The Effect of Chelated Zinc and Nano-Zinc and Interaction on Growth Traits of Wheat (Triticum Aestivum L.)

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Abstract

The field experiment was carried out in one of the farmers’ fields in Al-Fajr district, Dhi Qar governorate, located 90 km north of Nasiriyah city center, during the agricultural season 2020-2021. To show the effect of spraying different levels of chelated and nano zinc on the growth of wheat (Triticum aestivum L.). The experiment was conducted using factorial experiments according to the complete block design (RCBD). The experiment included two factors, the first factor using chelated zinc at five levels (0, 40, 80, 120 and 160 mg. L⁻¹), and the second factor using nano-zinc at five levels (0, 40, 80, 120 and 160 mg. L⁻¹). The results show that chelated zinc was a significant effect on the leaf area, the flag leaf, tiller number and chlorophyll, and no significant effect on plant height and spike length. As for the zinc nanoparticles, it had a significant effect on leaf area and chlorophyll, and no significant effect on the plant height, spike length and the tiller number. While the interaction affected significantly the leaf area, and no significantly affect the plant height, spike length, tiller number and chlorophyll.

Keywords: Chelated, Nano zinc, Growth, Wheat (Triticum aestivum L.).

1. Introduction

Wheat Triticum aestivum L. It is one of the crops belonging to the Poaceae family, which is one of the most important grain crops in Iraq and the world, with an estimated productivity of 6238 thousand tons for the winter season during the year 2020 and a cultivated area of 8574 thousand acres, covering the largest area planted for the wheat crop. Iraq is Ibba 95 and 99, Al-Buhuth, Tammuz, Latifa, Abu Ghraib as well as [1].

Although plants need microelements in relatively small quantities compared to their needs of major and secondary nutrients, however, the importance of providing all these plant elements for any crop in the quantities needed by the plant, which is necessary to obtain the highest yield in terms of quantity and quality, any deficiency of any element or more of the nutrients, whether it is one of the main, secondary or minor nutrients for a particular crop, which becomes the determining factor for the growth and productivity of that crop [2]. It is known that the micro nutrients were present in the soils of the dry and semi-dry region in relatively large quantities, which increases the need of the plant, but these quantities are not ready for absorption by plants because they are in the form of insoluble compounds in the soil solution [3]. The soils in Iraq contain high levels of lime, the tendency of soil reaction to alkaline, and the lack of organic matter are the main factors that reduce the availability of micro-mineral elements such as iron. Zinc and manganese, which have an important role in various vital activities through their entry into the composition and activity of many different enzymes responsible for the metabolic reactions carried out by the plant.

[5], indicated that the Iraqi soils are characterized by containing large proportions of calcium carbonate, which reach 500 mg, kg⁻¹, which causes an increase in the degree of interaction of these soils and makes them tend to alkaline, which leads to a lack of availability of micro-mineral elements such as iron. Zinc and manganese, which have an important role in various vital activities through their entry into the composition and activity of many different enzymes responsible for the metabolic reactions carried out by the plant.
Zinc plays an important role in the formation of chlorophyll, protein, lipids and carbohydrates, and is a cofactor in enzymes and hormones (DNA and RNA polymerase). Plants’ absorption of zinc is affected by the level of phosphate and calcium in the soil, as there is a statistically significant inverse relationship between phytic acid, calcium, phosphorous and zinc in the plant, while high calcium absorption can lead to an increase in the required zinc, and the symptoms of zinc deficiency are chlorosis or spotted leaves and roots that are not Natural [6].

Zinc is an essential mineral for plant metabolism, if it is present in small quantities, it increases the enzymatic activity, which improves the growth and yield of the plant, in addition to that zinc has an important role in regulating the metabolism of proteins and carbohydrates in the plant, and that zinc is not easily absorbed in the plant except by One of the methods of treatment is to convert it into the state of chelated zinc, as chelated zinc is a type of zinc supplement because it is linked to a chelating agent to make a stable water-soluble compound to enhance and facilitate the absorption of zinc by the plant [7]. The current study aims to demonstrate the effect of chelated zinc and nano-zinc and interaction on the growth traits of wheat (*Triticum aestivum* L.).

