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The Effect of Vermicompost, Urea, and Seaweed Extracts on Growth and Yield Characteristics of Yellow Maize (*Zea mays* L.).

Luma Salih Jabbar Al-Taweel **Zahraa Jassim Kadhum Al-Budairy**
Dept. of Soil Sciences and Water Recourses – College of Agriculture
Al-Qadisiyah University

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Abstract

In order to study the effect of adding vermicompost fertilizer, seaweed extracts, and nitrogen fertilizer on the growth and yield characteristics of maize. An experiment was carried out in one of the farms located in Nouriya district - Al-Diwaniyah governorate - Iraq during the autumn season 2019-2020.

The experiment was applied in the order of global trials according to the design of randomized full sectors and with three replications. The first factor included adding vermicompost fertilizer in three levels (0, 2 and 4 tons H^{-1}) coded A0, A1 and A2 respectively, while the second factor included adding seaweed extract at two levels (0 and 40 kg H^{-1}) symbolized for B0 and B1 respectively, while the third factor included adding nitrogen fertilizer in three levels (0, 120 and 240 kg N H^{-1}) coded as C0, C1 and C2, respectively.

The results of the experiment showed:

The levels of vermicompost differed significantly in most of the studied characterizes , as the A1 level achieved the highest results for leaf content of chlorophyll, dry weight of the root and vegetable group, total yield, and the percentage of protein in grains (45.86 SPAD, 11.641 and 57.13 gm plant $^{-1}$ 11.299 Mg H $^{-1}$ 12.30 %), respectively, while level A2 achieved the highest value of plant height (354.1 cm plant $^{-1}$).

The treatment of adding seaweed extracts B1 significantly affected most of the studied characterizes and gave the highest results for leaf content of chlorophyll, plant height, dry weight of root and vegetative group, total yield and percentage of protein (43.70 SPAD, 335.7 cm plant^{-1}, 10.983 and 54.73 gm.plant^{-1} and 10.361 Mg H^{-1} and 11.18%), respectively.

The treatment of adding C1 nitrogen fertilizer was significantly higher with the highest results for leaf content of chlorophyll, plant height, dry weight of root and vegetable group, total yield and protein content in grains (45.51 SPAD, 345.8 cm plant^{-1}, 11.054, 56.57 gm.plant^{-1} and 10.500 Mg.H^{-1} and 11.50%) respectively.

The research is part of MCs for 2nd author

Corresponding author: E-mail(***Zzaah94@gmail.com***)

Introduction

Soil is one of the natural ingredients in agriculture, and the extent of its quality and degree of fertility plays an important role in the productivity of various plants, and despite this importance, Iraqi soils, especially in the central and southern regions, are still suffering from a decrease in the readiness of many nutrients necessary for plant growth and development, which is due to many of reasons, including those related to the characteristics of the soil itself, such as the degree of soil interaction, texture and composition, as well as its low content of organic matter and others related to agricultural intensification, but the most prominent of which is the failure to follow the scientific method in soil nutrient management programs, which requires work on the application of appropriate fertilizer programs for each soil and the resulting from improvement of the physical, chemical and biological properties of the soil, and as a result an increase in its fertility (Colombo et al., 2002). The addition of nitrogen fertilizers is one of the factors that increase soil fertility and it is one of the major elements necessary for plants as a result of the physiological roles it plays within the plant tissue. but the excessive use of nitrogen fertilizers is a result of its loss from soils by volatilization and washing (Bronson, 2004, Al-Taweel and Abo-Tabikh, 2019), as well as the unexamined additions to this fertilizer have led to an imbalance of the readiness of the elements in the soil and the negative impact of that on its fertile state (Havlin et al., 2005), and to reduce these effects and reduce the problems resulting from them, the modern trends of agriculture invite for the observance of indicators of fit environmental management by reducing pollutants and replacing mineral fertilization or part of it with organic fertilizers, such as the use of seaweed extracts, which are one of the most important vital growth fertilizers due to their content of organic matter that retains humidity and helps in increasing the readiness of nutrients (Spinelli et al., 2009), as well as their content of the many natural compounds that act as growth regulators (O′Dell, 2003), and their role in improving the physical properties of the soil as they help in improving the conditions of ventilation, permeability, water holding, reducing the apparent density of the soil and increasing its porosity (Naseem, 2005).

It is also possible to limit or reduce the addition of mineral fertilizers by adding other types of organic fertilizers known as vermicompost, which is an organic fertilizer that earthworms produce by analyzing organic compounds and converting them into simple substances that the plant can benefit from. Studies have indicated that Vermicompost contains a number of enzymes such as Peroxidase, Protease and Amylase that enhance the effectiveness of soil microorganisms (Bottinellin et al., 2010). Negasa et al. (2007) stated that the addition of organic vegetable fertilizer by 4 tons H^{-1} contributed to the increase of plant height and the yield of yellow maize grains as 28.2 and 17.8%, respectively, compared to the comparison treatment, and Gudugi et al.(2012) stated that the addition of organic fertilizer 15 tons H^{-1} to yellow maize led to a significant increase in the dry weight characterize of the plant and the grain yield compared to the comparison treatment.

