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Effect of Soil Addition and Spray with Safety Compounds on Growth and Productivity of Tomato

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Abstract

The present study was carried out at a private farm in Abou-Homos distract, El-Behiera Governorate during 2019 and 2020 seasons to examined the role of the three soil application treatments seaweed, yeast and garlic extracts as well as the control (zero addition) and the three foliar spraying treatments Lithovit, potassium citrate and mono ammonium phosphate in addition to control (Tab water) on growth, fruit yield and quality of tomato hybrid "Soltana". The obtained results showed that all tomato growth traits, total chlorophyll, chemical constituents of plant foliage and fruit yield and its components significantly affected by soil application and foliar spraying treatments as well as their interactions in both seasons. In this respect, Tomato plants that treated with treated with seaweed extract as soil application and mono ammonium phosphate as foliar spraying had the highest; plant height, number of branches/plant, leaves number/plant, plant fresh weight, plant dry weight and leaves content of total chlorophyll, P, K and total carbohydrates content as well as the highest fruit yield per plant and per feddan in both seasons.

Key words: Tomato, soil addition, growth stimulants, fruit yield

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular and consumed vegetable in the world. Tomato fruits are rich sources of vitamins (vitamin C, A, B and K), minerals (potassium, calcium, sodium, magnesium, phosphorus, boron, manganese, zinc, copper and iron), and organic acids (citric, malic and acetic acids) which are known as health acids **(Meena *et al.*, 2014)**. The fruits of tomatoes are a source of lycopene (antioxidant) that have an active role in reducing cancer and heart disease **(Barber and Barber 2002)**. Egypt ranks fifth place in tomato production among the top 10 country in the world, where the cultivated area in Egypt was about 170862 Hectare produced total fruits reached 6.73 million tons **(FAO STAT 2020)**.

Tomato plants are characterized by high response to fertilization as yield and quality of fruits increases with the increase of fertilization rate. Tomato cultivators in Egypt usually use traditional mineral fertilizers as soil application or foliar spraying with great extravagance to increase yield. This extravagance in the use of mineral fertilizers represents a major danger Egyptian human health that consuming a large part of tomato fruit in fresh shapes also, the waste in mineral fertilization to large damage to environmental caused air, water and soil pollution.

Great efforts were made in the last two decided to find safe alternatives to mineral fertilizers. Organic fertilizers consider Eco-friendly materials that use successfully as safe alternatives to chemical fertilizers. Use of organic fertilizers can improve soil health, increase sustainable and economical production and provide sufficient quantities of safe and nutritious food **(Al-Taey *et al.*, 2018)**. Therefore, it is very usefull to partial substitution organic matter to mineral fertilizers. Organic fertilizers also, enhance soil physical and chemical properties and, reduce the requirements for chemical fertilizers **(Al-Taey *et al.*, 2018)**. There are many natural extracts that successfully used as safe nutrients to improve plants growth and yield such as seaweed, yeast and garlic extracts.

Seaweed extract is an organic fertilizer with highly nutritious values that encourage faster germination of seeds and enhance yield and resistant ability of several crops **(Dhargalkar and Pereria, 2005)**. It is a rich source for macro and micro nutrients which improve plant growth and yield. Seaweed extract contains many growth promoting substances such as cytokinins, auxin, gibberellins, abscisic acid, ethylene, polyamines and betaines **(Prasad *et al* ., 2010)**. Also, seaweed is an important source of organic matter and fertilizer nutrients. Applied seaweed extracts as soil application or foliar spraying resulted in great enhance to plant growth, improving yield and productivity of several crops **(Chiaiese *et al.* 2018)**.

Yeast extract is a rich source of nutrients for plants where contains amino acids, plant hormones, sugars, carbon, nitrogen, phosphorus, potassium, calcium, magnesium and several micronutrient **(Eata *et al.*, 2001)**. Using yeast extract as a fertilizer singnificantly improved vegetative growth and yield of many vegitable crops **(Khalil, 2015)**. Also, yeast extract contain sugars, proteins, amino acids, and organic humic and non-humic acids which contribute in large increase plant growth and yield production **(Patil *et al.*, 2016)**.

Garlic extract in an organic substance extracted from garlic bulb. it contains major components such as hydrodistillation were diallyl

trisulfide (33.6%), diallyl disulfide (28.1%), and allyl methyl trisulfide (17.8%) **(Kocic *et al.*, 2012)**. Garlic extract can modulate the antioxidant enzymes, chlorophyll content and soluble sugar content of the treated tomato plants. garlic extract foliar and root application increased tomato plant growth such as plant height, shoot fresh weight, root length, fruit size and weight. Similarly, differences were found in the antioxidative response of the treated plants; nonetheless, these treatments affected the abundance of chlorophyll, carotenoid, and the total soluble sugar contents in the plants **(Ahmad *et al.*, 2014)**. It was found that foliar application of lithovit significantly increased potato growth parameters (i.e. Plant height, branch number per plant, shoot fresh and dry weights, and leaf area per plant), as well as fruit number and total tuber yield per plant. Yield quality also significantly increased with lithovit application. **(Farouk, 2015)**.

Although tomato farmers use large quantities of ground fertilizers, but they are in most cases support their crop with some macro and micro nutrients or organic and amino acids as foliar spraying. These materials are mostly used to improve vegetable and fruit growth or rapid fruit maturity.