2. Material and Methods

2.1 The experiment site

The field experiment was carried out in one of the farmers’ fields in Al-Fajr district, Dhi Qar governorate, located 90 km north of Nasiriyah city center. Within latitude (N 57° 30") and longitude (E 21° 46") and a height of 5 m above sea level, during the agricultural season 2020-2021, and on 11/18/2020 at silty loam soil, to determine the effect of spraying different levels of chelated and nano zinc on the growth and yield of wheat (*Triticum aestivum* L.). Random soil samples were taken, with a depth of 0-30 cm, mixed well, and a sample was taken from it to conduct laboratory tests in the advisory office of the College of Agriculture, Al-Muthanna University (Table 1).

### Table 1. Some physical and chemical properties of soil before planting*.

| Properties                      | Unit       | Value  |
|---------------------------------|------------|--------|
| **Electrical Conductivity (EC)**| ds.m⁻¹     | 6.55   |
| pH                              |            | 7.55   |
| TDS                             | g. kg⁻¹    | 3.66   |
| Total Nutrient Content Nitrogen | g. kg⁻¹    | 1.89   |
| Phosphorus                      | g. kg⁻¹    | 11.45  |
| Zinc                            | PPM        | 0.45   |
| Calcium                         |            | 0.80   |
| Dissolved positive ions Magnesium| Cent. L⁻¹  | 0.31   |
| Potassium                       |            | 0.21   |
| Sodium                          |            | 1.20   |
| HCO                             |            | 0.42   |
| Dissolved negative ions SO₄     | mg. kg⁻¹   | 0.42   |
| CO₃                             |            | 0    |
| Cl                              |            | 0.61   |
| Organic matter                  | g. kg⁻¹    | 12.50  |
| Carbonate                       |            | 0.44   |
| CEC                             | Cent. kg⁻¹ | 16.48  |
| Soil types                      |            |        |
| Clay soil                       |            | 54.00  |
| Sandy soil                      |            | 17.00  |
| Silt soil                       | g/ kg⁻¹    | 29.00  |
| Soil Texture                    |            |        |
| Silt loam mixed                 |            |        |

* Analysis was carried out in Soil Science Department Laboratory, Agriculture College, Al-Muthanna University.
2.2 Study factors

The experiment included the following factors:

- The first factor: the use of chelated zinc, symbolized by C, and in five levels:
  - C1 (Nano zinc level 0 mg. L$^{-1}$).
  - C2 (Nano-Zn level 40 mg. L$^{-1}$).
  - C3 (Nano zinc level 80 mg. L$^{-1}$).
  - C4 (Nano-Zn level 120 mg. L$^{-1}$).
  - C5 (Nano-Zn Level 160 mg. L$^{-1}$).

- The second factor: the use of zinc nanoparticles, symbolized by N, and in five levels:
  - N1 (Nano zinc level 0 mg. L$^{-1}$).
  - N2 (Nano zinc level 40 mg. L$^{-1}$).
  - N3 (Nano zinc level 80 mg. L$^{-1}$).
  - N4 (Nano zinc level 120 mg. L$^{-1}$).
  - N5 (Nano-Zn level 160 mg. L$^{-1}$).

2.3 Field operations

The experimental land was plowed on 3/11/2020 and left until it was plowed and perpendicular to smoothing and leveling. The land was divided into 75 experimental units with dimensions of 2 x 2 meters. One experimental unit included ten agricultural lines with distances of 20 cm between the lines [8]. A distance of one meter was left between the experimental units as well as between the replicates. The experiment was carried out using a randomized complete block design (RCBD) with factorial trials. Where the levels of the first factor (chelated zinc) were placed in the main plots, while the levels of the second factor (nano-zinc) were placed in the secondary plots. Wheat seeds were planted for the cultivar Rashid for the winter agricultural season 2020-2021 and on 11/18/2020 (delayed due to climatic changes in this season, especially thunderstorms with large amounts of rain, which led to the delay in planting date) with a seed rate of 120 kg. ha$^{-1}$ [8]. Mineral fertilizer (urea fertilizer) (N 46%) was added at 120 kg N. ha$^{-1}$ and phosphate fertilizer (P2O5 46%) was added at 100 kg. ha$^{-1}$ [9].

