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# Effect of Spraying with Nano-Zinc and Mineral Npk Levels on Productivity and Grains Quality of Maize

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## ABSTRACT

Dual field trials were passed at Investigational Station Farm, Faculty of Agriculture, Mansoura University, Dakahlia Governorate, Egypt, throughout 2019 and 2020 time of year to study the outcome of spraying through nano-zinc levels (without, spraying with nano zinc at 200, 400 and 600 mg/L) and mineral NPK levels *i.e.* 100, 80, 60 and 40 % of proposed dosages on development, income and its features and characteristic of maize grains. Spraying maize thru Zn in nano from at 600 mg/L produced high ranking standards growing characters, income and its properties and quality characteristics of maize grains. Mineral fertilizing along with 120.0 kg N plus 45.0 kg $P_2O_5$ plus 24.0 kg $K_2O$/fed produced high-ranking standards of growing qualities, income and its properties and characteristic of maize grains. It could be concluded that spraying with nano zinc at 600 mg/L besides fertilizing with 120.0 kg N plus 45.0 kg $P_2O_5$ plus 24.0 kg $K_2O$/fed to produce utmost productivity and grains quality. While, to preserve high productivity and grains quality simultaneously lessen production charges and ecofriendly pollution, it could be proposed spraying with nano zinc at 600 mg/L as well as fertilizing with 96.0 kg N plus 36.0 kg $P_2O_5$ plus 19.2 kg $K_2O$/fed under ecological environments of Mansoura district, Dakahlia Governorate, Egypt.

***Keywords:*** Maize, nano zinc levels, NPK levels.

## INTRODUCTION

Maize (*Zea mays* L.) is the 3rd extremely valuable crop global, subsequent rice and wheat. The maize grains comprised of roughly 72% starch, 10% protein, 5% oil, 2% sugar, and 1% ash with the residual being water (Perry, 1988). Maize is one of the most important sources of edible oil besides secondhand as a fodder for livestock whether fresh, silage or grains.

Hence, a wonderful effort has been exerted to increase maize production either one by improving the cultivated area or expanding crop per unit area to lessen the difference between the production and the consumption. Thus, among factors that enhance maize productivity using nano zinc as foliar application and mineral nitrogen, phosphorus and potassium fertilizers levels as a new technique in fertilizing maize plants.

Zinc (Zn) is mandatory by plants for best possible metabolic rate, the effectiveness of this micro-component be contingent on its assimilation and translocation (Rengel, 2001). The use of zinc oxide nanoparticles (ZnO NPs) is well-thought-out a bio secure substantial for biotic types, since their effectiveness has been established to encourage the development of plants, in addition to in the destruction of sickness and the defense of plants for their antimicrobial action (Singh *et al.,* 2017). Uma *et al.* (2019) revealed that foliar application with nano ZnO at 500 ppm recorded higher ear length, No. kernels/ear, 100-kernel weight ultimately resulted in higher grain and stover crops/ha. Ram-Prosad *et al.* (2020) revealed that zinc is involved in manufacturing growth factors like auxins, which help plants create more cells and dry matter. Abbas *et al.* (2021) concluded that Zn foliar application especially in the nano form increased maize grain crop. Harish-Kumar *et al.* (2021) stated that application rate of 750 ppm of zinc nanoparticles put forward the maximum grain crop. Ahmad *et al.* (2022) specified that a great propounding for improving plant growing characteristics through nano ZnO bio-fortification in sandy-acidic soils. Azam *et al.* (2022) discovered that ZnO as nano-fertilizer heightened the growing characteristics and grain crop of maize. Choudhary *et al.* (2022) found that significantly highest grain, stover and biological crop were recorded with the dual foliar application of zinc-based nano-fertilizer at knee high stage and at 50 % tasseling stage over single stage foliar application. Reddy *et al.* (2022) concluded that because of the increased availability of macro and micronutrients to the plants, nano-Zn significantly improved plant progress and crop factors in maize. As a result, current agricultural research is focusing heavily on nano fertilizers as an alternative to chemical fertilizers, allowing for a more environmentally friendly approach in agriculture.

Crop improves up to maximum value and diminishes if utilized in an additional quantity of nitrogen. Nitrogen impacts numerous physiological and biochemical procedures in plant cells that eventually impact the development of plant. Appropriate nitrogen purposes as basal dosages at planting stage, split dosages at important growth stages such as knee high, and flowering stages are required for above average grain crop (Shrestha *et al.,* 2018; Ali *et al.,* 2019; Baloch *et al.,* 2020; Imran *et al.,* 2021; Bojtor *et al.,* 2022; Omar *et al.,* 2022 and Reddy *et al.,* 2022).