Mono ammonium phosphate is one of the most common components that used as a foliar spraying to improve growth and yield many crops. In this respect **Soumya *et al.*, (2009)** found significantly higher number of leaves plant-1 and marketable fruit yield with the application of Mono Ammonium Phosphate (MAP). Also, **Hegazi *et al.*, (2017**) showed that MAP gave remarkable improvement of pepper plant growth and fruits characters as compared to control (adding SP).

Potassium citrate is potassium salt of citric acid which considered one of the most important organic acids in the respiratory pathways into plant cell. The mitochondrial citric acid cycle provides the energy for ATP synthesis which is essential for different biochemical and physiological processes **(Taiz, and Zeiger 2002)**. It was found a significant increased leaf and branch number, total leaf area/plant, dry weight/plant total chlorophyll (SPDS), yield and yield components with the foliar spraying of KC **(Ahmed et al., 2014)**. Also, found that potassium citrate (KC) increase leaf area, improves leaf mineral content, enhancing yield and improved fruit quality as well as physical and chemical properties of mango trees. While, **Huang *et al.*, (2016)** showed that, appearance and nutritional quality of strawberry (soluble solid, titratable acid and vitamin C and maintained high SOD activity) were higher under potassium citrate than those of control.

Lithovit compound particles contain calcium carbonate (80%), magnesium carbonate (4.6%) and Fe (0.75%). The beneficial effect of this compound is being contains calcium carbonate (CaCO3) decomposes to calcium oxide (CaO) and carbon dioxide (CO2) in leaves stomata, and this CO2 increases photosynthesis process leading to increases in carbon uptake and assimilation, thereby increasing plant growth **(Carmen *et al.*, 2014)**. According to the previous review of some safe alternatives for mineral fertilizers, the present study objectives will be as follows:

- Evaluation of the impact of soil application with some organic extracts (seaweed, yeast and garlic extracts) on tomato growth, fruit yield and fruit quality under of El-Beheira Governorate conditions.
- Evaluation of the impact of the foliar spraying with some safe compounds (mono-ammonium phosphate, potassium citrate and Lithovit) on tomato growth, fruit yield and fruit quality under of El-Beheira Governorate conditions.

Materials and Method

Two field experiment were conducted at a private farm in Abou-Homos distract, El-Behiera Governorate during 2019 and 2020 to examined the role of the three soil application treatments seaweed, yeast and garlic extracts as well as the control (zero addition) and the three foliar spraying treatments Lithovit, potassium citrate and mono ammonium phosphate in addition to control (Tab water) on growth, fruit yield and quality of tomato hybrid "Soltana". The experimental soil physical and chemical properties are presented in Table 1.

Table 1: Soil physical and chemical properties of the experimental site

Parameters	Amount	
	2019	2020
Physical properties		
Clay%	66.23	66.56
Silt%	29.91	29.55
Sand%	3.86	3.89
Soil texture	Clay	
Chemical properties		

PH	7.31	7.46
EC(dsm^{-1})	0.87	0.90
Caco$_3$	-	
Organic matter %	0.66	0.64
Soluble cations meq100-1 g soil		
Ca++	3.45	3.49
Mg++	2.41	2.36
Na++	3.17	3.07
K+	0.15	0.15
Soluble anions meq100-1 g soil		
HCO3	2.13	2.24
Cl-	2.97	2.89
SO4	4.54	4.68

In the two seasons of 2019 and 2020 tomato hybrid "Soltana" was planted in the 15th March in field experiment designed in split plot with three replicates, where the three soil application treatments were allocated in the main plots and the three foliar spraying treatments as well as the control were randomly distributed in the sub-plots. The plot size was four ridges. Each ridge was four meters long and 1.7 m apart. Tomato seedlings were planted on one side of the ridge at 30 cm hill spacing with one plant per hill. All cultural practices (recommended irrigation and mineral fertilization, weed control and hand honing) were followed as recommended.

3.1.1. Treatments

The three soil application treatments seaweed, yeast and garlic extracts were added individually at the rate of 200 cm^3/plant through irrigation three times during tomato growth started after 2 weeks of planting with 2 weeks intervals between each application while, foliar spraying treatments with potassium citrate, Lithovit and mono ammonium phosphate were sprayed three times during tomato growth at the rate of 2g/L water started after 3 weeks with three week intervals between each spraying.

3.2. Data Recorded.

Ten guarded plants randomly taken from each sub-pot were used at the beginning of harvest in the two growing seasons to determine the following vegetative growth traits:

1. Vegetative growth traits:

1.1. Main stem length (cm).
1.2. Number of branches/plant.
1.3. Number of leaves/plant.
1.4. Plant fresh weight (g).
1.5. Plant dry weight (g).

2. Leaf chemical properties:

2.1. Leaves content of total chlorophyll (m/100g fw)**.**
2.2. Leaf content of nitrogen (g/100g FW).
2.3. Leaf content of phosphor (g/100g FW).
2.4. Leaf content of potassium (g/100g FW).

3. Fruit yield and yield components traits:

At harvest ten guarded plants randomly taken from each sub-pot were used to determine:

3.1. Average fruit weight (g).
3.2. Fruit yield/plant (kg)
3.3. Fruit yield/faddan (ton)

Note, seed yield/ faddan were estimates by convert seed yield/plot to faddan.

Statistical Analysis: Results were expressed as mean. The data were analyzed by using **Two-way** ANOVA followed by LSD test through SPSS 16 (version 4). The treatments means were compared using least significant difference (LSD) tested at significant levels of 5% and 1% respectively as described by **Gomez and Gomez (1984)**.

