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Effect of Selenium and Seaweed Extract Foliar Spraying on the Growth, Chemical Constituents and Mineral Composition of Rosemary and Moringa Plants

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Abstract: The effect of selenium (0.5, 1.0 and 1.5 ppm) and seaweed extract (5, 10 and 15% foliar spraying) compared to no- spray control were evaluated on rosemary (*Rosmarinus officinalis* L.) and moringa (*Moringa oleifera* L.) during 2017 and 2018 seasons. In rosemary, plant height, stem diameter and number of lateral branches/plant and fresh and dry weights of total biomass recorded the highest values plant when 1.0 ppm of selenium and 10% seaweed extract where foliar- sprayed, whereas higher doses of both material sprayed were negligible and similar to control. Root number and length were increased with 0.5 and 1.0 ppm selenium and seaweed extract at 10 and 15%. However, chlorophyll a, b, total carbohydrates, N content and C/N ratio were significantly affected with selenium and seaweed extract spraying when compared with control. P, K, Ca and Mg contents exhibited different responses to selenium and seaweed extract spraying, where P content no affected with different treatments. However, K, Ca and Mg recorded higher significant values with selenium at 1.0 and 1.5 ppm than control. Fe, Zn, Mn and Cu contents were greatly improved with 1.0 ppm of selenium, whereas the effects of seaweed extract did not follow an evident trend with either used concentrations or season of study. Meanwhile data recorded on moringa plants showed that the highest values of plant height and the number of lateral branches /plant were recorded by 1.5 sppm selenium and 10% seaweed extract spraying. Stem diameter was greatly improved when spraying. 0.5 ppm selenium and 5% seaweed extract. Fresh and dry weights of moringa plants were greatly affected with all selenium and seaweed extract praying treatments in the two seasons. Roots length and numbers per plant were improved with 1.5 ppm selenium and 10 & 15% seaweed extracts. An augmented effect on chlorophyll a and b was obtained with 1.5 ppm of selenium followed by 10 and 15% of seaweed extract spraying treatments. Total carbohydrates in moringa herb increased due to 1.5 ppm selenium spraying treatment. N content greatly increased with 1.5 ppm of selenium and 10 & 15% of seaweed extract spraying treatments. All applied selenium and seaweed extract treatments improved C/N ratio values than in the control. P content of moringa herb was not affected by the used treatments, whereas, the highest values of K% were obtained with 1.5 ppm of selenium and both 10 and 15% of seaweed extract. However, Mg content increased with 1.5 ppm of selenium and 15% seaweed extract. In contrast, application of selenium and seaweed extract decreased Ca content than control. Fe, Zn, Mn and Cu contents were increased especially with 1.5 ppm selenium and 10% seaweed extract on Fe and Zn contents. Mn content greatly increased with 1.5 ppm selenium whereas any a slight effect on Cu content in moringa herb was noticed due to the effect of the used treatments.

Key words: Rosemary · Moringa · Seaweed extract · Selenium · Vegetative growth · Mineral contents

INTRODUCTION

Moringa oleifera (drumstick tree) is a tree species as of late assessed in Cuba for creature bolstering, in light of the fact that its foliage establishes a source wealthy in evident protein with low nearness of antinutritional factors [1]. Moringa *oleifera* is outstanding for its multi-reason properties, wide versatility and simplicity of foundation. All aspects of the plant is of nourishment esteem, moringa leaves contain multiple times more ascorbic acid than oranges, multiple times more calcium than milk, multiple times more vitamin A than carrot,

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multiple times more potassium than banana and multiple times more protein than milk. Consequently, it is considered as a powerhouse of dietary benefit. However, the seeds of *Moringa oleifera* are utilized as a characteristic coagulant for raw water explanation, the powder of squashed seed portions can leave water clear with 90-99% of the microorganisms evacuated [2]. The seeds are additionally utilized for oil preparations; this oil is utilized in workmanship, makeup, drug and can be extended as food.

Rosemary (*Rosmarinus officinalis* L.) Family Lamiaceae (Labiatae), is one of the most significant therapeutic and fragrant lasting plants since ancient times. It is regularly utilized as a flavor agent. Its fundamental oil is utilized remedially, specifically in balneology. It is utilized a lot externally as parasiticide, cicatrisant, for strong agonies and stiffness, dermatitis, dandruff and exzema. It advances hair development and invigorates scalp. Internally, it is utilized for asthma, bronchitis challenging hack, to invigorate poor dissemination, for palpitation, debility, cerebral pain, neuralgia, rental weariness, apprehensive fatigue and stress-related issue, dyspepsia, hepatic issue, hyper cholesterolaemia and jaundice [3].

