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# EFFECT OF LEVELS AND METHODS OF ZINC ADDITION ON THE GROWTH AND YIELD OF WHEAT CULTIVATED IN SALINE SOILS

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**Abstract**

A field experiment on loamy soil was conducted in the Haditha district, Anbar province, Iraq, during the winter season of 2021-2022. The study aimed to determine the effect of different zinc levels and methods on wheat growth, yield, and tolerance to salinity. The experiment used a randomized complete block design (RCBD) with a split-plot arrangement and three replications. The seeds were soaked before planting with three zinc levels: 0 (control treatment, soaked in water only), 75 mg Zn $Kg^{-1}$ (seeds soaked in zinc at a concentration of 75 mg Zn $Kg^{-1}$), and 150 mg Zn $Kg^{-1}$ (seeds soaked in zinc at a concentration of 150 mg Zn $Kg^{-1}$) for eight hours. This was followed by two spray applications of the same concentrations, the first at the tillering stage and the second at the booting stage. Statistical analysis showed that adding zinc to soak the seeds and spraying it on the plants increased plant height, number of tillers, flag leaf area, grain yield, and 1000-grain weight. Additionally, it was observed that seed soaking and plant spraying with zinc increased the plant's tolerance to salinity by reducing the chloride and sodium concentration in the wheat straw and roots and increasing the potassium concentration and the potassium/sodium ratio in the wheat straw and roots. The best results were obtained using the 150 mg Zn $Kg^{-1}$ level (seed soaking and plant spraying) for most of the studied characteristics.

**Keywords:** Zinc, Spraying, Soaking, Wheat, Salty soil.

# تأثير مستويات وطرائق اضافة الزنك في نمو وحاصل الحنطة المزروعة في تربة مالحة

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**الخلاصة**

نفذت تجربة حقلية في قضاء حديثة التابع لمحافظة الانبار خلال الموسم الشتوي 2021- 2022 في تربة ذات نسجة مزيجة لمعرفة تأثير مستوى وطرائق اضافة الزنك في نمو وحاصل الحنطة ومدى قابليتها لتحمل الملوحة. نفذت التجربة وفقا لتصميم القطاعات العشوائية الكاملة (R.C.B.D) بترتيب الالواح المنشقة وبثلاثة مكررات، تضمنت التجربة نقع البذور قبل الزراعة بالزنك بثلاثة مستويات من الزنك، المستوى الاول 0: ويمثل معاملة المقارنة (نقع بالماء فقط) والمستوى الثاني نقع البذور بالزنك بتركيز 75 ملغم Zn كغم$^{-1}$ اما المستوى الثالث تضمن نقع البذور بالزنك بتركيز 150 ملغم Zn كغم$^{-1}$ لمدة ثمان ساعات ثم رش النبات بنفس التراكيز اعلاه على دفعتين الاولى عند مرحلة التفرعات والثانية كانت عند مرحلة البطان للنبات.

اظهرت نتائج التحليل الاحصائي ان اضافة الزنك نقعاً للبذور ورشاً على النبات زاد من صفة ارتفاع النبات وعدد الاشطاء ومساحة ورقة العلم وحاصل الحبوب ووزن 1000 حبة، كما لوحظ ان نقع البذور والرش بالزنك زاد من مقاومة النبات للملوحة عن طريق خفض تركيز الكلورايد والصوديوم في قش الحنطة والجذور كما زاد من تركيز البوتاسيوم ونسبة البوتاسيوم الى الصوديوم في قش الحنطة والجذور. أفضل النتائج تحققت عند استعمال المستوى 150 ملغم Zn كغم$^{-1}$ نقعاً للبذور ورشاً على النبات معاً في اغلب الصفات المدروسة.

**كلمات مفتاحية:** زنك، رش، تنقيع، حنطة، تربة مالحة.

## Introduction

The significant decrease in the crop productivity rate is due to the salt, water, and thermal stresses prevailing in Iraq; the salinity of irrigation water and soil, high temperatures, and the wilting that occurs in the hot afternoon all negatively affect the plant performance and its vital processes, and thus its productivity. Therefore, modern studies have focused on studying these obstacles and developing appropriate solutions, including using micronutrients (zinc), whether sprayed on the plant or through soaking the seeds, which would make the growing plants more resistant to environmental conditions. Zinc is a necessary nutrient for growth and production. It is added in limited quantities to support plant pods forming and various enzymes (10).

(26) indicated that adding zinc as a foliar spray is more effective and leads to an increase in the zinc concentration in wheat grains, increases its readiness, and leads to a more significant increase in fertilizer use efficiency compared to the ground addition method. (23) reported that improving the zinc concentration in grains by

adding zinc foliar exceeded 46.4% compared to the control treatment, while the ground addition method did not exceed more than 1.7%. Soaking seeds in zinc solutions is a practical method to increase the zinc content in seeds before planting to obtain good seeds and contribute to better plant growth. This technique increases seeds' ability to germinate under different environmental conditions (15 and 16).

