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ORIGINAL ARTICLE

EFFECT OF SEAWEED AND MICRO NUTRIENT NANO-FERTILIZERS ON GROWTH AND YIELD OF QUINOA PLANT GROWN UNDER SOIL CONDITIONS OF AL-GHARRAF, NASIRIYAH, IRAQ

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Abstract: A field experiment was conducted during the 2019-2020 agricultural season, at one of the fields of Al-Gharaf district, north of Nasiriyah, to study the response of the quinoa plant to adding three levels of seaweed fertilizer 0, 1 and 2 kg ha^{-1}, four levels of nano- micro nutrients were 0, 1, 2 and 3 kg ha^{-1}, which contain (Fe 8%, Zn 6%, Mn 4%, B 2%) and was dissolved in 400 liters of water ha^{-1}. The experiment was designed according to a Randomized Complete Block Design (RCBD) with three replicates. The results showed significant superiority of SW_2 seaweed fertilizer treatment, followed by the treatment of the NF_3 micronutrients in all growth and yield characteristics studied as compared to the comparison treatment. As for the binary interaction between fertilizing seaweed and nano-micro nutrients, the combination ($SW_2 + NF_3$) gave the highest significant increase in the characteristic of plant height, dry weight of the plant, and grain yield, reaching 84.93 cm, 54.79 g and 2.944 Mg ha^{-1}, respectively, the combination ($SW_2 + NF_1$) achieved the highest mean weight characteristic of 1000 grains of 3.257 g.

Key words: Seaweed, Micro nutrient nano-fertilizes, Quinoa, Al-Gharraf, Nasiriyah.

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1. Introduction

Quinoa (*Chenopodium quinoa*) is a herbaceous plant belonging to the family Amaranthaceae, the Andes Mountains in South America, it was currently grown in Bolivia, Peru, the United States, Ecuador and Canada as a food crop. Quinoa can be used as both human food and animal feed, characterized by its high nutritional value, high in protein and a wide range of minerals and vitamins. At recent years there has been an increase in interest in quinoa as a cereal crop, its production has increased exponentially all over the world, because of its good nutritional properties, but also because of its ability to grow and adapt under different climatic conditions, it can withstand frost, salinity, drought and the ability to grow in marginal soils.

Seaweed promotes seed germination and plant growth, it also promotes plant protection from pathogens and pests, by affecting soil processes, as it improves soil structure and increases the solubility of nutrients in the soil, as well as affecting plant physiology directly, through changes in root morphology and increased root colonization by mycorrhizal fungi [Halpern *et al.* (2015)]. The lack of readiness of the micronutrients, whether they are already in the soil or that is added in the form of mineral fertilizers, it was the result of the high degree of soil reaction. Iraqi soils were distinguished by their high concentrations of carbonate minerals and high soil pH values, leads to its transformation into forms that are not ready for absorption by the plant, its concentration in the soil decreased [Ali and Al-Juthery (2017) Al-Hasany *et al.* (2020)].

Nanotechnology can greatly increase crop yields by controlling nutrient release, as this technique has

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proven to be good in managing the resources of the agricultural sector and the mechanisms for delivering nutrients to plants, helps increase soil fertility and improve the activity of microorganisms, increased the decomposition of organic residues in the soil. The addition of nutrients was in the form of nanoparticles. It is one of the new tools used in agriculture to improve soil properties, enhancing crop yields [Devnita *et al.* (2018)].

2. Materials and Methods

A field experiment was conducted during the 2019-2020 agricultural season, at a field in Al-Gharaf district, 30 km north of Nasiriyah city center, it lies at longitude 46°, 28.3896'21 and latitude 14.6754' 20°31, in clay loam soil, to study the effect of adding three levels of seaweed fertilizer 0, 1 and 2 kg ha^{-1} and took the symbols SW_0, SW_1 and SW_2, respectively, which contains (46% organic matter and 4% amino acids), and four levels of micronutrients manufactured according to nanotechnology 0, 1, 2 and 3 $kgha^{-1}$ and took the symbols NF_0, NF_1, NF_2 and NF_3, which contains (Fe 8%, Zn 6%, Mn 4% and B 2%) and was dissolved in 400 liters of $waterha^{-1}$.

The experiment consisted of 12 treatments applied using a Randomized Complete Block Design (RCBD) with three replicates.

Samples were taken from the study soil before planting and for different sites and the samples were mixed well to obtain a compound sample, some chemical and physical analyzes were performed on it (Table 1).

