Response of Sweet Basil Chemical Constituents and Essential Oil Percentage to Foliar Application of Some Plant Extracts and Fe and Zn 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 chemical contents and essential oil percentage of sweet basil cv. Genovese.

The experiment was contained three replicates, each replicate contained 20 treatements (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 2 plant extracts of seaweed and moringa, 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 chemical contents and essential oil percentage of sweet basil cv. Genovese, in both growing seasons. Seaweed extract, being the most effective on chemical contents and essential oil percentage of sweet basil in both growing seasons.

This treatment followed by the moringa leaves extract, respectively. The lowest values in chemical contents and essential oil percentage of sweet basil as a result of control treatment without any plant extract.

Conclusively: it could be concluded that seaweed extract, and Fe at the rate of 100 ppm, being the most effective treatments on chemical contents and essential oil percentage of sweet basil .

Key words: Plant extracts – Fe – Zn – chemical contents - essential oil percentage - sweet basil

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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 is 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 (**Koba *et al.*,2009**). 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 (**Zhljazkov *et al.*,2008**).

Sweet basil is a multipurpose plant with great benefits in pharmaceutical, fragrance and food industries, medicinally, this plant and its volatile oil have long been used to treat nausea, mental fatigue colds, dysentery and rhinitis. The main active components of sweet basil have been characterized as terpenoids and phenyl propane derivatives (**Hassan *et al.*,2015**). Plant extracts are known as an environmental friendly for using without pollution to plants, especially for aromatic and medicinal plants like as, seaweed extracts and moringa leaf extracts.

Plant extracts as a biostimulants are emerging as commercial formulation for use as plant growth promoting factors and a method to improve the plants (**Battacharyya *et al.*,2015**). It provides an excellent source of bioactive compounds, such as carotenoids, protein, essential fatty acids, vitamins, amino acids, minerals and growth promoting substances (**El-Gohary *et al.*2023**).

Many investigators concluded that foliar application of seaweed extracts at 100 and 200 ppm significantly increased yield and oil percentage (**Shehata and Nosir ,2019)**. They added that spraying basil plants with seaweed extract at 50,100 and 200 ppm significantly increased chemical content, as well as essential oil percentage in basil leaves. **Mohamed *et al.*(2016)** indicated that foliar application with seaweed extracts at 2ml/L significantly increased yield of basil compared to the control treatment.

Moringa leaf extract is one of such alternatives, being studies to ascertain its influence on yield of several crops, thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (**El-Serafy and El-Sheshtawy,2020**).

It is known as one of the world most useful trees, as almost all parts of the tree has an impressive impact of food ,medicine and industrial process (**Moyo *et al.*,2011**). Moreover, spraying sweet basil plants with moringa oleifera leaf extracts resulted in a significant increase in chemical content compared to the unsprayed ones (**Hassanein *et al.*,2019**).

They added that moringa leaf extracts caused a significant increase of anthocyanin, total carbohydrates and superoxide dismutase in basil leaves compared to the untreated plants.

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 participate 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 (**Khater and Abd-Allah, 2017**).

The purpose of this research was to study the effect of seaweed extract, moring a extract and Zinc and iron micro-element on yield and oil yield of sweet basil(*Ocimum basilicum* L.) plants.

Materials And Methods

The present study was conducted during the two successive seasons of 2021/2022and 2022/2023 at a private farm in Menia El.Qamh-Sharkia Governorate, Egypt to investigate the effect of foliar application with moringa and seaweed extracts and Fe and Zn as chelated on yield and volatile oil content of sweet basil. 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 earthenware 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 40 cm 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 **Jackson (2007)** 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 (**Foidle *et al.*,2001**). 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 hormons, it was added at 3ml/l.

Foliar application treatments with 250 ppm iron and 250ppm zinc (Fe 8.5% and Zn 16%) as foliar spray of the chelated Fe- EDTA and Zn- EDTA too.

The treatments of seaweed and moringa extracts were applied as foliar spray on plant leaves 4times , first one was added after 45 days from transplant . The second time was after 15 days from the first , while the third was applied after 15 days from the second 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 and seaweed extracts, intervals.

