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Effect of Nano Biological and Mineral Fertilizers on Growth and Yield of Wheat (*Triticum aestivum* L.)

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Abstract: A field experiment was carried out in Al-Gharraf area of Thi–Qargovernorate during the agricultural season winter (2018-2019) insplit-plot arrangement and RCBD design with three replicationses., The main factor included mineral fertilization treatments were 0, 50 and 100% fertilizer recommendation. The secondary factor included bio-fertilization levels 0, 1.5 and 3kg ha^{-1}.The results showed that the treatment of mineral fertilizer exceeded the full recommendation of 50% in all traits, except 1000 grains weight**,** The results also indicated the superiority of treatment of nanofertilizer (without biofertilizer) in leaf area, spikes number, grains number, 1000 grains weight and grain yield, while 1.5kg ha^{-1}biofertilizer outperformed in plant height and biological yield.

***Keywords*:** Nanoparticles, Nano biological fertilizers, Growth, Yield, Wheat

The high population growth demand for food resources, make agricultural development more economical and efficient, as well as modern trends in environmental safety from pollution, modern techniques are used to reduce excessive use of chemical fertilizers, reduce nutrient losses in fertilization and increase yield (Ram et al 2017). Sustainable agriculture has focused on reducing the use of common chemical fertilizers, the adoption of new fertilizers that does not have a negative impact on the environment and human health (Parizad et al 2017). The application of bio-fertilization is one of the modern methods that reduce the excessive use of nitrogen fertilizers and increase the availability of phosphorus, potassium and other elements (Al-Khafaji 2018). Nanotechnology is one of the important and proposed solutions to increase agricultural production, more food can be produced at lower costs while reducing energy consumption, environmental pollution, however, many researches have detected toxicity conditions caused by nanoparticles of plants ranged This is not about technology but because of the materials properties (Al-Ramadi et al 2016). Nanotechnology offers ample scope for new applications in biotechnology, agriculture and fertilizer industry, nanoparticles possess special physical and chemical properties due to their high surface area, alternative natural resources can be used to make nanofertilizers to reduce environmental pollution and provide safety and health for humans, as well as the economic costs reduced from the chemical fertilizers use (Mahmoud et al 2017). The present study aimed to evaluate the response of wheat to of biofertilizers using nanotechnology and their interaction with levels of mineral fertilization (NPK).

MATERIAL AND METHODS

Agricultural operations: The field experiment was conducted in Thi–Qargovernorate, Al-Gharraf area (30 km north of Al-Nasiriyah city center) during the agricultural season 2018-2019**,** silty clay texture soil**,** of 1500 m^2 area. The land of experiment plowed perpendicular tillage with mulching plow, the harrowing and leveling process was then carried out, the field was divided into plots, $4m^2$ dimensions (2m * 2m), leaving a separation distance of 3 meters width between the replicate**,** 1 meter distance between the experimental units within the replicate, 2 meters distance between the main pieces within the replicate to prevent overlap of the experiment factors. Wheat seeds (Bohoth 22) were planted by 120 kg ha^{-1} in the lines form**,** 8 lines per experimental unit, the distance between the lines is 20 cm, the necessary irrigation waterways were opened according to the need of the plant, taking into account rainfall periods and climatic conditions. At the final ripening stage, the plant was harvested after five months.

Nitrogen fertilizer was added in the amount of 150 kg ha^{-1} (46% urea fertilizer form) in two batches, the first in the branching stage and the second in the flowering stage, P_2O_5 phosphate fertilizer was added in the amount of 80 kg ha^{-1} (triple super phosphate fertilizer P_2O_5% 44 form) at once before planting**,** potassium fertilizer was added 100 kg ha^{-1} (potassium sulphate fertilizer 41.5% K form) at once before planting, bio fertilizer containing three types of bacteria loaded on nanoparticles (*Azospirillium, Pseudomonas* and *Bacillus*), it was added at once before planting by dissolving the required quantity in 100 liters of water and distributing it to the experimental units.

Experiment factors: Mineral fertilization (NPK) treatments with three levels (0, 50 and 100% of the fertilizer recommendation with took the symbols M_0, M_1 and M_2, respectively). Bio-fertilization treatments with three levels (0, 1.5 and 3 kg $ha^{-1}$and symbols of B_0, B_1 and B_2, respectively.