Quinoa seeds were planted on 11/15/2019, after dividing the land into 4 m^2 plot, by the form of lines with 9 lines for each experimental unit and the distance between the lines is 20 cm, plants were watered as needed. NPK fertilizers were added in the form (urea, triple superphosphate and potassium sulfate) at 50% level of fertilizer recommendation for all treatments as a initiator. Phosphate fertilizer was added in the amount of 80 kg P ha^{-1} P2O5 44% in one batch before planting. Potassium fertilizer 150 kg ha^{-1} (41.5% K) was added in one batch before planting. Nitrogen fertilizer was added in an amount of 200 kg N ha^{-1} in the form of 46% N urea, divided into four installments (20.20, 30 and 30%), the first batch was added after a month of planting, then followed by the other batches, with a difference of one month between one batch and another. Seaweed fertilizer and micro nutrient nano-fertilizer were added in two batches, the first after a month and the second two months after planting, according to the manufacturer's recommendation (Fanavar Nano-Pazhoohesh Markazi Company, Iran).

Table 1: Some chemical and physical properties of the soil before planting.

Traits		Value	Unit
pH		7.88	
ECe		4.35	Dms. m^{-1}
O.M		6.82	g. kg^{-1}
Available Nitrogen		24	mg kg^{-1}
Available Phosphorus		12	mg kg^{-1}
Available Potassium		167	mg kg^{-1}
Calcium carbonate		208	g. kg^{-1}
Fe		0.28	mg kg^{-1}
Zn		0.15	mg kg^{-1}
Mn		0.29	mg kg^{-1}
B		0.31	mg kg^{-1}
Texture (clay loam)	Sand	270	g. kg^{-1}
	Silt	400	g. kg^{-1}
	Clay	330	g. kg^{-1}

2.1 Studied traits

1. **Plant height (cm):** When harvesting, 5 plants were taken randomly from each experimental unit. The plant height was measured from the ground level to the tip of the inflorescence on the main stem.
2. **The dry weight of the plant (g $plant^{-1}$):** The whole plant, except for the roots, was weighed, then air-dried and weighed.
3. **Number of branches per plant:** The number of branches per plant was calculated as an mean of five plants, taken randomly for each experimental unit.
4. **Number of leaves per plant:** The number of leaves per plant was calculated as an mean of five plants that were taken randomly for each experimental unit.
5. **1000 grains (g):** Calculate from the weight of 1000 grains randomly for each experimental unit using a sensitive electronic balance.
6. **Grain yield (mg ha^{-1}):** It was calculated from the yield of the unit area in square meters from each experimental unit and was converted on the basis of (mg ha^{-1}).

Statistical analysis

Data were analyzed statistically by analysis of variance using a randomized complete block design

Table 2: Effect of addition of seaweed and nanofertilizes on plant height (cm).

Nanofertilizes Seaweed	NF_0	NF_1	NF_2	NF_3	Mean
SW_0	45.15	47.26	48.47	56.44	49.33
SW_1	52.78	59.48	68.78	64.27	61.33
SW_2	61.35	77.04	84.69	84.93	77.00
Mean	53.09	61.26	67.31	68.55	
$L.S.D_{0.05}$	SW	NF	SW + NF		
	3.195	3.689	6.389		

Table 3: Effect of addition of seaweed and nanofertilizes on dry weight (g plant^{-1}).

Nanofertilizes Seaweed	NF_0	NF_1	NF_2	NF_3	Mean
SW_0	14.37	21.12	21.12	24.49	
SW_1	21.83	28.77	38.35	35.51	20.28
SW_2	32.92	45.00	54.59	54.79	31.12
Mean	53.09	31.63	38.02	38.26	46.82
$L.S.D_{0.05}$	SW	NF	SW + NF		
	2.942	3.398	5.885		

(R.C.B.D.) and with three replications, using the Genstat program, the means of the coefficients were compared using the least significant difference (LSD) at a probability level of 0.05.

3. Results and Discussion

Plant height (cm)

Table 2 shows significant differences between the adding seaweed fertilizer treatments, SW_2 outperformed and gave the best mean (77.00 cm), with a significant difference from the SW_1 treatment (61.33 cm), with an increase in the rate of the superior treatment amounting to 56.09%, as compared to the comparison treatment SW_0, which gave the lowest mean of 49.33 cm. The reason may be attributed to the seaweed fertilizer, which contains organic acids, provides ideal conditions for plant growth by increasing plant nutrient readiness and improving fertile soil properties, increases plant growth and height [Hasan and Turki (2019)].