The experimental treatments consisted of 15 treatments, which represented all combination between plant extracts (control, seaweed and moringa 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 15 treatements (3 levels of both extracts and control X 5 levels of micro-nutrients), five plants were used as a plot for each treatments.

Data were statistically analyzed using split plot design in both growing seasons. The main plot represented the both extracts of seaweed and moring and control treatment, while the control, Fe and Zn, were occupied in sub. Plots. Irrigation and agricultural practices were done whenever plants needed.

Data recorded:

Chemical constituent determination:

Chemical constituent determination were carried out at 100 days from transplanting, before flowering in both growing seasons. The following data were recorded, i.e.

1-N,P,K,Fe and Zn, according to the method described by **A.O.A.C.(1998).**

2-Victamin c (Ascorbic acid): It determined as described by the method of **Singh *et al.*(2002).**

3-Total carbohydrates : it determined according to the method described by **Dubois *et al.*(1956).**The essential oil percentage (%):

It was carried out at 100 days from transplanting , before flowering .

The essential oil percentage (%) : It was determined in the air dried herb using a modified Clevenger apparatus according to **Barton *et al.* (1989).**

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 **Snedecor and Cochran(1989), and SAS(2004).**

Table (2): The chemical analysis of Moringa extracts

The chemical analysis of seaweed extracts	Percentage%
Moisture	7.94%
Dry matler	92.06%
Organic matler	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

Results And Dicussion

Chemical constituents:

Effect of plant extracts:

Data of chemical constituents of sweet basil, i.e. N, P, K, Fe and Zn as affected by plant extracts are given in Tables (4, 5 and 6).

Results in these Tables clearly showed that seaweed extract, being the most effective treatment on chemical contents of sweet basil compared to the moringa leaf extract and control treatment .These results are true in both growing seasons.

The increase of the nutrients , i.e. N, P, K, Fe and Zn was (64.72, 57.61), (30.37, 22.59), (6.29, 3.47), (17.01, 13.36) and (10.08, 6.30) for seaweed and moringa extracts compared to the control treatment in the first season, and (63.87, 57.13), (25.92, 18.51) ,(6.30, 3.43) , (17.00, 13.35) and (9.56, 6.01) in the second season.

According to the important role of seaweed extract, **Salama and Yousef (2015)** concluded that seaweed as foliar spray contains a many compounds and elements,i.e.N, K, Ca, Mg, Fe, S, Zn, Boron, alganic acids and plant hormones, that stimulate the bioprocesses and increased the determined mineral of this study.

Moreover, regarding the vital role of moringa leaf extract, **Mohamed *et al.* (2022)** indicated that moringa leaf extract plays an important role as biostimulants substance due to is rich in phytohormones namely , Zeatin, GA and IAA, it contains macro and micro-nutrients, vitamins, amino acid, plant growth regulators , allele chemical and antioxidant.

They added that moringa leaf extract acts as one of the valuable plant biostimulant because it contains phenol, phytohormones , antioxidants, essential nutrients and ascorbates, these active compounds promote the plant for increasing its chemical contents and bioassay; **Mousa *et al* (2020) ,and Said Al- Ahl *et al.* (2017) , Mohamed *et al.*(2022)** who worked with seaweed extract and moringa leaf extract as foliar spray, respectively.

These results are in close agreement with those reported by **Mohamed *et al.* (2015) , and Shehata and Nosir (2019) , Mousa *et al.* (2020), and Mohamed *et al.* (2022)** who worked with seaweed extract and moringa leaf extract as foliar spray, respectively.

Effect of micro-nutrients:

The presented results in Tables (4 , 5 and 6) postulated that macro-nutrients (N, P and K) and micro-nutrients (Fe and Zn) were significantly augment due to foliar application the plants with micro-nutrients of Fe and Zn at the level of 100 and50 ppm. The results indicated that Fe at the level of 100 ppm , being the most effective in chemical composition of sweet basil (N, P, K, Fe and Zn) , followed by the treatments of Zn at the level of 100 ppm, Fe at 50 ppm and Zn at 50 ppm, respectively, compared to the control treatment.