Statistical analysis: The data were statistically analyzed using a split – plot arrangement in Randomized complete block design with three replications, the GenStat Twelfth Edition were used, the averages were compared to coefficients using the least significant difference (LSD) at a probability level of 0.05.

RESULTS AND DISCUSSION

Plant height: Significant differences (P≤0.05) among the mean treatments of mineral fertilizer addition**,** M_2 was superior and gave the best value for this trait, with no significant difference from treatment M_1, averaging 87.16 and 86.86 cm, with an increase of 7.81% and 7.44% sequentially compared to M_0(Table 1). It may be attributed to the increased availability of nutrients in the soil solution and the plant absorption, especially necessary nitrogen in the construction of chlorophyll, proteins, enzymes, hormones and amino acids, enter the cell division, elongation, then increase the growth and height of the plant (Al-Samawi 2012), consistent with Mandal et al (2015) noted the importance of nitrogen in increasing plant growth and height. The results also showed a significant effect (P≤0.05) of nanobiofertilizer, B_2 and B_1, which did not have a significant difference in plant height, gave an average of 86.55 and 86.15 cm with an increase of 5.34 and 4.56%, respectively, compared to B_0, due to the fact that the addition of nitrogen-fixing biofertilizers loaded on nanoparticles increased soil fertility and enhanced nutrient efficiency by reducing loss, especially nitrogen and thus increasing its readiness in the soil solution, which positively reflected the increased growth and plant height. Di-interaction between mineral fertilization and nanobiofertilizer had outperformed the M_1B_2, M_2B_2, M_2B_1 and M_1B_2 treatments as compared to the control, which did not significantly differ, M_1B_2 gave the highest plant height value (89.12 cm).

Flag leaf area (cm^2): The results of Table 1 shows the superiority (P≤0.05) of fertilizer treatments for the addition of mineral fertilizer, M_2 treatment was superior, gave the best value, followed by M_1, with no significant difference,46.22 and 46.13 cm^2 with an increase of 15.31% and 15.09%, respectively compared to the control, may be due to the physiological role of NPK mineral nutrients, which play an important role in increasing plant effectiveness, nitrogen was essential for photosynthesis and phosphorus is involved in the formation, division of living cells and cell membranes. Potassium is instrumental in plant growth through activation of various enzymes, stimulate root growth and cell division, regulate osmotic potential, open and close stomata, increased vegetative growth rates which lead to an increase in the number and size of leaves (Valizadeh and Milic 2016, Bekele 2018).

Table 1. Effect of nano biological and mineral fertilizer and interaction on wheat plant height (cm)*

Nano biological mineral	B_0	B_1	B_2	Mean
M_0	79.56 (38.57)	81.43 (41.45)	81.53 (40.23)	80.84 (40.08)
M_1	83.28 (43.38)	88.17 (48.69)	89.21 (46.03)	86.86 (46.03)
M_2	83.64 (43.58)	88.86 (48.99)	88.99 (46.37)	87.16 (46.31)
Mean	82.16 (41.84)	(46.37) 86.15	86.55 (44.21)	
LSD (0.05)	B = 1.203 (0.923) M = 2.372 (1.759) B * M = 2.372 (NS)			

*Flag leaf area (cm) in parentheses

The results showed that the addition of bio fertilizer manufactured according to nanotechnology had a significant effect(P≤0.05), B_1 was significantly higher at 46.37 cm^2, with an increase of 10.82% compared to B_0, due to the nanomaterials used as a biofertilizer carrier, they can remain in the soil for the longest time, These materials also stabilize the soil and organic soil material, which increased the vegetative growth of the plant, which in turn reflected on the flag leaf area (Ammar 2018), agreed with Kaviani and Negahdar (2016) that biofertilizers loaded on nanoparticles increased plant growth by increasing their lifespan in the soil, which allowed the plant to absorb nutrients longer and thus increase vegetative growth.