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Due to the fixation of phosphorus under Egyptian soil conditions, great attention must be paid to find the optimum rate of phosphorus application for maximum crop and higher quality of grains. Phosphorus has been recognized as a major element for plant nutrition and various recommendation on the rate of phosphorus for agronomic crop have been made. Ali *et al.* (2019) indicated that significant effect of phosphorus rates on days to plant tallness, No. grains ear$^{-1}$, grain crop, biological crop and harvest index. Bouras *et al.* (2021) showed that phosphorus applications tend to increase grain crop and biological crop. Getnet and Dugasa (2021) indicated that the highest grain crop was obtained with the highest rate of P (45 kg P/ha). Likewise, application of P significantly influenced dry biomass crop, plant tallness, ear length, No. ears per plant and 100-kernel weight. Naomi *et al.* (2021) reported that usage of 150 kg phosphate fertilizer ha$^{-1}$ of increased weight of 100 grains, while application 100 kg ha$^{-1}$ increased grain crop per hectare. Sankadiya and Sanodiya (2021) showed that growth parameters, crop features, grain crop/ha, stover crop/ha were found to be significantly highest with fertilizing maize with 70 kg P/ha.

Maize is mainly cultivated in the arable soils of Nile-valley, Nile-Delta and fertilized with N and P without any addition of K or micronutrients. One of the serious side effects of the high Dam construction is the deprival of silt from the soils. The native potassium content in the Egyptian soils has served as a potential reserve for crop removal of this element for the last 40 years. Gradual depletion of this reserve by continued cultivation should, therefore, be reconsidered in more extensive studies. Thus, must eventually lead to a comprehensive revision of the fertilization policy used presently for potassium. Under Egyptian conditions, soils are not rich enough to supply plants with their requirements of nitrogen, phosphorus and potassium. Nanganoa *et al.* (2020) described that a substantial soil potassium (K) insufficiency across various agro-ecological regions can have considerable impacts on maize production. Hence, potassium fertilizer is highly proposed to increase food production per unit area. Sankadiya and Sanodiya (2021) showed that growth parameters, crop features, grain crop/ha and stover crop/ha were found to be significantly highest with fertilizing maize with 60 kg K/ha. Ngosong *et al.* (2022) revealed that K fertilization produced further pay packet that with the 90 kg K ha$^{-1}$ rate being the most cost-effective for maize production. Wang *et al.* (2022) reported that K-fertilizer can enhance maize grain crop and soil available K content.

Thus, this research was founded to establish the impact of spraying with nano-zinc levels and mineral NPK levels on development, crop, its features and grains characteristic of maize S.C. Watanya-6.

## MATERIALS AND METHODS

Dual field trials were passed at Investigational Station Farm, Faculty of Agriculture, Mansoura University, throughout 2019 and 2020 time of year to study the outcome of spraying through nano-zinc levels and mineral NPK levels on development, income and its features and characteristic of maize grains.

Each experimentation was carried out in a strip-plot design including three replicates. The vertical-plots were designated to four foliar spraying with nano-zinc levels (without spraying "control treatment", spraying with nano zinc at 200, 400 and 600 mg/L in each spraying) twice after 30 and 45 days from planting. The horizontal plots were distributed to four mineral NPK levels *i.e.*, 100, 80, 60 and 40 % of the proposed dosages (120.0, 96.0, 72.0 and 48.0 kg N plus 45.0, 36.0, 27.0 and 18.0 kg $P_2O_5$ plus 24.0, 19.2, 14.4 and 9.6 kg $K_2O$/fed).

**Synthesis of metal nanoparticles:**

Zinc nanoparticles was eco-friendly synthesized using the method reported by Pattanayak and Nayak (2013) and slightly modified by El-Refai *et al.* (2018). Aqueous solutions of zinc sulfate and ascorbic acid were prepared using deionized water with three concertation levels (200, 400 and 600 ppm) for both solutions. Each concentration of ascorbic acid (20 mL) was added to the same concentration of metal salt solution (20 mL) by dropping very carefully to avoid rapid reaction which causes larger particle size and formation of precipitate under stirring for 2 hours at room temperature. The resulting nanoparticles were synthesized in an equimolar ratio of (1:1) according to Ibrahim *et al.* (2019).

Calcium super phosphate (15.5 % $P_2O_5$) was employed throughout soil provision (after determining the experimental units) at the aforementioned rates. The N-fertilizer in the manner of ammonium nitrate (33.5 % N) was utilized at the above-mentioned ratios as transmitting in two identical dosages one one-half after thinning (before the second irrigation) and the other half before the third irrigation. The K-fertilizer in the manner of K-sulphate (48 % $K_2O$) at formerly mentioned rates was utilized in one dose before the first irrigation.