Alwan (2002) indicated that there was a significant increase in the yield of yellow maize grains when adding 120 kg N H^{-1} of urea fertilizer as percentage a 31.88% in comparison treatment, and Olaniyan et al. (2004) noted that the level of 120 kg N H^{-1} was significantly excellence than the treatment comparison by giving it the highest average yield of yellow maise, amounting to 10.59 tons H^{-1}, and recent studies tend to raise the efficiency of production through the use of modern methods in serving the crop that can lead to an increase in the growth parameters and then increase the yield in quantity and quality, and from the materials used in this the field is seaweed extracts, which have been proven to influence the various growth parameters of different plants. The adding of seaweed extracts to the soil has an effective role in increasing the vegetative growth of yellow maize by 15-25%. Potter

(2005) indicated that seaweed extracts lead to an increase the growth of the root system, which gives the plant strength to grow and increase the absorption of nutrients from the soil, in addition to increasing the content of the leaves of chlorophyll and then increasing the dry weight of the plant, as seaweed extract activates the photosynthesis process and increases leaves content of chlorophyll and delaying the aging of leaves (Spinelli et al. 2009). Sunarpi et al. (2010) stated that there are at least 59 species of seaweed that are capable of stimulating vegetative indicators and their development, as well as contribute to increasing crop productivity and improving its quality as well as preserving its quality during storage (Kalidss et al., 2010).

Martials and Methods

A field experiment was carried out during the autumn season of 2019-2020 in one of the farms located in Al-Nouriya district / Al-Diwaniyah governorate-Iraq in soil, showing some of its chemical, physical and biological properties in Table (1) with the aim of studying the effect of vermicompost, seaweed extracts and urea and the interaction between them in the total numbers of bacteria and fungi in soil, yellow maize was planted during flowering and maturing stages.

Table (1): Some physical, chemical and biological characteristics of the study soil before planting.

Adjective	Value		Unit	Source
pH 1:1	7.69		-	(1965b،Black)
Ec 1:1	2.53		Ds m^{-1}	(1965b،Black)
CEC	22.13		$Cmol_c$ Kg^{-1} soil	(1976،Papanicolaou)
$CaCO_3$	255.00		gKg^{-1} soil	(1965b،Black)
Organic matter	4.65			
Ready nitrogen	26.11		$mgKg^{-1}$ soil	1982)،(Page
Ready potassium	137.00			
Ready phosphor	13.1			
Soil separators	sand	217.00	gKg^{-1} soil	(1965a،Black)
	silt	368.00		
	clay	415.00		
Texture	silt clay mixture			
Apparent density	1.33		Mgm^{-3}	
Total bacteria	17.3 10^6×		CFUg-1 dry soil	(1965b،Black)
Total fungi	6.6 10^4×			

The field soil was fertilized with triple superphosphate fertilizer (48%P_2O_5) at a rate of 100 kg P H^{-1} and potassium fertilizer in the form of potassium sulfate (41.5% K) at a rate of 120 kg K H^{-1} and fertilizers were added in one batch before planting, while the nitrogen fertilizer was added in the form of urea (N46%) according to the treatments in two batches, the first at the planting stage and the second at the flowering stage. As for the vermicompost fertilizer whose characteristics are mentioned in Table (2), it was added in conjunction with the addition of nitrogen fertilizer and according to the treatments, and for seaweed extract, was added in four batches distributed in order along the growing season and according to the treatments.

Table (2): Some chemical and physical analyzes of vermicompost fertilizer		
Adjective	Value	Unit
pH	6.20	-----
Ec 1:5	1.68	ds m^{-1}
Humidity	26.4	
Organic matter	43.24	
Organic carbon	25.14	%
Nitrogen	1.50	
C:N ratio	16.76	-----
Iron	0.11	
Manganese	0.68	
Zinc	0.05	
Cupper	0.33	Mg Kg^{-1}
Boron	0.29	
Nickel	0.044	
Cobalt	0.04	

The land was divided into 54 experimental units (Table 3) with dimensions (2 m × 2 m), which included 4 lines with a distance of 0.50 m and between a plant and another 0.25 m. Yellow maize seeds of a hybrid variety (Furat) were planted on July 27, 2019, by planting 3 seeds in the hole, then diluting to one plant after germination. The plants were harvested on November 27, 2019, when signs of maturity were evident from the drying out of the arid and the appearance of a black scar on the beans.

Table (3): Experiment treatments and their symbols		
No	Treatment Symbol	Name of treatment
1	A0B0C0	Without adding
2	A0B0C1	Adding the nitrogen fertilizer at the rate of 120 kg N H^{-1}
3	A0B0C2	Adding nitrogen fertilizer 240 kg N H^{-1}
4	A0B1C0	Adding seaweed extracts at a rate of 40 kg N H^{-1}
5	A0B1C1	Adding nitrogen fertilizer at a rate of 120 kg N H^{-1} + seaweed extracts at a rate of 40 kg H^{-1}
6	A0B1C2	Adding nitrogen fertilizer at a rate of 240 kg N H^{-1} + seaweed extracts at a rate of 40 kg H^{-1}
7	A1B0C0	Add vermicompost at a rate of 2 tons H^{-1}
8	A1B0C1	Adding nitrogen fertilizer at a rate of 120 kg N H^{-1} + vermicompost at a rate of 2 tons H^{-1}
9	A1B0C2	Adding nitrogen fertilizer at a rate of 240 kg N H^{-1} + vermicompost at a rate of 2 tons H^{-1}
10	A1B1C0	Adding seaweed extracts at a rate of 40 kg H^{-1} + vermicompost at a rate of 2 tons H^{-1}