As for the nano-zinc with a concentration of 12% and chelated zinc at a concentration of 14%, they were sprayed twice and used according to their levels in the study, the first spray was in the tiller stage, while the second spray was at the flowering stage, and it was used according to the levels of the study. Weeding and bush control were carried out during the planting season. Harvested on 4/21/2021.

2.4 Studied traits

2.4.1 Growth measures

2.4.1.1 Plant Height (cm)

It was calculated as an average of ten plants for each experimental unit, which were randomly selected after flowering stage, and the height was measured from the base of the plant to the top of the terminal spike, with the exception of the saffron.

2.4.1.2 Leaf area

It was calculated as an average of ten plants for each experimental unit, which were randomly selected after flowering stage, according to the following equation:

\[
\text{Leaf area} = \text{Leaf length} \times \text{maximum width} \times \text{correction factor 0.95} \quad [10]
\]
2.4.1.3 Spike length (cm)

It was calculated as an average of ten plants for each experimental unit, which were randomly selected after flowering stage, and the length was measured from the base of the spike to the end of the terminal spike, excluding the saffron.

2.4.1.4 Total number of tiller (tiller. m$^{-2}$)

Calculated from the area of square meters per experimental unit.

2.4.1.5 Chlorophyll content

It was calculated through the method of estimating the percentage of vegetation cover (NDVI estimation) and using the Handle Green Seeker device (Trimble Navigation, Sunnvale, CA) (Fig. 1), that NDVI stands for (Normalized Difference Vegetation Index), that is, the index of the difference in natural vegetative growth, which is calculated by light sensor according to the following equation:

$$\text{NDVI} = \frac{(\text{Near Infrared} - \text{Red})}{(\text{Near Infrared} + \text{Red})}$$

As the rays are fired from the Green Seeker device on the vegetation, which then receives only the rays reflected from the vegetation cover, which thus indicates the density of the vegetation cover in terms of the amount of chlorophyll formed by the vegetation cover, depending on each of [11, 12].

Figure 1. Handle Green Seeker device used to measure chlorophyll content in plants.

2.5 Statistical analysis

Statistical analysis of all studied traits was carried out using factorial experiments (Factorial) according to the Randomized Complete Block Design (RCBD) by the ready-made statistical program SPSS [13], and the averages were compared to calculate the least significant difference (LSD) at the level of significance 0.05.

3. Results and Discussion

3.1 plant height (cm)

Table 2. indicate the effect of chelated zinc and nano-zinc and their interaction on the height of wheat plant (Triticum aestivum L.), no significant differences were observed in all studied factors in plant height, the highest rate obtained when using chelated zinc is in C2 Which reached 117.13 cm compared to the control treatment (C1), which gave 115.67 cm, while C3 gave the lowest rates of plant height, which amounted to 114.27 cm.
As for nano-zinc, no significant differences were also observed between all levels of nano-zinc in plant height, and mathematically, N3 for nano-zinc gave the highest rate, which amounted to 117.07 cm, compared to the control treatment (N1), which amounted to 116.27 cm, and that the lowest rate was in N2 and N4, which she reached 115.27 cm.

As for the interaction between chelated zinc and nano-zinc in the same trait and for the same table, no significant differences were observed in all the combinations between chelated zinc and nano-zinc. When the combination (C2 × N4), which amounted to 121.00 cm, compared to the combination (C3 × N2), which amounted to 110.33 cm.

