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Effect of Nano Biological and Mineral Fertilizers on NPK Uptake in Wheat (*Triticum aestivum* L.)

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Abstract: A field experiment was conducted Al-Gharaf area in Dhi-Qar province during the season 2018-2019. The split-plot arrangement according to with completely randomized block design. The study included two factors, the main factor in the included mineral fertilization treatments, with three levels were measurement half fertilizer recommendation (N 75 + P 40 + K 50) kg ha^{-1} and full fertilizer recommendation (N 150 + P 80 + K 100) kg ha^{-1}. The secondary factor included bio-fertilization loaded on nanoparticles without addition, 1.5 and 3 kg ha^{-1}, to study the effect of nano biological and mineral fertilizers on NPK uptake of wheat cultivated at clay loam soil. There were significant differences in NPK in grain and straw. Non-significant differences in interaction treatments indicate that half fertilizer recommendations can reduce the mineral fertilizer.

***Keywords*:** Nano biological fertilizers, NPK uptake, Nanoparticles, Nutrients

Macro elements contribute more than 95% of plant biomass; can be obtained from inorganic or organic sources (Barati 2010). The needs of crop plants for macronutrients were increase as demand for food increases for the world's growing population, Increased demand for macronutrients is expected to reach 263 million tonnes by 2050 (Alexandrato and Bruinsma 2012). Nanomaterials were materials that have at least one dimension of nanoscale, which was in the range 1 nm to less than 1 micrometer (µm) (Ali and Al-Juthery 2019). Nanotechnology currently has a major role in crop production while maintaining environmental pollution, different nanomaterials provide a unique role in agriculture, such as nanoscale biosensors to detect moisture content, soil nutrient status, water management, nutrients and pesticides in crop fields, nanoparticles can be used as fertilizers and pesticide carriers (Qureshi et al 2018). The uses of nanofertilizers are effective tools for nutrient management in agriculture and reduces the rate of chemical fertilizer use per unit area (Singh et al 2017). During the last two decades, nanotechnology has produced a wide range of nanomaterials, mostly produced from synthetic materials or metal particles.Due to growing uncertainty about the negative effects of manufactured nanomaterials, there was interest in the development of natural nanoparticles, which can be utilized in medicine, agriculture, nutrition, engineering and other fields, depends on the production of waste and living organisms and biological treatment with nanotechnology, conversion of insoluble substances into biologically available forms (Griffin et al 2018). Biofertilizers widely used as an alternative to chemical fertilizers, fertilizer producers have introduced new types of nanotechnology-based fertilizers, biofertilizers consisting of environmentally friendly microorganisms provide nutrients to the plant, improve soil fertility and crop productivity, nanoparticles provided the advantage of efficient loading due to their large surface area, organisms can be loaded on them (Ghormade et al 2011, Jakiene et al 2015).The present study aims to study the effect of biofertilizer loaded on nanoparticles and levels of NPK mineral fertilizers in the absorbed quantity of NPK nutrients and their content in the straw and grain yield.

MATERIAL AND METHODS

Agricultural operations: Soil samples were collected before planting depth of 0 - 30 cm and was air dried, sieved from a 2 mm sieve, analyzed for some chemical, physical and biological properties (Table 1).

Experiment factors: The experiment included two factors as follows:

1. NPK mineral fertilizers and three levels (0, 50, 100%) of the fertilizer recommendation (150 N + 80 P + 100 K) kg ha^{-1}, the symbols M_0, M_1 and M_2 were taken sequentially.
2. Bio-fertilization carried on nanoparticles and three levels (0, 1.5, 3) kg ha^{-1}, the symbols B_0, B_1 and B_2 were taken in succession.