Results and Discussions

1- Effect of some soil applications and foliar spraying treatments as well as their interactions on tomato growth during 2019 and 2020 seasons.

The presented results in Table 2 indicated that all tomato growth traits i.e. plant height, branches number/plant, number of leaves/plant, plant fresh and weight significantly affected by soil application and foliar spraying treatments as well as their interactions in both seasons. The significant differences in all tomato growth traits under the different used soil application and foliar spraying treatments due to these treatments differ in their mode of action where these treatments differ in their chemical compositions.

1.1. Effect of soil application treatments:

Results in Table 2 showed that all tomato growth traits significantly differ under all soil application treatments. Tomato plants under all used treatments significantly exceeded in their growth measurements these plants in control. Tomato plants that treated

with seaweed extract as soil application had the highest; plant height (117.90 and 126.25 cm), number of branches/plant (9.30 and 10.63), leaves number/plant (67.05 and 72.50), plant fresh weight (1403.70 and 1455.83 g) and plant dry weight (235.43 and 243.88 g) in both seasons, respectively. In all growth traits the superiority of seaweed extract was followed by yeast extract then garlic extract. In the contrast of this, tomato plants under the control treatment showed the lowest, plant height (104.20 and 111.00 cm), number of branches/plant (6.98 and 7.73), leaves number/plant (58.83 and 62.01), plant fresh weight (1192.85 and 1244.28 g) and plant dry weight (201.25 and 209.45 g) in both seasons, respectively.

All soil application treatments i.e, seaweed, yeast and garlic extracts resulted in significant improve of all tomato growth compared to control. In the previous studies also these treatments led to significantly increased of some horticulture crops growth. As for seaweed extract; **Sutharsan *et al.*, (2014)** indicated that added seaweed extract with 20% of foliar application increased shoot dry weight and root dry weight of tomato plants. **Araghian *et al.*, (2015)** showed that used algae extract fertilizers resulted in improved tomato growth factors include the number of leaves and plant height, stem diameter, wet and dry weight of stem. Also, **Ozenc, and Sen (2017)** confirmed that applications liquid seaweed fertilizer in different tomato growth stages significantly increased in terms of plant growth when compared with control. **Souza *et al.*, (2017)** found that the highest leaf number, seedling height, root length, stem diameter and total dry matter obtained when tomato plants treated with 0.9 mL L^{-1} of seaweed extract every 7 days. In the same line, **Murtic *et al.*, (2018)** found positive effects of seaweed extract on growth and quality of cherry tomato are result of its specific composition, as well as ability of cherry tomato plants to utilize bioactive substances in seaweed extracts for its growth and development. **Mutale-Joan *et al.*, (2020)** found that significant root and shoot length improvement (112.65%, 53.70%); was recorded at treatment with Aphanothece sp and C. ellipsoidea CBEs respectively.

1.2. Effect of foliar spraying treatments:

Data showed in Table 2 cleared that all tomato growth traits significantly affected by foliar spraying treatments. All foliar spraying treatments resulted in significant improve in tomato growth compared to control. tomato plants that sprayed mono ammonium phosphate showed the highest; plant height (117.45 and 123.58 cm), number of branches/plant (9.10 and 10.45), leaves number/plant (67.30 and 71.36), plant fresh weight (1382.03 and 1445.65 g) and plant dry weight (230.93 and 239.18 g) in both seasons, respectively followed by potassium citrate then lithovit in all growth traits. On the other hand, tomato plants under the control treatment had the lowest; plant height (105.23 and 113.88 cm), number of branches/plant (6.98 and 8.20), leaves number/plant (58.98 and 63.40), plant fresh weight (1238.80 and 1270.45 g) and plant dry weight (203.43 and 212.25 g) in both seasons, respectively.

Foliar spraying of any of mono ammonium phosphate, potassium citrate and lithovit exceeded the control treatment in increase tomato growth in both seasons. The roles of these materials in enhance vegetables and other crops were observed by many researchers before. Respect to the effect of mono ammonium phosphate, **Soumya *et al.*, (2009)** found significantly higher number of tomato leaves plant-1 and leaf area were recorded with the application of Mono Ammonium Phosphate (MAP). **Hegazi *et al.*, (2017)** showed that growth of pepper plants were affected according to the source of phosphate, application of MAP recorded the highest values of plant height, number of leaves and branches, plant fresh and dry weights. Also, **Martins *et al.*, (2017)** found A linear increase was obtained for leaf area, seedling height, shoot and root fresh matter at 75mg P L-1. While, **Zhu, and Hampton (2017)** found that tomato plant height, stem diameter, and leaf chlorophyll content at 30 days after transplanting (DAT) were significantly affected by P rates. **Pavithra *et al.*, (2019)** showed that shoot weight, total fresh weight and dry weights of tomato had no significant values under soil mixture and nitrogen, phosphate and potassium (NPK). Also, **Ben Salah, *et al.*, (2022)** showed that the purification of mono-ammonium phosphate led to a significant enhancement on vegetative growth of tomato.

