*Plant Archives* Volume 20 No. 2, 2020 pp. 8430-8436 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

# EFFECT OF A FERTILIZER MANUFACTURED BY NANO TECHNOLOGY IN COMPARISON WITH MINERAL FERTILIZATION ON WHEAT

**M.A. Eweda[1], Asal M. Wali[1], O.M. Ibrahim[1], Gomaa[2], M.A. and E.E. Kandil[2]**

[1]Plant Production Department, Arid Lands Cultivation Research Institute, City of Scientific Research and Technological Applications, Borg El Arab, Alexandria, Egypt.

[2]Plant Production Department, The Faculty of Agriculture (Saba Basha), Alexandria University, Egypt.

## Abstract

Two field experiments were conducted during 2015/2016 and 2016/2017 winter seasons in calcareous soil at the Experimental Farm of City of Scientific Researches and Technological Applications in Borg Al-Arab, Alexandria, Egypt, to evaluate the effect of nanofertilizer (NPs), mineral fertilizers and their interaction on yield, yield components of wheat in the arid land. The experiment design was split plot system in three replications. Main plots were assigned to foliar application of Nano- fertilizer (control = water, 1 $cm^3$/L and 2 $cm^3$/L), while the sub-plots were occupied by the soil application of mineral fertilizers (100 % as recommended dose = RD, 75 % RD, 50% RD and 25% RD) in both seasons. The results revealed that NPK NPs and mineral NPK significantly affected yield and its components of wheat, where the highest mean values of most characters and grain yield recorded with the soil application of 100% RD mineral NPK plus foliar application of Nano fertilizer (NPK NPs) at the rate of 2$cm^3$/L in both growing seasons under the study conditions.

***Key words:*** wheat, grain yield, nano fertilizer, NPs, mineral fertilization, NPK.

## Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world. It is stable food for more than one third of the world population; it contributes more calories and protein in the world diet than any food crops.. The area devoted to wheat cultivation in Egypt an about 1.3 million ha and the average yield of wheat reached about 6.6 t/ha. (FAO, 2018).

The main aim of the Egyptian government in order to face the human needs, is the increase of wheat productivity per unit area in short term, some continuous extension efforts had been done at both horizontal and vertical levels by applying the good agricultural practices (GAP) through determining the best method of application, level and mixture of applicable nutritional elements.

Nanotechnology is a new scientific approach that includes the use of materials in nanometer-scale and uses it in various carriers from medicine to agriculture (Fakruddin, *et al.,* 2012). Nanotechnology is developed as the sixth revolutionary technology. It is considered as an emerging field of science widely in many scientific fields and supposed playing the vital role in the field of agriculture (Mousavi and Rezaei, 2011). Plant nutrition is crucial for agriculture production and crop quality and about 40 to 60% of the total world food production depends on the application of fertilizers (Roberts, 2009). Humic acid can replace 25 % of mineral fertilizers and produce insignificant increase in grain yield of wheat under calcareous soil conditions (Asal, *et al.,* 2015). Using nano-fertilizer (NPs) as foliar application at vegetative, flowering or filling stages increased yield and components of faba bean crop (Gomaa *et al*., 2016). Soil application of mineral fertilizer + foliar application of nano- fertilizer (NPs) gave enhancing yield and its components of maize. Fertilizing maize hybrid S.C. 168 with foliar application of nano-fertilizers (K and P) and soil application of mineral fertilization (K and P); increased both maize yield and its components (Gomaa *et al*., 2017). Plant height, yield and yield components of wheat were increased by foliar application of nano- fertilizer during both seasons (Kandil and Marie, 2017). Using nano- particles of NPKNPs elements increased yield and its components of two wheat cultivars as compared with NPK mineral fertilization in both seasons (Abdelsalam *et al*., 2019). Also Gomaa *et al.,* (2020) revealed that using micronutrient NPs increased yield, yield components and quality of maize crop.

The main objective of this study was to investigate the effect of a fertilizer manufactured by nano technology in comparison with mineral fertilization on wheat crop under conditions of newly reclaimed calcareous soil in Borg Al-Arab, Alexandria, Egypt, to improve wheat productivity.

## Materials and Methods

Two field experiments were conducted at the Experimental Farm of City of Scientific Researches and Technological Applications in Borg Al-Arab, Alexandria, Egypt, during 2015/2016 and 2016/2017 to study the effect of Nano fertilization in comparison with mineral fertilization on yield and quality of wheat Crop.

Some physical and chemical characteristics of the studied soil before sowing are presented in table 2 which was determined according to Tandon (1995).

The field experiment was ploughed twice before planting and wheat grain was drilled by hand in rows 20 cm apart at the rate of 75 kg/fed on November 22$^{th}$ and 23$^{th}$, respectively in both seasons. The plot size was 10.5 m$^2$ (3 × 3.5 m).

