Productivity of Wheat As Affected by Chelated and Nano Zinc Foliar Application and Nitrogen Fertilizer Levels

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ABSTRACT

The most important feature of nanotechnology in the development process of agriculture is that the use of nano fertilizers provides plants with nutrients progressively and in a regulated manner, the quality of application increases, contamination decreases and the risk of chemical fertilization decreases. Therefore, two field studies have been carried out in a private field in Derwatine Village, Nabrouh Center, Governorate of Dakahlia, Egypt, during 2016/2017 and 2017/2018. Two seasons were used to investigate the impact of foliar application of chelated and nano zinc (without spraying with chelated zinc at the rate of 2 g/liter and nano zinc at the rate of 200, 400 and 600 mg/L), nitrogen levels (100, 80 and 60 % of the recommended dose i.e. 80, 64 and 48 kg N/fed, respectively) as well as their interaction on productivity of wheat Gemmiza 12 cultivar. The experiments were conducted with three replicates in a strip-plot configuration. Five zinc foliar application treatments were given to the vertical-plots. The horizontal-plots were allocated three nitrogen levels.

Keywords: Wheat, treatments for foliar spraying, chelated zinc, nano zinc, N-levels, efficiency.

INTRODUCTION

Wheat (Triticum aestivum L.) is the world’s largest food source for human nutrition and the most widely grown crop with its specific protein characteristics and serves as an essential food and energy source (Abedi et al., 2010). In addition to being useful as a livestock feed, it is easily processed into different forms of food such as pizza, macaroni, biscuit, and candy. In Egypt, in the 2018 season, with a planted area of around 3,196 * million fed, wheat was the largest winter cereal crop and overall production exceeded 8,800 million tones with an average of 18.36 ar dab / fed (FAO, 2020). Production of wheat in Egypt is not adequate for consumption locally. Therefore, a great attempt has been made to improve the yield of wheat by either growing the field under cultivation or maximizing it. In order to satisfy continuous demand and to reduce the gap between the output and consumption of wheat, yield per unit area through the use of suitable agronomic practises such as the application of zinc foliar as chelated or nano forms and levels of nitrogen fertiliser.

Zinc has a major impact on fundamental plant life processes, such as metabolism and uptake of nitrogen, protein quality, photosynthesis, chlorophyll synthesis, activity of carbon anhydrase, resistance to abiotic and biotic stresses, and protection against oxidative damage (Cakmak, 2008). Zinc also plays an important role in the production of biomass (Kaya and Higgs, 2002), pollen function and fertilization (Pandey et al., 2006). Foliar nutrition is recognized as an essential fertilization tool among the fertilizer application methods, as foliar nutrients typically penetrate the leaf cuticle or stomata and reach the cells, facilitating simple and rapid nutrient utilization, growing photosynthetic pigments, wheat growth and yield (Kandoliya et al., 2018). Traditional farming methods use Zn sulphate (ZnSO4) or chelated EDTA-Zn for leaf and soil application. Foliar application of zinc greatly affects plant growth and crop production. In this concern, El-Habbasha et al. (2015) reported that Positive foliar application of Zn was positive for significant effect on wheat grain yield and its components. Sultana et al. (2016) Foliar application of zinc (zinc sulphate monohydrate, ZnSO4 H2O) at a rate of 0.04 percent has been shown to play a major role in the yield and yield components of wheat at the later growth stages. El-Dahshouri et al. (2017) It suggested that the yield and its wheat components were significantly affected by the application of zinc foliar and that, among other forms of fertilisation, the long-term application of zinc foliar had the most beneficial effects on grain yield. Doolittle et al. (2018) It concluded that the Zn fertilizers (Zn sulphate and Zn EDTA) used can be used to optimize current fertilization strategies and contribute to the production of more efficient Zn fertilizers for foliar use. Firdous et al. (2018) The effect of Zn application was shown to be important on the yields of grain and straw / ha, but had no effect on the length of the spike and the weight of a thousand grains. Khan et al. (2019) Maximum plant height, grain weight / spike, 1000-grain weight and grain yield / ha were reported to be registered with foliar zinc application (as a 25 g / L rate of zinc sulphate).