Table 2. Effect of chelated zinc and nano zinc and their interaction on plant height (cm) of wheat (Triticum aestivum L.).

| Nano-Zinc | N1 | N2 | N3 | N4 | N5 | Mean |
|-----------|----|----|----|----|----|------|
| C1        | 116.67 | 117.33 | 115.33 | 113.33 | 115.67 | 115.67 |
| C2        | 117.67 | 117.67 | 114.33 | 121.00 | 115.00 | 117.13 |
| C3        | 118.67 | 110.33 | 117.67 | 111.33 | 113.33 | 114.27 |
| C4        | 115.00 | 117.67 | 118.00 | 111.67 | 116.67 | 115.80 |
| C5        | 113.33 | 113.33 | 120.00 | 119.00 | 117.67 | 116.67 |
| Mean      | 116.27 | 115.27 | 117.07 | 115.27 | 115.67 | 115.67 |
| L.S.D.<sub>0.05</sub> &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &n
Table 3. Effect of chelated zinc and nano zinc and their interaction on leaf area (cm$^2$) of wheat (*Triticum aestivum* L.).

| Nano- Zinc | Mean |
|------------|------|
|            | N1   | N2   | N3   | N4   | N5   |
| C1         | 49.02| 45.12| 48.55| 48.20| 62.51|
| C2         | 47.57| 46.51| 55.34| 45.14| 57.72|
| C3         | 60.20| 36.40| 51.58| 46.73| 54.66|
| C4         | 70.68| 54.39| 53.84| 61.16| 62.96|
| C5         | 56.23| 53.76| 53.32| 55.74| 66.04|
| Mean       | 56.74| 47.24| 52.53| 51.39| 60.78|

L.S.D$_{0.05}$

Chelated Zinc | Nano Zinc | Interaction

2.033 | 2.033 | 5.117

3.3 Spike length (cm)

Table 4. shows the effect of chelated zinc and nano-zinc and their interaction on the characteristic of spike length (cm) for wheat (*Triticum aestivum* L.). It is noted from the results of the statistical analysis that there is no significant effect of chelated zinc on the characteristic of spike length at all levels, and that the control treatment has given The highest rate for this trait, which was 15.38 cm, compared to treatment C4, which gave the lowest rate, which was 15.25 cm.

As well as for nano-zinc in the same table, no significant differences were observed between all levels compared to the control treatment in spike length, and treatment N5 gave the highest average spike length, which was 15.51 cm compared to the control treatment, which gave an average of 15.43 cm, and the lowest average spike length was in the treatment N3, which reached 15.24 cm.

As for the interaction, no significant effect was observed in the same characteristic shown in the same table. The combination (C3 × N4) gave the highest average in the characteristic of spike length, which amounted to 16.28 cm, while the combination (C3 × N3) gave the lowest averages, which amounted to 14.47 cm.

Table 4. Effect of chelated zinc and nano zinc and their interaction on spike number (cm) of wheat (*Triticum aestivum* L.).

| Nano- Zinc | Mean |
|------------|------|
|            | N1   | N2   | N3   | N4   | N5   |
| C1         | 14.81| 15.29| 15.80| 14.97| 16.06|
| C2         | 15.90| 15.86| 14.98| 14.52| 15.28|
| C3         | 15.61| 14.51| 14.47| 16.28| 15.71|
| C4         | 15.68| 15.10| 15.02| 15.87| 14.88|
| C5         | 15.17| 15.24| 15.42| 14.82| 15.62|
| Mean       | 15.43| 15.20| 15.14| 15.29| 15.51|