Treatments were arranged in a split plot design with three replications. The main plots were designated for foliar application of Nano fertilizer treatments (control = water, 1cm$^3$/L and 2cm$^3$/L), while sub plot were allocated to five mineral fertilizer (NPK) treatments (100 % = 100N : 31$P_2O_5$ : 48$K_2O$ kg/fed as recommended dose = RD, 75 % RD = 75N:23.25 $P_2O_5$ : 36 $K_2O$ kg/fed, 50% RD = 50N : 15.50 $P_2O_5$ : 24 $K_2O$ kg/fed and 25% RD = 25N : 7.75 $P_2O_5$ : 12 $K_2O$ kg/fed) in both seasons.

Calcium-Super Phosphate (15.5% $P_2O_5$), potassium sulphate (48 % $K_2O$) were added during soil preparation and nitrogen fertilizer as ammonium nitrate (33.5% N) in three equal doses, the first dose at sowing, the second dose at the first irrigation and the last dose at the second irrigation in both seasons. The preceding crop was the Egyptian clover in the two growing seasons.

Nano-fertilizer was sprayed on wheat plants at rate 1cm$^3$/litter and 2cm$^3$/litter rat two times, 30 and 45 days after sowing (DAS). Analysis of the used nano-fertilizer was shown in table 1.

The recorded data were spike length (cm), spike number/m$^2$, grains number /spike, 1000-kernel weight (g), grain yield (ton./fed), straw yield (ton./fed), biological yield (ton./fed), harvest index (HI%) and protein (%).

All data were subjected to analysis of variance according to Gomez and Gomez (1984). The differences between all treatment means were measured by least significant differences (LSD). All statistical analysis was performed using analysis of variance technique by using CoStat statistical software package (CoStat, Ver. 6.311, 2005).

## Results and Discussion

The results presented in table 3 showed the effect of foliar application of nano, mineral fertilization and their interactions on spike length (cm), grain number/spike and spikes number/m$^2$ of Giza 168 wheat cultivar during both 2015/2016 and 2016/2017 seasons.

The same table showed that Nano fertilizer had a significant effect on spike length in the second season only, where the treatment of 1cm$^3$/L gave the highest mean value (17.35) where with increasing the concentration of nano fertilizer from control to 1cm$^3$, spike length tented to increase significantly with an increase percentage of 5.5%. Concerning mineral fertilization effect on spike length there was a significant effect in both seasons where in the first season the treatment of 75% mineral fertilizer gave the highest mean value (17.66) where with increasing the concentration of mineral fertilizer from control to 75% spike length tented to increase significantly with an increase percentage of 9.2%. While in the second season the treatment of 100% mineral fertilizer gave the highest mean value (17.50) with an increasing percentage 10.4% from control to 100%. With respect to the interaction there was a significant effect in the second season only, where the highest value of spike length (17.66) was obtained by 1cm$^3$ nano + 100 % mineral fertilizer. Table 3 indicated that grain number/spike was significantly affected by nano fertilizer, in both seasons where the treatment of 1cm$^3$ nano recorded the highest value (54.20 and 51.73) during the first and second seasons, respectively where with increasing the concentration of nano fertilizer from control to 1cm$^3$ grain number/spike tented to increase significantly with an increase percentage of 18.8%, 20.3% respectively in both season. With respect to mineral fertilizer effect there was a significant effect in both seasons where the

**Table 2:** Structure of Nano- compounds (amino mineral).

| Properties | N% | P% | K% | Fe% | Zn% | Mn% | Br% | Mo% | EDTA | Inert integrant % |
|---|---|---|---|---|---|---|---|---|---|---|
| Values | 8 | 5 | 6 | 4 | 4 | 2 | 0.02 | 0.02 | 1.50 | 69.46 |

**Table 2:** Somephysical and chemical properties of the experimental soil at Borg Al-Arab in both seasons.

| Soil properties | Seasons | |
|---|---|---|
| | 2015/2016 | 2016/2017 |
| Mechanical analysis | | |
| Clay % | 20.64 | 21.15 |
| Silt % | 16.31 | 16.20 |
| Sand % | 63.05 | 62.65 |
| Soil Texture | Sandy clay loam | |
| | Chemical properties | |
| PH (1:1) | 8.55 | 8.48 |
| E.C. (ds/m) | 1.08 | 1.16 |
| | Soluble cations (1:2) (meq/L.) | |
| $Ca^{++}$ | 3.00 | 3.12 |
| $Mg^{++}$ | 0.10 | 0.14 |
| $Na^{++}$ | 11.00 | 10.60 |
| $K^{+}$ | 1.30 | 1.35 |
| | Soluble anions (1:2) (meq/L.) | |
| $HCO^{-}_{3}$ | 4.40 | 4.65 |
| $Cl^{-}$ | 0.40 | 0.35 |
| $SO_4$ | 10.6 | 10.2 |
| Total nitrogen (ppm) | 220 | 235 |
| Available phosphorus (ppm) | 5.10 | 5.22 |
| Available potassium (ppm) | 420 | 430 |
| $CaCO_3$ | 32.50 | 33.70 |
| Organic Matter (O.M)% | 0.93 | 0.99 |

