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Response of sweet basil growth and photosynthesis pigments to foliar application of plant extracts and micro-nutrients fertilizer

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Abstract

The present study was conducted during the two successive seasons of 2021 and 2022 at a private farm in Menia El-Qamh - Sharkia Governorate, Egypt to investigate the effect of foliar application with moringa, seaweed and carnation extracts and Fe and Zn as chelated (Fe- EDTA and Zn- EDTA) on growth, and photosynthesis pigments of sweet basil cv. Genovese. The experiment was contained three replicates, each replicate contained 20 treatments (3 levels of both extracts and control X 5 levels of micro-nutrients). Data were statistically analyzed using split plot design in both growing seasons. The main plot represented the 3 plant extracts of seaweed moringa and carnation, and control treatment), while the control, Fe at 50 and 100 ppm and Zn at 50 and 100 ppm, were occupied in the sub - plots. Results revealed that plant extracts significantly increased vegetative growth, chlorophyll (a), chlorophyll (b) and carotenoids of sweet basil cv. Genovese, in both growing seasons. Seaweed extract, being the most effective on vegetative growth characters and photothynsis, i.e. Plant height, number of branches/ plant, number of leaves/plant, plant fresh weight and plant dry weight in the two times of cut (first and second cut) and chlorophyll (a), chlorophyll (b) and carotenoids in both growing seasons. This treatment followed by the moringa leaves extract and carnation bud extract, respectively. The lowest values in vegetative growth of sweet basil as a result of control treatment without any plant extract.

Keywords: Plant extracts, Fe, Zn, Sweet basil-growth, photosynthesis pigments.

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1. Introduction

Aromatic and medicinal plants are an important source of national income and foreign currency in Egypt. They are among the most important agriculture export commodities that are in demand in European and other international markets. Sweet basil is one of the most important species for export among the medicinal and aromatic plants, and it has a good reputation in the European countries. They are about 5-6 thousand feddans, and the exports are more than 6000 tons per year. Sweet basil (*Ocimum basilicum* L.) is known as member of Lamiaceae family and appreciated as an aromatic spice and medicinal plant [1]. It is an aromatic plant commonly cultivated in all parts commonly cultivated in all parts of the world. Economically, it is an important as a source of essential oils, medicines and ornamentals. There are 150 to 160 species belongs to this genus broadly dispersed over the warm regions of the world [2]. Plant extracts are known as an environmental friendly for using without pollution to plants, especially for aromatic and medicinal plants like as, seaweed extracts, moringa leaf extracts and carnation bud extracts.

Plant extracts as biostimulants are emerging as commercial formulation for use as plant growth promoting factors and a method to improve the plants [3]. Plant extracts provides an excellent source of bioactive compounds such as carotenoids, protein, essential fatty acids, vitamins, amino acids, minerals and growth promoting substances [4]. Many investigators concluded that foliar application of seaweed extracts at 100 and 200 ppm significantly increased plant height, shoot length, branch numbers / plant [5]. They added that spraying basil plants with seaweed extract at 50,100 and 200 ppm significantly increased chlorophyll (a and b) and carotenoids content. [6] indicated that foliar application with seaweed extracts at 2ml/L., significantly increased plant height, number of branches, fresh and dry weight of basil compared to the control treatment. Moringa leaf extract is one of such alternatives, being studies to ascertain its influence on growth and pigments content of several crops, thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers [7].

It is known as one of the world most useful trees, as almost all parts of the tree have an impressive impact of food, medicine and industrial process [8]. Moreover, spraying sweet basil plants with *Moringa oleifera* leaf extracts resulted in a significant increase in vegetative growth parameters, i.e leaf area, shoot length, shoot fresh and dry weight and number of branches compared to the unsprayed ones [9]. Micro-nutrients are essential for plant and lack of them reduces the productivity of the crop. Zinc is an important mineral element to activate many enzymes, such as carbonic anhydrase, and alcohol dehydrogenase. It is also necessary for the synthesis of the amino acid tryptophane, which turns into auxin(IAA) that helps to increase the growth of the plant and has a role in the synthesis of nucleic acids and proteins. Moreover, Iron plays an essential and necessary role in many enzymes, especially enzymes intervention or help in the process of respiration, which include system catalase, peroxidase and cytochrome oxidase. In addition, the iron participates in the processes of oxidation of these compounds, which is one of the important role in cell metabolism operation. It is important in the synthesis and maintenance of chlorophyll [10].The purpose of this research was to study the effect of seaweed, moringa and carnation extracts, and Zinc and iron micro- elements on growth and pigments content of sweet basil (*Ocimum basilicum* L.) plants.