The increase in N content of sweet basil was 70.66, 62.91, 55.47 and 55.47% by foliar spray with 100 ppm Fe, 100 ppm Zn compared to the control treatment, respectively in the first season. As well as, the increases in the second season were ; 68.89 ,60,93 ,53 ,34 and 52.97 % compared to the control treatment , respectively. In addition, the increase in P content of sweet basil 25.62, 19.92, 12.81 and 6.76 % , in the first season compared with control treatment, while, in the second season was 24.58 ,21.59 , 14.28 and 5.64 , respectively.

Regarding the increase in content of sweet basil by foliar spray with the level of Fe and Zn , were 11.55, 7.92, 4.55 and 2.02% in the first season , and were 11.20, 7.38 , 4.54 and 1.86% in the second season , compared to the control treatment , respectively.

Moreover, the increases in Fe content of sweet basil were 18.60, 12.64, 8.64 and 6.79% in the first season, and were 18.59, 12.65, 8.63 and 6.80%, respectively compared to the control treatment.

As well as, the increases in Zn content of sweet basil were 17.32, 12.41, 7.86 and 3.26%, respectively, in the first season, and 16.47, 11.40, 7.09 and 3.04%, respectively in the second season compared to the control treatment.

Regarding the important role of Fe and Zn in increasing the contents of macro and micro-nutrients in plants, **Marschner (1995)** illustrated that iron has important function in plant metabolism and the activities of same enzymes for gross changes in metabolic processes and then increased the macro and micro-nutrients in plant tissues. Moreover, He added that Zinc is an essential micro-nutrient that acts either as a metal component of various enzymes or as a functional , structural, or regulatory cofactor associated with saccharide metabolism, photosynthesis and protein synthesis and then increased the chemical contents of macro and micro –nutrients in tissue parts of plants.

In agreement with these results regarding the Fe and Zn are important in increasing the chemical content of sweet basil were those of **Said Al.Ahl and Mahmoud (2010), Kanwal *et al.*(2016) and Danaee and Abdossi (2021).**

The interaction effect of plant extracts and micro-nutrients:

It is realized from Tables (7 , 8 and 9) that the interaction between seaweed extract and 100 ppm Fe, caused an increases in chemical content of N, K, K ,Fe and Zn in both growing seasons.

This treatment followed by the interactions between seaweed extract + 100 ppm Zn, moringa leaf extract +50 ppm Fe, and moringa leaf extract + 50 ppm Zn, respectively.

It could be concluded that the treatment of interaction between seaweed extract and 100 ppm, being the most effective in chemical composition of sweet basil.

Ascorbic acid total carbohydrates contents:

Effect of plant extracts:

Results in Table (10) clearly demonstrated that plant extracts significantly increased the contents of ascorbic acid (vitamin c) and total carbohydrates of sweet basil.

The best result in this respect was obtained from seaweed extract in both growing seasons on the contents of Vit. C , and carbohydrates of sweet basil. The lower value was obtained as a result of the control treatment .

The increases in vitamin c from foliar spray with seaweed and moringa leaf extracts were , 8.43, 6.84, and 8.38, 7.02 % in the first and second seasons of this study compared to the control treatment. Moreover, the increases in total carbohydrates were 19.50, 11.01 and 19.38 , 10.31 % in the first and second seasons compared to the control treatment.

Regarding the role of seaweed and moringa leaf extract, **Ordog *et al.*(2004)** stated that seaweed extract enhanced the accumulate of active compounds that stimulate by the structure of seaweed compounds such as macro and micro-elements, amino acids, vitamin, cutokinins, auxins and abssisic acid which affect cellular metabolism in treated plants leading to enhanced translocation the active compounds in different parts of plants like carbohydrates and vitamin c and others.

Respecting the important role of moringa leaf extract, **Hassanein *et al.*(2019)** indicated that moringa leaf extract have several biological activities and nutritional components like vitamin A, B and C, minerals, calcium, protein and carbohydrates , which all considered are promote the translocation of active compounds in different parts of plants such as carbohydrates and vitamin c and many other compounds.