The results also showed that there were significant differences between the means of the treatments when adding the micronutrient fertilizers, the addition of the NF_3 fertilizer significantly outperformed (68.55 cm), with an increase of 29.12%, compared with comparison treatment, with a non-significant difference from the NF_2 addition level (67.31 cm). This is due to the positive role of nano-nutrients in improving soil properties, and improve efficiency and absorption of nutrients, characterized by a large surface area and a relatively small particle size [Janmohammadi1 *et al.* (2016)].

As for the binary interaction between seaweed fertilizers and micro nano-fertilizes, it had a significant effect, SW_2+NF_3 treatment outperformed and gave the highest mean for this trait (84.93 cm), which was not significantly different from the level of addition SW_2+NF_2, the percentage of the increase achieved was 38.43 and 38.04%, respectively, compared to the comparison treatment, it recorded the lowest mean of 61.35.

Dry weight (g plant^{-1})

Table 3 shows significant differences between the averages of fertilizer treatments for adding seaweed fertilizer, the treatment SW_2 outperformed the dry weight (46.82 g plant^{-1}), which was significantly different from the SW_1 level, with an increase in the superior treatment amounting to 130.86%, compared to the comparison treatment, the lowest average was 20.28 g plant^{-1}. The reason could be attributed to the role of seaweed fertilizer, contains organic matter and amino acids to improve soil building, promoted the growth of the plant and the increase of the shoots and thus the increase in the dry weight of the plant.

The addition of micronutrient fertilizer manufactured with nanotechnology also had a significant effect, the treatment of the highest level of fertilizer NF_3 was superior to giving the highest average

Table 4: Effect of addition of seaweed and nanofertilizes on number of branches.

Nanofertilizes Seaweed	NF_0	NF_1	NF_2	NF_3	Mean
SW_0	8.33	21.12	10.67	13.67	10.75
SW_1	12.67	13.33	17.33	16.33	14.92
SW_2	15.67	19.33	20.67	21.33	19.25
Mean	12.22	14.33	16.22	17.11	
$L.S.D_{0.05}$	SW	NF	SW + NF		
	1.771	2.045	NS		

Table 5: Effect of addition of seaweed and nanofertilizes on leave number.

Nanofertilizes Seaweed	NF_0	NF_1	NF_2	NF_3	Mean
SW_0	19.33	22.33	24.67	28.67	23.75
SW_1	35.33	35.67	41.33	41.67	38.50
SW_2	40.00	43.33	48.33	48.67	45.08
Mean	31.56	33.78	38.11	39.67	
$L.S.D_{0.05}$	SW	NF	SW + NF		
	2.399	2.770	NS		

dry weight of the plant which was 38.26 g $plant^{-1}$, it did not differ significantly from the treatment NF_2, which recorded an average value of 38.02 g $plant^{-1}$, with an increase of 66.05 and 65.01%, as compared to the comparison treatment of 23.04 g $plant^{-1}$, due to the nano-nutrients, increase the formation of chlorophyll and thus increase the rate of photosynthesis, leads to improved overall plant growth, thus increasing the dry weight of the plant.

The binary interaction between fertilizing seaweed and nanofertilizers had a significant effect on plant dry weight, the treatment outperformed SW_2+NF_3 and gave the highest average of 54.79 g $plant^{-1}$, with a non-significant difference from the level of addition SW_2+NF_2, which reached 54.59 g $plant^{-1}$, as for the comparison treatment, the lowest average was recorded at 14.37 g $plant^{-1}$.

The number of branches

Table 4 shows the significant differences between the averages of the fertilizer treatments for adding seaweed fertilizer, the treatment surpassed SW_2, gave the best significant value for the number of branches, at 19.25, with a significant difference from the SW_1 treatment, which recorded an average of 14.92, with an increase of 79.06% for the superior treatment, compared to the comparison treatment SW_0, which recorded the lowest average of 10.75. The reason for this was the role of seaweed fertilizer, which helped provide the plant with many nutrients necessary for plant growth, increased the vegetative growth, which in turn increased the number of branches formed in the plant [El-Rokiek *et al.* (2019)].

The results also showed that the addition of micronutrients fertilizer manufactured with nanotechnology at the highest level NF_3 led to a significant increase in the number of branches, gave the highest average of 17.11, with a significant difference from the level of fertilizer NF_2, which reached 16.22, with an increase of 40.01 and 32.73%, compared to the comparison treatment that gave the lowest value, which was 12.22, the increase in the number of branches may be due to the fact that these fertilizers are characterized by the slow release of nutrients, which increases the absorption of nano nutrients due to their small size, the activity of chloroplasts increases, promotes growth and increases the number of branches [Janmohammadi *et al.* (2016)].

