16	0.13	3.35	3.00
15th November	Con	1.20	0.99	0.03	0.03	0.74	0.63
	SWE	1.23	0.93	0.04	0.03	0.76	0.59
	MLE	1.30	1.12	0.05	0.04	0.97	0.83
	SA	1.24	1.10	0.05	0.05	1.13	1.07
	CH	1.42	1.40	0.09	0.10	1.95	2.19
15th December	Con	0.75	0.72	0.03	0.02	0.56	0.48
	SWE	0.78	0.77	0.03	0.03	0.66	0.49
	MLE	1.23	1.09	0.08	0.07	1.64	1.56
	SA	0.95	0.93	0.04	0.04	0.91	0.90
	CH	1.23	1.17	0.06	0.05	1.32	1.04
15th January	Con	0.30	0.35	0.01	0.01	0.17	0.17
	SWE	0.45	0.51	0.01	0.01	0.27	0.25
	MLE	0.87	0.78	0.04	0.04	0.76	0.78
	SA	0.76	0.59	0.03	0.02	0.65	0.50
	CH	0.85	0.65	0.03	0.04	0.75	0.59
L.S.D. at 5 %		0.075	0.091	0.007	0.013	0.16	0.28

Table (4):G.L.C. of coriander essential oil constituents (%) as affected by the interaction between sowing dates in(Sept, Oct and Jan) and foliar applications in the second season 2014 / 2015.

components	Essential oil constituents (%)														
	15th September					15th October					15th January				
	Con	SW	MLE	SA	Ch	Con	SW	MLE	SA	Ch	Con	SW	MLE	SA	Ch
α-pinne	0.16	1.02	0.36	0.40	1.16	3.74	0.92	5.13	11.6	0.66	0.61	1.29	0.59	10.0	2.80
Myrcene	2.03	4.46	4.55	4.28	4.01	7.75	3.65	4.39	1.92	3.52	5.47	5.38	5.05	4.50	5.21
β-pinene	0.31	0.75	0.74	0.64	0.73	-	-	-	-	0.42	-	-	0.75	-	-
Phyllandrene	0.54	1.27	1.39	1.64	1.22	1.84	1.81	1.88	-	0.95	0.65	-	0.52	-	-
p-cymene	2.87	6.21	6.67	6.14	4.47	6.35	6.47	5.18	2.67	5.19	5.58	3.54	3.72	3.26	4.32
Linalool	29.7	72.1	75.4	76.6	77.7	54.2	65.1	74.3	76.7	79.8	51.4	64.1	78.3	72.5	73.0
geraniol	0.46	-	0.42	0.56	0.44	-	-	-	-	-	-	-	-	-	-
Terpinene-4-ol	-	0.23	0.24	-	-	-	-	-	-	-	-	-	1.58	-	1.54
Borneol	0.15	0.37	0.43	0.89	0.69	-	0.87	0.50	-	-	-	-	0.67	-	-
Linalyl acetate	1.31	3.77	3.38	3.41	4.13	3.46	3.46	-	3.61	3.44	2.46	5.01	4.04	13.5	6.32
Geranyl acetate	0.77	1.93	1.80	1.63	1.97	1.45	0.67	2.75	3.02	2.09	0.70	4.11	1.17	-	-
Known	38.3	92.1	95.4	96.0	96.5	78.3	83.0	94.1	98.5	97.1	66.9	83.4	96.5	95.1	93.3

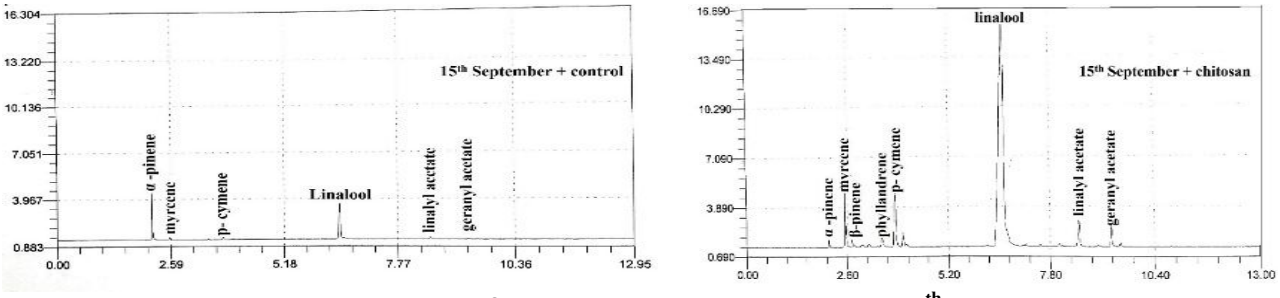


Fig. (3): G. L.C. chromatogram analysis of coriander oil constituents (%) on 15th September sowing date with different foliar applications.