NPK nutrients in straw (%): Plant samples were taken after the harvesting stage was completed and were dried in the oven and then grinded thoroughly using an electric mill. Sample of 0.2 g, was mixed 4 ml of concentrated sulfuric acid and turned black next day, and added to 1 ml concentrated perchloric acid. This was heated for half an hour and

Table 1. Chemical, physical and biological properties of soil samples before sowing

Parameters		Unit	Amount
pH			8
ECe		dsm^{-1}	5.89
O.M		Gkg^{-1}	9
$CaCO_3$		Gkg^{-1}	262
Dissolved ions	Calcium	$Mmoll^{-1}$	11.5
	Magnesium		6.5
	Sodium		15.5
	Potassium		0.5
	sulfate		12
	Chloride		27.3
	Bicarbonate		3.7
	Carbonates		0
Available nitrogen		$Mlkg^{-1}$	41
Available phosphorus			5.32
Available potassium			143
Soil	Clay	Gkg^{-1}	320
	Silt		410
	sand		270
	texture	Clay loam	
Total number of bacteria		$Cellg^{-1}$ dry soil	7.6×10^{6}

digestion was performed until the color of the solution became clear as evidence of complete digestion (Cresser and Parsons 1979).

Nitrogen: Nitrogen was determined by the distillation method after the addition of sodium 10 molar hydroxide by the use of a Microkjeldal device (Haynes 1980).

Phosphorus: Phosphorus was estimated by ammonium molybdate method and using Spectrophotometer (Haynes 1980).

Potassium: Potassium was estimated using the flame photometer (Haynes 1980).

NPK nutrients in grain (%): After harvest, five spikes per experimental unit were randomly taken, the samples were dried at 65°C until the weight was stable and grinded and nitrogen, phosphorus and potassium were evaluated as reported in the straw analysis.

RESULTS AND DISCUSSION

Nitrogen in Straw content (%): The differences with added of mineral fertilizer. The highest content of nitrogen in the straw, 0.87% was in M_2 with an increase of 6.09% and 45.00%, compared to M_1 and M_0, respectively (Table 2). Due to the role of mineral fertilizer in increasing nutrients availability in soil solution, increase their uptake by plant roots, increasing their concentration in the straw. Ahmad et al (2014) observed an increase in the content of nitrogen in the plant when mineral fertilizer was added. The straw content of nitrogen was affected by the bio fertilizer, B_1 was significantly higher, which increased by 0.81%, an increase of 20.89% compared to B_0, as bio-fertilizer loaded on the nanoparticles contains a non-symbiotic nitrogen-fixing bacteria, which contributed to increase the availability of nitrogen in the soil (Mardalipour et al 2014). The interaction of mineral and biofertilizer has a positive effect on of nitrogen, M_2B_2 outperformed by giving it the highest value of 0.93%, which was significantly similar to M_2B_1 with an increase of 63.15% compared to M_0B_0, because of the contribution of bio-fertilizer in improving soil properties and increasing nutrients availability.

Table 2. Effect of nano biological and mineral fertilizers and their interaction on NPK contents (%) in straw

Mineral/ Nano biological	M_0	M_1	M_2	Mean
Nitrogen (%)				
B_0	0.57	0.71	0.74	0.67
B_1	0.61	0.89	0.93	0.81
B_2	0.62	0.86	0.93	0.80
Mean	0.60	0.82	0.87	
LSD (p=0.05)	M = 0.02	B = 0.03	M * B = 0.04	
Phosphorus(%)				
B_0	0.09	0.14	0.15	0.13
B_1	0.11	0.21	0.22	0.18
B_2	0.11	0.19	0.20	0.17
Mean	0.10	0.18	0.19	
LSD (p=0.05)	M 0.045	B = 0.04	M * B = 0.07	
Potassium(%)				
B_0	0.48	0.57	0.64	0.56
B_1	0.51	0.75	0.83	0.69
B_2	0.52	0.77	0.82	0.70
Mean	0.50	0.69	0.76	
LSD (p=0.05)	M 0.04	B = 0.042	M * B = 0.07	

Phosphorus content in straw (%): Significant differences between the mean treatments of mineral fertilizer addition, M_2 and M_1, were significantly higher in the straw content of Phosphorus, they averaged 0.19 and 0.18%, an increase of 90 and 80%, respectively, compared to the M_0 comparison, which recorded the lowest value of 0.10%, due to the effectiveness of phosphate fertilizer added in the form of superphosphate in increasing the availability of soil phosphorus, as well as the addition of nitrogen fertilizer, which increased the growth and development of the upper part, increase the root area, reflected in the increase in the

