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Response of Sage (*Salvia Officinalis* L.) Plants to Zinc Application Under Different Salinity Levels.

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Abstract: Two field experiments were carried out during two successive seasons of 2003 and 2004. The experiments were conducted at the Experimental Farm of National Research Center (NRC), Dokki, Cairo, Egypt, to study how to decrease the harmful effect of soil salinity on sage (*Salvia officinalis* L.) plants under zinc application. Results reported that, the vegetative growth characters (Plant height, number of branches, fresh and dry weight) of sage plants treated by zinc with saline soil were greater than those treated with saline soil conditions only. The interaction between soil salinity and zinc application resulted in a marked decrease of essential oil percentage, total carbohydrates and proline content but essential oil (g/plant) and zinc content were increased compared to the treatments under soil saline conditions. Treatment of 2500 ppm soil salinity with zinc increased the components of V thujone and 1,8 cineol but it decreased the components of $- thujone and camphore compared with the control treatment. Our results suggested that sage plants were more tolerant to salinity when zinc application was carried out before transplanting.

Key words: Sage (*Salvia officinalis* L.), soil salinity, zinc, vegetative growth characters, chemical content.

INTRODUCTION

The genus Salvia L. includes about 900 species [1] and is the most numerous within the family Lamiaceae. *Salvia offcinalis* L. (Sage) plant is evergreen sub shrub and belong to Mediterranean region. Sage enjoys the reputation of being a panacea because of its wide range of medicinal effects: it has been used as an antihydrotic, spasmolytic, antiseptic and anti-inflammatory and in the treatment of mental and nervous conditions[2]. Sage is also used traditionally in food preparation.

Recently several authors reported the antioxidant properties of sage and some of its constituents, mainly phenolic compounds such as carnosic, rosmarinic, caffeic and salvianolic acids as well as other phenolic structure-based compounds[3]. Sage is, therefore, one of the favourite candidate species as a source of natural antioxidants in health care products. The essential oils (EOs) of some other plants have also been shown to have antioxidant and hepatoprotective activities[4], although the potentially hepatoprotective effects of sage EO have, to our knowledge, not been investigated. However, potentially toxic effects of sage EO to the liver. The main detoxifying organ may also exist and place limitations on the use of sage. Sage EO is a complex mixture of volatile compounds including monoterpenes, sesquiterpenes and diterpenes. Importantly, the EO contributes the unique flavour of sage and justifies the use of sage as a food condiment. Although some data already exist relating to the toxicity or antioxidant properties of some individual compounds (such as thujone)[5], to assess the effects of the complex mixture of EO as it reaches the consumer remains the best way to predict and prevent possible deleterious effects of its use.

Salinity in soil becomes a problem when the total amount of salts which accumulate in the root zone is high enough to negatively affect plant growth. Excess soluble salts in the root zone restrict plant root from withdrawing water from surrounding soil, effectively reducing the plant available water [6].

Many researchers studied the effect of soil salinity on growth, essential oil and chemical composition of several plants i.e. Abou El- Fadl *et al*.[7] indicated that, herb growth was decreased by increasing the soil salinity but essential oil and its components were increased in peppermint plant. Increasing soil salinity depressed the nutrient uptake in tomato plant[8]. El-Shafy *et. al*.[9] reported that, plant growth of *Ocimum basilicum* was significantly decreased by increasing the levels of soil salinity. Oil and its components of damsesea plant were

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increased with increasing salinity levels[10]. Khalid[11] demonstrated that, increasing salinity decreased plant growth and nutrient content but essential oil, total carbohydrates and proline content were increased but it decreased with addition of substances which help in salinity resistance of *Nigella sativa* L. plants.

Zinc plays an important role in many biochemical functions within plants. Zinc is an essential component over 300 enzymes[12]. In most of these enzymes, zinc makes up an integral component of the enzyme structure. The most distinct zinc deficiency symptoms – stunted growth and little leaf are presumably related to disturbances in the metabolism of auxins, indole acetic acid (IAA) in particular[13]. Zinc application to the soil ameliorated the tomato tolerability to soil salinity stress[8].