Soil samples were taken at haphazard from the investigational field area at a depth of 0 - 30 cm from soil outside before soil preparation to determine the mechanical and chemical soil estates as shown in Table 1.

**Table 1. Mechanical and chemical soil characteristics at the experimental sites during 2018/2019 and 2019/2020 seasons.**

**Physical properties**

| | **Particle size distribution** | | | **Texture** | **F.C.** | **P.W.P** | **Available water** | **Bulk** |
|---|---|---|---|---|---|---|---|---|
| | **Sand%** | **Silt%** | **Clay%** | | **%** | **%** | **%** | **Density g $cm^{-3}$** |
| 2019 | 21.1 | 32.6 | 46.3 | Clayey | 32.25 | 16.00 | 16.25 | 1.17 |
| 2020 | 21.2 | 33.5 | 45.3 | Clayey | 32.40 | 16.00 | 16.00 | 1.14 |

Chemical properties

| | O.M.% | $CaCO_3$ % | Available, ppm | | | E.C | Soluble cations, meq/L | | | | Soluble anions, meq/L | | | | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | $dS.m^{-1}$ | Ca | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $Co_3^{-}$ | $HCO_3^{-}$ | $Cl^{-}$ | $SO_4^{--}$ | |
| 2019 | 2.62 | 2.95 | 22 | 7 | 145 | 1.65 | 5.5 | 6.0 | 3.9 | 1.1 | 0.0 | 5.0 | 6.4 | 5.1 | 7.88 |
| 2020 | 2.87 | 2.50 | 31 | 11 | 175 | 1.71 | 5.0 | 5.6 | 4.5 | 2.0 | 0.0 | 5.5 | 7.0 | 4.6 | 7.5 |

The experimental field was well prepared. The conventional agricultural procedures for producing maize corresponding to the suggestions of Ministry of Agriculture have been, not including for the factors under investigation.

At harvesting period, samples of three restrained plants were taken at chance as of each one plot to decide; plant tallness (cm), ear tallness (cm), ear leaf space ($cm^2$) according to Gardner *et al.* (1985), ear distance in cm, ear thickness in cm, No. of rows/ear, No. of grains/row, ear grains weight in g, weight of 100 grains in g, grain crop (ardab/fed), protein and oil ratios in grains (%) according to A.O.A.C. (2007).

The acquired data were statistically evaluated as issued by Gomez and Gomez (1984) corresponding to the system of analysis of variance (ANOVA) for the strip – plot design. Least significant difference (LSD) technique was used as illustrated by Snedecor and Cochran (1980) to examine the variations amongst medication means at 5 % level of probability.

## RESULTS AND DISCUSSION

**Effect of foliar spraying with nano-zinc levels:**

Regarding the effect of foliar spraying with zinc levels in nano form (200, 400 and 600 mg/L in each spraying) in addition control treatment (without foliar spraying with nano-zinc) significantly affected growing characteristics, crop and its features and grains excellence of maize in both time of year (Tables 2 and 3).

**Table 2. The averages of plant and ear tallness, ear leaf space, ear length and diameter and No. rows/ear of maize as affected by spraying with nano-Zn and mineral NPK levels and their interaction throughout 2019 and 2020 summer seasons.**

