Effect of some Inorganic Substances to Improve Growth of Coriander (*Coriandrum sativum L.*) and Properties of Sandy Soil under Salinity Condition

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Abstract

Understanding the interactions among soil properties, salinity and the inorganic substances application is great importance for improving growth of Coriander [Coriandrum sativum L.] in sandy soils. In the present study, twenty seeds of Coriander were sown during the growing season 2016 to investigate the effect of some inorganic substances [Bentonite, Nano-selenium and Micronutrients mixture] on Coriander growth and properties of sandy soil under salinity condition. A split plot design replicated thrice-was used in this study. The results indicated significant succeed in enhancing all estimated soil properties, such as available nutrients in soil, EC, pH and bulk density. Besides, traits of coriander plant i.e., plant height, fresh, dry weights and plant chemical composition. Therefore, it could be recommended that adding of inorganic substances can improve the sandy soil properties and growth parameters of coriander plant.

Keywords: *Coriandrum sativum L; Bentonite, Nano-selenium; micronutrients mixture; salinity.*

1. Introduction

Coriander is native to southern Europe, northern Africa, and some parts of Asia, with extensive adaptation, well-growing power under different kind of soil and climate conditions. However, the yield and physiology of this plants is adversely affected by salinity [1]. Soil salinity triggers osmotic and ionic stresses that can lead to secondary stresses, for example, nutritional imbalances, and oxidative stress resulted due to the generation of reactive oxygen species [ROS] such as hydrogen peroxide [H_2O_2], superoxide [O_2^-] and hydroxyl [OH] radicals in plants [2].

The application of clay amendment in sandy soil increasing fertility with the essential element when the percentage of bentonite is over greater than 5% in sandy soil [3]. Bentonite exists as a 2:1-type crystal structure composed of two silicon-oxygen tetrahedrons sandwiched between a layer of aluminum-oxygen octahedrons [4]. Owing to the presence of Cu, Mg, Ca and other cations in the layered structure formed by the crystal, the interaction with the crystal is very unstable. In addition, it is easily exchanged with other cations, so it has better ion exchange. Bentonite can absorb hydrated cations [e.g., K^+, Na^+, Mg^{2+}], and its ion exchange capacity can reach 60~150 meq•100 g^{-1} [5]. The exchangeable Ca^{2+} ion of calcium bentonite acts mainly on Na^+ in the soil, which improves the desalination effect [6]. Studies have shown that bentonite reduces the hydraulic conductivity in the soil and increases the accessibility of the exchange surface, thus enhancing the cation exchange rate, which leads to the rapid release of cations from the soil colloid [7].

Selenium can increase the tolerance of plants to UV-induced oxidative stress, delay senescence, and promote the growth of ageing seedlings [8]. Recently, it has been shown that selenium has the ability to regulate the water status of plants under conditions of drought [9]. [10] Revealed that (Se) supplementation can be beneficial for garlic plants under salt stress. Application of selenium in plants reduces the harmful effects of salinity by increasing plant water balance and cell membrane integrity.

Selenium interaction with plants depends on its concentration, at lower concentrations, selenium stimulated growth, while at high doses it acted as pro-oxidant, reducing yields and inducing metabolic disturbances. The growth stimulating effect of Se may be related to its antioxidative function, as demonstrated by the decreased lipid peroxidation, H_2O_2 and superoxide radical production and increased antioxidants enzymes [11and12]. Therefore, the use of selenium for resistance and tolerance of plants to salinity can be in recommended dose in areas exposed to salinity. The effect of micronutrient elements on yield and crop performance has been reported by many investigators. [13] Stated that, yields were higher for the treatments with micronutrients. Micronutrients spraying led to increasing macro and micronutrients uptake as a result of improving root growth which consequently led to greater absorbing surface [14]. Therefore, the aim of this study was to study the effects of some inorganic substances [Bentonite, Nano-selenium and Micronutrients mixture] to enhance growth of Coriander plant and the properties of sandy soil under salinity condition.