Quantity absorbent of phosphorus by the plant, agreed with Jassim et al (2014).The straw content of Phosphorus was significantly affected by the levels of biofertilizer, B_1 gave the highest average of 0.18%, not significantly different with B_2, reached 0.17%, a significant difference from the comparison treatment B_0, which gave the lowest average of 0.13%, due to the phosphor-bacteria, which contribute to lowering the pH of the soil, through the secretion of organic acids, increase the availability of phosphorus. Similar trend was reported by Al-Dulaimi (2014) and Al-Juthery (2011).There was also significant interaction between mineral and biofertilizers, M_2B_1, M_1B_1 and M_2B_2 parameters gave the highest values, non-significant difference between them, an increase of 144.44%, 133.33% and 122.22%, respectively, compared with the comparison treatment M_0B_0**,** as a result of bio-fertilizer manufactured by nanotechnology, provides a large surface area for various metabolic processes in the plant, increases the rate of photosynthesis, improves growth indicators, demand for different nutrients (Singh et al 2017, Spruogis et al 2018).

Potassium content in straw (%): There were significant differences between the mean treatments of mineral fertilizer addition, M_2exceeded the highest content of potassium in the straw, was 0.76%, with an increase of 10.14 and 52.00% compared with M_1 and control treatment M_0respectively,due to NPK nutrients which may have enhanced potassium availability and it uptake by the roots (Table 2) Kubar et al (2019) reported similar results. The addition of biofertilizer resulted in a significant increase in the straw content of Potassium, B_2 outperformed by giving it the highest percentage of 0.79% and a non-significant difference from B_1, gave an average of 0.69%, an increase of 25.00% and 23.21%, respectively, compared with the control treatment B_0,because biofertilizer loaded on nanoparticles, contains some organisms that are able to dissolve some potassium-containing minerals, through the secretion of acids, release of potassium and increases its uptake by the plant and agreed with Abed et al (2016). The interaction between mineral and biofertilizers M_2B_1 achieved the highest content of potassium in the straw, with an average of 0.83% and an increase of 72.91% compared to control, no significant differences between superior treatment and M_2B_2, averaged 0.82%,due to nano-biofertilizer in regulating nutrient release, reduced the competition between nutrients, especially between potassium and ammonium at the absorption sites in the roots, thus increasing the availability and uptake of potassium (Rai et al 2015, Shivani et al 2018).**Nitrogen content in grain (%):** There were significant differences between the mean treatments of mineral fertilizer addition, M_2 and M_1 surpassed the content of nitrogen in grains, with an increase of 19.31 and 17.24% respectively comparative with control, M_2 achieved the highest content of nitrogen in grains of 1.73%, without a significant difference from treatment M_1 which was 1.70% (Table 3). The effect of bio-fertilizer application indicates significant differences between the average of fertilizer application, B_1 and B_2 exceeded in the content of nitrogen in grains, with an increase of 11.18 and 9.86%, respectively, compared to control, the highest percentage of nitrogen uptake in grains was 1.69%, without a significant difference from transaction B_2, which recorded 1.67%, the addition of nitrogen-fixing bio-fertilizer may have led to an increase numbers of bacteria in the soil, increase its efficiency in stabilizing atmospheric nitrogen, absorption was increased by the plant (Renuk et al 2015). The interaction between mineral and bio-fertilization indicates not significant increase in the grains content of nitrogen.