| Characters Treatments | Plant tallness (cm) | | Ear tallness (cm) | | Ear leaf space $(cm)^2$ | | Ear length (cm) | | Ear diameter (cm) | | No. rows/ear | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| A. Foliar spraying with nano-zinc levels: | | | | | | | | | | | | |
| Without | 251.4 | 238.3 | 133.8 | 104.1 | 510.3 | 556.5 | 18.81 | 18.93 | 4.18 | 4.37 | 12.16 | 12.83 |
| Nano-zinc at 200 mg/L | 271.6 | 242.6 | 140.5 | 107.7 | 590.4 | 637.2 | 18.97 | 19.24 | 4.27 | 4.84 | 12.50 | 13.00 |
| Nano-zinc at 400 mg/L | 289.4 | 246.9 | 146.6 | 117.3 | 693.0 | 655.3 | 21.01 | 19.58 | 4.45 | 4.98 | 12.66 | 14.66 |
| Nano-zinc at 600 mg/L | 309.0 | 251.5 | 150.2 | 122.2 | 773.3 | 725.7 | 21.09 | 21.00 | 4.86 | 5.13 | 14.00 | 14.83 |
| F. test | * | * | * | * | * | * | * | * | * | * | * | * |
| LSD at 5 % | 2.1 | 2.8 | 2.1 | 2.7 | 20.5 | 20.9 | 0.45 | 0.40 | 0.07 | 0.10 | 0.60 | 0.68 |
| B. NPK levels (ratio from the proposed doses): | | | | | | | | | | | | |
| 100 % | 290.0 | 250.9 | 152.7 | 115.9 | 710.4 | 705.8 | 20.26 | 20.64 | 4.66 | 5.08 | 13.83 | 15.00 |
| 80 % | 283.2 | 246.1 | 146.3 | 116.0 | 671.2 | 655.8 | 20.22 | 19.56 | 4.48 | 4.90 | 13.00 | 14.16 |
| 60 % | 276.5 | 242.7 | 139.7 | 112.0 | 612.4 | 617.2 | 19.82 | 19.45 | 4.41 | 4.81 | 12.50 | 13.33 |
| 40% | 271.6 | 239.6 | 132.5 | 107.5 | 573.1 | 596.0 | 19.59 | 19.09 | 4.20 | 4.53 | 12.00 | 12.83 |
| F. test | * | * | * | * | * | * | * | * | * | * | * | * |
| LSD at 5 % | 1.8 | 2.0 | 1.4 | 1.6 | 14.5 | 15.3 | 0.50 | 0.60 | 0.05 | 0.07 | 0.95 | 1.06 |
| C- Interaction (F. test): | | | | | | | | | | | | |
| A × B | * | NS | * | NS | * | * | NS | * | * | * | * | NS |

**Table 3. The averages of No. grains/row, grains weight/ear, 100-grain weight, grain crop/fed, protein and oil percentages in maize grains as affected by spraying with nano-Zn and mineral NPK levels and their interaction throughout 2019 and 2020 summer seasons.**

| Characters Treatments | No. grains /row | | Grains weight/ear (g) | | 100-grain weight (g) | | Grain crop (ardab/fed) | | Protein (%) | | Oil (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| A. Foliar spraying with nano-zinc levels: | | | | | | | | | | | | |
| Without | 37.16 | 35.00 | 182.0 | 141.6 | 44.18 | 44.20 | 25.04 | 25.18 | 7.18 | 6.88 | 6.01 | 5.71 |
| Nano-zinc at 200 mg/L | 39.25 | 42.41 | 188.3 | 168.3 | 45.27 | 45.24 | 25.73 | 25.81 | 7.27 | 6.97 | 6.09 | 5.78 |
| Nano-zinc at 400 mg/L | 40.91 | 48.00 | 215.4 | 196.2 | 45.45 | 45.48 | 26.87 | 26.76 | 7.45 | 7.14 | 6.96 | 6.61 |
| Nano-zinc at 600 mg/L | 41.91 | 51.08 | 234.5 | 212.9 | 46.06 | 46.15 | 29.09 | 28.60 | 7.86 | 7.53 | 7.60 | 7.21 |
| F. test | * | * | * | * | * | * | * | * | * | * | * | * |
| LSD at 5 % | 1.06 | 1.12 | 21.6 | 22.5 | 0.12 | 0.10 | 0.24 | 0.22 | 0.07 | 0.08 | 0.19 | 0.18 |
| B. NPK levels (ratio from the proposed doses): | | | | | | | | | | | | |
| 100 % | 41.83 | 49.16 | 215.8 | 192.5 | 45.68 | 45.85 | 27.19 | 27.38 | 7.67 | 7.35 | 7.16 | 6.80 |
| 80 % | 41.25 | 45.66 | 204.1 | 182.5 | 45.67 | 45.58 | 26.79 | 26.77 | 7.48 | 7.16 | 6.76 | 6.41 |
| 60 % | 38.91 | 42.58 | 201.6 | 175.0 | 45.41 | 45.44 | 26.56 | 26.53 | 7.41 | 7.10 | 6.68 | 6.33 |
| 40% | 37.25 | 39.08 | 198.7 | 169.1 | 44.20 | 44.21 | 26.17 | 25.68 | 7.20 | 6.90 | 6.06 | 5.75 |
| F. test | * | * | * | * | * | * | * | * | * | * | * | * |
| LSD at 5 % | 0.88 | 0.92 | 14.7 | 15.2 | 0.10 | 0.08 | 0.26 | 0.24 | 0.04 | 0.05 | 0.22 | 0.21 |
| C- Interaction (F. test): | | | | | | | | | | | | |
| A × B | NS | * | NS | NS | * | * | * | * | * | * | * | * |

It is clearly seen that, spraying maize plants two times thru Zn in nano from at the rate of 600 mg/L in each spraying produced the high-ranking standards of growing characteristics, crop and its features and grains excellence of maize in the two growing seasons. The second-best foliar spraying treatment was spraying maize plants thru Zn in nano from at the rate of 400 mg/L, which was followed by spraying thru Zn in nano from at the rate of 200 mg/L concerning its effect on growth characters, crop and its features and grains quality in both season. While, the lowest values of growing characteristics, crop and its features and grains excellence of maize were obtained due to the control treatment (without foliar spraying) in the two growing seasons.