2. Materials and Methods

A pot experiment was conducted on coriander [*Coriandrum sativum L*] plant during the spring season of 2016 at the Experimental Farm of the Faculty of Agriculture, Mansoura University, Dakhlia Governorate, Egypt. In this study, experimental treatments were arranged in a split plot design with three replicates. The twenty seeds of coriander plant were sown in small plastic pots (50 cm deep and 40 cm in diameter) filled with sandy soil at rate of 20 kg/pot. The three treatments of inorganic substances were used as: Bentonite [application of 2 kg Bentonite with 20 kg sandy $soil^{-1}pot^{-1}$]; Nano-selenium [applied by spraying at a rate of 50 mg L^{-1}]; micronutrients mixture [sprayed at a rate of 1g 5 L^{-1} tap water] and a control sample was prepared without adding any inorganic substances. The intended level of salinity was obtained by diluting seawater and added to plant irrigation at rate 10% [20 L seawater/200 L tap water] using dropping irrigation method.

2.1 Water analysis

Water samples were analyzed according to the standard methods of [15]. Water pH was measured by pH meter, electrical conductivity [EC] of water was determined by EC–meter. However, soluble calcium and magnesium in water [Ca^{+2} and Mg^{+2}] were determined by the versenate method as described by [16], soluble sodium and potassium in water [Na^{+} and K^{+}] were determined by using a flame photometer as explained by [16], carbonate and bicarbonate [CO_3^{-2} and HCO_3^{-}] were determined by titration with standardized sulfuric acid solution according to [16], chloride [Cl^{-}] was determined by titration with silver nitrate solution using potassium chromate indicator as described by [16], In addition, sulphate was determined by calculating the difference between sum of cations [Ca^{+2}, Mg^{+2}, Na^{+} and K^{+}] and anions [CO_3^{-2}, HCO_3^{-}, Cl^{-}]. The results of water analyze shown in table [1].

Table 1. Chemical characteristics of irrigation water used

Irrigation water used	pH	EC dSm^{-1}	Anions mmole L^{-1}				Cations mmole L^{-1}			
			$CO_3^{=}$	HCO_3^-	$SO_4^{=}$	Cl^-	Na^+	K^+	Ca^{++}	Mg^{++}
	6.56	4.38	--	3.49	11.99	22.96	26.56	0.59	3.44	7.85

2.2 Soil analysis

Soil samples were analyzed in experiment to the following determinations: mechanical analysis for soil was carried out using the pipette method as described by [17], Soil pH was measured according to methods of soil chemical analysis [18] by using pH meter, electrical conductivity of the soil paste extract was measured by EC–meter according to [18], bulk density was determined by the method described by [17], organic matter content was determined according to [19], total cations and anions were determined as described by [17]. However, soluble cations [Ca^{+2}, Mg^{+2}, Na^+ and K^+] and anions [CO_3^{-2}, HCO_3^-, Cl^-], were determined in soil-water extract as mentioned by [18], carbonate and bicarbonate [CO_3^{-2} and HCO_3^-] were determined by titration [18], chloride [Cl^-] was determined by titration with silver nitrate [18], sulphate was determined by calculating the difference between sum of cations and anions [18]. In addition, available nitrogen in the soil was extracted using 2.0 M KCl and determined by using micro-Kjelahl according to [16], available phosphorus in the soil was extracted with 0.5 M [$NaHCO_3$] adjusted at pH 8.5 as described by [20] and determined at a wavelength 660 nm by Spectrophotometer, available potassium was determined by extracting soil with 1.0 N ammonium acetate at pH 7.0 and measured using a flam photometer according to [16], available Fe, Mn, Zn and Se were extracted with diethylene-triamine-penta acitic acid [DTPA]. The solution is made up of a mixture of 0.005 M DTPA, 0.1 M triethanolamin [TEA] and 0.01 M CaCl , adjusted to pH 7.3. The concentrations in extracts were analyzed using an atomic absorption spectrophotometer; according to [19]. And the soil-extractable was [1:5] [soil: water]. Some chemical and physical characteristics of soil shown in table [2].