However, Rosemary, is an evergreen plant typical two the Mediterranean region. Rosemary has long been considered an important plant for its essential oil used in perfumes and medicine [4]. The plant was reported to possess several medicinal properties like carminative, stomachic, nervine spasmodic and stimulant. The leaves are also reported to possess anti-oxidant properties and used for culinary purposes [5]. The volatile oil of rosemary reaches to 1.43 % with the main component of 1.8-Cineole (35.8%) exhibit some medicinal purposes such as antinflammatory, antiseptic, antispasmodic and anti-diabetic [6-8].

Recently, selenium (Se) is a fundamental follow component for humans and creatures. However at high fixations, Se is lethal to living beings because of Se supplanting sulfur in proteins [9, 10]. The border line between helpful and hurtful Se fixations is moderately tight for living creatures. The insignificant Se focus in domesticated animals feed is 0.05–0.10 mg/kg dry scavenge, while the harmful Se fixation in creature feed is 2–5 mg/kg dry scrounge. In humans, the World Health Organization (WHO) and USDA prescribed the necessary human dietary admission of Se to be 55–200 ìg/day for grown-ups [10, 11].

Se has extraordinary potential for some features of biomedicine, natural chemistry and ecological science [12, 13]. Also, Se is utilized for acquiring greater bioactivity and wellbeing for concoction pesticide [14]. Selenium sulfide and sodium selenite have been tried for hindrance of certain pathogens [15, 16]. A blend fungicide of Dithane and sodium selenite was increasingly powerful against *Aspergillus funiculosus* and *Alternaria tenuis* [17]. The use of Se at low doses in contrast to manufactured fungicides for the control of plant illnesses, may decrease the potential risky impact on the earth and human wellbeing [18, 15].

In spite of the fact that Se is lethal at high doses, late examinations have demonstrated that it can impact plants at generally low fixations and may assume function in plant resistance against from a few kinds of abiotic stresses. Se can build the resilience of plants to UV-instigated oxidative pressure, postpone senescence and advance the development of NaCl stressed seedlings [19, 20, 21]. Also, it has been demonstrated that Se can control the water conditions of plants under states of dry season [22]. A defensive impact of Se on plants exposed to dangerous centralizations of cadmium has been accounted [23]. However, Chen and Sung [24] and Chu *et al.* [25] both announced that plants treated with Se and exposed to problematic temperature for the most part developed superior when compared to anything plants developed without Se.

Seaweed extract is another agent of common natural manure profoundly nutritious and support quicker germination of seeds, upgrade yield of a few harvested crops [26]. It leads to enormous growth when applied at miniaturized scale supplements [27, 28]. Seaweed extract assists to increase quantity and quality in agribusiness and agriculture. The utilizing of seaweed extract items improve seeds germination, seedlings advancement, increment plant resistance to ecological anxieties and improve plant development and yield [29-32]. Substances, for example, cytokinins, auxin, gibberellins, abscisic corrosive, ethylene, polyamines and betaines in were found concentrate [33]. Seaweed extract concentrate contains development advancing hormones (IAA and IBA), cytokinins, elements (Fe, Cu, Zn, Co, Mo, Mn and Ni), other nutrients and amino acids [34]. It was likewise announced that seaweed extract excrement is wealthy in potassium yet poor in nitrogen and phosphorus [35, 36]

Additionally, it acts as a trigger, two upgrade plant development at different stages of plants life [37]. Utilization of seaweed extract in natural cultivation method is perhaps the most secure approaches to moderate ecological assets, stay away from contamination and get nourishment and increase farming harvests. The extract of seaweed is natural and biodegradable in nature [38]. Its, K content has demonstrated to quicken the wellbeing and development of plants. Seaweed extract supplies nitrogen, phosphorous, potash just as other minerals like Zn, Mn, Mg, Fe, etc [39]. Its concentrate contains common plant development substances like auxins, gibberlins and cytokinins [40].

Depending on the great roles of selenium and seaweed extracts in enhancing growth and improving chemical constituents of the treated plants, to work was designed to evaluate the effect of spraying Se at 0.5, 1.0 and 1.5 mg /L (ppm) and seaweed extract at 5, 1o and 15% on the behavior of rosemary and moringa plants.

MATERIALS AND METHODS

This work was carried out during 2017 and 2018 seasons on rosemary (*Rosmarinus offecinalis* L.) and moringa (*Moringa oleifera* L.) plants to study the effect of selenium trace element and seaweed extract spraying on growth and chemical constituents of the herb of the two plants which consumed for many purposes.

Seedlings of moringa and rooted cutting of rosemary plants were transplanted on the first week of March in 2017 and 2018 seasons in 35 cm diameter pot filled with peat moss and sand (1:1) in the Ornamental Nursery, Faculty of Agriculture, Ain Shams Univ. Cairo, Egypt. The seedlings of rosemary and moringa were selected to be uniform in shape and exposed to all horticultural practices including irrigation, fertilization and pest management as recommended.