(2) stated that zinc is essential for plants because it reduces excessive absorption of sodium under salinity stress through its effect on the cell membrane permeability of the plant stem. Therefore, cell membranes show high permeability or leakage of some compounds from the roots under the influence of zinc deficiency (25). It was found that feeding plants with zinc effectively reduces sodium accumulation and improves the plant potassium/sodium ratio under the influence of salinity (20). (18) indicated that crop growth enhanced under the influence of salinity when increasing the potassium concentration and removing sodium ions or by improving the ratio of potassium /sodium ions and improving the efficiency of the respiration process and regulating osmotic potential by enhancing the plant system (18). (14) concluded that salinity is the environmental stress that negatively affects wheat productivity and quality by changing the plant's physiological and biochemical activities. Also, salt stress causes osmotic stress and ion toxicity by increasing the absorption of sodium ions and reducing the potassium/sodium ratio, which is attributed to the low osmotic potential within the plant roots. This imbalance affects the absorption and transport of other necessary ions in the cells and impedes the fundamental processes and functions of the plant (7). This study aims to examine the zinc effect and add methods to increase the plant's resistance to environmental stresses, especially salinity, as well as find the best fertilizer combination of soaking and spraying and its effect on the growth and yield of wheat.

## Materials and Methods

A field experiment was conducted in the Haditha district, Anbar Governorate, Iraq, during the winter season 2021-2022 in a mixed soil texture to study enhancing wheat’s resistance to salinity by soaking the seeds and spraying the plant with zinc and its effect on growth and yield. Representative random field soil samples were taken before planting to estimate some chemical, physical, and fertility characteristics of soil before planting according to the methods mentioned in (17), Table 1.

**Table 1: Some chemical, physical, and fertility characteristics of soil.**

| unit | value | characteristic | |
|---|---|---|---|
| | 7.03 | **pH -Soil reaction (saturated paste method)** | |
| ds.m$^{-1}$ | 6.06 | **ECe** | |
| g.kg$^{-1}$ | 3.8 | **Soil organic matter** | |
| g.kg$^{-1}$ | 235 | **Carbonate minerals** | |
| | 4.33 | **Gypsum** | |
| mmol.L$^{-1}$ | 15.3 | $Ca^{+2}$ | **Dissolved cations** |
| | 7.6 | $Mg^{+2}$ | |
| | 33.1 | $Na^{+}$ | |
| | 29.1 | $Cl^{-}$ | **Dissolved anions** |
| | 12.3 | $SO4^{=}$ | |
| | 18.7 | $HCO3^{-}$ | |
| | Nill | $CO3^{-}$ | |
| mg kg$^{-1}$ | 31.2 | **(N) Available nitrogen** | |
| | 10.3 | **(P) Available phosphorus** | |
| | 185.4 | **(K)Available potassium** | |
| | 1.1 | **(Zn) Available zinc** | |
| g.kg$^{-1}$ soil | 386 | (Sand) | **Soil particles** |
| | 406 | (Silt) | |
| | 208 | (Clay) | |
| | Loamy | **Soil texture** | |

The experiment was conducted using a randomized complete block design (RCBD) in a split-plot arrangement, with three replications and three sectors, each containing nine experimental units. The land was plowed and prepared on 11-14-2021, then divided into experimental units 2×4 m. Seeds were planted in lines within the experimental unit at a rate of 10 lines, and the distance between those lines was 20 cm. The distance between the experimental units was 50 cm, and the distance between sectors was 1m to control irrigation, fertilization, and crop service operations. Potassium and phosphorus fertilizers were added before planting during soil preparation according to the fertilizer recommendation of (4) at a rate of 100 kg K ha$^{-1}$ in the form of potassium sulfate (41.5% K), while phosphorus was added in the form of triple superphosphate (21%P) at a rate of 80 kg P ha$^{-1}$ at once. Nitrogen fertilizer was added as urea (46%N) at 180 kg N ha$^{-1}$ with irrigation water as a ground addition in the two batches; the first was three weeks after germination, and the second batch was at the booting stage. The seeds were soaked before planting with levels of zinc 0, 75, 150 mg Zn kg$^{-1}$ and potassium sulfate for 8 hrs (9). Then, the seeds were dried and planted on 11/20/2021 at a depth of 5 cm in lines by calculating the number of seeds per line per plate according to the equation mentioned before (22). A sprinkler irrigation system was used to irrigate the experiment. The plants were sprayed with zinc in two batches. The first batch was at the Tillering stage, while the second batch was at the Booting stage of the plant’s spike. The experimental treatments were as follows: T1 treatment: soaking the seeds and spraying with only water; T2 treatment: soaking the seeds with only water and spraying the plant with zinc at 75 mg Zn kg$^{-1}$; T3 treatment: soaking the seeds with only water and spraying with zinc at 150 mg Zn kg$^{-1}$; T4 treatment: soaking seeds with zinc at 75 mg Zn kg$^{-1}$, spraying the plant with only water; T5 treatment: soaking the seeds and spraying the plant with zinc at 75 mg Zn $kg^{-1}$; T6 treatment: soaking the seeds with zinc at 75 mg Zn $kg^{-1}$ and spraying the plant with zinc at 150 mg Zn $kg^{-1}$, T7 treatment: soaking the seeds with zinc at 150 mg Zn $Kg^{-1}$ and spraying the plant with only water, Treatment T8: soaking the seeds with zinc at 150 mg Zn $kg^{-1}$ and spraying the plant with zinc at 75 mg Zn $kg^{-1}$; T9 treatment: soaking the seeds and spray the plant with zinc at 150 mg Zn $kg^{-1}$. Plant height, flag leaf area, weight of 1000 seeds, and grain yield were measured. Plant samples were subjected to wet digesting according to the method proposed by (12). Sodium and potassium were determined using a flame photometer. Chloride was determined by titration with silver nitrate according to the procedure proposed by (19).

