Effect of Seaweed and Nano fertilizers on Growth and Nutrient content in Maize Plant

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ABSTRACT:

A field experiment was conducted during the 2022 agricultural summer season, at one of the fields of Jamajon Desouk, Kafr El-Sheikh Governorate, to study the response of the maize (*Zea mays* L,) to add three levels of seaweed fertilizer 0, 1 and 2 kg ha^{-1}, there were four levels of nano-macronutrients: 0, 15, 25, and 50% of the N, P, and K doses that are recommended. The Field experiment was a split plot design with three replicates. Total plot area was 10.5 m^2 (Each plot consisted of 4 lines 3 - meters in width and 3.5 m was used for estimating yield and yield components at harvesting. Results from this study demonstrated a considerable advantage of the SW2 seaweed fertilizer treatment over the comparison treatment for all growth and yield characteristics, followed by the treatment with NF2 macronutrients. The combination (SW2 + NF2) generated the most significant improvement in the characteristic of dry weight, yield of grains, and the highest values for (NPK) concentrations in the straw and grain because of the binary interaction between fertilizing seaweed and nano-macro nutrients.

Keywords: Seaweed; macronutrients; nano-fertilizers; maize.

INTRODUCTION:

Maize is the world's third most farmed crop, after only wheat and rice. Protein, crude fibre, ether extract, and carbohydrates are all found in maize. Maize supplies a significant quantity of energy in both human and animal diets (livestock). The crop delivers amino acids to the organism. (Piperno *et al.*, 2001) indicated that maize contains 2% minerals and 2% vitamins in addition to 80% of carbohydrates, 10% protein, and 3.5% fibres. (Guo *et al.*, 2005) according to studies, between 40% and 70% of the nitrogen and between 80% and 90% of the phosphorus in fertilizers that are applied either escape into the atmosphere or degrade into forms that are unsuitable for plant absorption. In addition to depleting resources and resulting in huge economic losses, it also seriously harms the ecosystem. (Khan *et al.*, 2009) According to studies, seaweeds are macro-algae that have a variety of uses, including waste treatment, integrated aquaculture, fertilizer, soil conditioner, animal feed, cosmetics, and biofuel (Halpern *et al.*,2015). it has been discovered that seaweed influences soil processes, improving soil structure and improving nutrient solubility, to encourage seed germination, plant growth, and plant defense against pathogens and pests, as well as directly impacting plant physiology through modifications in root influence and increased root colonization by fungi. (Alkhalil, 2011) in addition, seaweed, which is used to promote vegetative growth, is a fertilizer alternative to mineral fertilizers. It contains minerals (N, P, K, Ca, Mg, and S), amino acids, carbohydrates, plant growth hormones, and vitamins (Zodape,2001). It was found that seaweed fertilizers included a high concentration of nutrients such as nitrogen, phosphate, potassium, plant growth hormones, and trace minerals. This seaweed fertilizer increases seed germination and plant growth/crop production (Devnita *et al.*, 2018). Nanotechnology can greatly increase crop yields by controlling nutrient release, as this technique has proven to be effective in managing agricultural resources and the mechanisms for delivering nutrients to plants, increasing soil fertility, improving microorganism activity, and increasing the decomposition of organic residues in the soil. Nutrients were added in the form of nanoparticles. It is one of the latest agricultural techniques being utilized to improve soil qualities and hence crop production (Rico *et al.,* 2011).Nanomaterials boost critical plant processes. Plants' leaf and root surfaces, which are porous with nanoparticles, serve as entrance points for vital nutrients. Thus, nano-fertilizers improve plant nutrient absorption or enable complex uptake using molecular carriers or intracellular or ion channels. (Lubkowski, K. 2016) revealed that an integrated nano-fertilizer including NPK, and amino acids enhanced nutrient absorption and utilization in grain crops. Furthermore, nanotechnology can give the capability to connect nitrogen release from fertilizers with crop needs, but only if it can be directly absorbed by plants. When compared to traditional fertilizers, which were added extremely early and released in tiny quantities for up to 30 days, nano-fertilizers exhibited an early release and delayed nutrient release that lasted up to 60 days (Liu *et al.*, 2006). Because the release of nitrogenous and phosphate fertilizers coincides with crop absorption, the application of nanoparticles in fertilizers has also helped control the flow of nutrients from fertilizers. As a result, the loss of nutrients is decreased by direct plant uptake. reducing nutrient interactions with the soil in addition. (Basim *et al.*, 2021) the greatest increase in the plant's height dry weight and grain yield was shown to be produced by the combined effects of fertilizing seaweed and nano-fertilizers.