Sodium selenite used as Se source in this study and was purchased from Sigma Aldrish (St. Louis, USA). A commercial seaweed extract compound was utilized containing natural bioactive substances like vitamins, free amino acids, hormones and alginates extracted out of selected seaweeds (*Sargessum sp., Ascophyllum nodosum* and *Luminaria* sp.). The seaweed extract compound was kindly donated by the Union for Agricultural Development (UAD) Company, Cairo, Egypt. The chemical composition of commercial seaweed extract is presented in Table (1).

Selenium and seaweed extract were sprayed twice in the first of June and again on the same plants in first of July in both studied seasons. Seven treatments were sprayed as follows:

- Control was sprayed with tap water
- Spraying with 0.5 ppm selenium
- Spraying with 1.0 ppm selenium
- Spraying with 1.5 ppm selenium
- Spraying with 5% seaweed extract
- Spraying with 10% seaweed extract
- Spraying with 15% seaweed extract

Table 1: Chemical and biochemical analysis of the utilized commercial seaweed extract powder

Constituents		Macro and microelements	
Total amino acid	5%	K_2O	4.71%
Carbohydrates	35%	Ca	0.25%
Alginine acid	10%	S	3.56%
Manitol	4%	Mg	0.58%
Betaines	0.04%	Fe	150 ppm
IAA	0.03%	Zn	70 ppm
Cytokinins	0.02%	Mn	13 ppm
Organic (N)	3.12%	B	60 ppm
P_2O_2	2.61%	I	30 ppm

The experiment was arranged in a randomized complete block design (RCBD) with 4 replicates for each treatment and each replicate contained 4 rosemary or moringa plants (7 treatments x 4 replicates x 4 plants = 112 plants from each rosemary and moringa plants.

At the first of October 2017 and 2018 the following data were recorded:

Vegetative Growth Parameters: Plant height (cm), stem diameter (cm), number of lateral branches/plant, total fresh biomass (sum of aerial portion and root system (g/plant) and total dry biomass in (g/plant) were determined.

Root Characters: Root number/ plant and root length (cm) were measured.

Chemical Constituents: Chlorophyll "a" and "b" (mg/g fresh weight) were estimated in rosemary and moringa herbs according to the method set out by Moran and Porath [41]. However, total carbohydrates percentage (% dry weight) according to Herbert *et al*. [42], C/N ratio was calculated by dividing total carbohydrates by total N.

Mineral Contents: Herb samples were collected from the two plant species washed and dried at 70°C until constant weight achieved and then ground for determination the following nutrient elements:

Macronutrients: N, P, K, Ca and Mg%:

- Nitrogen: using the modified micro Kjeldahl method as lined by Pregl [43].
- Phosphorus: was estimated as the method described by Bringham [44].
- Potassium: was determined using flame photometer according to Westerman [45].
- Calcium and Magnesium, were estimated according to Pohl *et al*. [46].

Micronutrients: Fe, Zn, Mn and Cu (ppm): were determined in digested solutions and measured using an absorption spectrophotometer according to Chapman and Pratt [47].

Statistical Analysis: Results were statistically analyzed using the analysis of Variance (ANOVA) as described by Snedecor and Cochran [48]. The method of Duncan's multiple range tests was applied for the comparison between means according to Waller and Duncan [49].

RESULTS AND DISCUSSION

Rosemarey (*Rosmarinus officinalis* L.)

Effect on Vegetative Growth Parameters and Root Characters: It is clear from data in Tables (2 & 3) that selenium and seaweed extract greatly affected vegetative growth parameters in rosemary plant during 2017 and 2018 seasons. The data showed that in all treatments were superior than control and the great effect was recorded by 1.0 ppm selenium followed by 10% seaweed extract spraying treatments. However, seaweed extract at 5% spraying treatment had negligible effect and sometimes less than control. Stem diameter greatly increased with selenium spraying at 1.0 ppm followed by 10% seaweed extract spraying. Number of lateral branches per plant recorded the same trend of results as pointed out tarsier. The highest values of lateral branches (9.33 and 10.19) were recorded by 1.0 ppm of selenium in first and second seasons, respectively.

Fresh and dry weights of total biomass (sum total parts of the plant including roots and shoots weights, results (Table 3) indicated that selenium at 1.0 ppm and seaweed extract at 10% were superior than other treatments in increasing fresh and dry weights of total biomass. However, the highest doses of each substrate (1.5 ppm of selenium and 15% of seaweed extract) were negligible and less effect in this respect.