## Results and Discussion

Plant height cm: Figure 1 shows the effect of different fertilizer combinations on the plant height characteristic of wheat crops. The statistical analysis showed a significant effect of the different fertilizer combinations (soaking the seeds and spraying the plant with zinc). Treatment T8, which included (soaking the seeds with zinc at 150 mg zinc $kg^{-1}$ and spraying the plant with 75 mg zinc $kg^{-1}$), gave the highest average plant height of 100.3 cm. This treatment was significantly superior to all others except for T9 and T6.

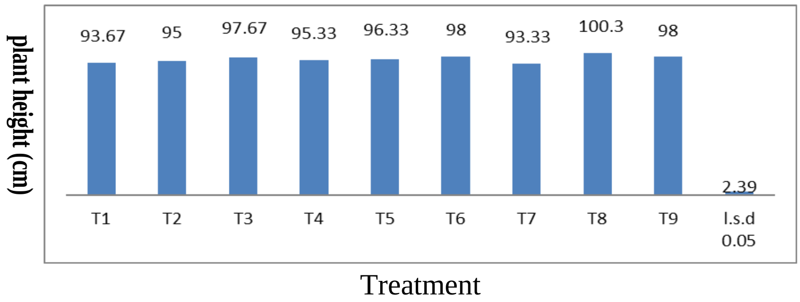


**Figure 1: Effect of different fertilizer combinations on plant height (cm).**

Fertilizer treatments T9 and T6 (soaking seeds with zinc at 75 mg Zn $kg^{-1}$), T5 (soaking seeds + spraying the plant with zinc at 75 mg Zn $kg^{-1}$), T4 (soaking seeds with zinc at 75 mg Zn $kg^{-1}$ + spraying the plant with only water), T3 (soaking the seeds in water only + spraying the plant with zinc at 150 mg Zn $kg^{-1}$) were increased the average height of plant, which were 4.62, 4.62, 2.83, 1.77, and 4.27%, respectively, compared to the control treatment T1 (soaking the seeds and spraying the plant with water only), which gave the lowest average of plant height, 93.67 cm. Most fertilizer combinations achieved an increase in plant height compared to the control treatment; this confirms the importance of zinc and its role in increasing the activation of plant cells for growth and division through increasing chlorophyll, which works to provide the cell with the necessary food to complete the physiological activities related to the activity of meristematic tissues in the apical plant tissues, this is consistent with (8).

Number of Tillers: Figure 2 shows the effect of the different fertilizer combinations on the number of Tillers of the wheat crop. The statistical analysis results indicate that the different fertilizer combinations have a significant impact compared to the control treatment. The T9 treatment was significantly superior to all other treatments except the T6 treatment. The T6 treatment achieved considerable superiority over the rest of the fertilizer treatments, except for the T8 and T5 treatments. The T9 treatment followed it, and its average Tillers reached 52.3. The T5 treatment also significantly outperformed the rest of the other treatments that were sprayed with only water (T4, T2, T1) except the T3 treatment, with an increased percentage of 51.7, 40.5, and 91.3%, respectively.

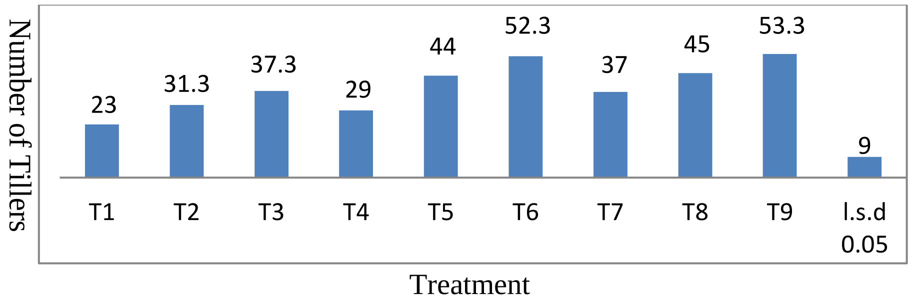


**Figure 2: The effect of different fertilizer combinations on the number of Tillers of wheat plants.**

The superiority of fertilizer combinations may be due to zinc's role in forming and dividing meristematic cells, which encourages the plant to increase the Tiller's number (13).