MATERIALS AND METHODS

Experiment

In the summer of 2022, a field experiment was carried out. at Jamajon, Desouk, Kafr El-Sheikh Governorate to investigate the interaction effects of seaweed fertilizer and nano fertilizers on the productivity and nutrient content of maize (*Zea mays* L.). The field experiment was a split-plot design with three replicates. A total plot area of 10.5 m^2 (each plot consisted of 4 lines of 3-meter width and 3.5-meter-long middle ridges) was used to estimate yield and yield components at harvesting, then three amounts of seaweed fertilizer (0, 1, and 2 kg ha^{-1}) and has been given the designations SW0, SW1, and SW2, respectively. which contains 46% organic matter and 4% amino acids, and four levels of macronutrients manufactured according to nanotechnology Which are (0, 15, 25, and 50) of N, P, and K indicated dosages and took the symbols NF0, NF1, NF2, and NF3 in the soil. At harvest (120 days from sowing), a random sample of plants was taken from each plot to determine the weight of grain yield, straw yield, and N, P, and K concentrations in grain and straw (%).

Soil sample

To show the clay soil before agriculture, a sample of the highest surface of the soil (0.0 to 30 cm) was taken from Jamajon, Desouk. Kafr El-Sheikh Governorate, the soil was crushed, air dried, and then sieved through a 2 mm sieve before being maintained in glass bottles. Table 1 contains information gleaned from the examination of the sample's physical and chemical properties.

Organic fertilizer

Farmyard manure (FYM), an organic form of manure, was used to prepare land for agricultural use. Table (2) lists its chemical characteristics.

Nano-fertilizers

Nanofertilizers have been delivered from the National Research Center in Dokki, Giza, Egypt. In the experiment, four nano (N+P+K) treatments at rates of 0.0, 15, 25, and 50% of the indicated dosages of N, P, and K have been used in comparison to the control treatment. A typical ammonium nitrate fertilizer with a 33.5% N-NH_4-NO_3 nitrogen concentration was used. Superphosphate (15%) P_2O_5 was used as a phosphorus source for nanofertilizer, in contrast. Potassium sulfate (48% K_2O) was used as a potassium source for nanofertilizer.

Producing a nanofertilizer.

Hexadecyl trimethyl ammonium bromide (HDTMABr) was used to surfactant modify the zeolite, according to Banishwal *et al.*, (2006). The HDTMABr solution (200 mg/L) and zeolite were combined in a 1:100 (solid: liquid) ratio. On an orbital shaker, the mixture was stirred for 7-8 hours at 150 rpm before being filtered. After being cleaned with double-distilled deionized water, the solid residue was dried in an oven for 4-6 hours. The surfactant-modified zeolite (SMZ) was then mechanically pulverized into tiny particles using a mortar and pestle.

Soil analysis

The hydrometer method was used to determine the particle size distribution (Ryan *et al.,* 1996). Using Collin's calcimeter, calcium carbonate concentration was calculated (Jackson 1973). The Walkley and Balk method was used to calculate the organic matter content (Jackson 1973). A 1:2.5 soil suspension was used to test the pH value of the soil reaction (Jackson, 1973). Jackson (1973) used a 1:2.5 soil water extract to measure electrical conductivity (E C). Micro Kildahl was used to assess the amount of available nitrogen (Jackson, 1973). According to the Olsen method, the amount of available phosphorus was measured calorimetrically (Jackson, 1973). A flame photometer can assess the amount of potassium and sodium that is available (Jackson, 1973). Ammonium purpurate was used as an indication for calcium, and Eriochrome black T was used as an indicator for magnesium + calcium while determining calcium Ca^{++} and magnesium Mg^{++} volumetrically using a versinate solution (Jackson, 1973). HCl was used to titrate soluble carbonates (CO_3) and bicarbonates (HCO_3) for the formation of phenolphthalein indicators and methyl orange indicators for the latter (Jackson, 1973). The ratio of the difference between the sum of the anions and the cations was utilized to calculate the sulfate.