Increasing of root length was clearly noticed with 1.0 ppm of selenium spraying. A similar effect was noticed with 10 and 15% of seaweed extract spraying, whereas selenium at 0.5 and 1.5 ppm were similar in their effect on root length and had less effect than other treatments .Root number per plant values were increased with selenium and seaweed extract than control, but superior effect was recorded by selenium spraying at 1.0 and 1.5 ppm with non-significant differences between them. Meanwhile, seaweed extract at 10 and 15% spraying came next without significant differences between them.

Effect on Chemical Constituents: As is evident in Table (4) chlorophyll a, chlorophyll b, total carbohydrates, nitrogen content and C/N ratio values were greatly affected with selenium and seaweed extract spraying on rosemary plants. Values of chlorophyll a and b were superior from all used treatments than the control and the greatest effect was recorded by selenium at 1.0 ppm and seaweed extract at 10% than in other treatments.

Total carbohydrates increased as a result of selenium and seaweed extract spraying from 15.2% in control to 26.8% with 1.0 ppm selenium spraying. The treatments of 1.0 ppm selenium and 10% seaweed extract exhibited the highest values of total carbohydrates. No significant differences were recorded between 10 and 15% of seaweed extract in their effect on total carbohydrates inside rosemary plants. N content ranged from 1.15 to 1.39% in rosemary treated plants compared to 0.96% in control in first season. However, the highest N contents were recorded by 0.5 and 1.0 ppm selenium and by 10 and 15% seaweed extract. The highest values of C/N ratios (19.28 in first season and 20.81 in second season) were recorded by 1.0 ppm selenium and 10% seaweed extract respectively.

Effect Macronutrients P, K, Mg and Ca Content (%): Data presented in Table (5) showed that selenium and seaweed extract spraying improved macronutrient levels in rosemary plants during 2017 and 2018 seasons. All treatments had no significant effect on P %.

K content greatly affected by all used treatments than control and the highest K% were recorded by 1.0 and 1.5 ppm of selenium spraying without significant differences between them.

The great effect of selenium and seaweed extract in increasing K content in rosemary herb is a good finding where it increased the nutritive values of rosemary herb. In addition, Mg% recorded the highest values with 1.0 ppm selenium and 10% seaweed extract spraying; whereas the other treatments recorded a medium values and slight differed than control. A great effect of selenium and seaweed extract spraying on Ca% in rosemary plants compared to control were recorded. The highest values of Ca content were recorded by 1.0 and 1.5 ppm of selenium and 10 and 15% seaweed extract without significant differences between each two concentrations of the same components.

Effect on Micronutrients Content (ppm): Fe, Zn, Mn and Cu: As it is evident in Table (6), an increase in Fe, Zn,

Table 2: Effect of selenium and seaweed extract spraying on vegetative growth characters of rosemary (*Rosmarinus officinalis* L.) during 2017 and 2018 seasons

Treatments	Plant height (cm)		Stem diameter (cm)		No. of lateral branch /plant	
	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	33.1 d	34.5 e	0.69 e	0.76 d	5.33 e	6.70d
Se at 0.5 ppm	40.9 c	45.4 cd	0.81 d	0.85 cd	7.14 cd	8.17 bc
Se at 1.0 ppm	56.7 a	63.6 a	1.14 a	1.12 a	9.33 a	10.19 a
Se at 1.5 ppm	46.2 bc	50.7 bc	0.97 bc	0.94 bc	8.03 bc	7.94 c
Seaweed at 5%	30.3 d	36.1 e	0.77 de	0.83 d	6.75 de	7.40 cd
Seaweed at 10 %	51.4 ab	53.0 b	1.06 ab	1.04 ab	8.16 b	9.05 b
Seaweed at 15 %	41.6 c	42.2 d	0.92 c	1.06 a	7.42 b-d	7.19 cd

Values followed by the same letter (s) are not significantly different at 5% level

Table 3: Effect of Selenium and seaweed extract spraying on total fresh and dry biomass in addition to root characters of rosemary (*Rosmarinus officinalis* L.) during 2017 and 2018 seasons

Treatments	Total fresh biomass weight (g)		Total dry biomass weight (g)		Root length (cm)		Root number per plant	
	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	205.2 d	206.8 e	66.2 e	66.7 d	18.4 d	17.8 d	19.7 d	17.2 e
Se at 0.5 ppm	256.7 c	292.2 d	82.8 cd	93.7 c	25.8 c	26.6 c	25.8 c	26.6 d
Se at 1.0 ppm	372.0 a	424.3 a	120.0 a	136.0 a	43.7 a	49.4 a	43.8 a	47.3 a
Se at 1.5 ppm	301.1 b	298.2 cd	97.0 bc	95.9 c	27.1 c	29.3 bc	47.1 a	42.5 ab
Seaweed at 5%	233.1 cd	255.4 e	74.7 de	72.0 d	19.6 d	18.4 d	23.1 cd	24.4 d
Seaweed at 10 %	332.6 ab	377.2 b	107.3 ab	121.3 ab	36.3 b	34.1 b	33.7 b	36.2 c
Seaweed at 15 %	307.9 b	333.2 c	99.0 b	106.8 bc	33.5 b	31.5 b	36.8 b	39.4 bc