Area of flag paper ($cm^2$): Figure 3 shows the effect of different fertilizer combinations on the flag leaf area of wheat plants. The statistical analysis results indicate a significant impact of the other fertilizer combinations compared to the control treatment. Treatment T9 achieved the highest value of 44.75 $cm^2$; it was followed by treatment T8 (soaking the seeds with zinc at a concentration of 150 mg Zn $kg^{-1}$ and spraying the plants with zinc at 75 mg Zn $kg^{-1}$), where the rate was 41.13 $cm^2$, followed by treatment T6 (soaking the seeds with zinc at a concentration of 75 mg Zn $kg^{-1}$ and spraying the plant with zinc at 150 mg Zn $kg^{-1}$), which reached 38.1 $cm^2$. Each of the treatments, T9, T8, and T6, achieved a significant effect compared to the rest of the other treatments, with an increased rate of 97.1, 81.1, and 67.8%, respectively, compared to the control treatment T1, which gave the lowest value for the flag leaf area, 22.7 $cm^2$. Regarding soaking seeds in only water, the T3 treatment was significantly superior to the T1 treatment, and the differences were insignificant with the T2. Zinc promotes plant growth and development by improving photosynthesis (21). It is significant in physiological and biochemical processes, enzyme activity, photosynthesis, and protein synthesis (21).

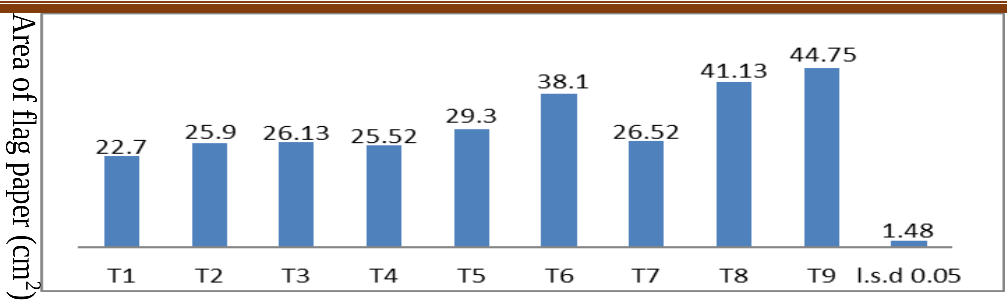


**Figure 3: The effect of fertilizer combinations on the flag leaf area of wheat plants, $cm^2$.**

The effect of fertilizer combinations on some wheat yield characteristics:

Weight of 1000 grain: Figure 4 shows how adding different fertilizer blends affects 1000 grain (g) weight. Treatment T9 achieved the highest significant difference, reaching 48.7 g, and it was significantly superior to all other combinations, with a percentage increase in weight that was 18.6%, compared to the control treatment T1. It was followed by the T6 treatment with an average of 46.5 g, which was significantly superior to the rest of the other combinations except for the T3, with an increase in the weight of 1000 grain of 13.2% compared to the control treatment T1.

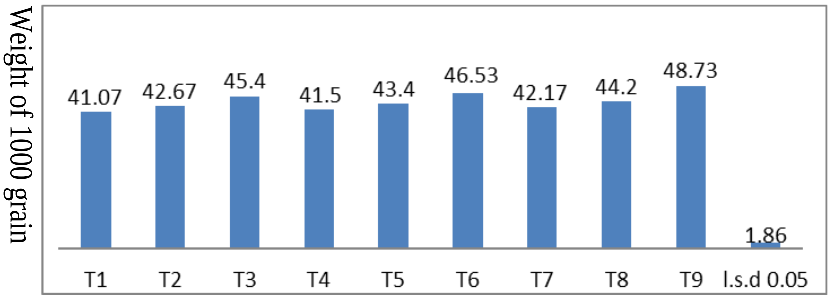


**Figure 4: Effect of different fertilizer combinations on the weight of 1000 gm grain.**

It is noted from Figure 4 that the seed soaking treatments with only water and its various combinations led to a significant increase compared to the control treatment. It is noted that treatment T3 (soaking the seeds in water and then spraying the plant with zinc at a level of 150 mg Zn $kg^{-1}$) and T2 (soaking the seeds in water only and spraying the plant with zinc at a level of 75 mg Zn $kg^{-1}$) were superior by an average of 45.4 and 42.6 g, respectively, compared to the control treatment T1, which their average amounted to 41 g, with an increase rate of 10.7 and 3.9% for each, respectively. Treatments T5, T7, and T8 achieved a significant increase in the weight of 1000 grain by 43.4, 42.17, and 44.2 g, respectively, and an increase in the weight of 1000 grain amounted to 5.6, 2.6, and 7.6%, respectively, compared to the control treatment T1.