Table 2. **Some chemical and physical characteristics of the tested soil**

Particle size distribution				Textural class		EC, dSm^{-1}	pH	O.M. (organic matter) ($g\ kg^{-1}$)					
Sand		Silt	Clay	Sandy									
95.59		3.11	1.30			3.02	8.56	4.10					
Soluble cations (mmole L^{-1})				Soluble anions (mmole L^{-1})				Available macronutreints, mg kg^{-1}			DTPA-Extractable mg kg^{-1}		
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K	Fe	Zn	Mn
2.12	1.70	1.55	0.17	ND	0.26	4.08	1.2	22.04	4.63	86.57	0.24	0.1	0.02
ND: note detected													

2.3 Plant measurements

At the beginning of harvest stage, the following measurements were recorded; plant height [cm], fresh and dry weights of plant [g], number of leaves/plants, besides chlorophyll content was determined in the fresh leaves of coriander plants at flowering stage according to the method described by [21]. For plant mineral analysis, plant samples were weighted, and digested using the mixture of sulphuric acid [H_2SO_4] and perchloric acid [$HCl\ O_4$] as described by [22]. The nutrients were: Total nitrogen, total phosphorus, Total potassium, and micro elements [iron, manganese, zinc, selenium].

2.4 Statistical analysis

The obtained data were subjected to analysis with MSTAT-C” computer software program using ANOVA analysis for split-split plot design as described by [23]; and least significant of difference [L.S.D]. method was used to difference between the treatment means at 5%.

3. Results and Discussion

3.1. Soil properties

3.1.1. Available N, P and K contents [mg kg^{-1}]

Means of available nitrogen, phosphorus and potassium content [mg kg^{-1}] as affected by inorganic amendments under sandy soil condition are presented in table [3]. Data demonstrated that the inorganic amendments had highly significant effect on available N, P and K content [mg kg^{-1}] in the sandy soil.

Table 3. An average of available N, P and K (mg kg^{-1}) soil as affected by inorganic amendments types under sandy soil conditions

Treatments	Available N	Available P	Available K
Control	220.88	49.22	853.11
Bentonite	326.44	79.77	868.88
Nano-selenium	331.22	61.66	847.44
Mix. of micronutrients	377.77	65.55	827.22
F. test	**	**	**
LSD at 5 %	5.849	2.625	1.235

3.1.1.1. Available N content [mg kg^{-1}].

The highest value of available nitrogen content [377.77 mg kg^{-1}] was recorded when spraying a mixture of micronutrients, with remarked increasing compared with other treatments. While, the lowest value of available N [220.88 mg kg^{-1}] was resulted with control treatment in sandy soil. Also, adding the bentonite to the sandy soil or spraying by Nano-selenium resulted the moderate values of [326.44 and 331.22 mgkg^{-1}, respectively], of available N content in the sandy soil with highly significant increasing compared with control treatment, and without significant differences between them. As presented in table [3].

3.1.1.2. Available P content [mg kg^{-1}]

The highest value of available P content [79.77 mg kg^{-1}] was recorded when adding bentonite, with remarked increasing compared with other treatments. The treatment of spraying with a mixture of micronutrients came in the second rank [65.55 mg kg^{-1}], then the spraying by Nano-selenium particles came in the third rank [61.66 mg kg^{-1}] with highly significant increasing compared with control treatment. While, the lowest value of available P content [49.22 mg kg^{-1}] was resulted from control treatment. As presented in table [3].

3.1.1.3. Available K content [mg kg^{-1}]

The highest value of available K content [868.88 mg kg^{-1}] was recorded when adding bentonite, with remarked increasing compared with other treatments. The control treatment came in the second rank [853.11 mg kg^{-1}], then the spraying by Nano-selenium particles came in the third rank [847.44 mg kg-^{1}], then the spraying by a mix of micronutrients came in the last rank [827.22 mg kg-1]. As presented in table [3]. Our results were in harmony with the results of [24] and [25].

3.1.2. DTPA-extractable micronutrients [Fe, Zn and Mn in mg kg^{-1}].

Means of DTPA-extractable Fe, Zn and Mn content [mg kg^{-1}] in the sandy soil as affected by inorganic amendments under sandy soil condition are presented in table 4. Data showed that the inorganic amendments had highly significant effect on DTPA-extractable Fe and Zn content [mg kg^{-1}], while it had no significant effect on DTPA-extractable Mn content [mg kg^{-1}] in the sandy soil.