Spikes number m^{-2}: Table 3 shows that a significant differences(p≤0.05) between the fertilizer treatments for the addition of mineral fertilizer, M_2 exceeded and gave the best significant spikes number value, a significant difference from $M_{1,}$ with averaged 461.6 and 458.2 spike m^{-2} sequentially compared to control, due to the processing of the plant with the essential nutrients NPK, which positively reflected on the increase in the spikes number, which agreed with Gul et al (2011) and Kubar et al (2019).The results in the same table showed that the addition of nanobiofertilizer superiority resulted in B_1 and B_2, which did not have a significant difference in this characteristic of 430.9 and 427.6 spike m^{-2}compared to control. This can be attributed to the fact that biofertilizers increase soil fertility, promote plant growth through dilution of inhibitory products, increase available of essential nutrients, especially nitrogen and phosphorus, thereby increasing growth indicators, including the spikes number, this is indicated by Shende et al (2017), which showed that the bio fertilizer loaded on nanoparticles has achieved a noticeable increase in the overall growth rate of the plant. There was also a significant effect ($P \leq 0.05$) of bilateral interaction between mineral fertilizer and nanobiofertilizer on plant spikes, M_2B_1 gave the highest mean of 482.9 spike m^{-2}, While M_0B_2 recorded the lowest mean of this trait was 338.2 spike m^{-2} with a decrease of 29.96%, may be the nanofertilizers used more efficient than conventional fertilizers because they interfere with the plant and cause many morphological and physiological changes, depending on chemical composition and size, they enhance the efficiency of nutrient use, reduce fertilizer losses by regulating nutrient release (Mahmoud et al 2017).

Number of grains spike^{-1}: Table 2 showed a significant increase ($p \leq 0.05$) in the of mineral fertilization treatments (M_2 and M_1), a non-significant difference between them**,** by giving the highest average number of spike grains^{-1}**,** which reached 71.53 and 71.36 spike grains^{-1}**,** with an increase of 28.07% and 27.77%, respectively compared to the comparative treatment, may be attributed to the availability of NPK nutrients, which stimulated the vital processes of photosynthesis, the regulation of hormones, which contributed to increasing the percentage of grain hold on the spikes, which positively reflected on the increase in the number of spike grains. The addition of bio-fertilizer loaded on nanoparticles resulted in a significant increase in the spike grain number, plants fertilized with treatment B_1 produced the highest average number of spike grians at 67.33 grain spike^{-1}, an increase of 3.01%, This may be due to the contribution of biofertilizers to increasing the available and soil content of essential nutrients such as nitrogen, phosphorus and potassium, as well as its ability to secrete some of the chemical compounds that stimulate growth hormones such as cytokines, gibberellins and indole acetic acid, increased growth indicators and thus increased accumulation of dry matter (Mohamed et al 2019).

1000 grains weight (g): Table 3 indicated that a significant differences ($P \leq 0.05$) between the fertilizer treatments when adding mineral fertilizer, the comparative treatment (M_0) outperformed 47.00 g, while the plants fertilized with fertilizer treatments (M_1 and M_2), which did not differ significantly, produced the lowest grain weight and averages 44.44 and 43.41 g respectively, due to the inverse relationship between the grains weight and spikelet number, Tables (3 and 4) shows a decrease in the spikes number and the grains number, which led to the contribution of photosynthesis products to increase the weight of grains (Al-Hassany, 2018), agreed with Al-Taher (2005).The treatments of nanobiofertilizer and the interaction between mineral fertilizer and the biofertilizer carried on nanoparticles showed no significant effects in this characteristic.

Grains yield (t ha^{-1}): The treatment of the addition of mineral fertilizer M_2 significantly superior ($p \leq 0.05$) in the grain yield trait, it gave the highest grain yield with an average value (6.921 t ha^{-1}), an increase of 60.91% compared to the comparison treatment, this is due to the availability and increased concentration of NPK nutrients in the plant (Al-Tahir et al 2013).The treatments of biofertilizer loaded on nanoparticles, treatment B_1 was superior ($p \leq 0.05$), which gave an average of 6.644 tha^{-1}, an increase over the comparison of 37.38%, inoculation with bio-fertilizers

Table 2. Effect of nano biological and mineral fertilizer and interaction on number of spikes m^{-2*}

Nano biological mineral	B_0	B_1	B_2	Mean
M_0	262.7 (55.13)	342.2 (55.84)	338.2 (56.57)	314.4 (55.85)
M_1	437.3 (70.19)	467.6 (72.82)	469.8 (71.07)	458.2 (71.36)
M_2	427.1 (70.77)	482.9 (73.31)	474.7 (70.51)	461.6 (71.53)
Mean	375.7 (65.36)	430.9 (67.33)	427.6 (66.05)	
LSD (0.05)	B = 7.19 (7.21) M = 6.60 (6.68) B * M = 11.25 (NS)			