1.3. Effect of the interaction:

The obtained results in Table 2 confirmed that tomato plants differ in their growth response to the different foliar spraying treatments under the different soil application treatments. The data revealed that sprayed tomato plants with mono ammonium phosphate resulted in a large increase in all growth traits under all soil application treatments compared with all other foliar spraying treatments. In the same way, used of seaweed extract as soil application resulted in large improve in all tomato growth traits over all foliar spraying treatments in both seasons. Tomato plants that treated with treated with seaweed extract as soil application and mono ammonium phosphate as foliar spraying had the highest; plant height (123.60 and 131.50 cm), number of branches/plant (10.70 and 12.20), leaves number/plant (73.30 and 76.80), plant fresh weight (1495.60 and 1565.70 g) and plant dry weight (245.70 and 252.60 g) in both seasons, respectively followed by seaweed extract + potassium citrate and yeast extract + mono ammonium phosphate in all growth traits during the two seasons of the stady. On the other side, tomato plants under the absence of both soil application and foliar spraying treatments (control + control) had the lowest; plant height (97.50 and 105.20 cm), number of branches/plant

(6.30 and 7.10), leaves number/plant (56.50 and 59.40), plant fresh weight (1145.50 and 1186.30 g) and plant dry weight (182.60 and 187.50 g) in both seasons, respectively.

Our results confirmed that fertilized tomato plants with seaweed extract as soil application combined with mono ammonium phosphate as foliar spraying improve all growth traits compared with all others treatments as well as control. Similar findings were obtained before by **Sutharsan *et al.*, (2014)**, **Araghian *et al.*, (2015)**, **Ozenc, and Sen (2017)**, **Souza *et al.*, (2017)**, **Murtic et al., (2018)** and **Mutale-Joan *et al.*, (2020)** which they found that significant increase of tomato growth under seaweed extract fertilization.

While, **Soumya *et al.*, (2009), Zhu, and Hampton (2017), Hafez, (2018)**, **Pavithra *et al.*, (2019)** and **Ben Salah *et al.*, (2022)** showed that mono-ammonium phosphate led to a significant enhancement on vegetative growth of tomato.

Table 2. Effect of some soil applications and foliar spraying treatments as well as their interactions on tomato growth during 2019 and 2020 seasons.

Factors		Plant height (cm)		Branches number/plant		Leaves number/plant	
		2019	2020	2019	2020	2019	2020
Soil app							
Control		104.20	111.00	6.98	7.73	58.83	62.01
Seaweed extract		117.90	126.25	9.30	10.63	67.05	72.50
Yeast extract		113.73	119.75	8.05	9.98	64.70	68.63
Garlic extract		109.43	116.53	7.68	8.58	62.20	65.65
LSD 5%		**2.40**	**1.76**	**0.31**	**0.29**	**1.17**	**1.82**
Foliar spray							
Control		105.23	113.88	6.98	8.20	58.98	63.40
Potassium citrate		112.45	119.35	8.38	9.48	64.13	68.11
Lithovit		110.13	116.73	7.55	8.78	62.38	65.93
Mono ammonium phosphate		117.45	123.58	9.10	10.45	67.30	71.36
LSD 5%		**2.13**	**1.88**	**0.27**	**0.28**	**1.57**	**1.60**
Soil app	**Foliar spray**						
Control	**Control**	97.50	105.20	6.30	7.10	56.50	59.40
	potassium citrate	105.30	112.80	7.20	7.90	59.20	62.33
	Lithovit	102.60	109.70	6.80	7.50	57.90	60.10
	Mono ammonium phosphate	111.40	116.30	7.60	8.40	61.70	66.20
Seaweed extract	**Control**	112.90	122.50	8.10	9.30	61.20	68.40
	potassium citrate	118.40	126.70	9.50	10.90	68.40	73.50
	Lithovit	116.70	124.30	8.90	10.10	66.30	71.30
	Mono ammonium phosphate	123.60	131.50	10.70	12.20	72.30	76.80
Yeast extract	**Control**	108.40	115.20	6.90	8.60	60.10	63.70
	potassium citrate	114.70	120.40	8.60	10.20	65.20	69.80
	Lithovit	112.30	118.60	7.40	9.40	64.10	68.10
	Mono ammonium phosphate	119.50	124.80	9.30	11.70	69.40	72.93
Garlic extract	**Control**	102.10	112.60	6.60	7.80	58.10	62.10
	potassium citrate	111.40	117.50	8.20	8.90	63.70	66.80
	Lithovit	108.90	114.30	7.10	8.10	61.20	64.20
	Mono ammonium phosphate	115.30	121.70	8.80	9.50	65.80	69.50
	LSD 5%	**3.53**	**3.12**	**0.45**	**0.46**	**2.61**	**2.65**

Table 2: Cont.