3.1.2.1. DTPA-extractable Fe [mgkg^{-1}]

The highest value of DTPA-extractable Fe content [222.88 mg kg^{-1}] was recorded when spraying Nano-selenium particles, with remarked increasing compared with other treatments. The spraying a mix of micronutrients came in the second rank [215.33 mg kg^{-1}], then the control treatment came in the third rank [141.00 mg kg^{-1}], then the adding of bentonite came in the last rank [117.77 mg kg^{1}]. As presented in table [4].

Table 4. An average of DTPA-extractable Fe, Zn and Mn (mg kg^{-1}) soil as affected by inorganic amendments types under sandy soil conditions.

Tretments	DTPA-extractable		
	Fe	Zn	Mn
Control	141.00	5.80	108.11
Bentonite	117.77	7.84	129.11
Nano-selenium	222.88	7.22	115.55
Mix. of micronutrients	215.33	8.38	120.77
F. test	**	**	NS
LSD at 5 %	1.198	0.269	-

3.1.2.2. DTPA-extractable Zn [mgkg^{-1}]

The highest value of DTPA-extractable Zn content [8.38 mg kg-1] was recorded when spraying mix of micronutrients, with remarked increasing compared with other treatments. The adding of bentonite came in the second rank [7.84 mg kg-1], then the spraying of Nano-selenium particles treatment came in the third rank [7.22 mg kg-1] with remarked increasing compared with the control treatment [without using any inorganic amendment] which came in the last rank [5.80 mg kg-1]. As presented in Table [4].

3.1.2.2. DTPA-extractable Mn [mgkg^{-1}]

On the contrary DTPA-extractable Mn [mgkg^{-1}] didn't significantly affected by inorganic amendments. These results are in accordance with those reported by [26] and [27].

3.1.2. pH, EC and bulk density

Means of pH, EC and bulk density in the sandy soil as affected by the inorganic amendments are presented in Table [5]. The inorganic amendments had highly significant effect on pH, EC and bulk density in the sandy soil.

3.1.2.1. pH value

The highest value of pH [7.68] was recorded when spraying a mix of micronutrients, then the control treatment came in the second rank [7.63], then spraying Nano-selenium particles came in the third rank [7.36], then adding bentonite [7.35] came in the last rank. As presented in table [5].

3.1.2.2. Electrical conductivity EC [dSm^{-1}]

The lowest value of EC [0.78 dSm^{-1}] was recorded when spraying a mix of micronutrients, with insignificant difference compared with the control treatment [0.83 dSm^{-1}], while, the highest values of EC [1.51 dSm^{-1} and 1.09 dSm^{-1}] was recorded when adding bentonite and spraying Nano-selenium particles, respectively. As presented in table [5].

Table 5. Average of pH value, EC (dSm^{-1}) and bulk density (g/cm^{3}) soil as affected by inorganic amendments types on sandy soil conditions.

Treatments	pH	EC (dSm^{-1})	Bd (g/cm^{3})
Control	7.63	0.83	1.40
Bentonite	7.35	1.51	1.39
Nano-selenium	7.36	1.09	1.42
Mix. of micronutrients	7.68	0.78	1.44
F. test	**	**	*
LSD at 5 %	0.117	0.075	0.033

3.1.2.3. Bulk density [g/cm³]

The lowest value [1.39 g/cm^3] was recorded when adding bentonite, with insignificant difference compared with the control treatment [1.40], while the highest values [1.44 and 1.42] was recorded when spraying a mix of micronutrients and spraying Nano-selenium particles, respectively. These results are in accordance with those reported by[25]. As presented in table [5].

3.2. Characteristics of the Coriander plant

3.2.1. Fresh, dry weights and height of the Coriander plant

Means of fresh, dry weights and height of the coriander plant as affected by the inorganic amendments are presented in table 8. The inorganic amendments had highly significant effect on fresh, dry weights and height of the coriander plant. For fresh weight, the highest value of fresh weight [52.45 g] was recorded when adding bentonite, with remarked increasing percentage [30.34 % and 19.8 %] compared with control and spraying Nano-selenium particles, respectively, and with insignificant increase compared with spraying a mix of micronutrient. The spraying a mix of micronutrient came in the second rank [449.04 g], then spraying Nano-selenium particles came in the third rank [43.79 g], then control treatment came in the last rank [40.24 g]. For dry weight, the highest value of dry weight [8.770 g] was recorded when spraying a mix of micronutrient, with remarked increasing percentage [69.6 %, 69.3 % and 40.3 %] compared with adding bentonite, spraying Nano-selenium particles and control treatments, respectively. The control treatment came in the second rank [6.25 g], then spraying Nano-selenium particles came in the third rank [5.186 g], then adding bentonite treatment came in the last rank [5.170 g]. As presented in table [6].