treatment of 100% mineral fertilizer recorded the highest value (54.88 and 51.22) during the first and second seasons, respectively where with increasing the concentration of mineral fertilizer from control to 100% grain number/spike tented to increase significantly with an increase percentage of 30.6%, 23.6% respectively in both seasons. Regarding the effect of interaction there was a significant effect in the second season only, where that the highest value of grain number/spike (57.00) was obtained by 1cm$^3$ nano + 75 % mineral fertilizer. Regarding the effect of nano fertilization on spikes number/m$^2$, Table 3 reported that there was a significant effect in both seasons where the treatment of 2 cm$^3$/L nano-fertilizer recorded the highest value (539.46 and 495.60) in the first and second seasons, respectively with an increasing percentage 10.4%, 22.8%, respectively from control to 2cm$^3$ in both seasons.With respect to mineral fertilizer effect, there was a significant effect in both seasons where the treatment of 100% mineral fertilizer recorded the highest value (522.00 and 496.66) during the first and second seasons, respectively where with increasing the concentration of mineral fertilizer from control to 100% spikes number/m$^2$ tented to increase significantly with an increase percentage of 18.5%, 24.7% respectively in both seasons. On the other hand, there was a significant effect of interaction in both seasons where in the first season the treatment of 2cm$^3$ nano+ 50% mineral fertilizers gave the highest value (560.33), while in the second season the highest value of spikes number/m$^2$ (531.66) was obtained by 2cm3 nano + 100% mineral fertilizer. Table 3 cleared that These results are in harmony with those obtained by Tarafdar *et al*., (2012), Farnia *et al.,* (2014), Gomaa *et al.,* (2016), Jyothi and Hebsur (2017), Kandil and Marie (2017) and Dewdar *et al.,* (2018) they indicated that application of nano-fertilizers significantly increased crop yield as compared to traditional fertilizers. This is mainly because of increased growth of plant parts and enhanced metabolic processes such as photosynthesis, which leads to higher accumulation and translocation of photosynthesis to the economic parts of the plant. It is also reported that foliar application of nano-fertilizers significantly increased yield of crops.

The same table showed that These findings are well agreed with those reported by El-Hag (2008), El-Mantawy (2008), Abo-Marzoka (2009), Ali and Elbordiny (2009), Njuguna *et al.,* (2010) and Jan *et al.,* (2011) who reported that increasing nitrogen levels up to 216 kg N/ha were significantly increased growth and yield analysis.

Table 4 revealed the effect of foliar application of nano, mineral fertilization and their interactions on, 1000 kernel weight (g), grain (ton/fed) and straw(ton/fed) yield. Regarding the effect of nano fertilization table 4 indicated that 1000 kernel weight was not significantly affected by nano fertilizer in both seasons, with respect to mineral fertilizer effect there was a significant effect in both seasons where in the first season the treatment of 100% mineral fertilizer gave the highest mean value (55.99.g) where with increasing the concentration of mineral fertilizer from control to 100% 1000 kernel weight tented to increase significantly with an increase percentage of 19.7% while in the second season the treatment of 50% mineral fertilizer gave the highest mean value (55.11g) where with increasing the concentration of mineral fertilizer from control to 50% 1000 kernel weight tented to increase significantly with an increase percentage of 14.8%. Regarding the effect of interaction there was a significant effect in the second season only. Where the highest value of 1000 kernel weight (57.33g) was obtained by 1cm$^3$ nano + 75 % mineral fertilizer. Concerning nano fertilizer effect on grain yield, the results shown in table 4 showed that there was a significant effect in both seasons where the treatment of 2cm$^3$ nano recorded the highest value (2.11 and 2.01 ton/fed) in the first and second seasons, respectively where with increasing the concentration of nano fertilizer from control to 2cm$^3$, grain yield tented to increase significantly with an increase percentage of 25.5%, 35.8% respectively in both seasons. Also, mineral fertilizer had a significant effect on grain yield where the treatment of 100% mineral fertilizer recorded the highest value (2.34 and 2.14) during the first and second seasons respectively where with increasing the concentration of mineral fertilizer from control to 100% grain yield tented to increase significantly with an increase percentage of 52.9%, 52.8% respectively in both seasons.