Plant analysis

Straw and seeds weighing 0.2 g each were digested in a solution of $HClO_4$ and H_2SO_4 in accordance with the method described by (Chapman and Pratt in 1978). The Microkjelhal was used to determine the amount of nitrogen (Jackson, 1973). Using ammonium molybdate and the method described by (Jackson 1973), phosphorus was calculated colourimetrically. Jackson (1973) states that the Flame photometrical method was used to determine potassium.

Statistical analysis

A thorough statistical analysis of variance (ANOVA) was performed on the data by Barbara and Brain (1994) using the Mintab program, and the least significant differences (LSD) were identified at the level of 0.05%.

RESULTS AND DISCUSSION

Effect of seaweed and Nano fertilizer rates on growth parameters of maize **plant.**

The data contained in Table (3) demonstrated that increasing the amount of seaweed and nanoparticle fertilizers increased the average dry weight and grain yield of maize plants. The percentage of dry weight and grain yield of maize plants were shown to be significantly impacted by the binary interaction between seaweed fertilizers and nano-fertilizers as compared to the control treatment.

Effect of seaweed and Nano fertilizer rates on shoot dry weight and grain yield (kg/h) of maize **plants.**

Regarding seaweed application rates, the outcomes presented in Table (4) demonstrated that the efficacy of the use of SW2 resulted in the greatest dry weight and grain yield values of (2818.899) and (3632.399 kg h^{-1}), respectively. Compared to the control treatment, the SW0 application resulted in the lowest results for dry weight and grain yield (2531.236 and 3400.512kg h^{-1}) respectively). These outcomes align with what Hasanand and Turki (2019) have accomplished. The cause may be linked to the seaweed fertilizer, which includes organic acids and creates perfect circumstances for plant development by enhancing the availability of nutrients to plants and enhancing the qualities of fertile soil, hence promoting plant growth and height.

Regarding the impact of applying nano-fertilizers at different rates, the data in Table (3) revealed that NF3 being applied led to the greatest values for dry weight and grain yield of (2920.582) and (3917.253 kg h^{-1}) respectively. In this regard, applying NF1 resulted in the lowest values for dry weight and grain yield, which were (2716.129) and (3547.278kg h^{-1}), respectively, as compared to the control treatment. The data gathered in this study are consistent with those made by Zheng *et al.*, (2005) who found that using nano-fertilizers boost crop productivity according to various research investigations. The main cause of this is an increase in photosynthesis, which in turn enhances plant growth, metabolism, and nutrient intake.

When compared to the control treatment, the SW2+NF2 treatment outperformed and produced the highest values, as well as the highest values for dry weight and grain yield (kg h-1) with the application of (SW2 + NF2) and the lowest values with the application of (SW1 + NF1). This indicates that the binary interaction between seaweed fertilizers and nanofertilizers had a significant impact.

The data shown in Table (4) suggests that increasing the amount of seaweed and nanofertilizer caused maize plants to have higher average N concentrations. When compared to the control treatment (100%), it was discovered that the binary interaction between seaweed fertilizers and nano-fertilizers significantly affected the percentage of N concentrations in maize plants.

Data introduced in Table (4) showed that nitrogen concentrations (%) in straw and grain significantly increased with the addition of seaweed. The greatest values for N (%) in straw and grain were (1.55) and (2.33) respectively, recorded with SW2 the application compared to other treatments, whereas the smallest values for N (%) in straw and grain were (1.22) and (1.88) respectively, recorded with SW0 application. The outcomes were consistent with those mentioned by Shehata *et al.*, (2011). showed that seaweed might supply plants with essential amounts of N, which could increase plant growth.

The data presented in Table (4) demonstrated that the use of nanofertilizers substantially raised the nitrogen concentrations (%) of straw and grain. In comparison to other treatments, NF2 application produced the best values for N (%) in straw and grain, which were 1.93 and 3.30, respectively. In contrast, NF3 used gave the lowest values for N (%) in straw and grain, which were 1.50 and 2.19, respectively. These outcomes are in line with what Lal (2008) has accomplished. According to reports, nutrient usage effectiveness (NUE), as well as preventing nutrients from getting fixed or lost in the medium, can all be improved with the use of nanofertilizers to regulate the slow release of nutrients from fertilizer granules. Nanofertilizers can be used repeatedly and have high utilization efficacy.