L.S.D$_{0.05}$

Chelated Zinc | Nano Zinc | Interaction

N.S | N.S | N.S

3.4 Total of tillers (tiller. m$^{-2}$)

Table (5) indicates the effect of chelated zinc and nano-zinc and their interaction in the characteristic of the number of tillers (tiller. m$^{-2}$) of wheat (*Triticum aestivum* L.), as it is noted from the results that there is a significant effect of chelated zinc on the characteristic of the number of tillers, as the treatment showed C5 Significantly superior to the control treatment, as well as both the control treatment and C2 significantly outperformed treatments C3 and C4, and treatment C5 gave the highest average number, which amounted to 673.02 tiller. m$^{-2}$ compared to the control treatment, which amounted to 610.64 tiller. m$^{-2}$, while treatment C4 gave the lowest rates, which amounted to 520.31 tiller. m$^{-2}$. This may be attributed to the fact that chelated zinc stimulated the production of a large number of tiller, as zinc’s easy access to the plant stimulates the plant to increase the activity of vital activities and increase the division and growth of meristematic cells, which in turn gives great vegetative and root growth with great efficiency to absorb other nutrients, which increases the number tiller per unit area [18].
The table indicates that there were no significant differences between all levels of zinc nanoparticles with the control treatment, and treatment N5 gave the highest rates with an average of 612.95 tiller m⁻² compared to the control treatment, which averaged 587.63 tiller m⁻², and the lowest rates were in treatment N3, which amounted to 579.25 tiller m⁻².

The same table shows that there is a significant effect of the interaction between chelated zinc and nano-zinc on the number of hulls of wheat, and the combination (C1 × N5) gave the highest rates, which amounted to 924.23 tiller m⁻², as for the combination (C1 × N2), it gave the lowest rates, which amounted to 382.39 tiller m⁻².

Table 5. Effect of chelated zinc and nano zinc and their interaction on total of tiller number (cm) of wheat (*Triticum aestivum* L.).

| Nano-Zinc | Mean  |
|-----------|-------|
| N1        | 481.43|
| N2        | 382.39|
| N3        | 608.63|
| N4        | 656.55|
| N5        | 924.23|
| Mean      | 612.95|

Table 6. Effect of chelated zinc and nano zinc and their interaction on chlorophyll content of wheat (*Triticum aestivum* L.).

3.5 Chlorophyll content

Table (6) show that the effect of chelated zinc and nano-zinc and their interaction on chlorophyll content of wheat (*Triticum aestivum* L.). The results showed a significant effect of chelated zinc on the chlorophyll content, as there was a significant increase in treatment C5 compared to the control and C2 treatments, which showed a significant superiority at the expense of treatments C3 and C4, and treatment C5 gave the highest rates of chlorophyll content, which amounted to 528.07 compared to the control treatment, which It reached 479.06, while the lowest rates were in the C4 transaction, which amounted to 408.27. The reason for the increase in the chlorophyll content in the wheat plant is due to the role of zinc in stimulating the photosynthesis process, so the concentration of solutes resulting from this process will increase, as zinc is included in the composition of all photosynthesis tissues, as well as in the composition of carbonic enzymes [19]. The zinc element participates in the formation of chlorophyll that is prepared for food and is necessary for the processes of cell division and elongation, and this leads to an increase in vegetative growth and thus an increase in the food manufactured inside the plant, which increases the yield of the plant [20].

The same table indicates that there are no significant differences between all treatments of nano-zinc in the content of chlorophyll, and treatment N5 gave the highest rates, which amounted to 480.87 compared to the control treatment, which amounted to 460.93, while the lowest rates of chlorophyll content were in treatment N3, which amounted to 454.60.

The same table shows that there is a significant effect of the interaction between chelated zinc and nano-zinc on the chlorophyll content. The combination (C1 × N5) gave the highest rates of chlorophyll content, which amounted to 725.00, while the combination (C4 × N1) gave the lowest rates of chlorophyll content, which amounted to 277.67.

| Nano-Zinc | Mean  |
|-----------|-------|
| N1        | 377.67|
| N2        | 300.00|
| N3        | 477.67|
| N4        | 515.00|
| N5        | 725.00|
| Mean      | 479.06|

| L.S.D₀.₀₅ | 39.116 |
|------------|--------|
| Chelated Zinc | N.S    |
| Nano Zinc   | 79.332 |
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