These increases in growing qualities, crop and its characteristics and grains excellence by foliar spraying by solution of nano zinc at various rates may be due to zinc plays an important role in the production of biomass (Kaya and Higgs, 2002), accordingly enhancement nutritive plant status, meristematic activity, and plant tallness. These results are in good accordance compatible with those recorded by Singh *et al.* (2017), Uma *et al.* (2019), Harish-Kumar *et al.* (2021), Ahmad *et al.* (2022), Azam *et al.* (2022), Choudhary *et al.* (2022) and Reddy *et al.* (2022).

**Effect of mineral NPK levels:**

The obtained results in clearly verification that mineral nitrogen, phosphorus, and potassium (NPK) levels significantly affected growing characteristics, crop and its features and grains excellence of maize in both time of year (Tables 2 and 3).

The achieved results showed that mineral fertilizing maize with 100 % of the proposed dosages (120.0 kg N plus 45.0 kg $P_2O_5$ plus 24.0 kg $K_2O$/fed) produced the high-ranking standards of growing characteristics, crop and its features and grains excellence of maize in the two growing seasons. This level followed by mineral fertilizing maize plants with 80 % of the proposed dosages (96.0 kg N plus 36.0 kg $P_2O_5$ plus 19.2 kg $K_2O$/fed), which followed by mineral fertilizing with 60 % of the proposed dosages (72.0 kg N plus 27.0 kg $P_2O_5$ plus 14.4 kg $K_2O$/fed) and then mineral fertilizing with 40% of the proposed dosages (48.0 kg N plus 18.0 kg $P_2O_5$ plus 9.6 kg $K_2O$/fed), which recorded the lowest values of growing characteristics, crop and its features and grains excellence of maize in the growing seasons.

The increases in growth characters, crop and its features and grains quality allied with increasing mineral NPK fertilizers level may be recognized to the role of nitrogen in protoplasm and chlorophyll formation, enhancement meristematic activity and cell division, consequently, increases cell size which caused increase in plant tallness. A similar observation was reported by Baloch *et al.* (2020), Imran *et al.* (2021), Naomi *et al.* (2021), Sankadiya and Sanodiya (2021), Bojtor *et al.* (2022), Ngosong *et al.* (2022), Omar *et al.* (2022), Reddy *et al.* (2022) and Wang *et al.* (2022).

**Effect of interaction:**

There were many significant influences on growing characteristics, crop and its features and grains excellence as a result of the interaction between foliar spraying with nano-zinc levels and mineral NPK levels (Tables 2 and 3). We present only the significant interaction on grain and protein and oil ratios in grains in both seasons.

From the achieved results of this study, it could be noticed that the high-ranking standards of grain crop/fed (Fig. 1), crude protein (Fig. 2) and oil (Fig. 3) percentages in grains were resulted from mineral fertilizing maize with 100 % of the proposed dosages (120.0 kg N plus 45.0 kg $P_2O_5$ plus 24.0 kg $K_2O$/fed) and spraying maize plants twice thru Zn in nano from at the rate of 600 mg/L in each spraying. The second-best interaction treatment without significant differences in most cases was mineral fertilizing maize with 80 % of the proposed dosages (96.0 kg N plus 36.0 kg $P_2O_5$ plus 19.2 kg $K_2O$/fed) and spraying maize plants twice thru Zn in nano from at the rate of 600 mg/L in each spraying regarding its effect on grain crop and grains quality in both seasons. The third best interaction treatment was mineral fertilizing maize with 60 % of the proposed dosages (72.0 kg N plus 27.0 kg $P_2O_5$ plus 14.4 kg $K_2O$/fed) and spraying maize plants twice thru Zn in nano from at the rate of 600 mg/L in each spraying in both seasons. While the lowest values of grain crop/fed, protein and oil ratios in grains were resulted from mineral fertilizing maize with 40 % of the proposed dosages (48.0 kg N plus 18.0 kg $P_2O_5$ plus 9.6 kg $K_2O$/fed) without foliar spraying with nano-zinc in both seasons.