11	A1B1C1	Adding nitrogen fertilizer at a rate of 120 kg N H^{-1} + seaweed extracts at a rate of 40 kg H^{-1} + vermicompost at a rate of 2 tons H^{-1}
12	A1B1C2	Adding nitrogen fertilizer at a rate of 240 kg N H^{-1} + seaweed extracts at a rate of 40 kg H^{-1} + vermicompost at a rate of 2 tons H^{-1}
13	A2B0C0	Add vermicompost at the rate of 4 tons H^{-1}
14	A2B0C1	Adding nitrogen fertilizer at a rate of 120 kg N H^{-1} + vermicompost at a rate of 4 tons H^{-1}
15	A2B0C2	Adding nitrogen fertilizer at a rate of 240 kg N H^{-1} + vermicompost at a rate of 4 tons H^{-1}
16	A2B1C0	Adding seaweed extracts at a rate of 40 kg H^{-1} + vermicompost at a rate of 4 tons H^{-1}
17	A2B1C1	Adding nitrogen fertilizer at a rate of 120 kg N H^{-1} + seaweed extracts at a rate of 40 kg H^{-1} + vermicompost at a rate of 4 tons H^{-1}
18	A2B1C2	Adding nitrogen fertilizer at a rate of 240 kg N H^{-1} + seaweed extracts at a rate of 40 kg H^{-1} + vermicompost at a rate of 4 tons H^{-1}

The chlorophyll was estimated in SPAD in the field using a 502 Chlorophyll-meter device, as the measurement was performed at the stage of 75% of flowering completion by taking the flag paper of ten plants taken randomly from each treatment.

The dry weight of the root and vegetative total of the plant (gm plant $^{-1}$) was calculated at the stage of full maturity, as five plants were randomly taken from the two middle lines of each experimental unit and the plant height was measured (plant cm^{-1}) starting from the area of plant contact with the soil until the male inflorescence by using a tape measure, the arithmetic mean of the five readings was taken, then the five plants were taken and the total vegetable were separated from the roots. They were washed with distilled water and air dried, then dried in an electric oven at a degree of 65m until the weight stabilized, then the average dry weight of the root and vegetable group was calculated.

Total quotient (tons H^{-1})

The total yield was calculated in the stage of full maturity after the vegetative growth stopped and the plant began to yellow, as the yield of five plants was randomly taken from each experimental unit and the plantlets were weighted and the yield of one plant was extracted from it and from it the yield of the experimental unit, then it was calculated per hectare.

The percentage of protein in grains (%)

After drying the plant samples, they were milled by a mill and the digestion process was carried out as indicated in the estimation of NPK elements in the plant. Then the nitrogen was estimated using a Micro-kjeldal device and the protein percentage was calculated based on Page et al. (1982):

% Protein =% N x 6.25

Results and Discussion

Leaf content of chlorophyll (SPAD)

It is evident from the results of Table (4) the significant effect of vermicompost in increasing the content of leaves of chlorophyll. Treatment A1 recorded the highest average for chlorophyll (45.86 SPAD) compared to the comparison treatment (A0), which recorded the lowest average of (36.33 SPAD). The reason of this increase in the chlorophyll content of leaves may be attributed to the role of adding vermicompost to the soil in increasing the ratios of nutrients, especially nitrogen and phosphorus, and increasing their absorption by the roots and increasing their percentage in the leaves, and this is agree with Al-Qaisi (2001) who indicated that there was a significant effect of adding organic fertilizer in increasing the amount of chlorophyll in leaves.

The results of the statistical analysis in Table (4) showed the superiority of the treatment of seaweed extracts B1, which recorded (43.70 SPAD) compared to the comparison treatment (B0) that recorded (41.07 SPAD). The reason for the increase in chlorophyll when adding seaweed extracts may be due to what this extract contains of amino acids and growth regulators that increase the activity of the vital processes of the plant and increase its growth and the resulting of increase in the chlorophyll content of leaves, and these results are agree with Al-Nasser (2016).

As for nitrogenous fertilizer, the treatment urea C1 exceeded in the content of leaves of chlorophyll and achieved (45.51 SPAD), followed by the treatment C2 that achieved (42.23 SPAD) , then the comparison treatment (C0) that achieved the lowest average for the leaf content of chlorophyll reaching (39.42 SPAD). The reason of treatment exceeded of adding 50% of the fertilizer recommendation to nitrogen may be due to the superiority of the treatment itself with the highest percentage of nitrogen in the leaves, as nitrogen enters the formation of the porphyrin rings that enter into the formation of the basic chlorophylls for the processes of photosynthesis and respiration, as well as its entry into the formation of the enzymatic accompaniments which are auxiliary factors for enzymes or other nitrogen-containing compounds in the plant as well as in the formation of energy compounds, especially ATP (Adenosine triphosphate), and this is consistent with what was mentioned by Al-Dulaimi (2002), Hammadi (2002), Tawainga et al. (2003), Zhao et al., (2003) and Muhana et al. (2015).

As for the binary interference resulting from the addition of vermicompost fertilizer and seaweed extracts, it had a significant effect on the chlorophyll content of leaves, as A1B1 combination gave the highest value of (49.06 SPAD) compared to combination A0B0, which gave the lowest value of (33.46 SPAD).

The binary interference resulting from the addition of vermicompost fertilizer and nitrogen fertilizer showed a significant effect on the chlorophyll content of leaves, as the A1C1 combination recorded the highest value of (50.77 SPAD) compared to the combination A0C0, which recorded the lowest value of (33.08 SPAD).