Several attempts were conducted to increase plant salt tolerance because, salinity and yield are of major concern to most of workers in order to maximize medicinal and aromatic plants production in arid and semi- arid areas in Egypt. Therefore, the aim of the present attempt, how to decrease the harmful effect of soil salinity on *Salvia officinalis* L. plants under zinc application.

MATERIAL AND MEHTODS

Two field experiments were carried out during two successive seasons of 2003 and 2004. The experiments were conducted at the Experimental Farm, National Research Center (NRC), Dokki, Cairo, Egypt.

Mechanical and chemical properties of the soil used in this study were determined according to Jackson[14] and Cottenie *et al.*[15] and are presented in Table (1).

Seedlings of sage (*Salvia officinalis* L.) were kindly obtained from the Department of Medicinal and Aromatic plants, Ministry of Agriculture, Egypt.

Pots of 30cm in diameter and 45cm depth insidely painted with tar (botamin) and their bottom holes were completely blocked to prevent water loss. Also each pot contained 10 kg clay soil. Then they were divided into seven main groups:

The first group contains a clay soil (as control), the second group contains a mixture of clay soil with sodium chloride salt (500 ppm), the third group contains a mixture of clay soil with sodium chloride salt (1000 ppm), the fourth group contains a mixture of clay soil with sodium chloride salt (1500 ppm), the fifth group, contains a mixture of clay soil with sodium chloride salt (2000 ppm), the sixth group, contains a mixture of clay soil with sodium chloride salt (2500 ppm), the seventh group, contains a mixture of clay soil with sodium chloride salt (3000 ppm).

Each group was divided into two subgroups at randomized experiment. The soil of the first subgroup was without zinc sulphate and the soil was mixed with zinc sulphate (5kg/fed or 0.05g/pot) of second subgroup before seedlings transplanting. Each subgroup contained three replicates, each replicate contained 5 pots and each pot contained three plants.

All agriculture practices operation other than experimental treatments were don according to the recommendation of Ministry of Agriculture, Egypt.

The seedlings transplanted to the pots in 1^{st} May in both seasons.

Harvesting: At full blooming, the plants were harvested 2 times (1st and 2nd cut) during the growing season by cut the plants and left 5cm above the soil and the different vegetative growth parameters were recorded in both seasons as follows:

Plant height (cm), number of branches./plant, fresh and dry weight (g/plant).

Chemical analysis: The followings chemical analysis were determined

Essential oil:

A-Extraction of essential oil: Air dried herb in the first and second time of harvesting (100g) were subjected to Hydro distillation for 3h using a Clevenger type apparatus[16].

B-Gas Chromatography-Mass Spectrophotometric (GC-MS) Analysis: The essential oil extracted from Sage (*Salvia offcinalis* L.) herb were collected from the first and second time of harvesting, after that, the best treatments (2500 ppm and 2500ppm + zinc) which gave the highest essential oil percentage and control treatment were selected and the component of essential oil were determined according to Adams[17].

The ADELSIGLC-MS system, equipped with a BPX5 Capillary Column (0.22mm idx25m, film thickness 0.25µm) was used. Analysis was carried out using helium as the carrier gas, with the flow rate at 1.0ml/min. The column temperature was programmed from 60°C to 240°C at 3°C/min. The sample size was 2µ1, the splitting ratio 1:20.The injection part temperature was 250°C. The ionization voltage applied was 70 eV, moss range m/z 41-400 a.m.u. The Kovat's indices were determined by co-injection of the sample with a solution containing a homologous series of n-hydrocarbons (C9-C22), in a temperature run identical to that described above. The separated components were identified by matching with the National Institute of Standards and Technology (NIST) mass-spectral library data, comparison of the

Table 1: Mechanical and Chemical properties of the soil.