* Number of grains spike $^{-1}$ in parentheses

Table 3. Effect of nano biological and mineral fertilizer and interaction on 1000 g*rains* weight (g)*

Nano biological mineral	B_0	B_1	B_2	Mean
M_0	47.22 (3.880)	47.33 (4.476)	46.44 (4.547)	47.00 (4.301)
M_1	43.67 (5.120)	46.89 (7.580)	42.78 (7.133)	44.44 (6.611)
M_2	42.67 (5.507)	43.56 (7.876)	44.00 (7.382)	43.41 (6.921)
Mean	44.52 (4.836)	45.93 (6.644)	44.41 (6.354)	
$LSD_{0.05}$	B = NS (0.340) M 1.374 (0.197) B*M = NS (0.501)			

*Grains yield (t ha^{-1}) in parentheses

Table 4. Effect of nano biological and mineral fertilizer and interaction on biological yield (t ha^{-1})

Nano biological mineral	B_0	B_1	B_2	Mean
M_0	13.14	14.28	15.58	14.33
M_1	17.29	22.32	23.75	21.12
M_2	22.36	26.96	26.77	25.36
Mean	17.6	21.19	22.03	
$LSD_{0.05}$	B 0.956	M 7.752	B * M = 7.650	

increased the soil content of organic matter and nitrogen, improved the availability of nutrients as well as their contribution to increasing the absorption capacity of the roots of the nutrients, led to increased vegetative growth, reflected in the increase and redistribution of photosynthesis products, contributed to the increase in grain yield (Mirzaei et al 2010). Mardalipour et al (2014) indicated an increase in the yield when nanobiofertilizers were added to the wheat plant. The interaction between mineral fertilizer and nanobiofertilizer levels significantly increased ($p \leq 0.05$) the average grain yield, M_2B_1 gave the best value amounting to 7.876 tha^{-1} with a percentage increase of 102.98%. This is due to the superiority of the aforementioned treatment in the spikes number and the grains number (Tables 2), which came as a result of its superiority in the flag leaf area, supports the direct relationship between the grain yield, the spikes number and the grains number.

Biological yield (t ha^{-1}): Table 4 indicated that a significant differences ($P \leq 0.05$) between the treatments of mineral fertilizer addition, M_2 was superior, gave the best value of the biological yield, a non-significant difference with M_1, averaging 25.36 and 21.12 t ha^{-1}, an increase of 76.97 and 47.38% compared to the comparison treatment. The reason for the increase in the biological yield may be due to the absorption of nutrients that increased the rate of photosynthesis, which was positively reflected in the weight gain of dry matter. Lemraski et al (2017); Jamal and Muhammad (2007) reported that the addition of mineral nutrients achieved significant differences in the dry weight of the vegetative total of rice and wheat respectively. The results showed that the nanobiofertilizer treatments (B_2 and B_1) significantly exceeded ($p \leq 0.05$) with B_0 without significant difference between them, each of 22.03, 21.19 and 17.60 t.ha^{-1}, respectively. This is due to biofertilizers loaded on nanoparticles in improving soil properties as well as increasing an availability of nutrients that the plant benefits in biological processes and the formation of various tissues and thus increase the vegetative total, as noted in Table 1.B_2 and B_1 treatments exceeded in the plant height, which was positively reflected on the increase of biological yield, which agree with Mardalipour et al. (2014) and Mir et al (2015). They showed that the addition of biofertilizers contributed significantly to increasing the vegetative growth in the barley maize crop respectively. There was a significant interaction ($p \leq 0.05$) between mineral fertilizer and nanobiofertilizer in biological yield. M_2B_1, M_2B_2, M_1B_2 and M_1B_1 were given the highest mean values of 26.96, 26.77, 23.75 and 22.32 t ha^{-1}, respectively, compared to control and other treatments, this result is consistent with the indications Spruogis (2018), which obtained a significant increase in the trait of the biological yield when adding nanoparticle fertilizers with NPK compound fertilizer to the barley plant.

CONCLUSIONS

Mineral fertilization with NPK nutrients contributed to the provision of adequate quantities during the crop growth stages, which improved growth and yield of wheat plant. The interaction mineral fertilizers with bio-fertilizer loaded on nanoparticles reduced the amount of mineral fertilizer added to 50% of the fertilizer recommendation in most studied traits, reduces excessive chemical fertilizers uses, soil pollution and preserves the environment from pollution.

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