These results supported by those recorded **by Esmaielpour, and Fatemi. (2020)**, **El-Boukhari *et al.*(2020) and Godlewska *et al.*(2021)** who worked with seaweed extract and moringa leaf extract, respectively.

Effect of micro-nutrients and their concentration :

The illustrated data in Table (10) clearly that Fe and Zn at the both concentration (100 and 50 ppm) significantly increases the active compounds of sweet basil ,i.e. vitamin c total carbohydrates. At the highest concentration of Fe, followed by Zn, considered the best treatments in this concern. The same trend with the lowest concentration of Fe and Zn, respectively. These results are true in both growing seasons.

The increases in vitamin c and carbohydrates in sweet basil were (26.92 ,20.52, 13.14, 5.63) and (23.21, 16.39, 10.95, 2.60) gradually decreased with 100 ppm fe, 100 ppm Zn, 50 ppm Fe and 50 ppm Zn, respectively, in the first season of this study . The same trend was recorded in the second season of this study , the increases in vitamin c and total carbohydrates were; (26.67, 19.96, 14.03, 5.44) and (22.69, 16.30, 10.65, 2.21) with gradually decreased from 100 ppm Fe, 100 ppm Zn, 50 ppm Fe and 50 ppm Zn, respectively.

As for the important role of Fe and Zn micro-nutrients, in increasing the active compounds of bail plants, in line with the foregoing , micro-nutrients affect active compounds in different parts of plant, **Marschner (1995**) pointed out that iron has important functions in plant metabolism, such as activating catalase enzyme associated with superoxide dismutase, as well as in photorespiration and the glycolate pathway and then activated the metabolic processes for formation and building the active compounds in plant parts.

Moreover, with the same author, he indicated that zinc is an essential micro-nutrient that acts either as a metal component of various enzymes or as a function structural , or regulatory cofactor associated with saccharide metabolism, photosynthesis, and protein synthesis and then active compounds synthesis.

Obtain results are in harmony with those recorded by **Said Al-Ahl and Mahmoud (2010)** with zinc and iron foliar application on sweet basil, **Kanwal *et al.* (2016)** with many micro-nutrients on basil, and **Danaee and Abdossi (2021)** who worked with Fe and Zn as foliar application on basil.

As well as, the same trend with **AwadAllah *et al.(*2022).**

The interaction effect between plant extracts and micro-nutrient :

According to data in Table (11), it could be concluded that the interaction between plant extracts (seaweed and moringa leaf extraxcts) and micro-nutrients (Fe and Zn) significantly increased vitamin c, and total carbohydrates of sweet basil. In this concern, the highest values of the active compounds of vitamin c, and total carbohydrates were recorded as a result of the treatment of seaweed extract with 100 ppm Fe , followed by Zn, respectively, but with lower valued than seaweed extract.

Essential oil (%)

Effect of plant extracts:

Data of essential oil percentage as affected by plant extracts, i.e. seaweed and moringa leaf extracts are given in Table (12). Results indicated that seaweed extract, being the most effective treatment in increasing the essential oil percentage of sweet basil, compared to the moringa leaf extract and control treatment without any plant extract(tap water only) .These results are true in both growing seasons.

The increase in essential oil percentage of sweet basil from foliar spray with seaweed and moringa leaf extracts was 52.36 and 43.94 % in the first season of this study, and was 50.75 and 42.92 % in the second season, respectively compared to the untreated with any plant extract (control treatment).

Regarding the vital role of seaweed and moringa leaf extracts, on the percentage of essential of sweet basil **Ordog *et al.*(2004)** illustrated that essential oil percentage of sweet basil was significantly increased as a result of seaweed extract, that may be due to its compounds such as macro and micro-nutrients amino acids, vitamins, cytokinins, auxins which affect on cellular metabolism and then enhanced crop yield and its essentials oil. Moreover **Salama and Yousef (2015)** demonstrated that cytokinins which in the seaweed extract cause enhancement of cell size and cell division and were effective in increasing the essential oil of sweet basil and its crop yield.