Texture	Sand (%)	Silt (%)	Clay (%)
Clay	24	9	67

Available (mg/100gm)		Total (mg/100gm)	Soluble anions (meq/L)				Soluble cations (meq/L)			EC	pH
K	P	N	SO4	Cl	HCO3	CO3	Na	Mg	Ca		
3.5	0.4	111	5.8	1.5	3.7	-	5.4	1.1	4.0	1.1	7.4

Available micronutrients (ppm.)

O.M (%)	CaCO3	Cu	Zn	Mn	Fe
1.42	1.4	15.7	20.6	27.5	87.5

Kovat's indices with those of authentic components. The quantitative determination was carried out based on peak area integration.

Zinc content determination: The samples of herb in the first and second time of harvesting were dried, ground and Zn extracted by acid digestion technique[15], concentrations were determined by atomic absorption spectrophotometer Berken-Elmer[18].

Total carbohydrates: Total carbohydrates was determined in herb in the first and second time of harvesting of each treatment according to methods of Dubois [19].

Proline: Proline was determined in leaves in the first and second time of harvesting according to
Bates *et al*[20].

Statistical analysis: The means of the obtained data were statistically analyzed according to the procedure outlined by Snedecor and Cochran[21].

RESULTS AND DISCUSSIONS

Effect of soil salinity, zinc and their interactions on the vegetative growth characters of sage (*Salvia offcinalis* L.) plants: Data in table (2) showed that, increasing soil salinity level progressively decreased the vegetative growth characters i.e. Plant height, number of branches, fresh and dry weight of sage plants. The highest level of soil salinity (2500ppm) caused the highest harmful effect on vegetative growth characters. Moreover, increasing soil salinity level up to 3000 ppm resulted complete death of plants either treated or non treated with zinc.

Regarding zinc application, Table (2) showed that the vegetative growth characters of sage plants treated by zinc were greater than those treated with saline soil condition. Results also indicated that sage plants were more tolerant to salinity when zinc level application was carried out before transplanting. The highest values of vegetative growth characters of *Salvia offcinalis* L. were obtained at the second time of harvesting during both seasons.

Effect of soil salinity, zinc and their interactions on the chemical content of sage (*Salvia offcinalis* L.) plants:
Essential oil percentage: Data in Table (3) indicated that the highest percentage of *Salvia offcinalis* L. essential oil was obtained at the first time of harvesting during both seasons. data showed that increasing soil salinity level without zinc application resulted in gradual increase in essential oil concentration , the interaction between soil salinity and zinc application resulted in a marked decrease of essential oil content compared to the treatments under soil saline conditions during both seasons.

Essential oil (g/plant): The treatments of interaction between soil salinity and zinc application resulted in a significant increase of essential oil (g/plant) in comparison with the treatments without zinc (under soil saline conditions) during both seasons (Table 3).

Chemical composition of essential oil: Results in Table (4) showed that, the effect of soil salinity level (2500ppm) alone or with zinc on the chemical composition of essential oil extracted from *Salvia offcinalis* L**.** herb. The main components were found to be V thujone (33.62 %), camphore (27.61 %), 1,8 cineol (11.27%) and $- thujone (6.15 %) for control treatment. Treatment of soil salinity alone (2500ppm) increased the components of V thujone and camphore but it decreased the components of 1,8 cineol and $- thujone compared with the control treatments. Treatment of 2500 ppm soil salinity with zinc increased the components of V thujone and 1,8 cineol but it decreased the components of $- thujone and camphore compared with the control treatment.

Total carbohydrates content: Data presented in Table (5) observed that total carbohydrate content pronouncedly increased at the second time of harvesting also increasing soil salinity level without zinc application resulted in gradual increase in total carbohydrates concentration , the

Table 2: Effect of soil salinity, zinc and their interactions on the vegetative growth characters of sage (*Salvia offcinalis* L.) plants.