Factors		Plant fresh weight (g)		Plant dry weight (g)	
		2019	2020	2019	2020
Soil app					
Control		1192.85	1244.28	201.25	209.45
Seaweed extract		1403.70	1455.83	235.43	243.88
Yeast extract		1350.20	1392.90	221.73	231.33
Garlic extract		1263.83	1323.65	212.58	221.30
LSD 5%		50.34	46.09	2.84	3.02
Foliar spray					
Control		1238.80	1270.45	203.43	212.25
Potassium citrate		1314.98	1377.45	221.95	229.88
Lithovit		1274.78	1323.10	214.68	224.65
Mono ammonium phosphate		1382.03	1445.65	230.93	239.18
LSD 5%		**44.39**	**35.90**	**3.21**	**2.66**
Soil app	**Foliar spray**				
Control	**Control**	1145.50	1186.30	182.60	187.50
	potassium citrate	1196.30	1257.20	207.60	215.70
	Lithovit	1172.50	1216.70	196.50	208.20
	Mono ammonium phosphate	1257.10	1316.90	218.30	226.40
Seaweed extract	**Control**	1325.70	1351.30	224.60	236.20
	potassium citrate	1418.30	1493.50	238.50	245.10
	Lithovit	1375.20	1412.80	232.90	241.60
	Mono ammonium phosphate	1495.60	1565.70	245.70	252.60
Yeast extract	**Control**	1282.10	1307.50	209.20	217.80
	potassium citrate	1388.60	1411.50	224.90	236.10
	Lithovit	1317.20	1365.40	217.80	229.50
	Mono ammonium phosphate	1412.90	1487.20	235.03	241.90
Garlic extract	**Control**	1201.90	1236.70	197.30	207.50
	potassium citrate	1256.70	1347.60	216.80	222.60
	Lithovit	1234.20	1297.50	211.50	219.30
	Mono ammonium phosphate	1362.50	1412.80	224.70	235.80
LSD 5%		**73.60**	**59.53**	**5.33**	**4.41**

2. Effect of some soil applications and foliar spraying treatments as well as their interactions on tomato leaves contents of nitrogen, phosphorus and potassium during 2019 and 2020 seasons.

The obtained data in Table 3 showed that tomato leaves contents of total chlorophyll, nitrogen, phosphorus significantly affected by soil application and foliar spraying treatments as well as their interactions in both seasons. These differ confirmed the wide diversity between the different treatments and this may be due the differences in chemical compositions of these treatments.

4.2.1. Effect of soil application treatments:

The presented data in Table 3 cleared that leaves contents of total chlorophyll, nitrogen, phosphorus significantly differ under the different soil application treatments in both seasons. Tomato plants that treated with seaweed extract showed the highest leaves contents of; leaves content of total chlorophyll (55.70 and 65.78 spad unit), nitrogen (2.54 and 2.66%), phosphorus (0.42 and 0.46 %) and potassium (1.99 and 2.11 %) in both seasons, respectively. In all cases seaweed extract was followed by yeast extract and garlic extract. In contrary, tomato plants under the control treatments showed the lowest leaves contents of; leaves content of total chlorophyll (44.80 and 51.75 spad unit), nitrogen (1.93 and 2.10%), phosphorus (0.32 and 0.35 %) and potassium (1.49 and 1.66 %) in both seasons, respectively.

Tomato leaves contents of total chlorophyll, nitrogen, phosphorus and potassium were larger under the soil application of seaweed, yeast and garlic extracts than control. Several studies

concluded the role of these materials in increased leaves chemical properties of different horticulture crops.

For the effect of seaweed extract, **Mutale-Joan *et al.*, (2020)** found that added seaweed extract to tomato plants maximized uptake of Nitrogen, phosphorus and potassium, which increased by 185.17%, 119.36% and 78.04% respectively compared with non-treated plants. While, **Ahmad *et al.*, (2014)** revealed that garlic extract can modulate the antioxidant enzymes, chlorophyll content and soluble sugar content of the treated tomato plants.

2.2. Effect of foliar spraying treatments:

The obtained data in Table 3 indicated that all tomato leaves contents of nitrogen, phosphorus and potassium significantly affected by the different foliar spraying treatments. All foliar spraying treatments led to significant increase in tomato leaves contents of total chlorophyll, nitrogen, phosphorus and potassium compared to control. tomato plants that sprayed with mono ammonium phosphate gave the highest leaves contents of; leaves content of total chlorophyll (54.48 and 63.38 spad unit), nitrogen (2.45 and 2.62 %) and phosphorus (0.43 and 0.47 %) while, tomato plants that sprayed with potassium citrate had the highest leaves contents of potassium with averages of 1.90 and 2.05 % in both seasons, respectively. Both mono ammonium phosphate and potassium citrate significantly exceeded lithovit in increase tomato leaves contents of total chlorophyll, N, P and K in both seasons. On the other side, tomato plants under the control treatment had the lowest leaves contents of; total chlorophyll (46.98 and 54.88 spad unit), nitrogen (2.04 and 2.19 %), phosphorus (0.31 and 0.34 %) and potassium (1.56 and 1.72 %) in both seasons, respectively.

Our results indicated that all foliar spraying treatments superior the control treatment in increased tomato leaves contents of nitrogen, phosphorus and potassium. In the previous studies mono ammonium phosphate showed positive effect in increase N, P and K statues in many crops such as, **Hegazi *et al.*, (2017)** showed an increase in photosynthetic pigments and minerals nutrition (N, P, K and Ca %) of pepper was recorded parallel to the increase of phosphorus availability (with MAP and MKP application). In the same line, **Souri, and Dehnavard (2017)** showed that leaf nitrogen concentration increased significantly by the application of ammonium. Also, **Hafez, (2018)** showed that tomato that treated with mono ammonium phosphate at rate of 75 and 100 kg / fed. gave the highest value of nitrogen and phosphorus.