With respect to the interaction between nano and mineral fertilizers there was no significant effect in both seasons. Also, Table 4 cleared that straw yield was significantly affected by nano fertilizer in both seasons, where the treatment of 2cm$^3$ nano recorded the highest value (4.30 and 4.63 ton/fed) during the first and second seasons, respectively where with increasing the concentration of nano fertilizer from control to 2cm$^3$, straw yield tented to increase significantly with an increase percentage of 22.1%, 12.1% respectively in both seasons.With respect to mineral fertilizer effect there was a significant effect in both seasons where the treatment of 100% mineral fertilizer recorded the highest value (4.70 and 4.89 ton/fed) during the first and second seasons, respectively where with increasing the concentration of mineral fertilizer from control to 100% grain yield tented to increase significantly with an increase percentage of 33.5%, 24.7% respectively in both seasons. On the other hand, there was a significant effect of interaction in the first season only, where the treatment of 1cm$^3$ nano+ 100% mineral fertilizers gave the highest value (4.94 ton/ fed.). Table 4 reported that these results are in harmony with those obtained by Tarafdar *et al.,* (2012), Farnia *et al.,* (2014), Gomaa *et al.,* (2016), Jyothi and Hebsur (2017), Kandil and Marie (2017) and Dewdar *et al.,* (2018) who indicated that application of nano-fertilizers significantly increased crop yield as compared to traditional fertilizers. This is mainly because of increased growth of plant parts and enhanced metabolic processes such as photosynthesis, which leads to higher accumulation and translocation of photosynthesis to the economic parts of the plant. It is also reported that foliar application of nano-fertilizers significantly increased yield of crops.

The same table showed that these findings are well agreed with those reported by Mehdi *et al.,* (2007), El-Hag (2008), El-Mantawy (2008), Abo-Marzoka (2009),

**Table 3:** Spike length, grain number/spike and spike number/m$^2$ of wheat cultivar Giza 168 as affected by nano fertilization,mineral fertilization and their interaction in both seasons.

| Season | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015/2016 | | | | | | 2016/2017 | | | | | |
| Chara-cters | Nano- fertilizer (cm$^3$/L water) (A) | Mineral (B) | | | | | Avg. (A) | Mineral (B) | | | | | Avg. (A) |
| | | Control | 25% | 50% | 75% | 100% | | control | 25% | 50% | 75% | 100% | |
| Spike length (cm) | Control | 15.20 | 16.43 | 16.50 | 17.36 | 16.40 | 16.38a | 14.73 | 17.2 | 16.73 | 16.13 | 17.36 | 16.43b |
| | 1cm$^3$ | 17.20 | 18.13 | 17.33 | 18.06 | 17.60 | 17.66a | 16.96 | 17.53 | 17.23 | 17.36 | 17.66 | 17.35a |
| | 2 cm$^3$ | 16.10 | 18.86 | 17.50 | 17.56 | 18.36 | 17.28a | 15.86 | 16.5 | 17.33 | 17.03 | 17.46 | 16.84b |
| | Average (B) | 16.16b | 17.14a | 17.11a | 17.66a | 17.45a | | 15.85c | 17.07ab | 17.1ab | 16.84b | 17.5a | |
| | $L.S.D_{0.05}$ (A) | ns | | | | | | 0.50 | | | | | |
| | $L.S.D_{0.05}$ (B) | 0.98 | | | | | | 0.54 | | | | | |
| | $L.S.D_{0.05}$ A*B | ns | | | | | | 0.97 | | | | | |
| Grain num-ber /spike | Control | 36.66 | 44.33 | 47.00 | 50.00 | 50.00 | 45.6b | 35.33 | 46.33 | 45.33 | 43.00 | 45.00 | 43.00c |
| | 1 cm$^3$ | 46.66 | 55.00 | 55.00 | 55.33 | 59.00 | 54.2a | 45.66 | 48.33 | 52.66 | 57.00 | 55.00 | 51.73a |
| | 2 cm$^3$ | 42.66 | 47.33 | 55.00 | 56.00 | 55.66 | 51.33a | 43.33 | 43.33 | 47.33 | 49.66 | 53.66 | 47.46b |
| | Average (B) | 42.00c | 48.88b | 52.33a | 53.77a | 54.88a | | 41.44c | 46.00b | 48.44ab | 49.88a | 51.22a | |
| | $L.S.D_{0.05}$ (A) | 4.24 | | | | | | 1.98 | | | | | |
| | $L.S.D_{0.05}$ (B) | 3.26 | | | | | | 2.80 | | | | | |
| | $L.S.D_{0.05}$ A*B | ns | | | | | | 4.75 | | | | | |
| Spikes num-ber /m$^2$ | Control | 357.00 | 445.00 | 510.00 | 466.66 | 464.00 | 488.53c | 360.00 | 380.00 | 395.00 | 446.33 | 435.00 | 403.26c |
| | 1 cm$^3$ | 457.66 | 457.33 | 481.33 | 438.66 | 558.33 | 478.66b | 365.66 | 434.33 | 451.66 | 464.00 | 523.33 | 446.00b |
| | 2 cm$^3$ | 506.66 | 548.66 | 560.33 | 538.00 | 543.66 | 539.46a | 469.00 | 497.33 | 490.00 | 490.00 | 531.66 | 495.60a |
| | Average (B) | 440.44c | 483.66b | 517.22a | 481.10b | 522.00a | | 398.22d | 437.22c | 445.55bc | 466.77b | 496.66a | |
| | $L.S.D_{0.05}$ (A) | 18.61 | | | | | | 26.15 | | | | | |
| | $L.S.D_{0.05}$ (B) | 30.61 | | | | | | 24.83 | | | | | |
| | $L.S.D_{0.05}$ A*B | 50.75 | | | | | | 46.14 | | | | | |

ns: not significant difference at 0.05 level of probability.