Values followed by the same letter (s) are not significantly different at 5% level

Table 4: Effect of selenium and seaweed extract spraying on chemical constituents of rosemary (*Rosmarinus officinalis* L.) during 2017 and 2018 seasons

Treatments	Chlorophyll a content (mg/g fresh weight)		Chlorophyll b content (mg/g fresh weight)		Total Carbohydrates (%)		N content (%)		C/N ratio	
	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	0.307 c	0.360 e	0.211 e	0.206 e	15.2e	14.9 e	0.96 c	1.06 c	16.15c	14.06 d
Se at 0.5 ppm	0.410 b	0.428 d	0.261 cd	0.283 cd	19.8 d	21.6 d	1.26 ab	1.41 ab	15.71 c	15.32 c
Se at 1.0 ppm	0.513 a	0.549 a	0.373 a	0.418 a	26.8 a	28.7 a	1.39 a	1.53 a	19.28 a	18.76 b
Se at 1.5 ppm	0.463 a	0.453 cd	0.318 bc	0.356 b	20.6 cd	23.3 cd	1.15 bc	1.15 c	17.91 b	20.26 a
Seaweed at 5%	0.395 b	0.381 b	0.243 de	0.237 de	16.6 e	17.7 e	1.16 b	1.13 c	14.31 d	15.66 c
Seaweed at 10 %	0.480 a	0.496 bc	0.347 ab	0.341 b	24.2 ab	28.1 ab	1.33 a	1.35 b	18.20 b	20.81 a
Seaweed at 15 %	0.467 a	0.518 ab	0.285 cd	0.319bc	23.4 bc	25.3 bc	1.27 ab	1.36 ab	18.43 ab	18.60 b

Values followed by the same letter (s) are not significantly different at 5% level

Table 5: Effect of selenium and seaweed extract spraying on P, K, Mg and Ca content (%) of rosemary (*Rosmarinus officinalis* L.) during 2017 and 2018 seasons

Treatments	P content (%)		K content (%)		Mg content (%)		Ca content (%)	
	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	0.21 a	0.20 a	1.14 de	1.03 c	0.16 c	0.18 bc	1.42 c	1.59 b
Se at 0.5 ppm	0.23 a	0.22 a	1.32 bc	1.12 bc	0.17 bc	0.19 a-c	1.59 bc	1.64 b
Se at 1.0 ppm	0.20 a	0.17 a	1.47a	1.32 a	0.24 a	0.22 a	1.92 a	2.08a
Se at 1.5 ppm	0.19 a	0.20 a	1.37 ab	1.23 ab	0.20 b	0.21 ab	1.63 a-c	1.67b
Seaweed at 5%	0.18 a	0.22 a	1.09 e	1.05 c	0.16 c	0.17 c	1.54 bc	1.61b
Seaweed at 10 %	0.20 a	0.19 a	1.32 bc	1.28 a	0.21 ab	0.19 a-c	1.83 ab	1.78ab
Seaweed at 15 %	0.19 a	0.18 a	1.24 cd	1.16 b	0.20 b	0.21 ab	1.79 ab	1.86ab

Values followed by the same letter (s) are not significantly different at 5% level

Table 6: Effect of selenium and seaweed extract spraying on micronutrient levels (ppm) Fe, Zn, Mn and Cu of rosemary (*Rosmarinus officinalis* L.) during 2017 and 2018 seasons

	Fe content (ppm)		Zn content (ppm)		Mn content (ppm)		Cu content (ppm)	
Treatments	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	193 d	218 d	12. 5 e	13.4 d	48.6 c	56.3 c	6.6 a	7.6 d
Se at 0.5 ppm	221 d	289 c	14.7cd	15.2 bc	54.4 bc	60.7 bc	7.4 c	8.1 cd
Se at 1.0 ppm	332 a	375 a	17.1a	16.8a	71.8 a	74.3 a	10.3 a	11.0 a
Se at 1.5 ppm	294 b	311 bc	15.3bc	16.3a	74.7 a	68.3 ab	9.2 b	10.7 a
Seaweed at 5%	257 c	307 bc	13.8d	14.3cd	56.9 bc	66.8 ab	6.9 cd	7.8 d
Seaweed at 10 %	307 ab	352 a	16.3ab	17.2a	68.5 a	68.3 ab	9.4 b	.4 c8
Seaweed at 15 %	311 ab	347 a	16.0b	15.4b	64.7 ab	59.6 bc	9.1 b	9.3 b

Values followed by the same letter (s) are not significantly different at 5% level

Mn and Cu in rosemary herb as a result of selenium and seaweed extract spraying were obtained when compared to the control. The highest values of Fe, Zn, Cu were obtained with 1.0 ppm of selenium whereas the highest value of Mn (74.7 ppm) were recorded with 1.5 ppm of selenium (refer to table 5 for details) treatment in the first season. Similar results were observed in the second season. The improvement in micronutrients levels can be explained by certain compounds that exist in seaweed extracts which improve nutrient uptake and their transport in plants as found and explained in detail by Chouliaras *et al.* [50].