2. Materials and Methods

The present study was conducted during the two successive seasons of 2021 and 2022 at a private farm in Menia El-Qamh - Sharkia Governorate, Egypt to investigate the effect of foliar application with moringa, seaweed and carnation extracts, and Fe and Zn as chelated on growth, and photosynthesis pigments of sweet basil cv. Genovese, Seeds of sweet basil (*Ocimum basilicum* L.) were obtained from Medicinal and Aromatic Plants Department, Horticulture Research Institute, Sakha, Kafr El-Sheikh Governorate, Egypt. At the 15th of March 2021 and 2022, basil seeds were planted in earthen ware pots 15 cm diameter and 15cm height with perforated bottoms. Five seeds were planted in each one. Pots were filled with clay loam soil. After 45 days from seed cultivation, uniform seedlings were transplanted to earthen ware pots of 30 cm diameter and 40cm height with perforated bottoms. All pots were filled with clay soil.

Physical and chemical properties of the soil used were determined according to the methods described by [11] and shown in Table 1.

Table 1: Physical and chemical properties of the soil used

Characters	Values
Physical proprieties:	
Coarse sand (%)	8.91
Fine sand (%)	10.63
Silt (%)	28.22
Clay (%)	52.24
Textural class	Clayey Loam
Chemical analysis:	
Organic matter (%)	1.44
Ca CO_3 (%)	0.55
Total phosphorus (%)	0.16
Total potassium (%)	0.25
pH	7.66
EC (dS/m)	0.66

The plants were fertilized by a commercially grade NPK fertilizer for two times with 15 days' interval for each cut. The moringa leaf extract was made as follows; two hundred grams were extracted in 500 ml H_2O using locally fabricated machine [12]. The extract was filtered through muslin cloths and centrifuged at 800 xg for 15 min. The supernatant was completed to one liter, then dilutions were made (20%,10% and5%) and kept at. 4°c till used. Seaweed extract produced by CHEMA company, contains Fe, Zn, Cu, Mn and Mo minerals, vitamins, enzymes, amino acids, sugars and plant hormones, it was added at 3ml/l. Foliar application treatments with 50 ,100 ppm iron and 50 ,100 ppm Zinc (Fe 8.5% and Zn 16%) as foliar spray of the chelated Fe- EDTA and Zn- EDTA too. The treatments of seaweed, moringa leaf extracts and carnation bud's extracts were applied as foliar spray on plant leaves 4 times, the first one was added after 45 days from transplanting. The second time was after 15 days from the first, while the third was applied after 30 days from the first cut, and the fourth was after 15 days from the third (45,60,75 and 90 days) from transplanting. As well as, the micro-nutrients were foliar sprayed 4 times after 5 days from adding the moringa, seaweed and carnation extracts, intervals. The experimental treatments consisted of 20 treatments, which represented all combination between plant extracts (control, seaweed moringa and carnation extracts) and five treatments of micro-nutrients as chelated form (0.0, 50 ppm Fe, 100 ppm Fe, 50 ppm Zn and 100 ppm Zn). The experiment was contained three replicates, each replicate contained 20 treatments (3 levels of both extracts and control X 5 levels of micro-nutrients), five plants were used as a plot for each treatment. Data were statistically analyzed using split plot design in both growing seasons. The main plot represented the 3 plant extracts of seaweed، moringa and carnation, and control treatment), while the control, Fe at 50 and 100 ppm and Zn at 50 and 100 ppm, were occupied in the sub - plots. Irrigation and agricultural practices were done whenever plants needed.