Ali and Elbordiny (2009), Mohamed (2009), Mostafa (2010), Njuguna *et al.,* (2010) and Jan *et al.,* (2011), Aown *et al.,* (2012), Raisi Tohidi-Nejad (2012) and Khan *et al.,* (2015). Whoreported that increasing nitrogen levels up to 216 kg N/ha were significantly increased growth and yield analysis.

Results presented in table 5 showed the effect of nano, mineral fertilization and their interactions on, biological yield and harvest index and protein%. Table 5 cleared that biological yield was significantly affected by nano fertilizer in both seasons, where the treatment of 2cm$^3$ nano recorded the highest value (6.41 and 6.64 ton/fed), respectively where with increasing the concentration of nano fertilizer from control to 2cm$^3$, biological yield tented to increase significantly with an increase percentage of 23%, 18.1% respectively in both seasons. With respect to mineral fertilizer effect there was a significant effect in both seasons where the highest values of biological yield in both seasons (7.05 and 7.04 ton/fed) were obtained by applying 100% of mineral fertilizers where with increasing the concentration of mineral fertilizer from control to 100% biological yield tented to increase significantly with an increase percentage of 39.3%, 32% respectively in both seasons. There was a significant effect of interaction in the first season only, where the treatment of 2cm$^3$ nano+ 100% mineral fertilizers gave the highest value (7.40 ton/fed). Concerning harvest index, the results shown in table 5 showed that there was no significant effect of nano-fertilizer in the first season, while in the second season nano fertilizer had a significant effect where the treatment of 2cm$^3$ recorded the highest value (30.01) where with increasing the concentration of nano fertilizer from control to 1cm$^3$, harvest index tented to increase significantly with an increase percentage of 13.7%. On the other hand mineral fertilizer had a significant effect on harvest index where the highest value of harvest index in both seasons (35.38 and 30.15) were recorded by using 75% of mineral fertilizers where with increasing the concentration of mineral fertilizer from control to 100% harvest index tented to increase significantly with an increase percentage of 9.5%, 13.7% respectively in both seasons. With respect to the interaction there was no significant effect in both seasons. Also, Table 5 showed that grain protein content was significantly affected by nano fertilizer in both seasons, where the treatment of 2cm$^3$/L nano recorded

**Table 4:** 1000-kernal weight (g), grain (ton/fed) and straw (ton/fed) yield of wheat cultivar Giza 168 as affected by nano fertilization, mineral fertilization and their interaction in both seasons.

| Season | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015/2016 | | | | | | 2016/2017 | | | | | |
| Chara-cters | Nano- fertilizer ($cm^3$/L water) (A) | Mineral (B) | | | | | Avg. (A) | Mineral (B) | | | | | Avg. (A) |
| | | Control | 25% | 50% | 75% | 100% | | control | 25% | 50% | 75% | 100% | |
| 1000-kernel wei-ght (g) | Control1 cm$^3$2 cm$^3$ | 44.66 | 54.33 | 55.00 | 56.00 | 55.66 | 53.13a | 44.66 | 51.33 | 54.00 | 57.33 | 55.00 | 52.46a |
| | 46.00 | 53.66 | 53.00 | 54.66 | 54.33 | 52.33a | 48.66 | 54.33 | 55.66 | 56.00 | 51.33 | 53.20a | |
| | 49.66 | 51.33 | 54.66 | 55.66 | 58.00 | 53.86a | 50.66 | 54.00 | 55.66 | 51.00 | 55.00 | 53.26a | |
| | Average (B) | 46.77c | 53.11b | 54.22ab | 55.44a | 55.99a | | 48.00b | 53.22a | 55.11a | 54.77a | 53.77a | |
| | L.S.D$_{0.05}$ (A) | ns | | | | | | ns | | | | | |
| | L.S.D$_{0.05}$ (B) | 2.12 | | | | | | 2.87 | | | | | |
| | L.S.D$_{0.05}$ A*B | Ns | | | | | | 5.08 | | | | | |
| Grain yield, (ton/ fed) | Control | 1.53 | 1.35 | 1.54 | 1.76 | 2.22 | 1.68b | 1.22 | 1.38 | 1.46 | 1.76 | 1.60 | 1.48c |
| | 1 cm$^3$ | 1.53 | 1.75 | 2.14 | 2.26 | 2.33 | 2.00a | 1.46 | 1.64 | 1.78 | 2.03 | 2.40 | 1.86b |
| | 2 cm$^3$ | 1.54 | 2.02 | 2.08 | 2.43 | 2.48 | 2.11a | 1.54 | 1.71 | 1.98 | 2.38 | 2.43 | 2.01a |
| | Average (B) | 1.53d | 1.70d | 1.92c | 2.15b | 2.34a | | 1.40c | 1.58bc | 1.74b | 2.05a | 2.14a | |
| | L.S.D$_{0.05}$ (A) | 0.18 | | | | | | 0.09 | | | | | |
| | L.S.D$_{0.05}$ (B) | 0.18 | | | | | | 0.19 | | | | | |
| | L.S.D$_{0.05}$ A*B | ns | | | | | | ns | | | | | |
| Straw yield (ton/ fed) | Control | 3.38 | 3.36 | 3.49 | 3.14 | 4.25 | 3.52b | 3.25 | 4.06 | 4.40 | 4.52 | 4.43 | 4.13b |
| | 1 cm$^3$ | 3.23 | 3.61 | 3.97 | 4.34 | 4.94 | 4.02a | 4.19 | 4.22 | 4.68 | 4.67 | 5.26 | 4.60a |
| | 2 cm$^3$ | 3.95 | 4.16 | 4.17 | 4.30 | 4.91 | 4.30a | 4.33 | 4.33 | 4.49 | 5.01 | 5.00 | 4.63a |
| | Average (B) | 3.52c | 3.71bc | 3.88b | 3.92b | 4.70a | | 3.92d | 4.20cd | 4.52bc | 4.73ab | 4.89a | |
| | L.S.D$_{0.05}$ (A) | 0.29 | | | | | | 0.32 | | | | | |
| | L.S.D$_{0.05}$ (B) | 0.24 | | | | | | 0.33 | | | | | |
| | L.S.D$_{0.05}$ A*B | 0.47 | | | | | | ns | | | | | |