Grain yield (Megagram $h^{-1}$): The results of Figure 5 show the effect of different fertilizer combinations on the yield of wheat grains (Megagram $h^{-1}$), as spraying zinc on the vegetative parts and soaking the seeds significantly increased the wheat plant's yield. Treatment T9 was significantly superior to all treatments, as it achieved an increase in yield at a rate of 4.2 Mg $ha^{-1}$, an increase of 18.6% compared to the control treatment T1, which was the least influential treatment at a rate of 2.73 Mg $ha^{-1}$. Treatment 6 outperformed all treatments, followed by T9, with a rate of 3.83 Mg $ha^{-1}$ and an increase in yield by 40.2% compared to the control treatment T1. Treatments T5 and T8 significantly increased yield by 3.43 and 3.5 Mg $ha^{-1}$, respectively, at 25.6 and 28.2% compared to the control treatment T1. Figure 5 indicates that spraying zinc at 150 mg Zn $kg^{-1}$ and soaking the seeds with zinc at 75 mg Zn $kg^{-1}$ led to an increase in yield. Treatments T2 and T3 achieved a significant increase in the yield at a rate of 3.23 and 3.73 Mg $ha^{-1}$, respectively, with an increase in yield of 18.3 and 36.6% for each compared to the control treatment T1.

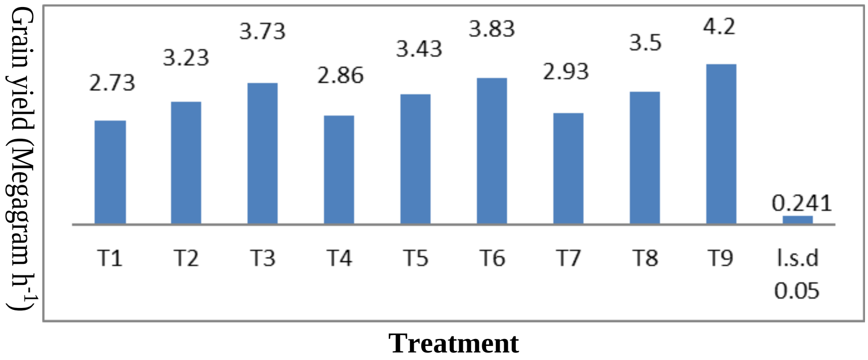


**Figure 5: Effect of different fertilizer combinations on wheat yield (Megagram $h^{-1}$).**

In Figures 4 and 5, the achieved increase was due to zinc's essential role in activating enzymes and forming chlorophyll while accelerating the formation of growth hormones (auxins) by stimulating the formation of Tryptophan. It also has an essential role in forming carbohydrates until the plant stores them in wheat grains, which increases the number and weight of grains, consistent with what was found (3).

Chloride concentration: 5-1 in wheat straw %: Figure 6 shows the effect of different fertilizer combinations on the chloride concentration in wheat straw. The statistical analysis showed that both the zinc concentrations sprayed on the shoots and the concentrations soaked in the wheat seeds had a significant effect on the chloride content of the plant. Treatment T9 achieved the slightest difference and was superior to all treatments. It led to a noticeable decrease in the chloride concentration in wheat straw by 38.7% compared to the control treatment T1. This was followed by treatment T6, which reduced chloride concentration by 26.1% compared to the control treatment T1. Treatments T3 and T5 achieved a chloride reduction of 18% compared to the control treatment T1, followed by treatment T8, which reduced by 4.5% compared to the control treatment T1.

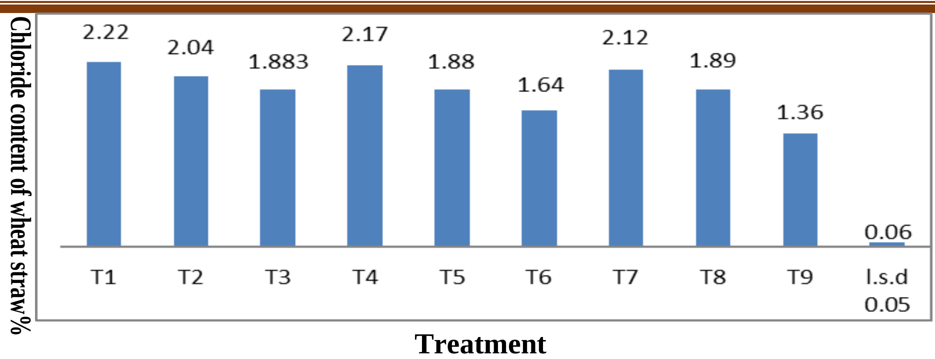


**Figure 6: Effect of different fertilizer combinations on the chloride content of wheat straw%.**

Chloride concentration in wheat root system %: Figure 7 shows the effect of different fertilizer combinations on the chloride concentration in the wheat roots. It is noted that the seed soaking treatments and plant spraying with zinc led to a reduction in the chloride concentration in the roots. The T9 treatment decreased the roots' chloride content by 45% compared with the control treatment T1. Treatment T3 followed with a decrease of 26% compared to the control treatment T1. T6 and T8 treatments reduced chloride levels by 25.1% compared to the control treatment, T1. Treatment T5 reduced the chloride level in wheat roots by 19.9% compared to the control treatment T1. Treatment T2 also decreased chloride concentration by 11.3% compared to the control treatment T1, and treatment T7 decreased chloride concentration by 5.2% compared to treatment T1.