As a modern technology, nanotechnology has solved many difficult problems in various fields of science and industry and has found its place and role in agriculture.
Plants easily ingest nano-compounds in large quantities, which can have harmful effects on plants and plant products. The highest yield per square metre was 60 g/ha for nano zinc oxide treatment and the lowest yield per square metre for control treatment without foliar zinc oxide. (Afshar et al., 2014). Jannohammadi et al. (2016) A major improvement in spike length, grain weight/spike, grain number per spike and grain yield by nano-fertilizer application has been observed. Garcia-Gomez et al. (2017) It noted that the effects of ZnO NPs on plants derive from changes in the physical, chemical and biological characteristics and catalytic properties of the materials used as nano-fertilizers. Kandil and Marie (2017) Such substantial increases in plant height, number of spikes/m², number of spikes/spike, number of grains/spike, weight of 1000 grains, crop, straw yields/fed using nano-fertilizer + amino acids have been shown. Al-Juthery et al. (2018) It was shown that major reactions were observed while spraying wheat plants with Super Micro Plus nano-fertilizer as compared to control and traditional NPK fertilizer treatments in plant height, length of spike and grain yield. Kah et al. (2018) Foliar applications of nano-fertilizers have proven to be successful because, compared to traditional fertilisation, they supply nutrients to plants in a gradual and regulated way. Nano-fertilizer application often requires smaller amounts than traditional fertilizer application, as well.

Nitrogen is one of the key nutrients that, if not properly applied, decreases the yield of wheat as it is required for rapid plant growth and high production per unit area. All plant biochemical processes are regulated primarily by nitrogen and its associated compounds, which are important for wheat growth and development. (Kandil et al., 2016; Litke et al., 2017; Mosanaei et al., 2017; Seadh et al., 2017; Belete et al., 2018; Imdad Ullah et al., 2018 and Liu et al., 2019). Therefore, one of the beneficial factors for growing wheat growth and productivity is the need to apply the required amount of nitrogen. (Ali et al., 2000).

This investigation was therefore developed to determine the impact on growth and grain quality of Gemmiza 12 bread wheat cultivar under the conditions of Dakahlia Governorate, Egypt of zinc foliar application treatments (comparison between chelated and nano zinc forms), nitrogen fertilizer levels.

**MATERIALS AND METHODS**

During the 2016/2017 and 2017/2018 seasons, two field experiments were carried out in a private field in Derwatine Village, Nabarouh Center, Dakahlia Governorate, Egypt, to research the impact of zinc foliar application treatments (chelated and nano forms), nitrogen fertilizer levels on bread wheat Gemmiza 12 cultivar productivity.

The experiments were conducted with three replicates in a strip-plot configuration. Five zinc foliar application treatments were allocated to the vertical-plots *i.e.* without foliar application (control treatment), foliar application with solution of chelated zinc in the form of Zn-EDTA at the rate of 2 g/liter and foliar application with solution of nano zinc at the rate of 200, 400 and 600 mg/L in each spraying.

- **Synthesis of metal nanoparticles:**

  The eco-friendly synthesis of zinc nanoparticles was carried out using the method mentioned by Pattanayak and Nayak (2013) and slightly modified by El-Refaie et al. (2018). For both solutions, aqueous solutions of zinc sulphate and ascorbic acid were prepared using deionized water with three levels of concentration (200, 400 and 600 ppm).

  Every ascorbic acid concentration (20 mL) was applied to the same metal salt solution concentration (20 mL) by To reduce very carefully to stop a rapid reaction causing greater particle size and the formation of precipitate at room temperature under stirring for 2 hours.

  The resulting nanoparticles were synthesised according to an equimolar ratio of (1:1) Ibrahim et al., (2019).