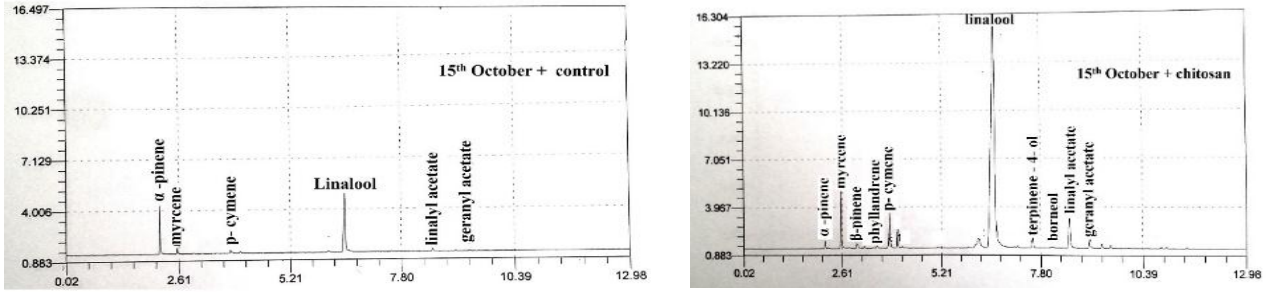


Fig. (4): G. L.C. chromatogram analysis of coriander oil constituents (%) on 15th October sowing date with different foliar applications.

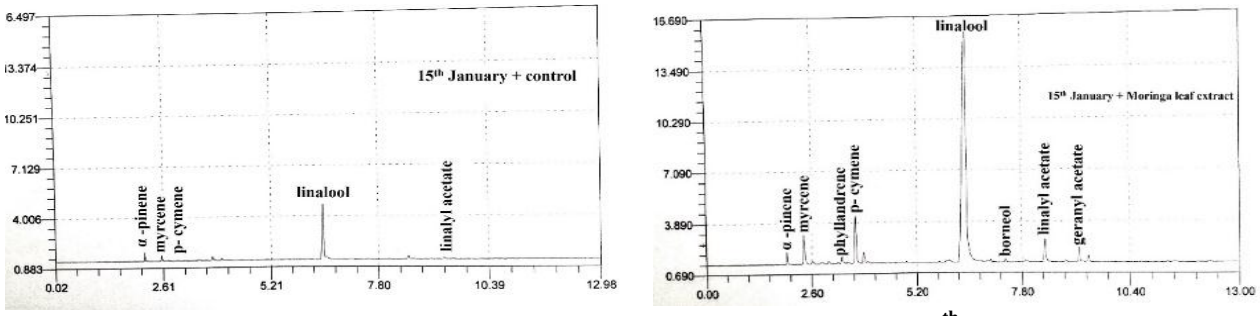


Fig. (5): G. L.C. chromatogram analysis of coriander oil constituents (%) on 15th January sowing date with different foliar applications.

CONCLUSION

Spraying coriander plants with bio-stimulants improved plant growth and fruit and essential oil yields. These bio-stimulants could be used to overcome stress conditions such as unfavorable climatic conditions. Chitosan was very effective than other biostimulants in most cases, while moringa leaf extract was more effective under stress of low temperature. The use of bio-stimulants, therefore, could be used successfully for other crops as well as become important for the Egyptian agriculture particularly in the field of production of medicinal and aromatic plants, especially when economical and environmental points of view are considered.

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تحسين النمو والمواد الفعالة فى نبات الكزبرة باستخدام بعض المنشطات الطبيعية تحت الظروف المناخية المختلفة

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أجريت هذه التجربة في المزرعة البحثية بالبرامون معهد بحوث البساتين بالمنصورة، مركز البحوث الزراعية خلال موسمين متتاليين من (٢٠١٣/٢٠١٤ و٢٠١٤/٢٠١٥) وذلك لدراسة تأثير مواعيد الزراعة المختلفة(ستنمبر، أكتوبر ، نوفمبر ، ديسمبر و يناير) وبعض أنواع من الرش الورقي لمنشطات النمو الطبيعية (مستخلص الأعشاب البحرية ، مستخلص المورينجا ، حامض السالسليك و الشيتوزان) والتفاعل بينهما على النمو الخضري ومحصول الثماروإنتاج الزيت لنبات الكزبرة. وكانت النتائج المتحصل عليها كالآتى:-أظهرت النتائج أن ميعاد الزراعة (أكتوبر) أعطى زيادة معنوية فى الصفات الخضرية ، محصول الثمار و مكونات الزيت الطيار مقارنة بمواعيد الزراعة ألاخرى فى كلا الموسمين.أعطى الرش الورقى ببعض منشطات النمو الطبيعية (الشيتوزان ، مستخلص المورينجا ثم يليهما حامض السالسليك) تأثيرا معنويا لجميع الصفات تحت الدراسة مقارنة بمستخلص ألاعشاب البحرية ومعاملة الكنترول.سجلت النباتات المنزرعة فى أكتوبر مع الرش بالشيتوزان أعلى القيم لمعظم صفات النمو ، المحصول الثمرى و إنتاجية الزيت الطيار مقارنة بمعاملات التفاعل الأخرى والكنترول.تم التعرف على ١١ مركب من التحليل الكروماتوجرافى للزيت الطيار حيث أعطت الزراعة فى أكتوبر مع الرش الورقى بالشتيوزان أعلى قيمة للمركب الرئيسى (لينالول) ٧٩.٨% وعند زراعة النباتات فى يناير مع الرش الورقى بمستخلص المورينجا أدى إلى زيادة المكون الرئيسى إلى ٧٨.٣% من نسبة الزيت.من واقع التجربة يمكن التوصية بإمكانية إنتاج نباتات الكزبرة تحت ظروف مناخية مختلفة باستخدام منشطات النمو الطبيعية ففى الزراعة المبكرة والموصى بها يمكن تحسين صفات النمو الخضرى ومحصول الثمار والزيت الطيار باستخدام الرش الورقى بالشيتوزان بينما فى الزراعة المتأخرة يوصى باستخدام الرش الورقى بمستخلص المورينجا.