On the other hand, the results of the binary interaction between seaweed extracts and nitrogen fertilizer showed a significant effect of the interaction between the study factors in the chlorophyll content of leaves (Table 4), as the highest value was reached by the combination B1C1 (47.32 SPAD) compared to the combination B0C0, which achieved the lowest value of (37.47). SPAD). The reason for the increase may be attributed to the role of seaweed extracts in providing additional quantities of nutrients, which reflected positively on the increase in the amount of chlorophyll, as 70% of the leaf nitrogen is inter in the composition of the chlorophyll pigment and the chloroplasts contain more than half of the total nitrogen content (Zafer et al. , 2011 and Faisal et al., 2013)

The effect of triple interaction between vermicompost, seaweed extracts and nitrogen fertilizers was significant in the chlorophyll content of leaves (Table 4), with the highest value in the combination A1B1C1 (55.90 SPAD), while the lowest value for the combination A0B0C0 was (30.07 SPAD).

Table (4): Leaf chlorophyll content (SPAD)

A2	A1	A0	(Vermicompost levels A tone H^{-1})
44.99	45.86	36.33	
	1.25		LSD 0.05
B1		B0	Seaweed Extract levels B kg H^{-1}))
43.70		41.07	
	1.02		LSD 0.05
C2	C1	C0	Average nitrogen fertilizer C (Kg N H^{-1})
42.23	45.51	39.42	
	1.25		LSD 0.05
Binary interference between (vermicompost) A × B (seaweed extract)			
B1		B0	

39.17	33.46	A0
49.06	42.66	A1
42.87	47.11	A2
1.77		LSD 0.05

Binary interference between (vermicompost) A × C (nitrogen fertilizer)			
C2	C1	C0	
39.30	36.55	33.08	A0
43.65	50.77	43.15	A1
43.73	49.22	42.02	A2
	2.17		LSD 0.05

Binary interference between (seaweed extract) B × C (nitrogen fertilizer)			
C2	C1	C0	
42.06	43.70	37.47	B0
42.40	47.32	41.37	B1
	1.77		LSD 0.05

Triple interference between treatments A × B × C				
C2	C1	C0		
36.57	33.73	30.07	B0	A0
42.03	39.37	36.10	B1	
43.30	45.63	39.03	B0	A1
44.00	55.90	47.27	B1	
46.30	51.73	43.30	B0	A2
41.17	46.70	40.73	B1	
	3.07			LSD 0.05

Plant height (cm plant^{-1})

It is noted from the results of table (5) that the addition of vermicompost caused a significant increase in the height of the yellow maize plant, as treatment A2 gave the highest average of height (354.1) cm plant^{-1} compared to the comparison treatment (A0), which recorded the lowest average (271.7) cm plants^{-1}. Organic matter has an important role in increasing plant height, and this may be due to the role played by organic fertilizers in reducing the degree of soil reaction, which has a clear effect on increasing the readiness of nutrients in the soil and some micro-nutrients and increasing the absorption of them by the roots and then increasing plant growth and development it. (Al Taweel, 2015)

Seaweed extracts B1 significantly outperformed in a plant height, and recorded an average of (335.7) cm plant^{-1} compared to the treatment of without addition of seaweed extracts (B0), which recorded (313.4) cm plant^{-1}. The reason may be due to the content of organic seaweed extracts of amino acids and hormones that increase the plant's nutrient content, stimulate the process of cell division, elongate cells, and thus increase plant growth. (Veysel et al., 2011).

The addition of nitrogen fertilizer levels (C0, C1 and C2) had a significant effect on the characters of plant height, the treatment (C1) achieved the highest average of plant height as (345.8) cm plant^{-1} compared to the treatment without adding nitrogen fertilizer (C0), which achieved (295.3) cm plant^{-1}. The reason of the increase in plant height when adding nitrogen fertilizer (urea) may be attributed to the positive role of nitrogen in increasing the activity of meristematic tissues and cell division, and the importance of nitrogen in building amino acids such as tryptophan, which composes the substance controlled to build auxins, which has a role in cell division and elongation (Loddo and Gooding, 2012), and these results are close with which founded by Abu Tabikh (2019).

The results show that the binary interference resulting from the addition of vermicompost fertilizer and seaweed extracts was significantly affected in the plant height, as the A1B1 combination recorded the highest value of (363.3) cm plant^{-1} compared to the A0B0 combination, which recorded the lowest value of (249.1) cm plant^{-1}.

On the other hand, the results of the binary interaction resulting from the addition of vermicompost fertilizer and nitrogen fertilizer showed a significant effect of the interaction between factors in plant height, as the combination A2C1 gave the highest value of (382.0) cm plant^{-1}, while the combination A0C0 gave the lowest value of (236.2) cm plant^{-1}.

It is also noticed that the binary interaction between seaweed extracts and nitrogen fertilizer had a significant effect on plant height (Table 5), as the combination B1C1 achieved the highest value of (356.6) cm plant^{-1} compared to the combination B0C0, which recorded the lowest value of (277.9) cm plant^{-1}. The reason for the superiority of the binary interaction treatment between seaweed extracts and 50% of the nitrogen fertilizer recommendation may be due to the extract's content of amino acids and plant hormones that increase the activity of the plant's vital processes as well as the ready-made nutrients provided by the nitrogen fertilizer, which caused the increase in plant growth and then increase its height.

The effect of triple interaction between vermicompost fertilizer, seaweed extracts and nitrogen fertilizer was significant on maize plant height (Table 5), as A1B1C1 combination recorded the highest value of plant height reaching (393.0) cm plant^{-1} compared to combination A0B0C0, which recorded the lowest value of (207.7) plant cm^{-1}.