2.3. Effect of the interaction:

Data in Table 3 confirmed that the tomato plants differ in their response to the different foliar spraying and soil application treatments. The data indicated that sprayed tomato plants with mono ammonium phosphate or potassium citrate led to significant increase leaves contents of total chlorophyll, N, P and K over all soil application treatments compared with the others treatments as well as control. Seaweed extract exceeded all soil application treatments in increase leaves contents of total chlorophyll, N, P and K across all foliar spraying treatments in both seasons. Tomato plants that treated with seaweed extract in addition to sprayed with mono ammonium phosphate had the highest leaves contents of; total chlorophyll (58.70 and 69.50 spad unit), nitrogen (2.74 and 2.91 %) and phosphorus (0.48 and 0.52 %) while, tomato plants that fertilized with seaweed extract and sprayed with potassium citrate had the highest leaves content of potassium (2.12 and 2.27%) in both seasons, respectively. In the contrast of this tomato plants under the control showed the lowest leaves contents of; total chlorophyll (41.20 and 48.60 spad unit), nitrogen (1.63 and 1.82%), phosphorus (0.25 and 0.27%) and potassium (1.33 and 1.48%) in the first and second seasons, respectively.

Tomato plants that sprayed with mono ammonium phosphate combined with the soil application of seaweed extract had the highest leaves contents of N, P and K in both seasons. these findings are in agree with those of **Mutale-Joan *et al.*, (2020)** where they found positive effect of adding seaweed extract to tomato plants in maximized uptake of Nitrogen, phosphorus and potassium, which increased by 185.17%, 119.36% and 78.04% respectively compared with non-treated plants.

In the same way, **Coutinho *et al.*, (2014)**, **Jasim *et al.*, (2014)**, **Hegazi *et al.*, (2017)**, **Souri, and Dehnavard (2017)** and **Hafez, (2018)** whom showed that tomato that treated with mono ammonium recorded the highest leaves contents of nitrogen, phosphorus and potassium in compared with untreated plants.

Table 3: Effect of some soil applications and foliar spraying treatments as well as their interactions on tomato leaves contents of total chlorophyll, nitrogen, phosphorus and potassium during 2019 and 2020 seasons.

Factors		N %		P%		K %		Total chlorophyll (spad unit	
		2019	2020	2019	2020	2019	2020	2019	2020
Soil app									
Control		1.93	2.10	0.32	0.35	1.49	1.66	44.80	51.75
Seaweed extract		2.54	2.66	0.42	0.46	1.99	2.11	55.70	65.78
Yeast extract		2.35	2.48	0.40	0.43	1.80	1.98	52.55	61.60
Garlic extract		2.18	2.33	0.36	0.39	1.64	1.80	49.13	56.68
LSD 5%		0.05	0.04	0.03	0.02	0.06	0.07	1.64	2.24
Foliar spray									
Control		2.04	2.19	0.31	0.34	1.56	1.72	46.98	54.88
Potassium citrate		2.32	2.44	0.39	0.42	1.90	2.05	51.38	59.83
Lithovit		2.20	2.33	0.36	0.39	1.67	1.83	49.35	57.73
Mono ammonium phosphate		2.45	2.62	0.43	0.47	1.79	1.94	54.48	63.38
LSD 5%		**0.07**	**0.08**	**0.02**	**0.02**	**0.06**	**0.05**	**1.25**	**1.39**
Soil app	**Foliar spray**								
Control	**Control**	1.63	1.82	0.25	0.27	1.33	1.48	41.20	48.60
	potassium citrate	2.04	2.15	0.34	0.36	1.66	1.82	46.10	52.10
	Lithovit	1.86	2.04	0.31	0.34	1.41	1.64	42.40	50.20
	Mono ammonium phosphate	2.18	2.37	0.37	0.41	1.54	1.70	49.50	56.10
Seaweed extract	**Control**	2.39	2.50	0.37	0.40	1.85	1.94	52.60	61.50
	potassium citrate	2.56	2.68	0.43	0.47	2.12	2.27	56.30	67.20
	Lithovit	2.48	2.56	0.41	0.44	1.96	2.05	55.20	64.90
	Mono ammonium phosphate	2.74	2.91	0.48	0.52	2.03	2.18	58.70	69.50
Yeast extract	**Control**	2.18	2.26	0.34	0.37	1.62	1.84	48.50	56.80
	potassium citrate	2.42	2.54	0.41	0.45	1.99	2.13	53.40	62.70
	Lithovit	2.30	2.45	0.38	0.41	1.74	1.91	51.50	60.40
	Mono ammonium phosphate	2.51	2.68	0.45	0.48	1.86	2.02	56.80	66.50
Garlic extract	**Control**	1.95	2.16	0.29	0.32	1.45	1.63	45.60	52.60
	potassium citrate	2.26	2.37	0.39	0.41	1.83	1.97	49.70	57.30
	Lithovit	2.15	2.28	0.33	0.38	1.58	1.73	48.30	55.40
	Mono ammonium phosphate	2.37	2.52	0.41	0.45	1.71	1.85	52.90	61.40
LSD 5%		**0.11**	**0.12**	**0.04**	**0.04**	**0.10**	**0.09**	**2.07**	**2.31**

3. Effect of some soil applications and foliar spraying treatments as well as their interactions on fruit yield of tomato during 2019 and 2020 seasons.

The presented results in Table 4 indicated that fruit yield traits of tomato i.e. average fruit weight, fruit yield/plant and fruit yield/fad significantly affected by soil application and foliar spraying treatments as well as their interactions in both seasons. The significant differences in fruit yield of tomato under the different used soil application and foliar spraying treatments due to these treatments differ in their mode of action where these treatments differ in their chemical compositions.