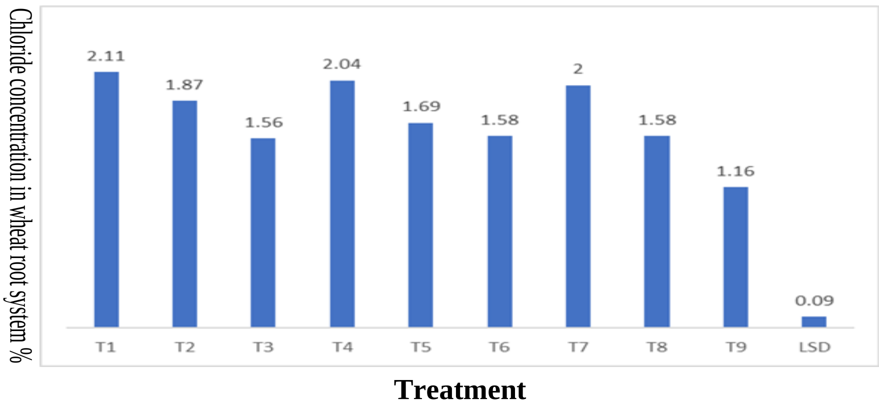


**Figure 7: Effect of fertilizer combinations on chloride concentration in wheat roots%.**

Sodium concentration in wheat root system %: Figure 8 shows the fertilizer treatment effect on the sodium concentration in the wheat roots, as a decrease in the sodium concentration in the roots was observed in all treatments, whether soaking or spraying on the plant. Treatment T5 achieved the lowest sodium concentration, which was 0.55%, significantly superior to all treatments except for T9, T8, and T3. The seed soaking treatments with only water, treatment T3 significantly decreased compared to treatments T2 and T1, and its value was 0.64%. As for the treatments whose seeds were soaked with zinc and whose plants were sprayed with zinc, the T8 treatment achieved the slightest difference, 0.61%, significantly superior to the T7 and T6 but insignificant with the T9.

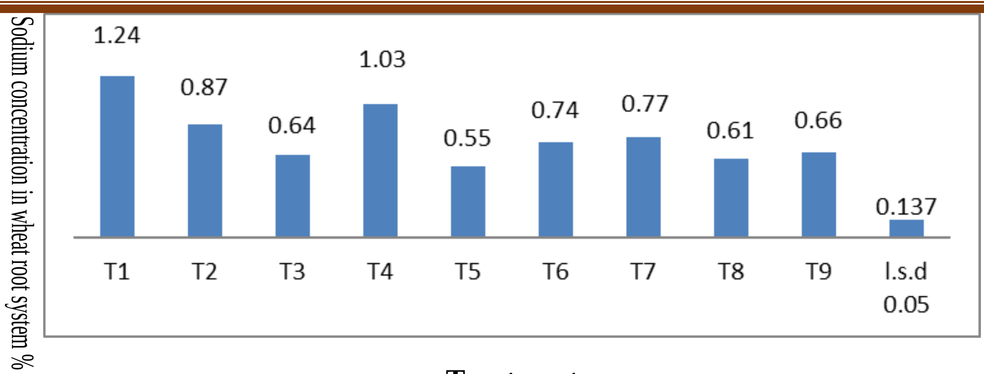


**Figure 8: Effect of different fertilizer combinations on sodium concentration in wheat roots%.**

Sodium concentration in wheat straw %: Figure 9 shows the different effects of fertilizer treatments on the sodium content of wheat straw. It was observed that the concentration of sodium in wheat straw decreased in all treatments, whether zinc was added, the seeds were soaked, or the plant was sprayed. Treatment T3 achieved the lowest significant percentage of 1.27% compared to treatments T2 and T1 for the treatments whose seeds were soaked in only water, indicating that soaking with 150 mg Zn $kg^{-1}$ (T3) significantly reduced sodium. Treatment T9 also achieved the smallest decrease, 1.08%, and thus significantly outperformed all treatments except for T6 and T3. Thus, it could be concluded that soaking the seeds and spraying them with zinc at 150 mg Zn $kg^{-1}$ had an essential role in preventing sodium absorption and its concentration in the plant, thus preventing its harmful effect.