Treatments	Soil salinity (ppm)	Plant height (cm)				Number of branches/plant				Herb fresh weight (g/plant)				Herb dry weight (g/plant)			
		1st Season		2nd Season		1st Season		2nd Season		1st Season		2nd Season		1st Season		2nd Season	
		1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut`	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut
No Zinc	Control	36	41.4	37.4	46.1	16.3	18.8	18.3	20.6	86.7	99.7	95.4	111.1	25.7	23.8	24.6	26.2
	500	36	41	34.9	45.6	16	18.2	17.9	18.2	83.7	95.4	89.2	96.8	19.7	22.4	21.4	22.4
	1000	33.3	37.7	34	44.4	14.3	16.2	15.1	16.9	77.9	88	77.8	82.1	17.9	20.3	19.8	21.6
	1500	32	36.5	33.2	43.1	13	14.8	13.2	14.6	59.3	67.6	62.7	70.9	14.7	16.7	17.3	19.8
	2000	32	35.8	29.1	38.4	12.3	13.8	11.2	12.3	56.4	64.5	55.3	61.3	13.7	15.7	16.9	17.1
	2500	25.7	29	24.1	35.6	9.7	10.9	8.1	9	54	59.1	48.1	50.7	13.3	15	16.1	16.7
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	Over all No Zinc	32.5	36.9	32.1	42.4	10.9	15.5	14.1	15.3	69.7	79.1	71.4	78.8	17.7	19	19.4	20.6
With Zinc	Control	41	47.2	43.3	49.8	17.7	23	23.2	25.4	89.7	109.2	105.4	116.9	21.4	25.5	27.2	29.3
	500	38.3	44.5	41	47.8	16.7	20.5	22.4	24.1	86.6	107.4	92.1	100.1	19.8	24.8	25.9	28.4
	1000	35	39.9	39.2	46.1	14.9	18	19.6	20.1	82	95	89.1	96.2	19.1	22.7	23.7	24.3
	1500	35	36.9	36.4	45	14	16	17.1	18.4	70.5	93.5	70.3	80.6	16.9	21.8	22.1	23.6
	2000	34	35	33.1	44.2	13.3	15.7	15.3	16.9	67.5	79.7	62.1	70.4	15.6	19.1	20.4	19.9
	2500	28	33	29.2	40	11.3	12.9	12.4	13.6	65.8	75.1	56.2	61.3	14.9	17.8	19.4	19.4
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	Over all with Zinc	35.2	39.4	37	44.3	14.7	17.7	18.3	19.8	77	93.3	79.2	87.6	18	22	23.1	24.2
Over all salinity	Control	38.5	44.3	40.4	48	17	20.9	20.8	23	88.2	104.5	102.3	114	23.3	24.7	25.9	27.8
	500	37.2	42.8	38	46.7	16.4	19.4	20.2	21.2	85.2	101.4	90.7	98.5	19.8	23.6	23.7	25.4
	1000	34.2	38.8	36.6	43.8	14.6	17.1	17.4	18.5	80	91.5	83.5	89.2	18.5	21.5	21.8	23
	1500	33.5	36.7	34.9	44.1	13.5	15.4	12.7	16.5	64.9	80.6	66.5	75.8	15.8	19.3	19.7	21.2
	2000	33	35.4	31.1	41.1	12.8	14.8	13.3	14.6	62	72.1	58.7	65.9	14.7	17.4	18.7	18.5
	2500	26.9	31	26.7	37.8	10.5	11.9	10.3	11.3	55.4	72.1	52.2	56	14.1	16.4	17.8	18.1
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
L.S.D. at 0.05																	
Salinity		4.17	3.22	4.3	3.38	2.29	3.01	2.9	3.1	7.2	8.1	11.2	12.3	4.6	4.1	3	3.1
Zinc		2.1	2.03	2.1	N.S	1.16	1.06	1.5	1.3	3.7	3.8	4.1	5.2	1.2	1.1	1.1	1.2
Salinity*Zinc		5.19	6.29	5.03	7.1	4.13	4.29	5.2	6	10.9	11	12.2	14	5.02	6..0	4.2	3.3

The values of the treatment (3000 ppm) were not statistically considered.

interaction between soil salinity and zinc application resulted in a marked decrease of total carbohydrates content during both seasons.