3.1. Effect of soil application treatments:

Results in Table 4 confirmed that all fruit yield of tomato plants significantly differ under all soil application treatments. Tomato plants under all used treatments significantly exceeded in their fruit yield than these plants in control. Tomato plants that treated with seaweed extract as soil application gave the highest; average fruit weight (129.33 and 136.43 g), fruit yield/plant (4.61 and 4.76 kg) and fruit yield/fad (35.86 and 37.08 ton) in both seasons,

respectively. In all fruit yield traits the superiority of seaweed extract was followed by yeast extract then garlic extract. In the contrast of this, tomato plants under the control treatment showed the lowest, average fruit weight (95.90 and 108.75 g), fruit yield/plant (3.56 and 3.80 kg) and fruit yield/fad (27.71 and 29.62 tons) in both seasons, respectively.

In the present study all soil application treatments exceeded the control treatment in all yield and yield components traits.

Seaweed extract in the previous studies also, showed great results in increase yield of several crops such as the studies of, **Saravanan *et al.*, (2003)** found that the number of tomato fruits per plant, and fruit yield per plant and per plot significantly increased with the application of 750 ppm chlormequat and 1680 ppm seaweed extract. **Csizinszky, (2009)** reported that early yield of marketable total fruit was higher with seaweed-based 'SOAR' bio stimulants than with control treatment. The higher yields were due to a trend toward a larger number of fruits rather than heavier weight per fruit. While, **Sutharsan *et al.*, (2014)** indicated that added seaweed extract with 20% of foliar application increased tomato fruit number by 57.87% and fruit yield per hectare by 58.70% compared to control. In the same way, **Ozenc, and Sen (2017)** confirmed that liquid seaweed fertilizer applications at different growth stages positively affected yield and nutrient content; especially the best results were obtained from 400 ml 100 L-1 application in the seedling stage. Also, **Murtic *et al.*, (2018)** sowed that seaweed extract positively influenced the yield compared to untreated plants.

3.2. Effect of foliar spraying treatments:

Results shows in Table 4 cleared that fruit yield traits of tomato significantly affected by foliar spraying treatments. All foliar spraying treatments resulted in significant improve in tomato yield compared to control. tomato plants that sprayed mono ammonium phosphate gave the highest; fruit yield/plant (4.47 and 4.64 kg) and fruit yield/fad (34.80 and 36.10 tons) in both seasons, respectively while, tomato plants that sprayed with potassium citrate showed the highest average fruit weight with averages of 123.93 and 133.40 g in the first and second seasons, respectively. On the other hand, tomato plants under the control treatment had the lowest; average fruit weight (107.43 and 114.88 cm), fruit yield/plant (3.80 and 4.00 kg) and fruit yield/fad (29.54 and 31.14 tons) in both seasons, respectively.

All foliar spraying treatments in the present study exceeded the control treatment in all fruit yield trait. Many previous studies have highlighted the role of these materials in improving yield of crops. For mono ammonium phosphate, **Harikrishna et al., (2002)** found that the highest tomato fruit yield (54.32 t/ha) was recorded upon treatment with recommended dose of nitrogen, phosphorus and potassium. **Sagheb, and Hobbi (2002)** revealed that tomato fresh fruit yield attained for N0, N1, N2, N3 and NS respectively 84, 76, 69, 36 and 26 tonnes/ha. The highest tomato yield was presented under urea-N0 treatment (155.4 kg/ha cm) and urea-N1 treatment (154.1 kg/ha cm) for 1998. Also, **Coutinho *et al.*, (2014)** reported that phosphate fertilization increased tomato fruit production. Maximum tomato yield was produced with the (estimated) application of 293 kg ha-1 of P2O5. While, **Kang, and Ying (2016)** found that tomato fruit yield increased with the increased phosphate fertilizer rate from 106.7-108 kg.ha-1. In the same line, **Khan *et al.*, (2017)** showed that Maximum tomato fruit and dry matter yields, fruit density, number of fruit kg-1, N, P and K uptake by tomato plant were obtained from treatment where full dose of N, P and K. **Souri, and Dehnavard (2017)** showed that tomato fruit diameter and fruit length increased significantly by the application of ammonium. According to **Hafez, (2018)** fertilization with mono ammonium phosphate at rate of 100 kg/ fed. recorded, generally, the best results of all the investigated fruit characters. **Ben Salah *et al.*, (2022)** showed that the purification of mono-ammonium phosphate led to a significant enhancement tomato yield attributes of tomato.

3.3. Effect of the interaction:

The results in Table 4 revealed that tomato plants differ in their yield response to the different foliar spraying treatments under the different soil application treatments. The data cleared that sprayed tomato plants with mono ammonium phosphate or potassium citrate resulted in a large increase in all yield traits under all soil application treatments compared with all other foliar spraying treatments. In the same way, used of seaweed extract as soil application resulted in large improve in all tomato yield traits over all foliar spraying treatments in both seasons. Tomato plants that treated with seaweed extract as soil application and mono ammonium phosphate as foliar spraying had the highest; fruit yield/plant (4.96 and 5.11 kg) and fruit yield/fed (38.62 and 39.76 tons) in both seasons, respectively. While, tomato plants that treated with seaweed extract + potassium citrate had the highest average fruit weight with averages of 137.50 and 145.30 g in the first and second seasons, respectively. On the other side, tomato plants under the absence of both soil application and foliar spraying treatments (control + control) had the lowest; average fruit weight (85.70 and 97.20 g), fruit yield/plant (3.22 and 3.51 kg) and fruit yield/fed (25.10 and 27.36 tons) in both seasons, respectively.