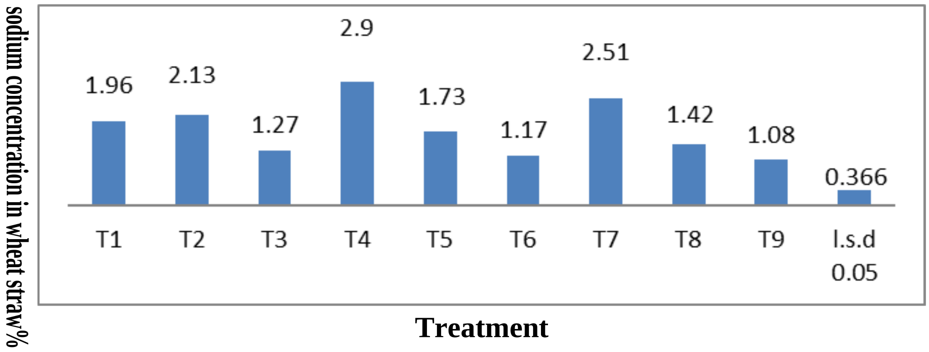


**Figure 9: Effect of different fertilizer combinations on sodium concentration in wheat straw%.**

Potassium concentration:

Potassium concentration in the root system of wheat: Figure 10 shows the effect of the different fertilizer combinations on the potassium concentration in wheat roots. The statistical analysis results showed a significant effect of the different fertilizer combinations (soaking the seeds and spraying the plant with zinc), as treatment T9 showed the highest percentage of potassium, at a rate of 1.38%, and this treatment was significantly superior to all treatments except for T6. Treatment T6 achieved significant superiority over all treatments except for T3, followed by T9, by 1.14%. Treatment T3 also outperformed treatments T2 and T1, whose seeds were soaked in only water, with a rate of 0.87%, followed by T2, with a rate of 0.77%. Both treatments were significantly superior to T1, but no significant differences existed.

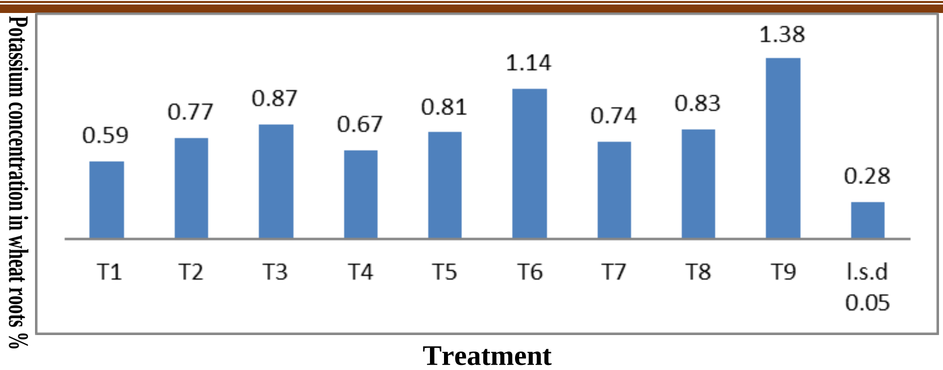


**Figure 10: Effect of different fertilizer combinations on potassium concentration in wheat roots %.**

Potassium concentration in wheat straw %: Figure 11 shows the effect of adding fertilizer treatments on the potassium content of wheat straw. It is noted that 2T achieved a significant difference represented by an increase in the potassium concentration in the wheat straw, and it outperformed each of the treatments T1, T4, and T7 by a rate of 1.65% and an increase of 60.1% compared to the control treatment T1. It is noted that in T4 and T7, both of which were sprayed with only water, soaking did not have an essential role in increasing the potassium concentration in wheat straw, i.e., spraying the plant with zinc was superior to soaking the seeds with zinc. Treatment T3 achieved a significant difference and outperformed the rest of the treatments, except for T6 and T9, at a rate of 2.64%.

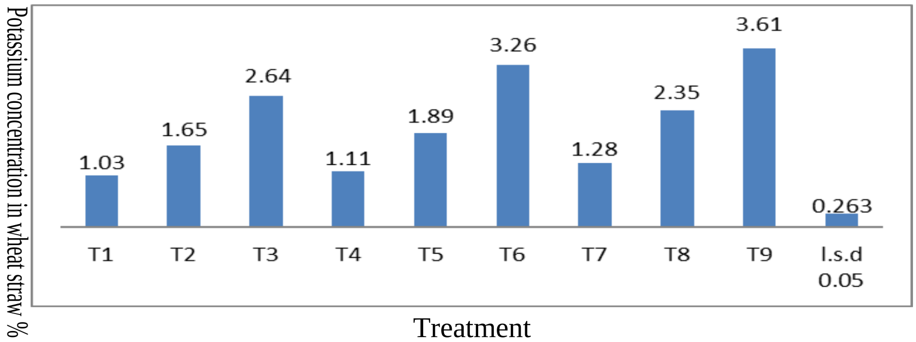


**Figure 11: Effect of different fertilizer combinations on potassium concentration in wheat straw, %.**

T4 and T7 increased the average potassium concentration of 1.11 and 1.28% for each of them, respectively, and exceeded the increase by 7.7 and 24.2%, respectively, compared to the control treatment T1. Treatments T5 and T8 achieved a significant difference in potassium in wheat straw at a rate of 83.4 and 128% for each of them, respectively, compared to the control treatment T1. Treatment T6 achieved the highest significant difference after T9, at a rate of 216%, outperforming all other treatments. Treatment T9 achieved the highest significant difference, represented by an increase in potassium concentration in wheat straw by a rate of 250%, superior to all other treatments.