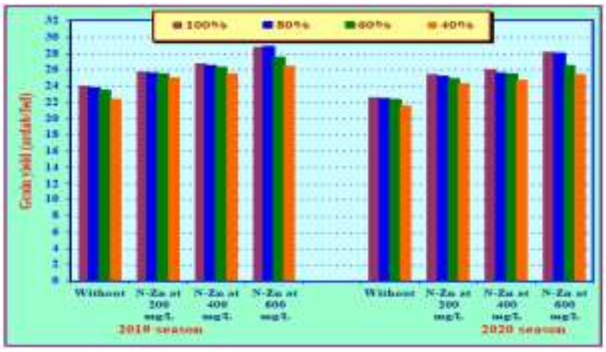


**Fig. 1. Grain crop (ardab/fed) as affected by the interaction between foliar spraying with nano-Zn levels and mineral NPK levels during 2019 and 2020 seasons.**


**Fig. 2. Protein percentage (%) in grains as affected by the interaction between foliar spraying with nano-Zn levels and mineral NPK levels during 2019 and 2020 seasons.**

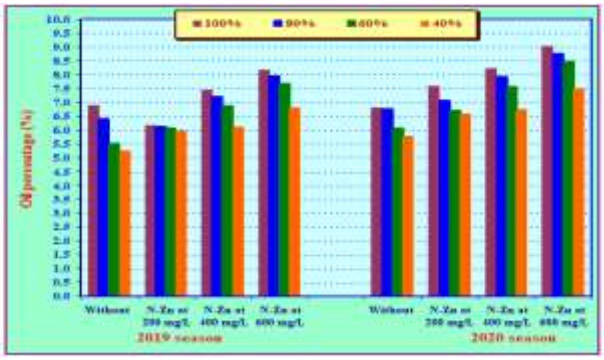


**Fig. 3. Oil percentage (%) in grains as affected by the interaction between spraying with nano-Zn levels and mineral NPK levels during 2019 and 2020 seasons.**

## CONCLUSION

From the accomplished results of this study, it could be concluded that foliar spraying maize plants twice after 30 and 45 days from sowing thru Zn in nano from at the rate of 600 mg/L besides mineral fertilizing with 100 % of the proposed dosages (120.0 kg N plus 45.0 kg $P_2O_5$ plus 24.0 kg $K_2O$/fed) to produce maximum productivity and grains quality. It could be proposed foliar spraying maize plants twice after 30 and 45 days from sowing thru Zn in nano from at the rate of 600 mg/L as well mineral fertilizing with 80 % of the proposed dosages (96.0 kg N plus 36.0 kg $P_2O_5$ plus 19.2 kg $K_2O$/fed) under the environmental conditions of Mansoura district, Dakahlia Governorate, Egypt.

## REFERENCES


A.O.A.C. (2007). Official Methods of Analysis. 18th Ed. Association of Official Analytical Chemists, Inc., Gaithersburg, MD, Method 04.

Abbas, H.H.; E.H. Noufal; I.M. Farid ; Manal, A. Attia ; Rehab, A. Ahmed and M.H.H. Abbas (2021). Effect of traditional sources of Zn and ZnO-nano-particles foliar application on productivity and P-uptake of maize plants grown on sandy and clay loam soils. Environ. Biodiv. Soil Sec., 5: 59-72.

Ahmad, W.; J. Nepal; X. Xin and Z. He (2022). Nano zinc-oxide enhanced photosynthetic apparatus and photosystem efficiency of maize (*Zea mays* L.) in sandy-acidic soils. Research Square, 2022, doi.org/10.21203/rs.3.rs-1236243/v1.

Ali, S.A.; L. Tedone; L. Verdini ; E. Cazzato and G. De-Mastro (2019). Wheat response to no-tillage and nitrogen fertilization in a long-term faba bean-based rotation. Agron., 9, 50; doi: 10. 3390 /agronomy 9020050.

Azam, M.; H.N. Bhatti; A. Khan; L. Zafar and M. Iqbal (2022). Zinc oxide nano-fertilizer application (foliar and soil) effect on the growth, photosynthetic pigments and antioxidant system of maize cultivar. Biocat. and Agric. Biotech., 42, July 2022, 102343.

Baloch, N.A.; A.A. Kaleri; G.M. Laghari; A.H. Kaleri; G.S. Kaleri; A. Mehmood and M.M. Nizamani (2020). Effect of nitrogen levels and application scheduling on the growth and crop of maize. J. Appl. Res. in Plant Sci., 1(2): 42-52.

Bojtor, C.; S.M.N. Mousavi; A. Illés; F. Golzardi; A. Széles; A. Szabó; J. Nagy and C.L. Marton (2022). Nutrient composition analysis of maize hybrids affected by different nitrogen fertilization systems. Plants, 11, 1593. doi.org/ 10.3390/plants11121593.