Soil application of seaweed extract and foliar spraying of mono ammonium phosphate resulted in the largest increase in tomato yield attributes compared with all used treatments in both seasons. similar findings were obtained before by, **Saravanan *et al.*, (2003)**, **Csizinszky, (2009)**, **Sutharsan *et al.*,**

(2014), **Ozenc, and Sen (2017)** and **Murtic *et al.*, (2018)** showed that seaweed extract positively influenced the yield compared to untreated plants.
In the same line, **Harikrishna *et al.*, (2002)**, **Sagheb, and Hobbi (2002)**, **Coutinho *et al.*, (2014)**, **Kang, and Ying (2016)**, **Khan *et al.*, (2017)**, **Souri, and Dehnavard (2017)**, **Hafez, (2018)** and **Ben Salah *et al.*, (2022)** showed that mono-ammonium phosphate led to a significant enhancement yield attributes of tomato and others crops.

Table 4. Effect of some soil applications and foliar spraying treatments as well as their interactions on fruit yield of tomato during 2019 and 2020 seasons.

Factors		Fruit weight (g)		Total yield/ plant (kg)		Total yield/ fed (ton)	
		2019	2020	2019	2020	2019	2020
Soil app							
Control		95.90	108.75	3.56	3.80	27.71	29.62
Seaweed extract		129.33	136.43	4.61	4.76	35.86	37.08
Yeast extract		123.38	130.05	4.35	4.49	33.82	34.97
Garlic extract		114.80	121.60	4.00	4.13	31.12	32.12
LSD 5%		1.32	2.23	0.05	0.08	0.78	1.49
Foliar spray							
Control		107.43	114.88	3.80	4.00	29.54	31.14
Potassium citrate		123.93	133.40	4.20	4.37	32.70	34.04
Lithovit		113.00	121.25	4.04	4.18	31.47	32.51
Mono ammonium phosphate		119.05	127.30	4.47	4.64	34.80	36.10
LSD 5%		**2.36**	**1.91**	**0.09**	**0.08**	**0.92**	**0.84**
Soil app	**Foliar spray**						
Control	**Control**	85.70	97.20	3.22	3.51	25.10	27.36
	potassium citrate	105.90	119.50	3.67	3.86	28.61	30.09
	Lithovit	92.30	105.70	3.43	3.69	26.75	28.71
	Mono ammonium phosphate	99.70	112.60	3.90	4.15	30.36	32.31
Seaweed extract	**Control**	121.40	128.60	4.26	4.44	33.16	34.57
	potassium citrate	137.50	145.30	4.68	4.86	36.41	37.86
	Lithovit	126.80	132.60	4.53	4.64	35.24	36.11
	Mono ammonium phosphate	131.60	139.20	4.96	5.11	38.62	39.76
Yeast extract	**Control**	117.90	122.50	4.02	4.23	31.25	32.91
	potassium citrate	129.80	138.20	4.39	4.53	34.17	35.29
	Lithovit	120.60	127.80	4.32	4.38	33.62	34.11
	Mono ammonium phosphate	125.20	131.70	4.66	4.83	36.25	37.58
Garlic extract	**Control**	104.70	111.20	3.68	3.82	28.64	29.72
	potassium citrate	122.50	130.60	4.06	4.23	31.62	32.91
	Lithovit	112.30	118.90	3.89	4.00	30.27	31.11
	Mono ammonium phosphate	119.70	125.70	4.36	4.46	33.95	34.75
LSD 5%		**3.90**	**3.17**	**0.14**	**0.12**	**1.53**	**1.40**

Conclusion

We can recommend tomato farmers in E- Beheira governorate for using seaweed extract as a soil application with foliar spraying three times during the growing season with mono-ammonium phosphate to obtain the highest fruits yield and quality.

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تأثير إلاضافةالارضية والرش ببعض منشطات النمو الامنة على نمو وإنتاجية الطماطم

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أجريت الدراسة الحالية في مزرعة خاصة بمركز ابو حمص ، محافظة البحيرة خلال عامى 2019 و 2020 مواسم لتقييم دور ثلاثة من معاملات الاضافة الأرضية هى مستخلص الطحالب البحرية ومستخلص الخميرة ومستخلص الثوم بالإضافة للكنترول (بدون إضافة) وكذلك ثلاث من معاملات الرش الورقى هى الليثوفيت (كالسيوم كربونات)، سترات البوتاسيوم واحادى فوسفات الأمونيوم بالإضافة إلى الكنترول على النمو ومحصول الثمار وجودتها لهجين الطماطم "سلطانة".وقد أظهرت النتائج المتحصل عليها أن جميع صفات النموالخضرى والكلوروفيل الكلي والمكونات الكيميائية لأوراق النبات والمحصول الثمرى ومكوناتها تأثرت معنوياً بالاضافات الارضية ومعاملات الرش الورقي وتفاعلاتها في كلا الموسمين. وفي هذا الصدد ، كانت نباتات الطماطم التي عوملت بمستخلص الطحالب البحرية كاضافة ارضية والرش الورقى باحادى فوسفات الأمونيوم هي الأعلى فى طول النبات ، عدد الأفرع / النبات ، عدد الأوراق / النبات ، الوزن الطازج والجاف للنبات ،واعلى محتوى الأوراق من الكلوروفيل الكلي والنتيروجين، الفوسفور ، البوتاسيوم ومحتوى الكربوهيدرات الكلي وكذلك أعلى محصول ثمرى لكل من النبات والفدان في كلا الموسمين.