Zinc content: Regarding zinc content, data presented in Table (5) showed that zinc content pronouncedly increased at the second time of harvesting. Increasing soil salinity level without zinc application resulted in gradual decrease in zinc concentration , the interaction between soil salinity and zinc application resulted in a marked increase of zinc content during both seasons.

proline content: Data presented in Table (5) showed that, proline content increased at the second time of harvesting, increasing soil salinity level without zinc application resulted in gradual increase in proline concentration , the interaction between soil salinity and zinc application resulted in a marked decrease of proline content compared with the treatments under soil saline conditions during both seasons.

Table 3: Effect of soil salinity, zinc and their interactions on the essential oil content extracted from sage (*Salvia offcinalis* L.) plants.

Treatments	Soil salinity (ppm)	Essential oil Percentage				Essential oil (g/plant)			
		1st Season		2nd Season		1st Season		2nd Season	
		1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut
No Zinc	Control	0.48	0.43	0.47	0.45	0.1234	0.1023	0.1156	0.1179
	500	0.5	0.5	0.5	0.48	0.0985	0.112	0.107	0.1075
	1000	0.55	0.53	0.63	0.6	0.0985	0.1076	0.1247	0.1296
	1500	0.62	0.54	0.64	0.62	0.0911	0.0909	0.1107	0.1228
	2000	0.64	0.56	0.65	0.64	0.0877	0.0879	0.1099	0.1094
	2500	0.65	0.67	0.76	0.72	0.0865	0.1005	0.1224	0.1202
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Over all No Zinc		0.57	0.54	0.61	0.59	0.0936	0.1002	0.1152	0.1179
With Zinc	Control	0.4	0.38	0.42	0.4	0.0856	0.0969	0.1142	0.1172
	500	0.45	0.4	0.48	0.45	0.0891	0.0992	0.1243	0.1278
	1000	0.5	0.45	0.6	0.53	0.0955	0.1022	0.1422	0.1288
	1500	0.51	0.48	0.61	0.57	0.0862	0.1046	0.1348	0.1345
	2000	0.55	0.6	0.63	0.6	0.0858	0.1146	0.1285	0.1194
	2500	0.56	0.61	0.72	0.7	0.0834	0.1086	0.1397	0.1358
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Over all with Zinc		0.5	0.49	0.58	0.54	0.0976	0.1043	0.1306	0.1273
Over all salinity	Control	0.44	0.41	0.45	0.43	0.1065	0.0996	0.1351	0.1185
	500	0.47	0.45	0.49	0.47	0.0925	0.1056	0.1157	0.1177
	1000	0.53	0.49	0.62	0.57	0.097	0.1049	0.1335	0.1292
	1500	0.57	0.51	0.63	0.6	0.0886	0.0978	0.1226	0.1287
	2000	0.6	0.58	0.64	0.62	0.0868	0.1013	0.1192	0.1144
	2500	0.65	0.64	0.74	0.71	0.085	0.1046	0.1311	0.128
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
L.S.D. at 0.05									
Salinity		0.03	0.03	0.03	0.03	0.0004	0.0005	0.0002	0.0004
Zinc		0.02	0.02	0.02	0.02	0.0003	0.0003	0.0002	0.0003
Salinity * Zinc		0.03	0.03	0.03	0.03	0.0006	0.0007	0.0005	0.0007

* The values of the treatment (3000 ppm) were not statistically considered.

Increasing soil salinity levels up to 2500 ppm progressively decreased the vegetative growth characters, these results are in agreement with those obtained by Osawa[22] who reported that, salinity causes growth reduction due to the low osmotic potential of the medium and by specific ion effect as a secondary cause, and Vyas *et al*[23] observed that, the disturbance of vital activity of plants during salt stress is associated with growth reduction due to a marked alternation in their metabolism and to decrease in organic matter production . Increasing soil salinity up to 3000 ppm resulted complete death of plants, these results also are confirmed by those of Osawa[22] who said that, sodium and chloride are the most prominent potentially toxic ions of saline substrate. Increasing soil salinity level resulted in gradual increase in essential oil concentration (as percentage). Our results are in agreement with those reported by Baher *et al*[24], they observed that, essential oil percentage increased under stress of *Satureja hortensis* L. plants.