2.1. Data recorded

Growth characters were carried out at the first and second cuts after 90 and 180 days from transplanting, respectively before flowering. The following data were recorded, i.e. plant height (cm) above 10cm of soil surface, number of branches plant, number of leaves / plant, fresh and dry weights of herb(g/plant) and leaves pigments (Photosynthetic pigments):

The photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) were determined in the leaves of the investigated plant at the average of 120 days from transplanting, in both growing season. The spectrophotometric method recommended by [13] was used. A known fresh weight of leaves was homogenized in 85% aqueous acetone for 5 min. The homogenate was centrifuged and the supernatant was made up to volume with 85% aqueous acetone. The extinction was measured against a blank of pure 85% agueous acetone at 3 wave lengths of 452.5, 644 and 663 nm using spectrocolourimeter DC Tiny 25III Model TUDC12B4.Taking into consideration the dilutions made of the pigment fraction, chlorophyll a, chlorophyll b and carotenoids were determined in gram fresh weight using the following equations:

Chlorophyll a= 10.3E663-0.918E644 = mg/g f.w.

Chlorophyll b=19.7 E644-3.87E663 = mg/g f.w.

Carotenoids =4.2E425.5-(0.026chlorophyll a+0.426 chlorophyll b) = mg/g f.w.

2.2. Statistical analysis

All data were calculated with three replicates and were expressed as means, and differences were analyzed using split plot design, and LSD P values of <0.05 were considered to be significant according to [14,15].

3. Results and Discussion

3.1. Vegetative growth characters

3.1.1. Effect of plant extracts

Data in Tables (4-8) revealed that plant extracts significantly increased vegetative growth of sweet basil cv. Genovese, in the first and second cut in both growing seasons. Seaweed extract, being the most effective on vegetative growth characters, i.e. plant height, number of branches/ plant, number of leaves/plant, plant fresh weight and plant dry weight in the two times of cut (first and second cut) in both growing seasons. This treatment followed by the moringa leaves extract and carnation bud, respectively. The lowest values in vegetative growth of sweet basil as a response of control treatment without any plant extract. Regarding the important role of seaweed extract in increasing vegetative growth of basil plants**,** [3] confirmed that seaweed extracts as a biostimulants are emerging as commercial formulations for use as plant growth promoting factors and a method to improve the plants. Moreover, [4] illustrated that seaweed provides an excellent source of bioactive compounds such as carotenoids, protein, essential fatty acids, vitamins, amino acids, minerals and growth promoting substance. Also, [16] concluded that growth enhanced by seaweed extracts may be due to components such as macro and micro elements, amino acid, vitamins, cytokinins, auxins and abssisic acid (ABA). Like growth substance which affect cellular metabolism in treated plants leading to enhanced growth.Respecting the vital role of moringa leaf extract, [7] stated that moringa leaf extract is one of such alternative, being studies to ascertain its influence on growth, thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers. [17] demonstrated that moringa leaf extract have zeatin, minerals and purine adenine derivatives of cytokinin and amino acids which they help to improving growth of plants. Moreover, [18] pointed out that moringa oleifera acts a good natural antioxidant system to promote the plant to building the tissue with a good growth. These results are accordance with those reported by [19,20] who they worked on basil with seaweed extracts, as well as [9,21,22] who worked with morning extracts on basil.

3.1.2. Effect of micro-nutrients

Data presented in Tables (4-8) study the effect of micro-nutrients, i.e. Fe and Zn on vegetative growth of sweet basil plants; plant height, number of branches, number of leaves, plant fresh weight and plant dry weight. The results revealed that the highest concentration (100 ppm) of both Fe and Zn caused an increases in the parameters of vegetative growth of sweet basil plants at the two cuts in both growing seasons of this study, but the Fe at 100 ppm, being the most effective on vegetative growth characters. These results followed by the same trend at the concentration of 50 ppm Fe and 50 ppm Zn, respectively. Regarding the important role of Zn in improving plant growth characters, [23,24] confirmed that Zinc is an essential micro-nutrient that act either as metal component of various enzymes or as a functional, structural, or regulatory cofactor associated with saccharide metabolism, photosynthesis, and protein synthesis and then increased plant growth. The present study was in accordance by [25,10,26,27,28] they worked on micro-nutrients on sweet basil.