Table (5): Plant height (cm plant^{-1})			
(Vermicompost levels A tone H^{-1})	A0	A1	A2
	271.7	348.0	354.1
LSD 0.05		9.2	
Seaweed Extract levels B kg H^{-1}))	B0		B1
	313.4		335.7
LSD 0.05		7.5	
Average nitrogen fertilizer C (Kg N H^{-1})	C0	C1	C2
	295.3	345.8	332.6
LSD 0.05		9.2	
Binary interference between (vermicompost) A × B (seaweed extract)			
	B0		B1
A0	249.1		294.2
A1	332.7		363.3
A2	358.6		349.6
LSD 0.05		13.0	
Binary interference between (vermicompost) A × C (nitrogen fertilizer)			
	C0	C1	C2
A0	236.2	278.8	300.0
A1	331.0	376.7	336.3
A2	318.8	382.0	361.3
LSD 0.05		15.9	
Binary interference between (seaweed extract) B × C (nitrogen fertilizer)			
	C0	C1	C2
B0	277.9	335.1	327.3
B1	312.8	356.6	337.8

LSD 0.05			13.0	
Triple interference between treatments A × B × C				
		C0	C1	C2
A0	B0	207.7	254.3	285.3
	B1	264.7	303.3	314.7
A1	B0	299.3	360.3	338.3
	B1	362.7	393.0	334.3
A2	B0	326.7	390.7	358.3
	B1	311.0	373.3	364.3
LSD 0.05			22.4	

The Dry Weight of the Root Total (gm. plant^{-1})

It is noted from Table (6) that the addition of vermicompost gave a significant increase in the dry weight of the root total, as treatment A1 recorded the highest average dry weight of the root total, reaching (11.641) gm. plant^{-1} compared to the treatment of the without adding of vermicompost (A0), which recorded the lowest average of (9.453) gm. plant^{-1}, and the reason may be attributed to the positive effect of organic matter in increasing the growth and development of roots by increasing the supply of nutrients, including phosphorous and nitrogen (Coelho et al., 2016), and these results are agree with Al-Zuhairi (2020).

The addition of seaweed extracts (B1) led to a significant increase in the average dry weight of the root total and achieved the highest average for the character of (10.983) gm.plant^{-1} compared to the treatment of no addition of seaweed extracts (B0), which recorded the lowest average of (10.699) gm. plant^{-1}. The reason for the increase in the dry weight of the root total may be attributed to the characteristics of seaweed extracts and their containment of hormones that stimulate the process of cell division and the increase in the growth of lateral capillaries of the roots, which leads to an increase in the surface area of these roots and thus increase their efficiency in absorbing water and nutrients from the soil and the positive reflection of that on the weight of the roots (Pettit, 2003 and Asik et al., 2009).

The addition of nitrogen fertilizer levels significantly affected the average dry weight of the root total (Table 6), as treatment C1 recorded the highest average dry weight of the root total, reaching (11,054) gm. plant^{-1} compared to the treatment without adding nitrogen fertilizer (C0), which recorded the lowest average for the characteristic (10.647) gm.plant^{-1}, the reason for the increase is due to the role of adding nitrogen fertilizer in improving the physical, chemical and biological properties of the soil, which led to improving the spread and growth of the root total and then increasing its dry weight (Makinde et al., 2010), and these results were similar to that founded by Elijah Al-Tawil (2015) and Abu Tabikh (2019).

It is noticed from the results that the binary interaction between vermicompost fertilizer and seaweed extracts had a significant effect on the dry weight of the root total, as the combination A2B0 recorded the highest value of (12.249) gm.plant^{-1} compared to combination A0B0, which recorded the lowest value of (8.792) gm.plant^{-1}. The reason for the increase may be due to the role of vermicompost fertilizer and seaweed extracts in increasing root secretions, accelerating plant growth, increasing the number and size of plant cells, as well as improving their performance in absorbing water and nutrients and thus increasing the dry weight of the root part (Al-Khafaage et al., 2013).

As for the binary interaction between vermicompost fertilizer and nitrogen fertilizer, its effect was significant on the dry weight of the root total, as the A1C1 combination achieved the highest value of (12.180) gm.plant^{-1} compared to the A0C0 combination, which achieved the lowest value of (9.052) gm.plant^{-1}.

On the other hand, the effect of the binary interaction between seaweed extracts and nitrogen fertilizer was significant in the dry weight of the root total (Table 6), as the combination B1C1 gave the highest value of (11.480) gm.plant^{-1} compared to the combination B0C0, which recorded the lowest value of (10.621) gm.plant^{-1}.

The results of the statistical analysis in Table (6) show that there was a significant effect of the triple interaction between the vermicompost fertilizer, seaweed extracts and nitrogen fertilizer on the dry weight of the root total, as the A1B1C1 combination recorded the highest dry weight value of the root total, reaching (12.840) gm.plant^{-1} compared to the A0B0C0 combination that the lowest value was (8.163) gm.plant^{-1} .

Table (6): The dry weight of the root total (gms plant^{-1})				
(Vermicompost levels A tone H^{-1})		A0	A1	A2
		9.453	11.641	11.429
LSD 0.05			0.143	
Seaweed Extract levels B kg H^{-1}))		B0		B1
		10.699		10.983
LSD 0.05			0.117	
Average nitrogen fertilizer C (Kg N H^{-1})		C0	C1	C2
		10.647	11.054	10.822
LSD 0.05			0.143	
Binary interference between (vermicompost) A × B (seaweed extract)				
		B0		B1
A0		8.792		10.113
A1		11.054		12.228
A2		12.249		10.609
LSD 0.05			0.203	
Binary interference between (vermicompost) A × C (nitrogen fertilizer)				
		C0	C1	C2
A0		9.052	9.398	9.908
A1		11.462	12.180	11.282
A2		11.428	11.538	11.275
LSD 0.05			0.248	
Binary interference between (seaweed extract) B × C (nitrogen fertilizer)				
		C0	C1	C2
B0		10.621	10.628	10.847
B1		10.673	11.480	10.797
LSD 0.05			0.203	
Triple interference between treatments A × B × C				
		C0	C1	C2
A0	B0	8.163	8.747	9.467
	B1	9.940	10.050	10.350
A1	B0	10.907	11.520	10.737
	B1	12.017	12.840	11.827
A2	B0	12.793	11.617	12.337
	B1	10.063	11.550	10.213
LSD 0.05			0.351	