Increasing soil salinity level resulted in gradual increase total carbohydrates concentration, these results are confirmed by those of Khalid[11], he demonstrated that, total carbohydrates content was increased with increasing salinity levels of *Nigella sativa* L. plants. Increasing soil

Table 4: Effect of the treatments of 2500 ppm saline soil , 2500 ppm saline soil +Zn and control on the chemical constituents of essential oil extracted from sage plant.

Component name	Control	2500 ppm	2500 ppm + Zn
1- butyle acetate	0.97	0.23	0.23
Camphor	27.61	31.24	22.87
Camphene	1.4	1.15	1.12
Sapinene	0.78	0.32	0.49
$- caryophyllene	0.52	0.46	2.68
Bornyl acetate	1.28	0.52	1.11
$- pinene	1.26	2.68	2.38
Myrcene	1.19	1.89	1.18
Terpinolene	0.28	0.23	0.43
(-terpinene	0.61	0.42	0.48
Borrneol	1.89	1.15	0.37
"- pinene	1.17	0.13	0.22
Limonene	3.15	1.12	1.13
Myrcene	0.33	0.21	0.18
$- cymene	0.72	0.14	0.61
$- thujone	7.29	5.42	6.15
Ocimene	0.29	0.38	0.38
Viridiflorol	2.74	2.14	2.65
"- phellandrene	0.39	0.42	0.43
1.8 cineol	1.27	8.42	16.34
Linalol	0.62	0.67	0.74
"-terpinene	0.25	0.32	0.19
"- thujone	33.62	40.38	37.25
Germacrene D	0.42	0.17	0.41

salinity level resulted in gradual increase in proline concentration. These findings are in accordance with those obtained by Blum and Ebercon,[25] , they indicated that , proline is regarded as a source of energy , carbon and nitrogen for the recovering tissues, so it increased under saline conditions.

Increase soil salinity level resulted in a marked decrease of zinc content. These data are near to the observations of El-Sherif *et al*[8], they reported that increasing soil salinity decrease the dry matter content of plants so zinc was decreased.

Zinc addition to the soil might enhance the soil salinity resistance of *Salvia offcinalis* L. Plants. These results are in accordance with the results of Youssef[26] who observed that the aforementioned effect could be explained by the change in the physico- chemical properties of protoplasm colloids and water condition which were produced an increase in viscosity and decrease in permeability of the root and leaf cell protoplasm, Shulka and Mukhi[27] they reported that, adding zn to saline soil increasing the vegetative growth characters of sage plants compared with soil salinity conditions was perhaps related to the increase of absorbance of Ca, Mg, k and zn, Maischner[13] , recorded that, zinc addition enhanced plants to overcome the hazards effect of soil salinity due to the role of zinc on some growth enzymes such as B-indole acetic acid, and Soliman *et al*[28] said that, Zinc is required for

Table 5: Effect of soil salinity, zinc and their interactions on the chemical content of sage (*Salvia offcinalis* L.) plants.