Respecting the important role of moringa leaf extract, **Alkuwayti *et al.*(2020)** stated that moringa leaf extract have a mixture of various categories of active compounds that passes biostimulanting properties such as, carbohydrates, nitrogenous compound, hormones and polyphenols as well as, these compound increase the essential oil of sweet basil.

Similar findings were obtained by **Mohamed *et al.* (2016) and Shehata and Nosir (2019), Hassanein *et al.*(2019) and Mousa *et al.*(2020),** on seaweed extracts and moringa leaf extract, respectively.

Effect of micro-nutrient :

Results in Table (12) clearly indicated that Fe and Zn in both concentrations (100 and 50 ppm) significantly increased the essential oil of sweet basil. The highest value Fe at the concentration of 100 ppm, caused an increases in essential oil (%), followed by the treatments of 100 ppm Zn, 50 ppm Fe and 50 ppm Zn, respectively.

In this concern, the increases in essential oil percentage of sweet basil were 66.38, 50.62, 44.49 and 38.63% with 100 ppm Fe, 100 ppm Zn, 50 ppm Fe and 50 ppm Zn, in the first season, respectively.

Moreover, the increases in the second season were 63.47, 48.07, 42.09 and 36.78, respectively. As for the important role of Fe and Zn on the essential oil percentage of sweet basil, **Kanwal *et al.*(2016) and Kumar *et al.* (2022)** concluded that Iron is required at several steps in the biosynthetic pathways, such as biochemical reactions which increase the translocation of essential oil of sweet basil.

Moreover, **Hanif *et al.*(2016 and 2017) and Tolay (2021)** illustrated that Zinc (Zn) is an essential element for plant that act as a metal component of various enzymes or a functional structural or regulatory co-factor and for protein synthesis, photosynthesis, the synthesis of auxin, cell division, the maintance of membrane structure and function, and then enhanced the yield and essential oil formation in the plant parts.

These results are confirmed with those obtained by **Abbasifar *et al.(*2020) , Danaee and Abdossi (2021) and Awadallah *et al.* (2022),** who showed that micro-nutrients like Fe and Zn, significantly increased the yield and and essential oil of basil.

The interaction effect of plant extracts and micro-nutrients:

The presented results in Table (13) postulated that the interaction between plant extracts and micro-nutrients concentration, significantly increased the essential oil percentage of sweet basil. Results indicated that seaweed extract with Fe- fertilizer as foliar spray at the concentration of the highest concentration, i.e. 100 ppm , caused an increases in the percentage of essential oil of sweet basil. This treatment followed by the seaweed extract with the highest value of Zn, i.e. 100 ppm, Fe, moringa leaf extract with 50 ppm Fe and moringa leaf extract at 50 ppm Zn, respectively.

These results are true in both growing seasons. These results for the seaweed extract with the highest concentrations of Fe and Ze (100 ppm) may be due to its bioactive compounds in increasing essential percentage in sweet basil with highest concentration of Fe or Zn, that stimulate the active processes in stimulate the enzymes for increasing the essential oil in plant (**El- Naggar *et al.* (2020).**

Conclusively: it could be concluded that seaweed extract, and Fe at the rate of 100 ppm, being the most effective treatments on chemical contents and essential oil percentage of sweet basil .

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Table (4): Effect of plant extracts and micro- nutrients on N and P (%) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	N (%)		P (%)	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	**1.392**	**1.409**	**0.270**	**0.297**
Seaweed	**2.293**	**2.309**	**0.352**	**0.374**
Moringa	**2.194**	**2.214**	**0.331**	**0.352**
LSD(0.05)	**0.007**	**0.005**	**0.003**	**0.007**
Micro-nutrients				
0.0	**1.316**	**1.344**	**0.281**	**0.301**
50 ppm Fe	**2.046**	**2.0611**	**0.317**	**0.344**
100 ppm Fe	**2.246**	**2.263**	**0.353**	**0.375**