ns: not significant difference at 0.05 level of probability.

the highest value (8.84 and 7.79 %), respectively. With increasing the concentration of nano fertilizer from control to 2cm$^3$/L, grain protein content tented to increase significantly with an increase percentage of (0.45% and 7.5%), respectively in both seasons. With respect to mineral fertilizer effect, there was a significant effect in both seasons where the highest values of grain protein content in both seasons (9.05 and 7.72 %) were obtained by applying 50% of mineral fertilizers. With increasing the concentration of mineral fertilizer from control to 50% grain protein content tented to increase significantly with an increase percentage of (4.62% and 7.67%), respectively in both seasons. On the other side, there was a significant effect of interaction on grain protein content in both seasons where the treatment of 2 cm$^3$/L nano+ 50% mineral fertilizers gave the highest values (9.40 and 9.48), respectively.Results are in harmony with those obtained by Tarafdar *et al.,* (2012), Farnia *et al.,* (2014), Gomaa *et al.,* (2016), Jyothi and Hebsur (2017), Kandil and Marie (2017) and Dewdar *et al.,* (2018) they indicated that application of nano-fertilizers significantly increased crop yield as compared to traditional fertilizers. This is mainly because of increased growth of plant parts and enhanced metabolic processes such as photosynthesis, which leads to higher accumulation and translocation of photosynthesis to the economic parts of the plant. It is also reported that foliar application of nano-fertilizers significantly increased yield of crops.

The same table showed that these findings are well agreed with those reported by Mehdi *et al.,* (2007), El-Hag (2008), El-Mantawy (2008), Abo-Marzoka (2009), Ali and Elbordiny (2009), Mohamed (2009), Mostafa (2010), Njuguna *et al.,* (2010) and Jan *et al.,* (2011), Aown *et al.,* (2012), Raisi Tohidi-Nejad (2012) and Khan *et al.,* (2015). Who reported that increasing nitrogen levels up to 216 kg N/ha were significantly increased growth and yield analysis.

## Conclusion

The obtained results referred that the economic fertilization treatment for the maximum grain, straw and biological yields of wheat '*Giza168*' and a good quality could be accomplished with combination between soil application of mineral fertilizer (100 % RD NPK) and foliar application of nano-fertilizer (2 cm$^3$/L) under Borg El- Arab, Alexandria Governorate conditions and similar.

**Table 5:** Biologicalyield (ton/fed), harvest index and protein% of wheat cultivar Giza 168 as affected by nano fertilization, mineral fertilization and their interaction in both seasons.