Phosphorus content in grain (%): The addition of mineral fertilizer led to a significant increase in the grains content of phosphorus, M_2 achieved the highest percentage (0.40%), without a significant difference from treatment M_1, which gave an average of 0.38% and an increase of 66.66 and 58.33% sequentially compared to the control treatment, due to the addition of mineral phosphate fertilizer to the soil, which increased the uptake of phosphorus in the soil, increased the concentration of phosphorus absorbed in the grain and are in

Table 3. Effect of nano biological and mineral fertilizers and their interaction NPK (%) ingrains

Mineral/ Nano biological	M_0	M_1	M_2	Mean
Nitrogen (%)				
B_0	1.41	1.54	1.62	1.52
B_1	1.49	1.83	1.76	1.69
B_2	1.46	1.73	1.81	1.67
Mean	1.45	1.70	1.73	
LSD (p=0.05)	M = 0.15 B = 0.13		M * B = NS	
Phosphorus(%)				
B_0	0.22	0.34	0.36	0.31
B_1	0.25	0.40	0.41	0.35
B_2	0.24	0.41	0.43	0.36
Mean	0.24	0.38	0.40	
LSD (p=0.05)	M 0. 03 B = 0. 03		M * B = NS	
Potassium(%)				
B_0	1.07	1.24	1.32	1.21
B_1	1.13	1.56	1.57	1.42
B_2	1.10	1.69	1.64	1.48
Mean	1.10	1.50	1.51	
LSD (p=0.05)	M = 0.17	B = 0.10	M * B = 0.20	

agreement with Aurelien et al (2016). Significant differences between the averages of bio fertilizer addition, B_2 and B_1, which did not differ significantly, were significantly higher, gave the highest averages of 0.36 and 0.35% with an increase of 16.12 and 12.90% compared to B_0 which gave the lowest value of 0.31%,due to the added bio-fertilizer that contains phosphor-bacteria, increased of phosphorus uptake in the soil. thus increasing its concentration in the grain (Ghazal et al 2018). Not significant differences between the mean treatments due to the interaction between the levels of mineral and nano-biofertilizer.**Potassium content in grains (%):** The significant differences due to the addition of mineral fertilizer increased the potassium concentration in the grain, the highest value was at the level of 100% of the fertilizer recommendation in treatment M_2, which was 1.51%, not significantly different from treatment M_1, and an increase of 37.27 and 36.36%, respectively, compared to the comparison treatment M_0,M_1 also outperformed the comparison with the lowest value of 1.10%, agreed with Thummanatsakun and Yampracha (2018). Bio-fertilizer also had a significant effect on the grains content of Potassium, B_2 exceeded by an insignificant difference from B_1 and gave an average of 1.148 and 1.42% with an increase of 22.31 and 17.35% compared to the control treatment, due to the ability of organisms in the added bio-fertilizer to secrete some hormones and growth regulators, especially auxin (IAA), which has an important in promoting the nutrients uptake including potassium and thus increasing its concentration in grains (Salman and Shammari 2011,Renuka et al (2015). The interaction between mineral and biofertilizer levels was significant for this characteristic compared to the comparison treatment, M_1B_2 was characterized by achieving the best content of potassium in grains of 1.69%, not significantly different from treatments M_2B_2, M_2B_1 and M_1B_1 which averaged 1.64, 1.57 and 1.56%, respectively, compared to the comparative treatment, which recorded the lowest value for this characteristic of 1.07% and a decrease from the superior treatment of 36.68%. The most of the interactions between mineral fertilizer and nano Biological fertilizers manufactured with nanotechnology, showed the possibility of reducing the addition of mineral fertilizer to 50% of the fertilizer recommendation, no significant differences in the concentrations of NPK nutrients in the straw and grain of wheat plant when adding 100% or 50% of the fertilizer recommendation, helps reduce the use of high concentrations of chemical fertilizers, cause a lot of environmental problems, can be attributed to the efficiency of bio-fertilizers manufactured with nanotechnology, which enhance the efficiency of nutrient use, reduces fertilizer loss by regulating nutrient release due to the large surface area due to its small size, increased the availability of NPK nutrients in the soil and their uptake by the plant, this increased their concentration in the plant and then their transition to grains (Mahmoud et al 2017, Singh et al 2017).

CONCLUSIONS

The use of bio-fertilizer loaded on nanoparticles interacted with mineral fertilizer, whether it is full recommendation or half fertilizer recommendation, achieved the highest significant response to plant content of NPK nutrients, reduced the quality of mineral fertilizers added in half, this reduces excessive use of mineral fertilizers and reduces soil toxicity.

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