Moringa (*Moringa oleifera* L.)

Effect on Vegetative Growth Parameters and Root Characters: It is clear from data in Tables (7 and 8) that vegetative growth measurements of Moringa plants were greatly affected with selenium and seaweed extract in both seasons of this study.

The highest values of plant height (2.18 and 2.23 m) were recorded by 1.5 ppm selenium followed by seaweed extract at 10% (1.93 and 1.99) in the first and second seasons, respectively (Table 7). No significant difference between 0.5 ppm and control was detected in the first season

Stem diameter recorded the highest value with 1.5 ppm selenium whereas, the lowest values were obtained with 0.5 ppm selenium and 5% seaweed extract without significant differences between them and control plants. However, number of lateral branches per plant significantly increased than in the control due to spraying of 1.5 ppm selenium and 10% seaweed extract. A slight effect from 0.5 ppm of selenium on lateral branches was obtained where it was similar to control without significant differences between them.

Total fresh and dry biomass weights of moringa plants were greatly affected with selenium and seaweed extract spraying during the two studied seasons (Table 8). It is well known that total biomass of plant means sum of shoot and root and increasing of this character improve the herb weight which consumed for many benefits. However, all used treatments were superior in the part than control in increasing fresh and dry biomass weights of Moringa plant especially with 1.5 ppm of selenium followed by 15% seaweed extract.

Root length (cm) and root number per plant significantly increased than in the control with all used treatments but the greatest effect was recorded with 1.5 ppm of selenium followed by 10 and 15% of seaweed extracts. It is well known that increasing of root surface (length and number) improve nutrients uptake and consequently increase shoot growth and herb yield. Nevertheless, 0.5 ppm selenium was similar to control in affecting root length and number without significant differences between them.

Effect on Chemical Constituents: Data in Table (9) showed that both chlorophyll a and b were greatly affected with different treatments of selenium and seaweed extract in moringa plant during 2017 and 2018 seasons.

The highest values of chlorophyll a were obtained with 1.5 ppm selenium followed by 10 and 15% of seaweed extracts. For instance, chlorophyll an increased from 0.713 in control to 0.966 mg/g fresh weight with 1.5 ppm selenium treatment spraying and chlorophyll b increased from 0.483 in control to 0.612 mg/ g fresh weight with 1.5 ppm selenium, treatment in the first season. Similar trend was obtained in the second season.

Percentage of total carbohydrates was greatly affected by the different treatments applied in this research where it increased from 39.8% in control to 58.3% in plants sprayed with 1.5 ppm selenium. Meanwhile, 10 and 15% of seaweed extract came in the second rank in affecting significantly the percentage of total carbohydrates in moringa plant. Regarding to N%

Table 7: Effect of selenium and seaweed extract spraying on vegetative growth characters of moringa (*Moringa oleifera* L.) during 2017 and 2018 seasons

	Plant height (m)		Stem diameter (cm)		N. of lateral branch /plant	
Treatments	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	1.62 e	1.58 d	6.17 d	6.04 d	13.8 e	14.3 e
Se at 0.5 ppm	1.69 de	1.77 c	6.41 d	6.34 d	15.6 de	15.3 de
Se at 1.0 ppm	1.82 c	1.78 c	7.18 c	7.61 c	20.0 bc	21.0 bc
Se at 1.5 ppm	2.18 a	2.33 a	8.52 a	8.86 a	27.5 a	29.3 a
Seaweed at 5%	1.76 cd	1.81 c	6.50 d	6.63 d	17.5 cd	18.0 cd
Seaweed at 10 %	1.93 b	1.99 b	7.29 bc	7.65 bc	25.8 a	27.0 a
Seaweed at 15 %	1.85 bc	1.97 b	7.84 b	8.46 b	22.3 b	22.8 b

Values followed by the same letter (s) are not significantly different at 5% level

Table 8: Effect of selenium and seaweed extract spraying on root characters of moringa (*Moringa oleifera L.*) during 2017 and 2018 seasons