50 ppm Zn	2.046	2.056	0.300	0.318
100 ppm Zn	2.144	2.162	0.337	0.366
LSD (0.05)	0.010	0.007	0.004	0.009
Interaction (AxB):				
LSD (0.05)	0.017	0.120	0.007	0.016

Table (5):Effect of plant extracts and micro- nutrients on K (%) and Fe (mg /kg D.W.) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	K (%)		Fe (mg/ kg D. W.)	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	1.208	1.253	157.179	157.232
Seaweed	1.284	1.332	183.917	183.969
Moringa	1.250	1.296	178.180	178.230
LSD(0.05)	0.003	0.002	0.004	0.002
Micro-nutrients				
0.0	1.186	1.232	158.306	158.360
50 ppm Fe	1.240	1.288	171.991	172.040
100 ppm Fe	1.323	1.370	187.756	187.810
50 ppm Zn	1.210	1.255	169.070	169.123
100 ppm Zn	1.280	1.323	178.330	178.387
LSD (0.05)	0.004	0.003	0.002	0.002
Interaction (AxB):				
LSD (0.05)	0.007	0.005	0.005	0.005

Table (6): Effect of plant extracts and micro- nutrients on Zn (mg /kg D.W.) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Zn (mg/ kg D. W.)	
	2021/2022	2022/2023
Plant extracts		
0.0	45.011	45.261
Seaweed	49.552	49.589
Moringa	47.851	47.981
LSD(0.05)	0.0112	0.125
Micro-nutrients		
0.0	43.885	44.246
50 ppm Fe	47.336	47.386
100 ppm Fe	51.486	51.536
50 ppm Zn	45.320	45.592
100 ppm Zn	49.330	49.291
LSD (0.05)	0.0145	0.161
Interaction (AxB):		
LSD (0.05)	0.025	0.279

Table (7) : The interaction effect of plant extracts and micro- nutrients on N and P (%) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	N (%)					P (%)				
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	1.266	1.326	1.586	1.316	1.466	0.240	0.276	0.293	0.253	0.286

Seaweed	1.366	2.450	2.666	2.426	2.556	0.310	0.353	0.393	0.333	0.373
Moringa	1.316	2.363	2.486	2.396	2.410	0.293	0.323	0.373	0.313	0.353
LSD (0.05)	0.017					0.007				
	2022/2023 season									
0.0	1.283	1.343	1.603	1.333	1.483	0.266	0.303	0.320	0.270	0.326
Seaweed	1.403	2.453	2.683	2.433	2.573	0.323	0.386	0.413	0.353	0.393
Moringa	1.346	2.386	2.503	2.403	2.430	0.313	0.343	0.393	0.333	0.380
LSD (0.05)	0.120					0.016				

Table (8) : The interaction effect of plant extracts and micro- nutrients on K (%) and Fe (mg /kg D.W.) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	K (%)					Fe (mg/ kg D. 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	1.126	1.216	1.286	1.166	1.246	141.163	152.213	179.103	150.283	163.133
Seaweed	1.186	1.286	1.356	1.266	1.326	170.323	183.163	196.543	181.143	188.413
Moringa	1.246	1.216	1.326	1.196	1.266	163.433	180.596	187.623	175.783	183.463
LSD (0.05)	0.007					0.010				
	2022/2023 season									
0.0	1.17	1.26	1.33	1.21	1.28	141.21	152.26	179.15	150.33	163.18

	3	3	3	3	3	6	6	6	6	6
Seaweed	1.233	1.340	1.403	1.310	1.373	170.376	183.216	196.596	181.196	188.460
Moringa	1.290	1.263	1.373	1.243	1.313	163.486	180.636	187.676	175.836	183.516
LSD (0.05)	0.005					0.005				

Table (9) : The interaction effect of plant extracts and micro- nutrients on on Zn (mg /kg D.W.) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Zn (mg/ kg D. W.)				
Micro-nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts					
0.0	41.563	44.683	49.433	43.213	46.163
Seaweed	45.930	49.803	53.163	47.323	51.543
Moringa	44.163	47.523	51.863	45.423	50.283
LSD (0.05)	0.025				
0.0	42.913	44.733	49.483	43.263	46.213
Seaweed	45.913	49.853	53.213	47.373	51.593
Moringa	44.213	47.573	51.913	46.140	50.066
LSD (0.05)	0.279				