As for the binary interaction between seaweed fertilizers and nano-fertilizers, it had a significant effect; the SW2+NF2 treatment outperformed and gave the highest values, also the best numbers for yields of grains and straw nitrogen contents (%) were 2.31 and 3.98(%) with the application of (SW2 + NF2), the lowest levels of N content in grain and straw, although were 1.60 and 2.01 (%) with the application (SW1) + (NF1) compared with control treatments. The outcomes were consistent with those mentioned by Khan *et al.*, (2009) through publication, it might be proved seaweed and nanoparticle fertilizers increase branch count, leaf area, and dry weight percentages. Since seaweed does not damage the water, soil, or air and is rich in nutrients, growth regulators, vitamins, and organic acids, it is both affordable and environmentally friendly. Additionally, plants can easily absorb them.

Effect of seaweed and nano-fertilizer rates on phosphorous concentration (%) of straw and grain by maize plants.

Data introduced in Table (5) showed that P concentrations (%) of straw and grain significantly increased with the application of seaweed, with the greatest P (%) values in straw and grain being (0.44) and (0.79) when using SW2 in comparison to other therapies, respectively, while the lowest values for P (%) in straw and grain were (0.25) and (0.35), respectively, recorded with the SW0 application. The outcomes of this investigation concurred with those of Blunden *et al.* (1992), who found that seaweed aids in the establishment of robust roots in plants that can more effectively absorb nutrients and water, as well as the promotion of vegetative development by accelerating chlorophyll synthesis. The production and quality of the products are also improved by enhancing the balanced and long-term uptake of macronutrients from the soil.

Data presented in Table (5) indicated that the use of nanofertilizers significantly boosted the P concentrations (%) of straw and grain. In comparison to other treatments, the use of NF2 recorded the greatest P (%) values in straw and grain as (0.55) and (0.35), respectively, whereas the application of NF1 recorded the lowest P (%) values in straw and grain as (0.28) and (0.66), respectively. The research results of this study are consistent with Mikhak *et al.*, (2017) findings that nutrient encapsulation and nanoparticle fertilizers can limit the release of micro- and macronutrients to places in plants. The SW2+NF2 treatment outperformed and generated the most significant results, as well as the greatest P concentrations in straw and grain yield (%), were 0.66 and 0.99 (%) with the use of (SW2 + NF2), while lower P concentrations in straw and grain yield (%) were 0.56 and 0.71 (%) with the application of (SW1) + (NF1) compared to control treatments. The resultant results obtained were consistent with those mentioned by Khan *et al.* (2009). It has been demonstrated that adding seaweed and nanoparticle fertilizers increases branch count, leaf area, and dry weight percentages. Since seaweed does not damage the water, soil, or air and is rich in nutrients, growth regulators, vitamins, and organic acids, it is both affordable and environmentally friendly. Additionally, plants can easily absorb them.

Effect of seaweed and nano-fertilizer rates on potassium concentration (%) of straw and grain by maize plants.

The information in Table (6) demonstrated that increasing the amount of seaweed and Nano fertilizers caused maize plants to have higher average K concentrations. When compared to the control treatment (100%), it was discovered that the binary interaction between seaweed fertilizers and nano-fertilizers significantly affected the percentage of K uptake by maize plants.

Data introduced in Table (6) showed that K concentrations (%) of straw and grain significantly increased with the application of seaweed. The greatest amounts of K (%) in straw and grain were recorded with SW2 the application compared to other treatments, while the lowest levels of K (%) in straw and grain were recorded with the application SW0. The outcomes of this investigation concurred with those of Blunden *et al.* (1992), who found that seaweed aids in the establishment of robust roots in plants that can more effectively absorb nutrients and water, as well as the promotion of vegetative development by accelerating chlorophyll synthesis. The production and quality of the products are also improved by enhancing the balanced and long-term uptake of macronutrients from the soil.