	Fresh total biomass weight (g)		Dry total biomass weight (g)		Root length (cm)		Root number per plant	
Treatments	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	408.3 f	428.6 f	103.6 e	108.2 f	21.7 e	21.4 d	20.2 e	22.2 e
Se at 0.5 ppm	512.2e	538.2 e	130.5 d	133.2 e	25.4 e	24.0 d	24.2 d	27.6 d
Se at 1.0 ppm	562.9 d	577.4 d	143.4 c	144.3 d	32.4 cd	33.7 c	27.2 c	29.2 c
Se at 1.5 ppm	610.4 a	634.5 a	155.3 a	158.5 a	46.7 a	49.5 a	32.8 a	34.8 a
Seaweed at 5%	520.7 e	538.6 e	131.2 d	143.8 e	30.7 d	31.9 c	27.0 c	30.8 b
Seaweed at 10 %	503.2 c	601.7 c	146.1 c	150.4 c	41.0 b	44.2 b	29.7 b	31.7 b
Seaweed at 15 %	601.9 b	623.2 b	150.2 b	155.8 b	36.3 bc	39.4 b	28.9 bc	31.8 b

Values followed by the same letter (s) are not significantly different at 5% level

Table 9: Effect of selenium and seaweed extract spraying on chemical constituents of moringa (M*oringa oleifera* L.) during 2017 and 2018 seasons

	Chlorophyll a content (mg/g fresh weight)		Chlorophyll b content (mg/g fresh weight)		Total Carbohydrates (%)		N content (%)		C/N ratio	
Treatments	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	0.713 d	0.698d	0.483 d	0.478 d	39.8d	38.6 d	2.10 b	2.04 c	18 .95e	19.92 e
Se at 0.5 ppm	0.765 c	0.749c	0.516 cd	0.516 d	40.5d	40.9 d	2.11 b	2.05 c	19.19 de	19.95 d
Se at 1.0 ppm	0.851 b	0.868 b	0.542 bc	0.542 c	46.4c	47.8 c	2.17 b	2.21 b	21.38 c	21.63 c
Se at 1.5 ppm	0.966a	0.952a	0.612 a	0.612 a	58.3a	61.2 a	2.36 a	2.43 a	24.70 a	25.19 a
Seaweed at 15%	0.753 cd	0.730cd	0.495 d	0.485 d	44.3c	45.1 c	2.13 b	2.07 c	20.80 cd	21.79 c
Seaweed at 10%	0.936ab	0.953a	0.594 ab	0.611 ab	52.7b	56.9 ab	2.31 a	2.37 a	22.81 b	24.00 b
Seaweed at 15%	0.920 ab	0.948 a	0.548 bc	0.562 bc	55.4ab	59.6 ab	2.28 a	2.34 a	24.30 a	25.47 a

Values followed by the same letter (s) are not significantly different at 5% level

Table 10: Effect of selenium and seaweed extract spraying on P, K, Mg and Ca content (%) of moringa (*Moringa oleifera* L.) during 2017 and 2018 seasons

	P content (%)		K content (%)		Mg content (%)		Ca content (%)	
Treatments	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018	Season 2017	Season 2018
Control	0.47 a	0.45 a	2.19 c	2.11 d	0.39 c	0.41 bc	1.75 a	1.71 a
Se at 0.5 ppm	0.51 a	0.49 a	2.22 bc	2.28 c	0.38 c	0.43 bc	1.70 a	1.77 a
Se at 1.0 ppm	0.49 a	0.47 a	2.35 b	2.46 ab	0.42 b-d	0.45 bc	1.74 a	1.84 a
Se at 1.5 ppm	0.48 a	0.48 a	2.64 a	2.51 a	0.52 a	0.56 a	1.49 b	1.65 a
Seaweed at 5%	0.46 a	0.50 a	2.24bc	2.33 bc	0.43 bc	0.38 bc	1.69 ab	1.75 a
Seaweed at 10%	0.54 a	0.54 a	2.53 a	2.61 a	0.44 bc	0.40 bc	1.63 ab	1.69 a
Seaweed at 15%	0.51 a	0.51 a	2.51 a	2.56 a	0.47 ab	0.46 b	1.65 ab	1.77 a

Values followed by the same letter (s) are not significantly different at 5% level

Table 11: Effect of selenium and seaweed extract spraying on micronutrient contents Fe, Zn, Mn and Cu (ppm) of moringa (*Moringa oleifera* L.) during 2017 and 2018 seasons

	Fe content (ppm)		Zn content (ppm)		Mn content (ppm)		Cu content (ppm)	
Treatments	Season 2017	Season 2018	Season 2017	Season 2017	Season 2018	Season 2017	Season 2018	Season 2018
Control	187 d	183 e	12.6 c	12.1 d	76.9 cd	73.4 d	7.7 cd	7.4 d
Se at 0.5 ppm	196 d	202 de	12.1 c	12.5 d	80.3 c	84.2 c	7.6 cd	8.4 c
Se at 1.0 ppm	246 b	261 bc	14.7 ab	16.0 ab	81.7 c	85.7 c	8.4 b	9.0 b
Se at 1.5 ppm	267 a	295 a	15.4 a	16.4 a	115.6 a	122.4 a	9.1 a	9.6 a
Seaweed at 5%	213 c	220 d	12.2 c	12.5 d	73.4 d	77.0 d	7.4 d	7.2 d
Seaweed at 10 %	255 ab	246 c	15.3 a	15.0 c	109.8 b	116.3 b	8.1 bc	8.7 bc
Seaweed at 15 %	251b	274 ab	14.1 b	15.7 bc	78.8 c	77.4 d	8.3 b	9.2 ab