3.1.3. Effect of interaction between plant extracts and micro-nutrients concentration

Data in Tables (11-15) investigated the effect of seaweed extract and moringa extract with Fe and Zn at 100, 50 ppm on vegetative growth of sweet basil plants. The results indicated that seaweed extract caused a significantly increased in all the parameters of sweet basil growth in both the cuts at the first and the second cut during both growing seasons, followed by the interaction effect at seaweed extract at highest concentration of Zn (100ppm). In addition, the same trend with moringa leaf extract with Zn at 100 ppm and 50 ppm, respectively. From these results it can be concluded that seaweed extracts, being the most effective on vegetative growth character of sweet basil in both concentrations, more than moringa leaf extract.

Table 2: The chemical analysis of Moringa extracts

The chemical analysis of seaweed extracts	Percentage%
Moisture	7.94%
Dry matter	92.06%
Organic matter	88.35%
Ash	11.65%
Total lipid	13.55%
Nitrogen free extract	14.05%
Total protein	28.59%
Crude fiber	32.15%
Mineral composition(ppm):	
Mg	147.5
Ca	111.0
K	559.00
Na	21.50
Zn	0.125
Cu	0.53

Tablet 3: The chemical analysis of seaweed extracts

The chemical analysis of seaweed extracts	Percentage
N	1%
K	2.5%
Ca	0.17%
Mg	0.43%
Fe	0.06%
S	2.2%
Zn	0.99%
B	3.87%
Plant hormones (ppm)	500

Table 4: Effect of plant extracts and micro- nutrients on plant height of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Plant height (cm) First cut		Plant height (cm) Second cut	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	42.866	46.082	43.329	45.072
Seaweed	69.132	72.798	70.392	72.993
Moringa	60.401	63.568	61.263	64.095
LSD(0.05)	0.004	0.005	0.004	0.112
Micro-nutrients				
0.0	49.336	53.676	49.730	52.003
50 ppm Fe	58.790	61.926	59.502	61.475
100 ppm Fe	62.424	65.503	63.821	66.165
50 ppm Zn	56.106	59.435	56.502	59.424
100 ppm Zn	60.676	63.540	61.736	64.533
LSD (0.05)	0.005	0.007	0.005	0.145
Interaction (AxB):				
LSD (0.05)	0.009	0.013	0.009	0.251

Table 5: Effect of plant extracts and micro- nutrients on number of branches of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Number of branches First cut		Number of branches Second cut	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	33.829	34.601	35.676	35.912
Seaweed	68.084	68.682	70.152	70.278
Moringa	64.121	64.686	65.733	65.797
LSD(0.05)	0.004	0.016	0.049	0.115
Micro-nutrients				
0.0	32.306	33.283	34.360	34.786
50 ppm Fe	60.566	61.633	62.682	62.748
100 ppm Fe	63.133	64.126	65.166	65.327
50 ppm Zn	58.150	58.597	60.015	60.036
100 ppm Zn	62.566	62.633	63.685	63.745
LSD (0.05)	0.005	0.021	0.063	0.149
Interaction (AxB):				
LSD (0.05)	0.009	0.037	0.109	0.258

Table 6: Effect of plant extracts and micro- nutrients on number of leaves of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Number of leaves Second cut		Number of leaves First cut	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	32.337	33.340	33.443	33.878
Seaweed	36.836	38.317	38.001	38.504
Moringa	34.404	35.824	35.444	35.972
LSD(0.05)	0.112	0.076	0.022	0.005
Micro-nutrients				
0.0	30.963	32.022	32.004	32.457
50 ppm Fe	35.456	36.691	36.496	36.831
100 ppm Fe	37.030	38.602	38.216	38.722
50 ppm Zn	33.071	34.315	34.247	34.851
100 ppm Zn	36.110	37.505	37.183	37.730
LSD (0.05)	0.145	0.098	0.0280	0.007
Interaction (AxB):				
LSD (0.05)	0.251	0.169	0.049	0.012

Table 7: Effect of plant extracts and micro- nutrients on fresh weight / sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Fresh weight / plant (g) First cut		Fresh weight / plant (g) Second cut	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	284.166	296.884	284.481	300.288
Seaweed	452.256	466.194	452.326	467.070
Moringa	439.994	460.674	440.134	461.324
LSD(0.05)	0.002	0.121	0.057	0.0261
Micro-nutrients				
0.0	342.346	349.824	342.804	355.123
50 ppm Fe	388.706	407.862	388.835	408.505
100 ppm Fe	429.014	458.273	429.123	459.306
50 ppm Zn	391.660	401.671	391.755	402.236
100 ppm Zn	408.966	421.956	409.051	422.633
LSD (0.05)	0.002	0.156	0.073	0.033
Interaction (AxB):				
LSD (0.05)	0.001	0.270	0.127	0.058