| Season | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015/2016 | | | | | | 2016/2017 | | | | | |
| Chara- | Nano- fertilizer | Mineral (B) | | | | | Avg. | Mineral (B) | | | | | Avg. |
| cters | (cm$^3$/L water) (A) | Control | 25% | 50% | 75% | 100% | (A) | control | 25% | 50% | 75% | 100% | (A) |
| Biol- | Control1 cm$^3$2 cm$^3$ | 4.92 | 4.71 | 5.04 | 4.90 | 6.48 | 5.21b | 4.47 | 5.45 | 5.86 | 6.28 | 6.03 | 5.62b |
| ogi- | | 4.76 | 5.36 | 6.12 | 6.60 | 7.27 | 6.02a | 5.66 | 5.86 | 6.46 | 6.70 | 7.66 | 6.47a |
| cal | | 5.50 | 6.18 | 6.25 | 6.73 | 7.40 | 6.41a | 5.87 | 6.05 | 6.48 | 7.40 | 7.43 | 6.64a |
| yield | Average (B) | 5.06d | 5.42c | 5.80b | 6.08b | 7.05a | | 5.33c | 5.79c | 6.27b | 6.79a | 7.04a | |
| (ton. | L.S.D$_{0.05}$ (A) | 0.39 | | | | | | 0.39 | | | | | |
| /fed) | L.S.D$_{0.05}$(B) | 0.27 | | | | | | 0.46 | | | | | |
| | L.S.D$_{0.05}$ A*B | 0.58 | | | | | | ns | | | | | |
| Har- | Control | 31.18 | 28.67 | 30.86 | 35.90 | 34.33 | 32.19a | 27.28 | 25.18 | 24.98 | 27.99 | 26.47 | 26.38c |
| vest | 1 cm$^3$ | 32.13 | 32.58 | 34.94 | 34.07 | 31.99 | 33.14a | 26.09 | 27.93 | 27.78 | 30.23 | 31.27 | 28.66b |
| ind- | 2 cm$^3$ | 28.08 | 32.83 | 33.10 | 36.17 | 33.77 | 32.79a | 26.11 | 28.40 | 30.65 | 32.22 | 32.67 | 30.01a |
| ex | Average (B) | 30.46c | 31.36bc | 32.97abc | 35.38a | 33.36ab | | 26.49b | 27.17b | 27.80b | 30.15a | 30.14a | |
| (%) | L.S.D$_{0.05}$ (A) | ns | | | | | | 1.00 | | | | | |
| | L.S.D$_{0.05}$(B) | 2.75 | | | | | | 1.91 | | | | | |
| | L.S.D$_{0.05}$ A*B | ns | | | | | | ns | | | | | |
| Pro- | Control | 8.25 | 8.79 | 8.71 | 9.14 | 9.14 | 8.80a | 6.98 | 6.94 | 6.65 | 7.10 | 8.53 | 7.24b |
| tein | 1 cm$^3$ | 8.45 | 8.23 | 9.05 | 8.45 | 8.45 | 8.52b | 7.31 | 7.36 | 7.02 | 6.97 | 6.97 | 7.13b |
| (%) | 2 cm$^3$ | 9.27 | 7.93 | 9.40 | 8.84 | 8.79 | 8.84a | 7.21 | 6.69 | 9.48 | 8.16 | 7.43 | 7.79a |
| | Average (B) | 8.65b | 8.32c | 9.05a | 8.81b | 8.79b | | 7.17c | 6.99d | 7.72a | 7.41b | 7.64a | |
| | L.S.D$_{0.05}$ (A) | 0.21 | | | | | | 0.18 | | | | | |
| | L.S.D$_{0.05}$(B) | 0.23 | | | | | | 0.14 | | | | | |
| | L.S.D$_{0.05}$ A*B | 0.42 | | | | | | 0.29 | | | | | |

ns: not significant difference at 0.05 level of probability.

## References


Abdelsalam, N.R., E.E. Kandil, M.A. Al-Msari, M.A. Al-Jaddadi, H.M. Ali, M.Z. Salem and M.S. Elshikh (2019). Effect of foliar application of NPK nanoparticle fertilization on yield and genotoxicity in wheat (*Triticum aestivum* L.). *Science of The Total Environment*, **653:** 1128-1139.þ

Abo-Marzoka, S.A.M. (2009). Response of Some Wheat Cultivars to Biofertilization. Ph. D. Thesis, Fac. Agric. Kafr El- Sheikh. Univ., Egypt.

Ali, L.K.M. and M.M. Elbordiny (2009). Response of wheat plants to potassium humate application. *Appl. Sci. Res.,* **5(9):** 1202-1209.

Aown, M., S. Roza, M.F. Saleem, S.A. Anjum, T. Khaliq and M.A. Wahid (2012). Foliar application of potassium under water deficit conditions improved the growth and yield of wheat (*Triticum aestivum* L.) *J. Animal and Plant Sci.,* **22(2):** 431-437.

Asal, M.W., A.B. Elham, O. Ibrahim and E. Ghalab (2015). Can humic acid replace part of the applied mineral fertilizers? A study on two wheat cultivars grown under calcareous soil conditions. *International Journal of Chem. Tech. Research*, **8(9):** 20-26.þ

CoStat, 6.311, copyright (c).1998-2005. Cohort software 798 light house Ave. PMB320, Monterey, CA93940 and USA. Email: info@cohort.com and

Dewdar, M.D., M.S. Abbas, A.S. El-Hassanin and H.A.A. El-Aleem (2018). Effect of Nano Micronutrients and Nitrogen Foliar Applications on Sugar Beet (*Beta vulgaris* L.) of Quantity and Quality Traits in Marginal Soils in Egypt. *Int. J. Curr. Microbiol. App. Sci.*, **7(8):** 4490-4498.

El-Hag, D.A. (2008). Effect of Nitrogen Fertilizer Rates on Productivity and Quality of Some Wheat under Different Density. M.Sc. Thesis, Kafr- Sheikh Univ. 105P.