Values followed by the same letter (s) are not significantly different at 5% level

result data, it was clear that the highest values of N% were obtained by 1.5 ppm selenium and 10 and 15% of seaweed extracts. The other treatments including selenium at 0.5 and 1.0 ppm and 5% of seaweed extract exhibited similar values to control. C/N ratio values obtained indicate that all applied selenium and seaweed extract treatments clearly effected C/N ratio where it increased from 18.95 in untreated (control plants), to 24.70 in 1.5 ppm selenium treated plants. However, 15% seaweed extract was superior and similar to 1.5 ppm selenium without significant differences between them.

Effect on Macronutrients Contents P, K, Mg and Ca Content (%): Result data in Table (10) showed no significant effects to different applied treatments were obtained on P in herbs of moringa plant where their effect were similar to control.

Generally, P content in moringa herbs ranged from 0.47 to 0.54 % regardless of applied treatment. However, K content in moringa herbs greatly increased with all used treatments, but the most superior effects were recorded by 1.5 ppm of selenium and 10 and 15 % of seaweed extracts without significant differences between them. A slight non-significant effect was obtained with 0.5 ppm selenium which was similar to control. Mg content in moringa herb positively increased with 1.5 ppm selenium and 15% seaweed extracts. However, spraying with 0.5 ppm selenium had no significant defect compared in the control. On the contrary, application of selenium and seaweed extract to moringa plant decreased the level of Ca% than in the control, without significant differences between them.

Effect on Micronutrients Contents (ppm): Fe, Zn, Mn and Cu: Result data in Table (11) showed that Fe, Zn, Mn and Cu contents were greatly affected with different treatments on moringa plant during 2017 and 2018 seaweed.

Fe content increased from 187 ppm in control to 267 ppm in selenium treated plant with 1.5 ppm and to 255 ppm in 10 % seaweed extract treated plants with 10%. However, no significant differences were obtained between 0.5 ppm selenium and control in the first season. Similar trend was obtained in the second season. Zn content result values indicate that 1.0 and 1.5 ppm selenium and 10% seaweed extract treatments exhibited the highest values than other treatments or control. Generally, it could be concluded that the used treatments in this research raised Zn content from 12.6 ppm in control to 15.4 ppm with 1.5 ppm selenium treatment. In addition, Mn content in moringa herb greatly increased with 1.5 ppm selenium and 10% seaweed extract compared with other treatments or control. No significant effects were obtained due to 0.5 and 1.0 ppm selenium or 5 and 15% seaweed extract were obtained compared to control. A slight effect was noticed due to the used treatments on Cu content in moringa herb, where it increased with 1 and 1.5 ppm of selenium and 15% of seaweed extract when compared to control. Generally, it is clear that selenium at 1.5 ppm and seaweed extract at 10% were effective in augmenting the content of micronutrients in moringa herb and consequently increase and improve the nutritive value of consumed herb of moringa.

It could be concluded that, the positive effected of selenium on both rosemary and moringa plants was found and in harmony as reported by Seppanen *et al.* [51] and Vanuze Costa *et al.* [16] who demonstrated that Se affected the chemical composition and antioxidant proprieties and at low concentration activates mechanisms that can alleviate oxidative stress in the chloroplast and enhance potato plants growth parameters. However, the effect of Se is dose dependent and more related to the plant species [52].

Foliar spraying with an appropriate Se concentration can promote rapid development, increase the net photosynthetic rate and chlorophyll content, protect from high temperature stress, chilling stress, drought stress and several types of abiotic stress [53].

The use of seaweed extracts has become an attractive option as both a fertilizer and bio-stimulant. Liquid extracts obtained from seaweeds gained importance either as spray or soil drench on several crops to simulate growth and yield, to develop environmental stress tolerance, increase nutrient uptake and enhance antioxidant properties [54].

The great effect of seaweed extract on rosemary and moringa plants was attributed to the fact that seaweed extract contained large scale supplements, follow components minerals like Zn, Mn, Mg and Fe natural substances like amino acids and plant development controllers, for example, auxin, cytokinin and gibberellins [40, 28, 27]. Many researchers demonstrated that this extract advanced the development and yield of harvest plants [55-57].

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