Dry weight of shoots (gm. plant $^{-1}$)

The results of table (7) showed the significance of adding vermicompost fertilizer in increasing the average dry weight of the shoots. Treatment A1 recorded the highest average for the character, which was (57.13) $gm.plant^{-1}$ compared to the treatment without adding vermicompost (A0), which recorded the lowest average of (46.36) $gm.plant^{-1}$. The reason of the increase when adding vermicompost fertilizer may be attributed to its role in increasing the readiness of nutrients in the soil and then increasing them in the plant, including nitrogen and phosphorus, and increasing the chlorophyll content of leaves (Table 4), which led to an increase in the photosynthesis process and an increase in its metabolites and its reflection on the dry weight of the shoots. This is in agree with Al-Zuhairi (2020) results.

The treatment of adding seaweed extracts (B1) significantly outperformed the average dry weight of the shoots and gave an average of (54.73) gm. $plant^{-1}$ compared to the treatment of without addition of seaweed extracts (B0), which gave the lowest average for the character of (52.30)$gm.plant^{-1}$. The reason of the increase may be attributed to the content of seaweed extracts of nutrients, amino acids, and growth regulators that increased the nitrogen and phosphorous content of the leaves and the positive reflection of that in the increase in leaf chlorophyll content (Table 4), plant height (Table 5), dry weight of the root total (Table 6) and the effect of this increases the activity of plant life processes, increases the efficiency of the photosynthesis process, increases the dry matter resulting from it, and its accumulation in the plant, and its reflection on the increase in the dry weight of the shoot, and this is agree with the results of Al-Nasser (2016).

The addition of nitrogen fertilizer levels showed a significant effect on the dry weight of the shoots (Table 7), as treatment C1 recorded the highest average for the character, reaching (56.57) gm. $plant^{-1}$ compared to the treatment without adding nitrogen fertilizer (C0), which recorded (51.28) gm. $plant^{-1}$. The reason may be attributed to the superiority of the same treatment with the highest percentage of nitrogen and phosphorous in the leaves, the content of the chlorophyll in the leaves , the plant height (Tables 4 and 5), the dry weight of the root total (Table 6), and the positive effect of that in activating the physiological activities within the plant tissue and then increasing the dry weight of the shoots. These results are agreement with Akdeniz et al (2006) and al-Saadoun and al-Dahri (2011).

The effect of the interaction resulting from the addition of vermicompost fertilizer and seaweed extracts was significant in the dry weight of the shoots, as the combination A1B1 gave the highest value of (60.54) gm. $plant^{-1}$ compared to the combination A0B0, which gave the lowest value of (43.44) gm. $plant^{-1}$.

The effect of the binary interaction resulting from the addition of vermicompost fertilizer and nitrogen fertilizer was significant in the dry weight of the shoots, as the A1C1 combination recorded the highest value of (62.19) gm. $plant^{-1}$ compared to the A0C0 combination, which recorded the lowest value of (42.35) gm. $plant^{-1}$, and this shows that the interaction between organic and mineral fertilizers reflected positively in plant growth by improving soil physical, chemical and biological properties and increasing nutrient readiness and processing for plant growth (Houot et al. 2009 and Prendergast-Miller et al., 2014).

As for the binary interaction between seaweed extracts and urea, it had a significant effect on the dry weight of the shoots, as the combination B1C1 achieved the highest value of (59.06) gm. $plant^{-1}$ compared to the combination B0C0, which achieved the lowest value of (50.38) $gm.plant^{-1}$ (Table 7)).

The results indicate a significant effect of the triple interference resulting from the addition of vermicompost fertilizer, seaweed extracts and nitrogen fertilizer on the dry weight of the shoots (Table 7), as the A1B1C1 combination recorded the highest value of (66.65) gm. $plant^{-1}$ compared to the combination A0B0C0, which recorded the lowest value of (Table 7). 38.36) gm. $plant^{-1}$.

Table (7): The dry weight of the shoots (gm. plant $^{-1}$)				
(Vermicompost levels A tone H^{-1})		A0	A1	A2
		46.36	57.13	57.06
LSD 0.05			1.27	
Seaweed Extract levels B kg H^{-1}))		B0		B1
		52.30		54.73
LSD 0.05			1.03	
Average nitrogen fertilizer C (Kg N H^{-1})		C0	C1	C2
		51.28	56.57	52.70
LSD 0.05			1.27	
Binary interference between (vermicompost) A × B (seaweed extract)				
		B0		B1
A0		43.44		49.27
A1		53.72		60.54
A2		59.75		54.38
LSD 0.05			1.79	
Binary interference between (vermicompost) A × C (nitrogen fertilizer)				
		C0	C1	C2
A0		42.35	47.02	49.70
A1		53.87	62.19	55.33
A2		57.61	60.50	53.08
LSD 0.05			2.19	
Binary interference between (seaweed extract) B × C (nitrogen fertilizer)				
		C0	C1	C2
B0		50.38	54.11	52.42
B1		52.18	59.06	52.98
LSD 0.05			1.79	
Triple interference between treatments A × B × C				
		C0	C1	C2
A0	B0	38.36	44.76	47.19
	B1	46.34	49.28	52.20
A1	B0	49.07	57.73	54.36
	B1	58.68	66.65	56.29
A2	B0	63.70	59.84	55.70
	B1	51.52	61.15	50.46
LSD 0.05			3.10	