As for the binary interaction between fertilizing seaweed and nanoforms, it had no significant effect on this trait.

Leave number

Table 5 shows the significant differences between the averages of the seaweed fertilizer addition treatments, as the number of sheets increased, as the increasing level of addition increased, the highest value for this characteristic when transaction SW_2 was 45.08,

Table 6: Effect of addition of seaweed and nanofertilizes on 1000 grains weight(g)

Nanofertilizes Seaweed	NF_0	NF_1	NF_2	NF_3	Mean
SW_0	1.977	2.513	2.580	2.750	2.455
SW_1	2.777	2.943	3.063	3.137	2.980
SW_2	3.040	3.257	3.230	3.100	3.157
Mean	2.598	2.904	2.958	2.996	
$L.S.D_{0.05}$	SW	NF	SW + NF		
	0.0509	0.0588	0.1018		

Table 7: Effect of addition of seaweed and nanofertilizes on grain yield (Mg ha^{-1}).

Nanofertilizes Seaweed	NF_0	NF_1	NF_2	NF_3	Mean
SW_0	0.741	0.952	1.170	1.766	1.157
SW_1	1.938	2.366	2.674	2.536	2.378
SW_2	2.539	2.753	2.939	2.944	2.794
Mean	1.740	2.023	2.261	2.415	
$L.S.D_{0.05}$	SW	NF	SW + NF		
	0.1113	0.1285	0.2226		

with a significant difference from treatment SW_1, which gave an average of 38.50, while the comparison treatment recorded the lowest average for this trait, which was 23.75. This may be due to seaweed fertilizer, which improved better nutrient absorption by plant root cells, increased photosynthesis, which led to an increase in vegetative growth and then an increase in the average number of leaves in the plant.

As for the addition of micronutrients fertilizer made with nanotechnology, it led to a significant increase in the number of papers, plants that were fertilized with NF_3 gave the highest average number of leaves, with 39.67, with a non-significant difference from the addition of NF_2 treatment, which gave an average of 38.11, while the comparison treatment recorded the lowest average for this characteristic, which was 31.56, the reason could be due to nano fertilizers, helped improve the absorption of nutrients by the plant cells, increased the growth of plant parts, including the leaves [Lemraski *et al.* (2017)].

As for the binary interaction between fertilizing seaweed and nanofertilizers, it had no significant effect on this trait.

1000 grains weight (g)

Table 6 shows the existence of significant differences between the averages of the fertilizer treatments for adding seaweed fertilizer, treatment SW_2 outperformed in the weight of 1000 grains (3.157 g), a significant difference from the treatment SW_1 (2.980 g), with an increase of 28.59 and 21.38%, compared to the comparison treatment, the lowest average was 2.455 g. The reason for this is due to the positive role that seaweed fertilizer plays in influencing the soil's physical and chemical properties, as well as increasing the activity of micro-organisms present in the soil, which promotes plant growth, which in turn has a positive effect on grains [El-Bassiouny *et al.* (2014)].

The results showed a significant effect of the addition of micronutrient fertilizer made with nanotechnology, the treatment outperformed NF_3 by giving the highest mean weight of 1000 grains, which was 2.996 g, the difference was not significant for NF_2, which gave a mean of 2.958 g, while the comparison treatment recorded the lowest average for this trait, which was 2.598 g. The increase is attributed to the nanofertilizers in improving soil properties, help transport and absorb ready-made nutrients into the soil, resulting in better crop growth, the ease of transporting carbohydrates from the source to the downstream and increasing the fullness of the bean [Al-Juthery *et al.* (2018)].

As for the binary interaction between seaweed fertilizer and micro-nutrients nanofertilizers, it had a significant effect on this characteristic, and the treatment SW_2+NF_1 was significantly superior to it, which gave the highest average of 3.257 g, the difference was not significant for the interference treatment SW_2+NF_2, which was 3.230 g, as for the comparison treatment, the lowest average was 3.040 g.

Grain yield (mg ha^{-1})

Table 7 indicates significant differences between the averages of seaweed fertilizer addition treatments, as the treatment SW_2 outperformed and gave the best value for the grain yield, which was 2.794 Mg ha^{-1}, with a significant difference from treatment SW_1, which recorded an average of 2.378 Mg ha^{-1}, and an increase in the superior treatment amounted to 141.42%, compared to the comparison treatment, it gave the lowest mean of 1.157 Mg ha^{-1}, the reason for the increase in the grain yield may be due to the addition of seaweed fertilizer, improve the soil's physical and chemical properties, in addition to improving the activity of micro-organisms in the soil and equipping plants with the necessary nutrients, which contributed to the increase in vegetative growth, reflected positively on the increase in the total plant yield [Lavini *et al*. (2014)].