Bouras, H.; B. Aouaziz; R. Choukr-Allah; A. Hirich ; K.P. Devkota and B. Bouazzama (2021). Phosphorus fertilization enhances productivity of forage corn (*Zea mays* L.) irrigated with saline water. Plants, 10, 2608, doi.org/10.3390/ plants10122608.

Choudhary, P.; D. Singh; M.K. Kaushik; S.S. Sharma; H.K. Jain; V. Saharan ; D.P. Singh ; R.K. Sharma and D. Chouhan (2022). Production, productivity and quality of maize (*Zea mays* L.) as affected by foliar application of zinc-based nano-fertilizer and different fertility levels. The Pharma Inn. J., 11(2): 1878-1882.

El-Refai, A.A.; G.A. Ghoniem ; A.Y. El-Khateeb and M.M. Hassaan (2018). Eco-friendly synthesis of metal nanoparticles using ginger and garlic extracts as biocompatible novel antioxidant and antimicrobial agents. J. Nanostruct. Chem., 8(1): 71-81. https :// doi.org/10.1007/s40097-018-0255-8.

Gardner, F.P.; R.B. Pearce and R.L. Michell (1985). Physiology of crop plant. Iowa State Univ. Press Ames. Iowa. USA pp. 58-75.

Getnet, B.E. and T. Dugasa (2021). Response of maize crop and crop related components to different levels of nitrogen and phosphorus fertilizers. Acta Sci. Agric., 3(1): 3-8.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research. 2nd Ed., Jhon Wiley and Sons Inc., New York, pp: 95-109.

Harish-Kumar, K.; S. Adithya and V.P. Savalgi (2021). Evaluation of foliar application of zinc nanoparticles on growth and crop parameters of maize (*Zea mays* L.) grown under greenhouse conditions. Intern. J. of Chem. Studies, 9(1): 1464-1467.

Ibrahim, F.Y.; A.Y. El-Khateeb and A.H. Mohamed (2019). Rhus and safflower extracts as potential novel food antioxidant, anticancer, and antimicrobial agents using nanotechnology. Foods, 8, 139. https :// doi .org/10.3390/foods8040139.

Imran, M.; A. Ali and M.E. Safdar (2021). The impact of different levels of nitrogen fertilizer on maize hybrids performance under two different environments. Asian J. Agric. Bio., 4, 202010527, doi. Org /10 .35495/ajab.2020.10.527.

Kaya, C. and D. Higgs (2002). Response of tomato (*Lycopersicon esculentum* L.) cultivars to foliar application of zinc when grown in sand culture at low zinc. Sci. Hort., 93: 53-64.

Nanganoa, L.T.; F.A. Ngome; C. Suh and S.D. Basga (2020). Assessing soil nutrients variability and adequacy for the cultivation of maize, cassava and sorghum in selected agro-ecological zones of Cameroon. Intern. J. of Agron., 1-20, doi: 10.1155/2020/8887318.

Naomi, M.R.; I.A. Supriyono and N. Pardono (2021). Role of phosphate fertilizer on growth and crop of hybrid maize (*Zea mays* L.). IOP Conf. Series: Earth and Environ. Sci., 637, 012070, doi:10.1088/1755-1315/637/1/012070.

Ngosong, C.; A.T. Enow; M.N.E. Olougou and A.S. Tening (2022). Optimizing potassium fertilizer rates for sustainable maize (*Zea mays* L.) production on the volcanic soils of Buea, Cameroon. Fund. and App. Agric., 7(1): 11-20, doi: 10.5455/faa.969718.

Omar, S.; R. Abd Ghani; H. Khaeim; A.H. Sghaier and M. Jolánkai (2022). The effect of nitrogen fertilization on crop and quality of maize (*Zea mays* L.). Acta Alimentaria, 51(2): 249-258, 10.1556/ 066. 2022. 00022.

Pattanayak, M. and P.L. Nayak (2013). Ecofriendly green synthesis of iron nanoparticles from various plants and spices extract. Int. J. Plant Anim. Environ. Sci., 3(1): 68-78.

Perry, W.P. (1988). Corn as a livestock feed. In Sprague, C.E. & Dudley, J.W. (eds) Corn and corn improvement, (3rd edition) (pp: 941-963), American Society of Agronomy, Madison, WI.

Rahmani, F.; A. Peymani; E. Daneshvand and P. Biparva (2016). Impact of zinc oxide and copper oxide nano-particles on physiological and molecular processes in *Brassica napus* L. Indian J. of Plant Physiol., 21(2): 122- 128.