Total Yield (Mg H^{-1})

The results of table (8) indicate that there are significant differences between the levels of vermicompost addition, as treatment A1 recorded the highest average total yield of (11,299) Mg.H^{-1} compared to the treatment of without addition of vermicompost (A0),which recorded (6.901) Mg.$H^{-1.}$ The reason for this increase may be attributed to the superiority of the same treatment in the percentage of nitrogen and phosphorous in the leaves and the content of chlorophyll in the leaves (Table 4) and the dry weight of the root total and shoots (Tables 6 and 7) and the effect of this on increasing the transport and accumulation of dry matter in the reproductive parts of the plant, which reflected positively on the increase in the percentage of pollination and fertilization of florets and then increasing the total yield, and this is agree with that findings by Golabi et al. (2006), Farhad et al. (2009), Nasim et al. (2012).

As for the treatment of adding seaweed extracts, it was significantly superior and recorded (10.361) Mg H^{-1} compared to the treatment of without addition of seaweed extracts, which recorded (9.227) Mg H^{-1}, and the reason for the increase in the total yield of yellow maize is attributed to the role of adding seaweeds extracts in increase the nitrogen and phosphorous content of the leaves, leaf chlorophyll content (Table 4), plant height (Table 5), dry weight of the root total (Table 6) and the shoots. (Table 7).

The addition of nitrogen fertilizer had a significant effect on the total yield of maize, as treatment C1 recorded the highest average total yield of (10.500) Mg H^{-1} compared to the treatment without adding nitrogen fertilizer (C0), which recorded the lowest average of (9.019) Mg H^{-1} (Table 8). The superiority treatment of adding nitrogen fertilizer by half the recommended amount may be due to the higher results for most of the vegetative growth characters of the plant (Tables 4, 5, 6 and 7), which led to the production of high rates of dry matter, its transfer and accumulation in the reproductive parts of the plant, and thus the total yield increased.

The effect of the binary interaction between vermicompost fertilizer and seaweed extracts was significant in the total yield, as the A1B1 combination recorded the highest value of (12.551) Mg H^{-1} compared to the combination A0B0, which recorded the lowest value of (5.788)Mg H^{-1}. The reason may be due to the role of seaweed extracts, which have a direct effect on the vegetative and root growth of the plant, as it has a role in stimulating the absorption of nutrients, as well as the role of vermicompost in increasing the readiness of the elements and its reflection on increasing the total yield (Veysel et al., 2011 and Shehata et al., 2011).

The results showed that there was a significant effect of the binary interaction resulting from the addition of vermicompost fertilizer and nitrogen fertilizer on the total yield of maize, as the A1C1 combination achieved the highest value, which reached (12.790) Mg H^{-1} compared to the A0C0 combination, which achieved the lowest value of (5.363) MgH^{-1}. This may be attributed to the complementarity between nitrogen fertilization and vermicompost, which leads to the availability of nutrients to the plant and to fill a needs in the growing season because the organic fertilizer helps to create a balance between the nutrient content of the soil and the amount of production, and this is agree with Brar (2001) .

As for the binary interaction between seaweed extracts and nitrogen fertilizer, it had a significant effect on the total yield, as the combination B1C1 recorded the highest value, reaching (11,497) Mg H^{-1} compared to the combination B0C0, which recorded the lowest value of (8.646) Mg H^{-1} (Table 8)). This may be due to the fact that seaweed extracts contain amino acids within their components that work to increase plant growth and its content of nutrients as this is reflected in the yield as well as the addition of seaweed extracts is more effective and activity compared to mineral fertilizer alone for the plant, and these extracts by containing the amino acids they will reduce nitrogen loss by volatilization resulting from urea hydrolysis (Veysel et al., 2011).

The results of Table (8) indicate that there is a significant effect of a triple interference between the study treatments (vermicompost, seaweed extracts, and nitrogen fertilizer) on the total yield of yellow maize, as the A1B1C1 combination gave the highest value of total yield which reached (13.479) Mg H^{-1} compared to the A0B0C0 combination that gave the lowest value of the total was (4,388) Mg H^{-1}. The reason is due to the role of vermicompost, which is rich in nutrients and contributes to increasing its readiness in the soil and increasing its absorption by the plant by the secretion of growth-stimulating substances, and production of chelating compounds and the acidification of the medium, as well as the integrated role of mineral composts and seaweed extracts, and this is consistent with both Golabi et al (2006), Kumari et al (2008), Aseri et al (2009), and Kidinda et al (2015).