Table 6. An average of fresh weight (g), dry weight (g) and plant height (cm) of the coriander plant as affected by inorganic amendments types under sandy soil condition.

Treatments	Fresh Weight (g)	Dry Weight (g)	Plant Height (cm)
Control	40.24	6.250	39.22
Bentonite	52.45	5.170	41.33
Nano-selenium	43.79	5.186	39.11
Mix. of micronutrients	49.04	8.770	41.88
F. test	**	**	**
LSD at 5 %	4.121	0.914	1.099

3.2.2. Plant height

The highest value of plant height [41.88 cm] was recorded when spraying a mix of micronutrient, with remarked increasing percentage [7.1 % and 6.8 %] compared with spraying Nano-selenium particles and control treatments, respectively. The adding bentonite came in the second rank [41.33 cm], then control treatment came in the third rank [39.22cm], then spraying Nano-selenium particles treatment came in the last rank [39.11cm].

3.2.3. Total N, P and K (%)

Means of total N, P and K [%] in the coriander plant tissue as affected by the inorganic amendments are presented in Table 9. the inorganic amendments had highly significant effect on total N,P and K percentage [%].

3.2.3.1. Total Nitrogen [N %]

The highest percentage of nitrogen [2.166%] was recorded when spraying a mixture of micronutrients, with significant increasing compared with other treatments, while the lowest percentage of N [1.923 %] was resulted from spraying by Nano-selenium particles. Also, adding the bentonite to the sandy soil or control treatment recorded the moderate percentages of N [2.041 and 2.013%, respectively], with insignificant difference between them, and with insignificant increasing compared with treatment of spraying Nano-selenium particles. As presented in table [7].

Table 7. An average of total N, P and K (%) in the coriander plant tissue as affected by inorganic amendments types, as well as their interaction under sandy soil condition.

Treatments	N (%)	P (%)	K (%)
Control	2.013	0.493	3.84
Bentonite	2.041	0.507	3.35
Nano-selenium	1.923	0.517	4.26
Mix. of micronutrients	2.166	0.608	4.68
F. test	**	**	**
LSD at 5 %	**0.126**	**0.030**	**0.211**

3.2.3.2. Total phosphorus (P %)

The highest percentage of phosphorus [0.608 %] was recorded when spraying a mixture of micronutrients, with significant increasing compared with other treatments. While, the lowest percentage of phosphorus [0.493 %] was resulted from control treatment. Spraying Nano-selenium particles and adding the bentonite to the sandy soil recorded the moderate percentages of phosphorus [0.517 and 0.507 %, respectively], with insignificant difference between them, and with significant increase compared with control treatment. As presented in table [7].

3.2.3.3. Total potassium (K %)

The highest percentage of potassium [4.68 %] was recorded when spraying a mixture of micronutrients, with significant increase compared with other treatments, while the lowest percentage of potassium [3.35%] was resulted from adding the bentonite to the sandy soil. Spraying Nano-selenium particles and control treatment recorded the moderate percentages of potassium [4.26 and 3.84 %, respectively], with significant difference between them, and with highly significant increasing compared adding bentonite treatment. As presented in table [7]. These results are in covenant with those reported by [28; 24and 25].

4. Conclusion

The present work was carried out to study the effect of inorganic amendments with respect to *Coriandrum sativum L*. growth and properties of sandy soil under salinity. Data of this study showed significant effect of inorganic amendments to improve plant growth and soil properties.

In conclusion it is recommended to additive of inorganic amendments to sandy soil might be appropriate amendment for enhancing nutrient availability and thereafter improving coriander plant growth, and sandy soil quality.

5. References

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