- **Nanoparticles characteristic via Transmission Electron Microscope (TEM):**

  The size, shape, surface area, crystal structure and morphological data of the nanoparticles obtained were characterized by TEM (JEOL-TEM-2100) transmission electron microscopy attached to a CCD camera with an acceleration voltage of 200 kV. Every sample of synthesised metal nanoparticles was prepared by suspending on copper-coated carbon grids, the sample and the solvent were able to slowly evaporate until the TEM images were captured. At the Central Laboratory, Electron Microscope Unit, Faculty of Agriculture, Mansoura University, Mansoura, Egypt, TEM measurements were registered.

- **Nanoparticles characteristic via Zeta potential:**

  Zeta potential analysis is a technique that uses Malvern Instruments Ltd Zeta Potential Ver. 2.3 at the Central Laboratory, Electron Microscope Unit, Faculty of Agriculture, Mansoura University, Mansoura, Egypt, to assess the surface charge of nanoparticles in suspensions.

  The volume of the foliar solution was 200 litres/fed and spraying was carried out twice after 35 and 50 days of sowing by hand sprayer (for experimental plots) until saturation point. At 0.02 percent concentration, Tween-20 was used as a wetting agent.

  Three nitrogen fertilizer levels were allocated to the horizontal plots, i.e. 100, 80 and 60 percent of the prescribed dose (80, 64 and 48 kg N/fed, respectively). At the above amounts, the nitrogen fertilizer in the form of ammonium nitrate (33.5 percent N) was used as a transmitter in two equivalent doses prior to first and second irrigation.

  Each experimental unit was 3 x 3.5 m occupying a 10.5 m² field (*i.e.* 1/400 feddan). Rice (Oryza sativa L.) in both seasons was the previous summer crop.

  Before soil preparation, To test the physical and chemical properties of the soil, soil samples were taken randomly from the experimental field area at a depth of 0-30 cm from the soil surface, as shown in Table 1.

  Through two pouching’s, Compaction, division and then, as previously described, divided into experimental units with dimensions, the experimental area was well prepared. During soil preparation (after deciding the experimental units) at a rate of 150 kg/fed, calcium super phosphate (15.5 % P2O5) was added.
Table 1. Physical and chemical soil characteristics at the experimental sites during 2016/2017 and 2017/2018 seasons.

<table>
<thead>
<tr>
<th>Soil analyses</th>
<th>2016/2017</th>
<th>2017/2018</th>
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<tbody>
<tr>
<td>A: Mechanical analysis:</td>
<td></td>
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<tr>
<td>Coarse sand (%)</td>
<td>3.77</td>
<td>3.72</td>
</tr>
<tr>
<td>Fine sand (%)</td>
<td>22.14</td>
<td>23.09</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>44.74</td>
<td>43.68</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>29.35</td>
<td>29.51</td>
</tr>
<tr>
<td>Texture class</td>
<td>Clay loam</td>
<td>Clay loam</td>
</tr>
<tr>
<td>E.C. ds. M⁺ (1 : 5)</td>
<td>1.05</td>
<td>0.93</td>
</tr>
<tr>
<td>pH (1 : 2.5)</td>
<td>8.02</td>
<td>7.86</td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>1.55</td>
<td>1.65</td>
</tr>
<tr>
<td>S.P. (%)</td>
<td>62.10</td>
<td>62.30</td>
</tr>
<tr>
<td>T. CaCO₃ (%)</td>
<td>4.23</td>
<td>4.09</td>
</tr>
<tr>
<td>Available (mg/kg)</td>
<td>N</td>
<td>46.58</td>
</tr>
<tr>
<td>Extractable (mg/kg)</td>
<td>P</td>
<td>5.42</td>
</tr>
<tr>
<td>DTPA (ppm)</td>
<td>K</td>
<td>160.50</td>
</tr>
<tr>
<td>Mn</td>
<td>1.28</td>
<td>1.39</td>
</tr>
</tbody>
</table>

The cultivation took place on 10th and 15th November in the first and second seasons, respectively.