El-Mantawy, R.F.Y. (2008). Response of Wheat Plants to Chemical and Bio- Fertilization. M.Sc. Thesis. Fac. of Sci. Al- Azhar Univ., Egypt.

Fakruddin, M., Z. Hossain and H. Afroz (2012). Prospects and applications of nanobiotechnology: a medical perspective. *Journal of nanobiotechnology*, **10(1):** 31.

FAO. (2018). Food and Agriculture Organisation Statistics, FAOSTAT. From www.fao.org/faostat.

Farnia, A. and A. Ghorbani (2014). Effect of K Nano-fertilizer and N- bio fertilizer on yield and yield components of Red bean (*Phaseolus vulgaris* L.). *Intern. J. Biosci.,* **5(12):** 296-303.

Gomaa, M.A., E.E. Kandil and A.M. Ibrahim (2020). Response of maize to organic fertilization and some nano-micronutrients. *Egyptian Academic J. of Biological Sci., H. Botany,* **11(1):** 13-21.

Gomaa, M.A., E.E. Kandil, A.A. Zeid and M.S. Bilkees (2016). Response of some faba bean varieties to fertilizers manufactured by nanotechnology. *J. Advan. Agric. Resh.,* **21(3):** 384-399.

Gomaa, M.A., F.I. Radwan, E.E. Kandil and D.H.H. Al-Challabi (2017). Comparison of some New Maize Hybrids Response to Mineral Fertilization and some Nanofertilizers. *Alex. Sci. Exch. J.*, **38(3):** 506-514.

Gomez, W.K. and A.A. Gomez (1984). Statistical Procedures for Agric. Res., An international Rice Res. Institute Book, John Wiley and Sons. Inc. NewYork, USA.

Jyothi, T.V. and N.S. Hebsur (2017). Effect of nano- fertilizers on growth and yield of selected cereals. *Agric. Reviews,* **38(2):** 112-120.

Kandil, E.E. and E.A. Marie (2017). Response of some wheat cultivars to nano-, mineral fertilizers and amino acids foliar application. *Alex. Sci. Exch. J.*, **38(1):** 53-68.

Kandil, E.E., N.R. Abdelsalam, M.A. Mansour, H.M. Ali and M.H. Siddiqui (2020). Potentials of organic manure and potassium forms on maize (*Zea mays* L.) growth and production. *Scientific Reports,* **10(1):** 1-11.

Khan, M.A.M., W. Abbas, M.D. Gogi, M.A. Ali and M.F. Raza (2015). Impact of micro and macro-nutrient foliar fertilizer use on the populationof wheat aphid, Diuraphis noxia (*Hemiptera: Aphididae*) and wheat yield. *Academic J. Entom.,* **8(1):** 05-11.

Liu, R. and R. Lal (2015). Potentials of engineered nanoparticles as fertilizers for increasing agronomic productions. *Science of the Total Environment*, **514:** pp.131-139.

Mohamed, B. (2009). Effect of Nitrogen Potassium Fertilizer on Yield and Component some Wheat Genotypes. M.Sc. Thesis of Fac. Agric. Kafr El- Sheikh Univ., Egypt.

Mostafa, M.I. (2010). Agricultural Studies on Yield and Groin Quality of Wheat Crop. M.Sc. Thesis, Fac. Agric. Kafr El-Sheikh Univ., Egypt.

Mousavi, S.R. and M. Rezaei (2011). "Nanotechnology in Agriculture and Food Production". *Journal of Applied Environmental and Biological Sciences,* **1(10):** 414-419.

Njuguna, M.N., M. Munene, H.G. Mawangi, J.K. Waweru and T.E. Akuja (2010). Effect of seeding rate and nitrogen fertilizer on wheat grain yield in marginal areas of eastern Kenya. *Journal of Animal and Plant Sci.,* **7(3):** 834-840. (C.F. CD Computer Room System).

Raisi, M.J. and E. Tohidi-Nejad (2012). Effect of Organic Manure and foliar potassium application on yield performance of wheat cultivars (*Triticum aestivum* L.). *Int. Res. J. Appl. and Basic Sci.,* **3(2):** 286-291.

Roberts, T.L. (2009). The role of fertilizer in growing the world's food. *Better crops*, **93(2):** 12-15.

Singh, J. and J.H. Skerritt (2001). Chromosomal control of albumins and globulins in wheat grain assessed using different fractionation procedures. *J. Cereal. Sci.,* **33:** 163–181.

Tandon, H. (1995). Methods of Analysis of Soil, Plants, Waters and Fertilizer, p: 144. Fertilizers Development and Consultation Organization, New Delhi, India.

Tarafdar, J.C., R. Raliya and I. Rathore (2012). Microbial synthesis of phosphorous nanoparticle from tri-calcium phosphate using *Aspergillu stubingensis* TFR-5. *J. Bionanosci.,* **6:** 84–89.