Data presented in Table (6) demonstrated that applying nano fertilizers significantly increased the k concentrations (%) of straw and grain. Compared to other treatments, the application of NF2 produced the most significant values for k (%) in straw and grain, which were (2.36) and (2.27) respectively, while the application of NF1 produced the lowest values for k (%) in straw and grain, which were (1.70) and (1.43) respectively. These findings are in line with those made by Fansuri *et al.*, (2008), who found that using nanofertilizers increases agricultural production. Higher photosynthesis promotes quicker plant growth, metabolism, and nutrient uptake, which causes this.

The SW2+NF2 treatment outperformed and produced the highest values, while the greatest K concentrations in straw and grain yield (%) were 2.55 and 2.89 (%) with the addition of (SW2 + NF2), whereas the lowest P concentrations in straw and grain yield were 1.79 and 1.52 (%) with the addition of (SW1) + (NF1) compared to control treatments. The outcomes from this study agreed with those released by Halpern *et al.*, (2015) it has been demonstrated that adding seaweed and nanoparticle fertilizers increases branch count, leaf area, and dry weight percentages. Since seaweed does not damage the water, soil, or air and is rich in nutrients, growth regulators, vitamins, and organic acids, it is both affordable and environmentally friendly. Additionally, plants can easily absorb them.

CONCLUSION

The use of seaweed and nano-fertilizers has had a significant impact on maize growth and nutrient concentration, as well as on the costs of fertilizers and the environment. In this regard, the best treatment was (SW2 + NF2), It caused the attributes indicated above to have their greatest value. Thus, it can be said that seaweed and nano fertilizers are suitable substitutes for conventional soluble fertilizers since they release nutrients more slowly, enabling plants to take up the nutrients before they are lost.

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Table 1: Some physical and chemical properties of investigated soil

Property			
Particle size distribution, %		Sand	19.33
		Silt	29.47
		Clay	51.20
Textural grade			Clay
O.M %			1.26
Ca CO3 (%)			4.01
pH (Soil paste)			7.99
EC (dSm^{-1}, at 25 ^{o}C) 1:5			0.58
Soluble ions ($meq\ l^{-1}$)	Cations	Ca^{++}	0.84
		Mg++	1.39
		Na+	3.03
		K+	0.62
	Anions	CO3--	-
		HCO3-	1.87
		CL	2.44
		SO4--	1.57
Total soluble ($mg\ kg^{-1}$)		N	39.11
		P	3.99
		K	218.10
		Fe	14.19
		Zn	2.99
		Mn	11.30

Table 2: Some chemical analysis of the applied organic matter.

Material	pH 1:5	EC 1:5	C: N ratio	O.M %	N %	P %	K %	Fe ppm	Zn ppm	Mn ppm
F.Y.M	8.03	1.43	17:2	41.59	1.66	0.77	0.86	351	82	83

Table 3: Effect of seaweed and nano-fertilizer on dry weight and grain yield in maize plant ((kg h-1).

	dry weight (kg h-1)					grain yield (kg h-1)				
Nanofertilizes Seaweed	NF0	NF1	NF2	NF3	Mean	NF0	NF1	NF2	NF3	Mean
SW0	2531.236	2716.129	2894.849	2920.582	2765.699	3400.512	3547.278	3881.648	3917.253	3686.673
SW1	2649.957	2872.905	3093.681	3007.747	2906.073	3500.844	3695.721	4102.536	3920.751	3686.673
SW2	2818.899	2973.904	3280.513	3108.023	3045.335	3632.399	3875.330	4145.425	4057.972	3686.673
Mean	2666.697	2854.313	3123.014	2978.784		3511.252	3706.109	4076.536	3931.992	
Control " treatment 100%RD) dry weight				3084.352		Control"treatment100%RD) grain weight				4099.874
L.S.D 0.05	SW 1.789		NF 1.023		SW + NF2.006	SW 2.241		NF 2.099		SW + NF 3.998

Table 4: Effect of seaweed and nano-fertilizer on nitrogen content (%) of straw and grain in maize plant.