Treatments	Soil salinity (ppm)	Total carbohydrates percentage				Zinc (ppm)				Proline (µm/g)			
		1st Season		2nd Season		1st Season		2nd Season		1st Season		2nd Season	
		1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut
No Zinc	Control	12.5	13.7	11.9	12.6	7.1	8	6.8	7.4	3.1	3.6	3	3.4
	500	14.1	15.2	13.7	14.7	6.9	7.2	6.4	6.8	3.7	3.9	3.2	3.6
	1000	16.2	17.1	16.9	17.1	5.7	5.8	6	6.2	3.9	4.3	3.5	3.9
	1500	17.3	18.6	18.4	19.2	4.1	4.3	5.2	5.4	4.2	4.7	3.7	4.1
	2000	20.6	22.4	20.5	20.9	4	4.1	4.2	4.7	5.1	5.3	4.9	5.1
	2500	21.2	22.7	23.2	28.8	3.6	3.5	2.9	3.1	5.7	5.9	5.1	6.9
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Over all No Zinc		17	18.3	17.4	18.9	5.2	5.5	5.3	5.6	4.3	4.6	3.9	4.5
With Zinc	Control	11.2	12.2	10.3	11.1	8.1	8.4	7.6	8.5	3	3.1	2.7	2.8
	500	12	13.3	11.2	13.2	7.6	7.9	6.9	7	3.2	3.3	3	3.2
	1000	14	15.4	15	15.6	6.1	6.4	6.2	6.5	3.4	3.6	3.3	3.4
	1500	15	16.9	17.6	18.4	5.2	5.9	5.4	5.8	3.6	3.9	3.5	3.7
	2000	19	20.1	19.3	19.6	4.3	4.9	4.6	4.9	3.9	4.1	4	4.1
	2500	19.2	20.7	21.2	26.4	3.9	4.2	3.1	3.7	4.2	4.5	4.2	4.3
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	Over all with Zinc	15.1	16.4	15.8	17.4	5.9	6.3	5.6	6.1	3.6	3.8	3.5	3.6
Over all salinity	Control	11.9	13	11.1	11.9	7.6	8.2	7.2	8	3.1	3.4	2.9	3.1
	500	13.1	14.3	12.5	14	7.3	7.6	6.7	6.9	3.5	3.6	3.1	3.4
	1000	15.1	16.3	16	16.4	5.9	6.1	6.1	6.4	3.7	4	3.4	3.7
	1500	16.2	17.8	18	18.8	4.7	5.1	5.3	5.6	3.8	4.3	3.6	3.9
	2000	19.8	21.3	19.9	20.3	4.2	4.5	4.4	4.8	4.3	4.7	4.5	4.6
	2500	20.2	21.7	22.2	27.6	3.8	3.9	3	3.4	4.4	5.2	4.7	5.6
	3000*	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
L.S.D. at 0.05													
Salinity		0.81	0.51	0.42	0.39	0.04	0.07	0.07	0.09	0.2	0.17	0.13	0.12
Zinc		0.6	0.4	0.31	0.32	0.01	0.03	0.04	0.06	0.1	0.15	0.11	0.11
Salinity * Zinc		0.91	0.7	0.81	0.71	0.08	1	0.09	1.02	0.3	0.21	0.15	0.14

* The values of the treatment (3000 ppm) were not statistically considered.

photosynthesis and enhences shoot and root growth.

The interactions between soil salinity and zinc application resulted in a marked decrease of essential oil percentage, total carbohydrates and proline content but essential oil (g/plant) content was increased. Generally salinity treatments decreased significantly oil yield per plant, these decrements were as result of inhibited herb weight. The effect of zinc application on essential oil yield it can be noticed that, zinc enhanced the accumulation of essential oil yield during both seasons. These results may be due to the promoted effect on herb weight.

These results are confirmed by those of Khalid[11], he demonstrated that, essential oil percentage, total carbohydrates and proline content were decreased with addition of substances which help in salinity resistance but essential oil (g/plant) was decreased of *Nigella sativa* L. plants.

The obtained constituents of essential oil extracted from *Salvia offcinalis* L. herb were also found by Teissedre and Waterhouse[4] on the same plant. The effect of different treatments on essential oil constituents may be due to its effect on enzymes activity and metabolism improvements.

The interaction between soil salinity and zinc application resulted in a marked increase of zinc content compared with the treatments that did not received zn . These data are near to the observations of El-Sherif *et al*[8] they reported that addition zinc increase the dry matter content of sage plants compared to the treatments under soil salinity conditions, so, the interaction between soil salinity and zinc application resulted in a marked increase of zinc content.

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