Table (8): Total yield (M H^{-1})				
(Vermicompost levels A tone H^{-1})		A0	A1	A2
		6.901	11.299	11.180
LSD 0.05			0.855	
Seaweed Extract levels B kg H^{-1}))		B0		B1
		9.227		10.361
LSD 0.05			0.480	
Average nitrogen fertilizer C (Kg N H^{-1})		C0	C1	C2
		9.019	10.500	9.862
LSD 0.05			0.550	
Binary interference between (vermicompost) A × B (seaweed extract)				
		B0		B1
A0		5.788		8.015
A1		10.047		12.551
A2		11.845		10.516
LSD 0.05			0.832	
Binary interference between (vermicompost) A × C (nitrogen fertilizer)				
		C0	C1	C2
A0		5.363	6.964	8.377
A1		10.259	12.790	10.848
A2		11.453	11.747	10.360
LSD 0.05			1.019	
Binary interference between (seaweed extract) B × C (nitrogen fertilizer)				
		C0	C1	C2
B0		8.646	9.504	9.530
B1		9.391	11.497	10.194
LSD 0.05			0.832	
Triple interference between treatments A × B × C				
		C0	C1	C2
A0	B0	4.388	5.600	7.375
	B1	6.338	8.327	9.380
A1	B0	8.071	11.113	10.956
	B1	12.446	14.467	10.741
A2	B0	13.479	11.798	10.259
	B1	9.390	11.696	10.461
LSD 0.05			1.440	

The percentage of the grains protein (%)

The results of the statistical analysis shown in table (9) indicate that there are significant differences in the average protein content in grains when adding vermicompost, as treatment A1 recorded the highest protein content in grains, reaching (12.30%) compared to the comparison treatment (A0), which recorded (8.25%). The increase in protein content in grains may be due to the increase in nitrogen content in the leaves (table 20), as nitrogen enters the formation of amino acids, which are the main block for proteins building. (Abu Dahi and Al-Younes, 1988).

The results of the statistical analysis showed that the treatment of seaweed extracts (B1) significantly outperformed the percentage of the grains protein, as it recorded (11.18%) compared to the comparison treatment (B0), which recorded (10.34%). The reason for the increase may be due to the fact that the addition of seaweed extracts led to an increase in the proportion of nitrogen in the leaves, then the nitrogen , indirectly works on the speed of absorption and transfer of the other elements by entering into the formation of chlorophyll pigments, thus increasing the process of carbon representation and building of proteins of great importance in stimulating plant growth, which led to increase the efficiency of plant absorption and accumulation of the other of the elements, including phosphorous and potassium, and as a result increased protein in the grains (Abu Dahi and Younes, 1988). These results are in agreement with Al-Khafaji (2010), El-Awadi et al. (2011), and Abdel-Mawgoud et al (2011).

As for nitrogen fertilizer, the results of the statistical analysis showed significant differences between its three levels (C0, C1 and C2). Treatment C1 (adding 50% of the fertilizer recommendation) recorded the highest protein content in grains reaching (11.50%) compared to the comparison treatment (C0) that was recorded (9.90%). The reason may be attributed to the amount of nitrogen absorbed in the vegetative part, which was transformed into the grains, which led to an increase in protein, and this is agreement with Al-Ani (2018).

The effect of the binary interaction between vermicompost fertilizer and seaweed extracts was significant in the protein content of the grains, as the A1B1 combination gave the highest value (12.91%) compared to the A0B0 combination, which gave the lowest value (6.94%).

The effect of the binary interaction between vermicompost and nitrogen fertilizer was significant in the proportion of protein in the grains, as the A1C1 combination recorded the highest value, reaching (13.43%) compared to the A0C0 combination, which recorded the lowest value of (6.88%).

As for the binary interaction between seaweed extracts and nitrogen fertilizer, it had a significant effect on the protein content in the grains (Table 9). The treatment B1C1 gave the highest value (12.10%) compared to the combination B0C0 which gave (9.58%).

The results of the statistical analysis in table (9) show that there was a significant effect of the triple interference between vermicompost fertilizer, seaweed extracts and nitrogen fertilizer in the proportion of protein in grains, as the A1B1C1 combination achieved the highest value of (13.59%) compared to the combination A0B0C0, which recorded the lowest value of (5.66%).

The results show the positive role of adding vermicompost fertilizer and seaweed extract in raising the efficiency of using yellow maize for nitrogen fertilizer by reducing 50% of its recommended amount and the positive effect of that in improving plant growth and development by increasing the availability of the necessary nutrients and raising the efficiency of the root total to absorb these elements, as a result, increase the efficiency of the photosynthesis process, produce high rates of dry matter in the vegetative growth stage, and increase its transmission and accumulation in the reproductive parts of the plant, which is reflected positively on increases the process of pollination and fertilization, then increasing the total yield as well as improving the quality of grains.

Table (9): The percentage of protein in grains (%)

(Vermicompost levels A tone H^{-1})	A0	A1	A2
	8.25	12.30	11.73
LSD 0.05		0.25	
Seaweed Extract levels B kg H^{-1}))	B0		B1
	10.34		11.18
LSD 0.05		0.20	
Average nitrogen fertilizer C (Kg N H^{-1})	C0	C1	C2
	9.90	11.50	10.87
LSD 0.05		0.25	

Binary interference between (vermicompost) A × B (seaweed extract)

	B0	B1
A0	6.94	9.55
A1	11.68	12.91
A2	12.38	11.07
LSD 0.05	0.35	

Binary interference between (vermicompost) A × C (nitrogen fertilizer)

	C0	C1	C2
A0	6.88	8.29	9.57
A1	12.00	13.43	11.46
A2	10.81	12.78	11.60
LSD 0.05		0.43	

Binary interference between (seaweed extract) B × C (nitrogen fertilizer)

	C0	C1	C2
B0	9.58	10.90	10.52
B1	10.21	12.10	11.23
LSD 0.05		0.35	

Triple interference between treatments A × B × C

		C0	C1	C2
A0	B0	5.66	6.85	8.31
	B1	8.10	9.73	10.82
A1	B0	11.59	12.25	11.19
	B1	12.41	14.61	11.72
A2	B0	11.50	13.59	12.06
	B1	10.11	11.97	11.13
LSD 0.05			0.61	

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