Ram-Prosad, N.; R. Hasim; C.H. Nitin; B. Animesh-Ghosh and H. Gora-Chand (2020). Effect of Zn and B on the growth and nutrient uptake in ground nut. Current J. App. Sci., 39(1): 1-10.

Reddy, B.M.; S. Elankavi; M.S. Kumar; M.V. Sai and B.D. Vani (2022). Effects of conventional and nano fertilizers on growth and crop of maize (*Zea mays* L.). Bhartiya Krishi Anusandhan Patrika, doi: 10.18805/BKAP500.

Rengel, Z. (2001). Genotypic differences in micronutrient use efficiency in crops. Comm. Soil Sci. Plant Anal., 32: 1163-1186.

Sankadiya, S. and L. Sanodiya (2021). Effect of phosphorus and potassium levels on growth and crop of maize (*Zea mays* L.). The Pharma Inn. J., 10(10): 1347-1350.

Shrestha, J.; A. Chaudhary and D. Pokhrel (2018). Application of nitrogen fertilizer in maize in Southern Asia: a review. Peruvian J. of Agron., 2(2): 22-26.

Singh, A.; N.B. Singh; S. Afzal; T. Singh and I. Hussain (2017). Zinc oxide nanoparticles: A review of their biological synthesis, antimicrobial activity, uptake, translocation and biotransformation in plants. J. Mater. Sci., 53: 185-201.

Snedecor, G.W. and W.G. Cochran (1980). "Statistical Methods" 7th Ed. The Iowa State Univ. Press, Iowa, USA.

Uma, V.; H.M. Jayadeva; H.M. Atheekur-Rehaman; G.G. Kadalli and N. Umashankar (2019). Influence of nano zinc oxide on crop and economics of maize (*Zea mays* L.). Mysore J. Agric. Sci., 53(4): 44-48.

Wang, X.; W. Hu; X. Ning; W. Wei; Y. Tang and Y. Gu (2022). Effects of potassium fertilizer and straw on maize crop, potassium utilization efficiency and soil potassium balance. Arch. of Agron. and Soil Sci., doi: 10.1080/03650340.2022.2025997.

## تأثير الرش الورقى بمستويات من النانو زنك والتسميد المعدنى بـ NPK على إنتاجية وجودة حبوب الذرة الشامية

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### الملخص

أقيمت تجربتان حقليتان بالمزرعة البحثية بمركز التجارب والبحوث الزراعية، كلية الزراعة - جامعة المنصورة - خلال موسمي 2019 و2020م، بهدف دراسة تأثير الرش الورقي بمستويات من النانو زنك والتسميد المعدني بمستويات من NPK على النمو والمحصول ومكوناته وصفات جودة حبوب الذرة الشامية. نفذت كل تجربة في تصميم الشرائح المتعامدة في ثلاث مكررات. أوضحت النتائج المتحصل عليها أن الرش الورقى لنباتات الذرة الشامية مرتين بمحلول النانو زنك بمعدل 600 مجم / لتر أدى للحصول على أعلى القيم لصفات النمو والمحصول ومكوناته وصفات جودة الحبوب في موسمي النمو. أظهرت النتائج المتحصل عليها أن التسميد المعدني للذرة الشامية بنسبة 100٪ من الجرعات الموصى بها سجلت أعلى قيم لصفات لصفات النمو والمحصول ومكوناته وصفات جودة الحبوب في كلا موسمي النمو. من النتائج المتحصل عليها يمكن استنتاج أن الرش الورقي لنباتات الذرة الشامية مرتين بعد 30 و45 يوم من الزراعة بمحلول النانو زنك بمعدل 600 ملجم / لتر بالإضافة إلى التسميد المعدني بنسبة 100٪ من الجرعات الموصى بها (120.0 كجم نيتروجين + 45.0 كجم فو$_2$أ$_5$ + 24.0 كجم بو$_2$أ /فدان) أدى للحصول على أقصى إنتاجية وجودة للحبوب. فى حين أنه للحفاظ على الإنتاجية العالية وجودة الحبوب وفي نفس الوقت تقليل تكاليف الإنتاج والحد من التلوث البيئي، يمكن التوصية بالرش الورقى لنباتات الذرة الشامية مرتين بعد 30 و45 يومًا من الزراعة بمحلول النانو زنك بمعدل 600 ملجم / لتر مع التسميد المعدني بنسبة 80٪ من الجرعات الموصى بها (96.0 كجم نيتروجين + 36.0 كجم فو$_2$أ$_5$ + 19.2 كجم بو$_2$أ/فدان) تحت الظروف البيئية لمنطقة المنصورة، محافظة الدقهلية، مصر.