Table 8: Effect of plant extracts and micro- nutrients on dry weight / sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Dry weight / plant (g) First cut		Dry weight / plant (g) Second cut	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	77.234	80.787	77.990	79.702
Seaweed	96.353	100.373	97.066	99.373
Moringa	91.947	94.147	92.504	94.214
LSD(0.05)	0.044	0.051	0.183	0.220
Micro-nutrients				
0.0	76.888	80.066	77.712	79.905
50 ppm Fe	88.026	91.123	88.760	90.908
100 ppm Fe	99.796	103.750	100.391	102.538
50 ppm Zn	84.023	85.830	84.580	85.707
100 ppm Zn	93.823	97.976	94.491	96.421
LSD (0.05)	0.058	0.065	0.237	0.2843
Interaction (AxB):				
LSD (0.05)	0.100	0.113	0.410	0.123

Table 9: Effect of plant extracts and micro- nutrients on chlorophyll (a and b) of sweet basil leaves during 2021/2022 and 2022/2023 seasons

Treatments	Chlorophyll (a) (mg/g f.w.)		Chlorophyll (b) (mg/g f.w.)	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	0.934	0.937	0.678	0.692
Seaweed	1.063	1.065	0.728	0.734
Moringa	1.027	1.027	0.714	0.730
LSD(0.05)	0.009	0.003	0.013	0.009
Micro-nutrients				
0.0	0.943	0.943	0.625	0.643
50 ppm Fe	1.006	1.016	0.723	0.728
100 ppm Fe	1.055	1.056	0.753	0.760
50 ppm Zn	1.003	1.000	0.705	0.723
100 ppm Zn	1.031	1.033	0.726	0.740
LSD (0.05)	0.011	0.004	0.017	0.012
Interaction (AxB):				
LSD (0.05)	0.021	0.007	0.029	0.021

Table 10: Effect of plant extracts and micro- nutrients on total chlorophyll and total carotenoids of sweet basil leaves during 2021/2022 and 2022/2023 seasons

Treatments	Total carotenoids (mg/g f.w.)	
	2021/2022	2022/2023
Plant extracts		
0.0	0.379	0.385
Seaweed	0.436	0.447
Moringa	0.409	0.420
LSD(0.05)	0.005	0.007
Micro-nutrients		
0.0	0.365	0.375
50 ppm Fe	0.410	0.418
100 ppm Fe	0.446	0.455
50 ppm Zn	0.395	0.404
100 ppm Zn	0.423	0.433
LSD (0.05)	0.007	0.009
Interaction (AxB):		
LSD (0.05)	0.012	0.015

Table 11: The interaction effect of plant extracts and micro- nutrients on plant height of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Plant height (cm) First cut					Plant height (cm) Second cut				
Micro- nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season									
0.0	35.776	43.526	47.886	42.636	44.636	34.836	44.590	48.946	42.566	45.706
Seaweed	56.716	71.516	75.126	68.126	74.176	57.776	72.576	77.190	69.193	75.226
Moringa	55.516	61.326	64.260	57.686	63.216	56.576	62.390	65.326	57.746	64.276
LSD (0.05)	0.009					0.009				
	2022/2023 season									
0.0	39.416	47.196	49.576	45.833	48.386	35.410	45.380	50.573	44.810	49.380
Seaweed	62.196	74.386	79.476	71.276	76.656	61.190	75.380	79.473	71.273	77.650
Moringa	59.416	64.196	67.456	61.196	65.576	59.410	63.856	68.450	62.190	66.570
LSD (0.05)	0.013					0.251				