The results also showed that there was a significant increase in this characteristic when adding the nanofertilizers, the treatment NF_3 recorded the highest mean of 2.415 Mg ha^{-1}, and a significant difference from treatment NF_2, which amounted to 2.261 Mg ha^{-1}, with an increase of 38.79 and 29.94%, compared to the comparison treatment, the lowest mean was recorded for this trait, which was 1.740 Mg ha^{-1}. The reason for this is because the nano fertilizers enhanced the absorption of water and nutrients in the soil, photosynthesis products increase in the plant, contributed to an increase in dry matter and thus an increase in the yield [Seghatoleslami and Forutani (2015)].

As for the binary interaction between seaweed fertilizer and micro-nutrients nanofertilizers, it had a significant effect, and the treatment SW_2+NF_3 outperformed significantly, and it gave the highest average of 2.944 Mg ha^{-1}, with a non-significant difference from the SW_2 + NF_2 interaction treatment (2.939 Mg ha^{-1}), as for the comparison treatment, the lowest mean was recorded at 2.539 Mg ha^{-1}.

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References

Al-Hasany, A.R.K., S.K.J. Alhilfi and T.M.K. Alfarjawi (2020). Effect of foliar feeding with nano-boron on the growth and yield of two cultivars of faba bean crop (*Vicia faba* L.). *Int. J. Agricult. Stat. Sci.*, **16(1)**, 237-241.

Ali, N.S. and H.W.A Al-Juthery (2017). The Application of Nanotechnology for Micronutrient in Agricultural Production. *The Iraqi Journal of Agricultural Sciences,* **48(4)**, 984-990

Al-Juthery, H.W.A., K.H. Habeeb, F.J.K. Altaee, D.K.A. AL Taey and A.R.M. Al-Tawaha (2018). Effect of foliar feeding of different sources of nano-fertilizers on growth and yield of wheat. *Bioscience Research*, **15(4)**, 3988-3997.

Devnita, R., B. Joy, M. Arifin, A. Setiawan, S. Rosniawaty and F.S. Meidina (2018). The Phosphorus Status of Andisols as Influenced by Nanoparticles of Volcanic Ash and Rock Phosphate. *International Conference and Exhibition on Powder Technology Indonesia*, 030035-1-030035-7.

El-Bassiouny, H.S.M., B.A. Bakry, A.A. Attia and M.M. Abd Allah (2014). Physiological role of humic acid and nicotinamide on improving plant growth, yield and mineral nutrient of wheat (*Triticum durum*) grown under newly reclaimed sandy soil. *Agric. Sci*., **5**, 687-700.

El-Rokiek, K.G., G.D. Mona, S.S. Mervat and E.E. Mohamed (2019). The effect of the natural extracts of garlic or Eucalyptus on the growth, yield and some chemical constituents in quinoa plants. *Bulletin of the National Research Centre,* **43**, **119**.

Halpern, M., B. Asher, O. Maya, M. Dror, M. Torsten and Y. Uri (2015). The Use of Biostimulants for Enhancing Nutrient Uptake. *Advances in Agronomy*, **130**, 141-174.

Hasan, B.K. and Turki M.S. (2019). Effect of Nano Biological and Mineral Fertilizers on Growth and Yield of Wheat (*Triticum aestivum* L.). *Indian Journal of Ecology*, **46(8)**, 97-101.

Janmohammadi, M., A. Navid, A.E. Segherloo and N. Sabaghnia (2016a). Impact of nano-chelated micronutrients and biological fertilizers on growth performance and grain yield of maize under deficit irrigation condition. *Biologija*, **62(2)**, 134-147.

Lavini, A., C. Pulvento, R. d'Andria, M. Riccardi, R. Choukr-Allah, O. Belhabib, A. Yazar, C. Incekaya, S. Metin Sezen, M. Qadir and S.E. Jacobsen (2014). Quinoa's potential in the Mediterranean region. *J. Agro. Crop Sci*., **200**, 344-360.

Lemraski, M.G., G Normohamadi, H. Madani, H.H. Sharif Abad and H.R. Mobasser (2017). Two Iranian Rice Cultivars' Response to Nitrogen and Nano-Fertilizer. *Open Journal of Ecology*, **7**, 591-603.

Seghatoleslami, M. and R. Forutani (2015). Yield and Water Use Efficiency of Sunflower as affected by nano ZnO and Water Stress. *Journal of Advanced Agricultural Technologies,* **2(1)**, 34-37.