	N (%) in straw					N (%) in grain				
Nanofertilizes Seaweed	NF0	NF1	NF2	NF3	Mean	NF0	NF1	NF2	NF3	Mean
SW0	1.22	1.56	1.93	1.50	1.55	1.88	2.94	3.30	2.19	2.58
SW1	1.29	1.60	2.01	1.69	1.65	2.12	2.01	3.72	2.33	2.72
SW2	1.55	1.77	2.31	1.82	1.86	2.33	3.02	3.98	3.11	3.11
Mean	1.35	1.64	2.08	1.67		2.11	2.89	3.67	2.54	
Control " treatment 100%RD) N (%)				2.00		Control " treatment 100%RD) N (%)				2.99
L.S.D 0.05	SW 0.003		NF 0.002		SW + NF 0.005	SW 0.004			NF 0.003	SW + NF 0.006

Table 5: Effect of seaweed and nano-fertilizer rates on phosphorous concentration (%) of straw and grain in maize plant.

	P (%) in straw					P (%) in grain				
Nanofertilizes Seaweed	NF0	NF1	NF 2	NF3	Mean	NF0	NF1	NF2	NF3	Mean
SW0	0.25	0.28	0.55	0.49	0.39	0. 35	0. 66	0.75	0. 72	0.75
SW1	0.29	0.56	0.59	0.53	0.49	0. 61	0. 71	0.88	0.81	0.85
SW2	0.44	0.59	0.66	0.56	0.56	0. 79	0. 79	0.99	0.92	0.96
Mean	0.33	0.48	0.60	0.53		0.58	0.72	0.87	0.81	
Control " treatment 100%RD) P (%)			0.53			Control " treatment 100%RD) P (%)				0.85
L.S.D 0.05	SW 0.001	NF 0.001	SW + NF 0.002			SW 0.004	NF 0.005			SW + NF 0.008

Table 6: Effect of seaweed and nano-fertilizer rates on potassium concentration (%) of straw and grain in maize plant.

	K (%) in straw					K (%) in grain				
Nanofertilizes Seaweed	NF0	NF1	NF2	NF3	Mean	NF0	NF1	NF2	NF3	Mean
SW0	1.11	1.70	2.36	2.09	1.82	1.03	1.43	2.27	1.80	1.66
SW1	1.59	1.79	2.41	2.18	1.99	1.19	1.52	2. 71	2.11	1.61
SW2	1.66	2.02	2.55	2.28	2.13	1.31	1.79	2.89	2.49	2.12
Mean	1.45	1.84	2.44	2.18		1.18	1.58	2.63	2.13	
Control " treatment 100%RD) K (%)				2.39		Control " treatment100%RD) K (%)				2.57
L.S.D 0.05	SW 0.003	NF 0.002		SW + NF 0.005		SW 0.003				NF0.004 SW + NF 0.005

تأثير الطحالب البحرية وأسمدة النانو على النمو وتركيز العناصر الغذائية لنبات الذرة

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الملخص العربي:

أجريت تجربة حقلية خلال الموسم الصيفي الزراعي 2022 بأحد حقول قرية جماجون دسوق بمحافظة كفر الشيخ لدراسة استجابة نبات الذرة (Zea mays L,) لإضافة ثلاثة مستويات من الطحالب البحرية 0 ، 1 و 2 كجم هكتار-1 و أربعة مستويات من أسمدة النانو كانت 0 و 15 و 25 و 50٪ من الجرعات الموصى بها من المغذيات N و P و K وكان تصميم التجربة الحقلية عبارة عن تصميم قطعة منقسمة بثلاث مكررات إجمالي مساحة القطعة 10.5 م2 (تتكون كل قطعة من 4 خطوط عرض 3 متر في 3.5 متر. أظهرت النتائج تفوق معنوي للمعاملة بلطحالب البحرية SW2 تليها معاملة العناصر الكبرى NF2 في كل صفات النمو واالمحصول المدروسة مقارنة بمعاملة الكونترول أما بالنسبة للخلط بين الطحالب البحرية والمغذيات النانوية فقد أعطى التوليفة (SW2 + NF2) زيادة معنوية في صفات الوزن الجاف وحاصل الحبوب وأعلى قيم لـ (تركيزات (NPK في القش والحبوب مقارنة بالكنترول.

الكلمات الاسترشادية : الطحالب البحرية، أسمدة النانو ، المغذيات الكبرى، نبات الذرة.