Table (10): Effect of plant extracts and micro- nutrients on vitamin C (mg /100 g F.W.) and total carbohydrates (%) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Vitamin C (Ascorbic acid) (mg/100 g F. W.)		Total carbohydrates (%)	
	2021/2022	2022/2023	2021/2022	2022/2023
Plant extracts				
0.0	29.264	29.328	11.506	11.573
Seaweed	31.733	31.788	13.750	13.817
Moringa	31.268	31.388	12.773	12.766
LSD(0.05)	0.115	0.220	0.018	0.042
Micro-nutrients				
0.0	27.104	27.233	11.458	11.523
50 ppm Fe	30.668	31.055	12.713	12.751
100 ppm Fe	34.401	34.497	14.118	14.138
50 ppm Zn	28.632	28.717	11.756	11.778
100 ppm Zn	32.668	32.670	13.336	13.402
LSD (0.05)	0.020	0.285	0.010	0.054
Interaction (AxB):				
LSD (0.05)	0.035	0.128	0.017	0.093

Table (11) : The interaction effect of plant extracts and micro- nutrients on vitamin C (mg /100 g F.W.) and total carbohydrates (%) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Vitamin C (Ascorbic acid) (mg/100 g f. w.)					Total carbohydrates (%)				
Micro-nutrients	0.0	50 ppm	100 ppm	50 ppm	100 ppm	0.0	50 ppm	100 ppm	50 ppm	100 ppm

		Fe	Fe	Zn	Zn		Fe	Fe	Zn	Zn
Plant extracts	2021/2022 season									
0.0	25.190	29.370	33.353	27.136	31.270	9.956	11.326	12.886	10.706	12.656
Seaweed	28.240	32.190	35.420	29.590	33.226	12.623	13.870	15.246	12.846	14.166
Moringa	27.883	31.350	34.430	29.170	33.510	11.796	12.943	14.223	11.716	13.186
LSD (0.05)	0.035					0.073				
	2022/2023 season									
0.0	25.240	29.360	33.666	27.133	31.233	10.023	11.393	12.953	10.773	12.723
Seaweed	28.536	32.153	35.433	29.553	33.263	12.693	13.933	15.313	12.913	14.233
Moringa	27.923	31.646	34.393	29.466	33.513	11.853	12.926	14.150	11.650	13.250
LSD (0.05)	0.128					0.093				

Table (12):Effect of plant extracts and micro- nutrients on essential oil (%) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Treatments	Essential oil (%)	
	2021/2022	2022/2023
Plant extracts		
0.0	0.760	0.792
Seaweed	1.158	1.194
Moringa	1.094	1.132

LSD(0.05)	0.006	0.004
Micro-nutrients		
0.0	0.717	0.753
50 ppm Fe	1.036	1.070
100 ppm Fe	1.193	1.231
50 ppm Zn	0.994	1.030
100 ppm Zn	1.080	1.115
LSD (0.05)	0.008	0.006
Interaction (AxB):		
LSD (0.05)	0.015	0.0107

Table (13): The interaction effect of plant extracts and micro- nutrients on essential oil (%) of sweet basil plant during 2021/2022 and 2022/2023 seasons

Interaction	Essential oil (%)				
Micro- nutrients	0.0	50 ppm Fe	100 ppm Fe	50 ppm Zn	100 ppm Zn
Plant extracts					
0.0	0.700	0.740	0.900	0.706	0.753
Seaweed	0.740	1.230	1.390	1.160	1.273
Moringa	0.713	1.140	1.290	1.116	1.213
LSD (0.05)	0.015				
0.0	0.730	0.770	0.933	0.740	0.790
Seaweed	0.780	1.260	1.430	1.193	1.310
Moringa	0.750	0.180	1.330	1.156	1.246
LSD (0.05)	0.0107				