Using the broadcasting Afar process, wheat seeds at the rate of 75 kg / fed were sown. After 25 days of sowing, the first irrigation was applied, and then plants were irrigated every 21 days until the dough level. The potassium fertiliser in the form of potassium sulphate (48% K2O) at 24 kg K2O / fed was transmitted in one dose prior to the first irrigation treatment. Popular agricultural practises for growing wheat, with the exception of the factors under review, have been practised in compliance with the guidelines of the Ministry of Agriculture.

At harvesting, one square meter was randomly selected from each plot to estimate; Plant height (cm) on average of ten plants from the soil surface to the top of the main stem spike, number of spikes / m² by counting the number of active tillers per square meter, Spike length (cm) as the average of ten spikes from the base of the main spike to the tip, number of spikelet / spike as the average of ten spikes by counting the number of grains per spike, Amount of grains / spike by weighting whole grains of spike extracted as an average of ten spikes, grain weight / spike (g) by weighting whole grains of spike extracted as an average of ten spikes, 1000-grain weight (g) by weighting 1000 grains of each sample, grain yield / fed by harvesting whole plants in each plot and dry air, then threshed and weighed the grains at 13% moisture in kg and fed by harvesting whole plants in each plot In kg / plot, the sample was weighted, then translated to ton per feddan.

All data are statistically analysed for the strip-plot configuration according to the methodology of variance analysis (ANOVA) as published by Gomez and Gomez (1984) Using the machine programme kit "MSTAT-C". The Least Significant Difference (LSD) approach was used to measure the variations between the means of treatment at a 5% likelihood level as defined by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Nanoparticles characteristic: 
   1. Nanoparticles characteristic via Transmission Electron Microscope (TEM):

   Bio-reduced ascorbic acid zinc nanoparticles were characterised by TEM measurements to validate the existence of zinc nanoparticles in order to approximate the structure, aggregation and particle size of synthesised nanoparticles in compliance with TEM measurements. Ibrahim et al., (2019). As shown in Fig. 1, For synthesised nanoparticles, TEM was performed at a (100 nm) magnification value.

![Fig. 1. Zinc nanoparticles shape, aggregation and particle size as characterized by Transmission Electron Microscope (TEM).](image)

The particle size varies from 25.20 to 44.10 nm. For square aggregation, the shape of particles was spherical and fewer figures were tetragonal. Smaller particles produce more surface area, justifying more powerful reactions.

2. Nanoparticles characteristic via Zeta potential:

   Zeta Potential is an important instrument to consider the condition of the surface of the nanoparticle and to forecast the nanoparticle’s long-term stability. Nanoparticles provide a surface charge that pulls a thin layer of opposite-load ions to the surface of the nanoparticle, The Zeta Potential approach has been used to determine the surface charge of nanoparticles. The electrical potential at the boundary of the double layer is known as the Zeta potential of the particles and has values that usually range from +100 mV to -100 mV.

   Nanoparticles have double layers of ion travel as it diffuses in the solution. Fig 2 Synthesized zinc nanoparticles using ascorbic acid have been shown to have a Zeta potential value of 0.307 mV, which is extremely stable since nanoparticles with Zeta potential values greater than -25 mV or less than +25 mV usually have high stability levels (Soheyla and Foruhe, 2013).

![Fig. 2. Zeta potential of zinc nanoparticles](image)
2. Effect of zinc foliar application treatments:

With regard to the effect of treatment with zinc foliar application (foliar application with chelated zinc solution in the form of Zn-EDTA at a rate of 2 g / litre and foliar application with nano zinc solution at a rate of 200, 400 and 600 mg / L for each spray in additional control treatment, i.e. without zinc foliar application) on yield and its characteristics (plant height, number of spikes/m², spike length, number of spikelets/spike, number of grains/spike, grains weight/spike, 1000 – grain weight, grain and straw yields/fed), in the two rising seasons, it was necessary (Tables 2 and 3).