Potassium/sodium ratio:

Potassium/sodium ratio in wheat straw: Figure 12 shows the effect of fertilizer treatments on the potassium/sodium ratio in the wheat straw, as the statistical analysis showed that there is a significant difference represented by an increase in the potassium/sodium ratio in the wheat straw when zinc is added to the plant as a spray and for the seeds to be soaked. The spraying treatments with zinc at 150 mg Zn $kg^{-1}$ and soaking with zinc at the same concentration significantly increased the potassium/sodium ratio.

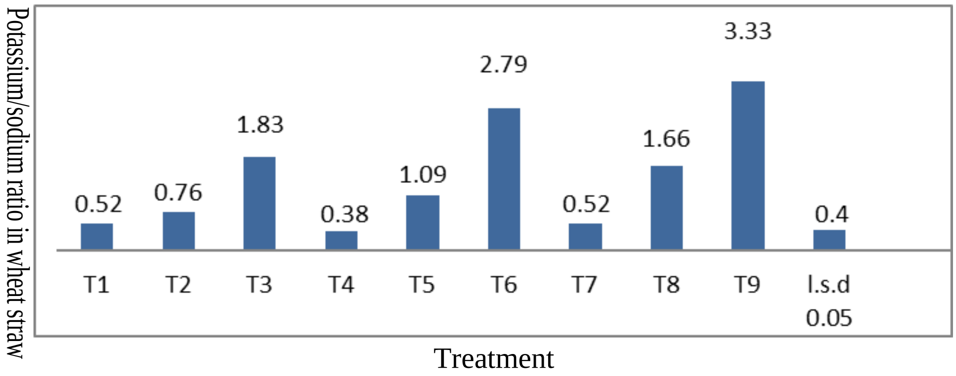


**Figure 12 The effect of fertilizer combinations on the potassium/sodium ratio in wheat straw.**

Potassium/sodium ratio in wheat root system: Figure 13 shows the effect of different fertilizer treatments on wheat roots' potassium/sodium ratio. It is noted that the fertilizer treatments led to significant effects on the potassium/sodium ratio, as the spraying treatments with zinc at 150 mg Zn $kg^{-1}$ generally achieved significant differences. The treatments led to an apparent increase in the potassium/sodium ratio. The Figure showed that T5 was superior by a percentage of 1.46, followed by treatment T8 by 1.35. Both treatments were significantly superior to most of the remaining treatments, whose seeds were soaked with zinc at varying concentrations, as soaking had an essential role in increasing the potassium concentration and reducing the sodium concentration.

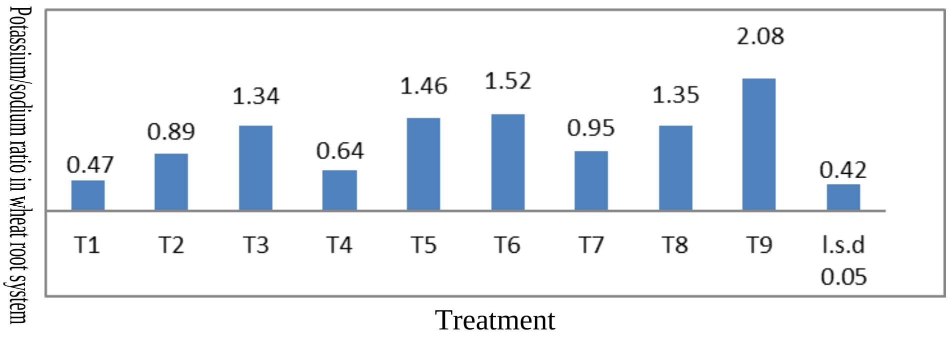


**Figure 13: The effect of different fertilizer combinations on the potassium/sodium ratio in wheat roots.**

The results in Figures 6, 7, 8, 9, 10, 11, 12, and 13 showed that adding zinc led to a reduction in the sodium concentration and chloride in wheat straw and roots, as it contributed to reducing salinity by reducing the accumulation of salt elements (sodium and chloride). In other words, it increased wheat's tolerance to salinity by establishing a mechanism that regulates sodium and chloride absorption (6). Zinc added to the plant in sufficient quantities also prevents sodium absorption and accumulation by increasing the integrity of the root cell membrane (24). The reason for the highest potassium concentration in wheat straw and roots with the increase in added zinc is due to the role of zinc in activating nutrient absorption processes, including potassium, which is consistent with (1). Zinc is an enzyme activator and the nucleic acids formation and participates in the amino acid tryptophan formation, which is the primary substance for the manufacture of indole acetic acid, a hormone (auxin) necessary for elongation and cell growth, which increases the plant's root system length, its growth, and its penetration into the soil, thus increasing the nutrients absorbed by the plant (5 and 11).

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