Table 12: The interaction effect of plant extracts and micro- nutrients on number of branches of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Number of branches First cut					Number of branches Second cut				
Micro- nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season									
0.0	28.413	34.173	37.153	33.213	36.193	30.296	36.210	39.146	35.320	37.410
Seaweed	36.153	76.340	79.173	71.363	77.393	38.170	78.556	81.153	73.516	79.366
Moringa	32.353	71.253	73.013	69.873	74.113	34.613	73.363	75.20	71.210	74.280
LSD (0.05)	0.009					0.109				
	2022/2023 season									
0.0	29.163	35.143	38.103	34.253	36.343	31.253	36.280	39.193	35.376	37.280
Seaweed	37.136	76.423	80.113	71.396	78.343	38.433	78.513	81.536	73.473	79.433
Moringa	33.550	72.363	74.163	70.143	73.213	34.673	73.453	75.253	71.260	74.346
LSD (0.05)	0.037					0.258				

Table 13: The interaction effect of plant extracts and micro- nutrients on number of leaves of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Number of leaves First cut					Number of leaves Second cut				
Micro- nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season									
0.0	27.676	33.176	35.096	31.560	34.176	28.716	34.250	36.200	32.733	35.316
Seaweed	33.856	37.856	39.116	35.216	38.296	34.740	38.863	40.533	36.533	39.336
Moringa	31.516	35.336	36.876	32.436	35.856	32.556	36.376	37.916	33.476	36.896
LSD (0.05)	0.251					0.251				
	2022/2023 season									
0.0	28.376	34.223	36.103	32.676	35.320	29.503	34.283	36.260	33.903	35.440
Seaweed	35.273	38.703	41.513	36.476	39.620	35.330	38.840	41.623	36.690	40.040
Moringa	32.416	37.146	38.190	33.793	37.576	32.540	37.370	38.283	33.960	37.710
LSD (0.05)	0.169					0.169				

Table 14: The interaction effect of plant extracts and micro- nutrients on fresh weight / sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Fresh weight / plant (g) First cut					Fresh weight / plant (g) Second cut				
Micro-nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season									
0.0	260.680	279.160	323.253	268.180	289.560	261.786	279.433	323.366	268.186	289.633
Seaweed	387.180	453.420	490.340	453.180	477.160	387.173	453.426	490.446	453.353	477.233
Moringa	379.180	433.540	473.450	453.620	460.180	379.453	433.646	473.556	453.726	460.286
LSD (0.05)	0.150					0.127				
	2022/2023 season									
0.0	261.620	287.060	347.330	273.353	315.060	276.296	287.703	348.006	273.696	315.736
Seaweed	399.300	473.420	516.480	470.440	471.330	399.976	474.096	518.156	471.116	472.006
Moringa	388.553	463.106	511.010	461.220	479.480	389.096	463.716	511.756	461.896	480.156
LSD (0.05)	0.270					0.058				

Table 15: The interaction effect of plant extracts and micro- nutrients on dry weight / sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Dry weight / plant (g) First cut					Dry weight / plant (g) Second cut				
Micro-nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season									
0.0	69.700	75.293	88.453	71.273	81.453	70.723	76.046	89.010	71.830	82.343
Seaweed	81.513	95.233	112.293	89.453	103.273	82.403	96.123	112.963	90.010	103.830
Moringa	79.453	93.643	98.643	91.343	96.743	80.010	94.110	99.200	91.900	97.300
LSD (0.05)	0.100					0.410				
	2022/2023 season									
0.0	74.153	77.143	91.023	73.793	87.823	73.336	77.166	91.056	73.793	83.156
Seaweed	84.943	99.923	118.003	93.933	105.063	84.943	99.256	114.336	93.266	105.063
Moringa	81.103	96.303	102.223	90.063	101.043	81.436	96.303	102.223	90.063	101.043
LSD (0.05)	0.113					0.123				

Table 16: The interaction effect of plant extracts and micro- nutrients on chlorophyll (a and b) of sweet basil leaves during 2021/2022 and 2022/2023

Interaction	Chlorophyll (a) (mg/g f.w.)					Chlorophyll (b) (mg/g f.w.)				
Micro- nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season									
0.0	0.903	0.920	0.970	0.933	0.946	0.586	0.716	0.733	0.656	0.700
Seaweed	0.973	1.073	1.123	1.053	1.093	0.663	0.730	0.773	0.716	0.726
Moringa	0.953	1.033	1.073	1.023	1.053	0.626	0.723	0.753	0.743	0.723
LSD (0.05)	0.021					0.029				
	2022/2023 season									
0.0	0.903	0.933	0.973	0.923	0.953	0.613	0.703	0.743	0.681	0.723
Seaweed	0.973	1.083	1.123	1.053	1.093	0.666	0.750	0.773	0.730	0.753
Moringa	0.953	1.033	1.073	1.023	1.053	0.650	0.733	0.763	0.760	0.743
LSD (0.05)	0.007					0.021				