It is clear that from the data provided in Tables 2 and 3, the best transaction to increase yield and its characteristics was the foliar spraying of wheat plants twice (after 35 and 50 days after sowing) with nano zinc solution at a rate of 400 mg / L for each spraying. In the two rising seasons, the highest values of any of these characters were reported. Foliar pulverization of wheat plants twice also with nano-zinc solution at a rate of 600 mg / L for each spray, put secondly after the intermediate rate of nano-zinc (400 mg / L) with respect to its yield effect and its characteristics, Foliar spraying is accompanied twice with nano-zinc solution at a rate of 200 mg / L in each spray and then by foliar spraying twice with chelated zinc solution in the form of Zn-EDTA and at a rate of 2 g / litre of water in each spray during The first season and the second, by contrast, control treatment (without zinc foliar application) in both seasons gave the lowest yield values and their attributes.

Table 2. Plant height averages, number of spikes/m², spike length , number of spikelet's / spike and number of grains / spike as influenced by foliar application treatments for zinc (Zn), levels of nitrogen fertilizer (as a combination of prescribed doses) and their association during the seasons of 2016/2017 and 2017/2018.

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<tbody>
<tr>
<td>Treatments</td>
<td>Plant height (cm)</td>
<td>Number of spikes/m²</td>
<td>Spike length (cm)</td>
<td>Number of spikelets / spike</td>
<td>Number of grains / spike</td>
<td></td>
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<tr>
<td>Without</td>
<td>97.9</td>
<td>100.8</td>
<td>205.8</td>
<td>220.3</td>
<td>11.09</td>
<td>11.95</td>
<td>12.93</td>
<td>13.75</td>
</tr>
<tr>
<td>Chelated-Zn</td>
<td>106.4</td>
<td>106.6</td>
<td>270.8</td>
<td>290.8</td>
<td>12.66</td>
<td>13.10</td>
<td>16.11</td>
<td>16.82</td>
</tr>
<tr>
<td>Nano-Zn (200 mg/L)</td>
<td>111.2</td>
<td>111.0</td>
<td>305.5</td>
<td>324.0</td>
<td>13.94</td>
<td>14.45</td>
<td>17.31</td>
<td>17.97</td>
</tr>
<tr>
<td>Nano-Zn (400 mg/L)</td>
<td>116.9</td>
<td>117.4</td>
<td>362.6</td>
<td>378.2</td>
<td>16.24</td>
<td>16.47</td>
<td>20.97</td>
<td>21.38</td>
</tr>
<tr>
<td>Nano-Zn (600 mg/L)</td>
<td>115.8</td>
<td>116.0</td>
<td>333.4</td>
<td>350.1</td>
<td>15.76</td>
<td>16.45</td>
<td>19.35</td>
<td>19.72</td>
</tr>
</tbody>
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Table 3. Grain weight / spike averages, 1000-grain weight, grain and straw yields per feddan as influenced by treatments for zinc (Zn) foliar use, nitrogen fertiliser levels (as a ratio of prescribed doses) and their relationship during the seasons of 2016/2017 and 2017/2018.

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<tbody>
<tr>
<td>Treatments</td>
<td>Grains weight/spike (g)</td>
<td>1000 - grain weight (g)</td>
<td>Grain yield (ardab/fed)</td>
<td>Straw yield (t/fed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without</td>
<td>3.242</td>
<td>3.367</td>
<td>59.74</td>
<td>61.36</td>
<td>11.51</td>
<td>12.49</td>
<td>10.74</td>
<td>1251</td>
</tr>
<tr>
<td>Chelated-Zn</td>
<td>3.996</td>
<td>4.183</td>
<td>65.22</td>
<td>66.40</td>
<td>14.15</td>
<td>14.96</td>
<td>1.352</td>
<td>1470</td>
</tr>
<tr>
<td>Nano-Zn (200 mg/L)</td>
<td>4.629</td>
<td>4.727</td>
<td>68.52</td>
<td>69.65</td>
<td>15.85</td>
<td>16.89</td>
<td>1.482</td>
<td>1569</td>
</tr>
<tr>
<td>Nano-Zn (400 mg/L)</td>
<td>6.121</td>
<td>6.324</td>
<td>74.88</td>
<td>76.07</td>
<td>19.54</td>
<td>19.97</td>
<td>2.021</td>
<td>2112</td>
</tr>
<tr>
<td>Nano-Zn (600 mg/L)</td>
<td>5.713</td>
<td>5.884</td>
<td>72.94</td>
<td>74.46</td>
<td>17.37</td>
<td>17.98</td>
<td>1.660</td>
<td>1704</td>
</tr>
</tbody>
</table>

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These results on grain yield per unit area of foliar application therapy with chelated or nano types of zinc may have been attributed to Chelated zinc plays an important role in plant processes such as nitrogen fixation, nitrogen and protein content uptake, photosynthesis, chlorophyll synthesis, activity of carbon anhydrase,
From the achieved results of this study, it could be noticed that 100% of the prescribed dosage, mineral fertilizing wheat plants i.e. 80 kg N/fed in addition foliar spraying two times (after 35 and 50 days from sowing) with solution of nano zinc at the intermediate rate (400 mg/L) in each spraying resulted in highest values of grain yield/fed (Fig. 3) and straw yield/fed (Fig. 4) in the first and second seasons. However, Mineral fertilizing wheat plants with 80 percent of the recommended dose (64.0 kg N/fed) were the second best contact procedure, as well as foliar spraying with nano-zinc solution at a rate of 400 mg/L in each spray, followed by mineral fertilizing wheat plants with 100 percent of the recommended dose, i.e. 80 kg N/fed and foliar spraying with nano-zinc solution at a rate of 80 percent of the recommended dose.

CONCLUSION

From the accomplished results of this study, it could be concluded that, in addition to mineral fertilization with 80 kg N / fed, the foliar spraying of Gemmiza 12 cultivar wheat twice after 35 and 50 days of sowing with nano zinc solution at a rate of 400 mg / L in each spray produces optimum productivity and efficiency, though retaining high productivity and grain quality though...
minimizing production costs and environmental emissions, foliar spraying twice with nano zinc solution at a rate of 400 mg/L could be recommended for each spray, in addition to mineral fertilization with 64 kg N/ fed under the environmental conditions of Nabarouh Center, Dakahlia Governorate Egypt.

REFERENCES


تثر انتاجية القمح بالرش الورقي بمستويات النانو زنك المخلبى ومستويات السماد النيتروجيني في موسمين النمو، ا، امين محمد الخطيب، و، حسن أحمد شوقي، جامعة المنصورة، مصر، خلال موسمي 2011-2012 ومصر، خلال موسمي 2012-2013.

وقد تم استخدام النانو زنك بالرغم من دراسات سابقة بتقنيات أخرى، حيث استخدمت تقنيات الريزومات النانوية لتحمل العناصر الغذائية للنباتات بشكل أكثر وفقاً لتقنية النانو في تحسين النمو والكفاءة في المحاصيل. وتبينت دراسات سابقة أن استخدام النانو زنك قد يقلل من استخدام السماد النيتروجيني ويعزز الكفاءة في المحاصيل.

بحثنا فضلاً، أن استخدام النانو زنك يمكنه إضافة قيمة إضافية إلى الاستخدامات التقليدية للفوسفات، حيث يمكنه تحسين الكفاءة في محاصيل القمح، كما أن النانو زنك يمكن استخدامه في مجالات أخرى مثل الصيدلة وتقنية نقل الجزيئات والمواد في الصيدلة.

لذا، نست貂د أن استخدام النانو زنك يمكن أن يكون أداة كفيفة في محاصيل القمح، حيث يمكنه تحسين الكفاءة في المحاصيل وتعزيز الإنتاجية من المحصول. ونأمل أن يساهم هذا البحث في تعميق فهمنا لتأثيرات النانو زنك على محاصيل القمح ومراقبة التحولات المستمرة في استخدام هذه التقنيات في المحاصيل.