Table 17: The interaction effect of plant extracts and micro- nutrients on total carotenoids of sweet basil leaves during 2021/2022 and 2022/2023 seasons

Interaction	Total carotenoids (mg/g f.w.)				
Micro- nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts	2021/2022 season				
0.0	0.346	0.380	0.416	0.360	0.393
Seaweed	0.383	0.430	0.480	0.433	0.453
Moringa	0.366	0.420	0.443	0.393	0.423
LSD (0.05)	0.012				
	2022/2023 season				
0.0	0.353	0.383	0.423	0.363	0.403
Seaweed	0.396	0.443	0.490	0.443	0.463
Moringa	0.376	0.430	0.453	0.406	0.433
LSD (0.05)	0.015				

3.2. Photosynthetic pigments

3.2.1. Effect of plant extracts

Data in Tables (9 and 10) revealed that the both of seaweed extract and moringa leaf extract significantly increased the photosynthetic pigments of sweet basil leaves compared to the untreated plants with plant extract. Seaweed extract, being the most effective treatment on chlorophyll a, chlorophyll b and total chlorophyll, as well as carotenoids of leaves. Regarding the important role of seaweed extract on photosynthetic pigments of sweet basil leaves, [29] concluded that seaweed extract significantly increased chlorophyll a and chlorophyll b and carotenoids of basil leaves. They added that these results may be due to the function of the seaweed extracts which contains on bioactive compounds that stimulate the photosynthetic pigments and due to the increasing plant growth parameters (Tables 4-8). Respecting the vital role of moringa extract on photoaynthetic pigments of basil leaves, [30] illustrated that moring leaves have several biological activities and nutritional components like vitamin A, B and C, minerals, which encourage the plant growth (Tables 4-8), and increased the leaves number and leaf area for increasing the chlorophyll content and carotenoids of leaves (Tables 9 and 10). These results are in conforming with the findings of [4,16,20,31] who worked on seaweed extract, and [30,17,9,32,33] who worked on moringa extract.

3.2.2. Effect of micro-nutrient (Fe and Zn)

Data presented in Tables (9 and 10) show that Fe and Zn significantly increased photosynthetic pigments of sweet basil leaves compared to the control treatment. The concentration of highest levels of Fe and Zn (100 ppm) caused a gradually increased in chlorophyll a, chlorophyll b, total chlorophyll (a+b) and carotenoids of sweet basil leaves. These results are followed by the concentrations of Fe and Zn at the level of 50 ppm from every micro-nutrient on photosynthetic pigments. These results are true in both growing seasons. The lowest values of photosynthetic pigments of sweet basil leaves were recorded from the control treatment without any foliar spraying of micro-nutrients. As the important role of Fe on photosynthetic pigments, [34] concluded that Iron (Fe) is a co-factor for approximately 140 enzymes that catalyze unique biochemical reactions. Thus, Iron fills many essential roles in plant growth and development, including chlorophyll synthesis [35]. As well as [23] confirmed that Zinc (Zn) is an essential element for plant that act a metal component of various enzymes or a functional structural or regulatory cofactor and protein synthesis, photosynthesis, and then increased the photosynthetic pigments of leaves. These results are accordance with those recorded by [10,24,25,27] who worked with micro-nutrients on basil plants.

3.2.3. The interaction effect of plant extracts and micro-nutrients

Data in Tables (16 and 17) explain that seaweed extract with highest level of Fe at 100 ppm, gave the highest values of photosynthetic pigments of sweet basil leaves, in both growing seasons.

This result is followed by the interaction between the same plant extract (seaweed) and 100 ppm Zn, moringa leaf extract with 50 ppm Fe and moringo extract with 50ppm Zn, respectively.

4. Conclusions

It can be concluded that plant extracts significantly increased vegetative growth, chlorophyll (a), chlorophyll (b) and carotenoids of sweet basil cv. Genovese, as well as Fe and Zn fertilizer with its highest level.

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