Effect of Spray with Nano NPK, Complete Micro Fertilizers and Nano Amino Acids on Some Growth and Yield Indicators of Maize (Zea mays L.)

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Abstract

In order to evaluate some growth and yield indicators of maize plant towards foliar spray by Nano NPK and Nno complete micro (NCM) fertilizers, and Nano amino acids (NAA). A field experiment was implemented in the summer season of 2019 according to the Randomized Complete Block Design (RCBD) with three replicates for each treatment. The experiment consisted of two factors; the first factor consisting of: control, Nano NPK (20-20-20) and NPK (12- 12-36); while the second factor consisting of: control, NCM, NAA and NCM + NAA.

The studied indicators on maize plant included chlorophyll content in leaves (SPAD unit), plant height (m), stem diameter (cm), biological yield (ton. h⁻¹), grains yield (ton. h⁻¹), harvest index (%). Results showed the significant superiority of Nano NPK (12-12-36) spray in achieving the highest means for all studied indicators. Spraying of NCM + NAA achieved the highest means for chlorophyll content in leaves, stem diameter, grains yield and harvest index. The interaction of the study factors gave by the combination of Nano NPK (12-12-36) with NCM + NAA, the highest means of chlorophyll content in leaves, plant height, stem diameter, grains yield and harvest index.

Keywords: Nano NPK, NCM, NAA, Maize.

1. Introduction

1.1. Background

Maize (Zea mays L.) has many beneficial properties. Its importance in current and future global food security is no less important in the Global carbon budget (C4 plant) as well as its tolerance to dry and semi-arid environments [1]. Maize is one of the important strategic crops, with multiple uses for agricultural and industrial fields, and it occupies the third place in terms of cultivated area and production in the world after the crops of wheat and rice, and because it is a quad carbon plant (C4), it is characterized by high production capacity compared with other cereals crops are also the first on record for average grain yield per unit area [2].

In spite of the significant importance of this crop and the growing interest in its cultivation in Iraq, there is a deterioration in its agricultural production and a decrease in the cultivated areas during the last decade and based on data and statistics issued by the Iraqi Agricultural Statistics Directorate and the Arab Organization for Agricultural Development, the total area cultivated by maize crop decreased from 154.70 thousand hectares in 2007 to 117 thousand hectares in 2010, with a decrease of 24%. The same statistics indicated a decrease in the production rate from 366.66 thousand tons in 2007 to 267 thousand tons in 2010, and a decrease of 27 % [3].

Essential nutrient supplementation (fertilizer elements) is a must in improving crop productivity and soil fertility [4]. However, careful management of fertilizers is one of the most basic requirements for sustainable agricultural development [5, 6]. Thus, large quantities of fertilizers are used to improve soil fertility and crop productivity [7, 8]. It has also been unambiguously observed that one third of crop productivity is attributable to fertilizers and the other depends on the efficiency of the use of other agricultural inputs; however the efficiency of nutrient use for conventional fertilizers is barely limited to between 30 – 40 % [9]. Nano-fertilizers are nutrient vectors that are developed using raw materials Substrates of nanoscale ranging from 1 – 100 nm. Nanoparticles have a wide surface area and the ability to retain an abundance of nutrients
and release them slowly and stably so as to facilitate the absorption of nutrients that corresponds to crop requirements without any disadvantages associated with specialized fertilizer inputs [10].

Nanomaterials stimulate a number of Bio aspects of plant biology, plant root and leaf surfaces are the main nutrient gate for plants with porous nanomaterials [11, 12]. Thus, the addition of nanofertilizers can improve the absorption of plant nutrients through these pores, or it can facilitate the complex process by using molecular vectors or root secretions by creating new pores, or by endocytosis channels or ion channels [13]. Moreover, it has been clearly observed through a large number of research that reducing the size of nanomaterials facilitates increasing the ratio of mass surface of particulars, and as a result an enormous amount of nutrient ions is slowly and steadily absorbed for an extended period of time, thus fertilizer nanostructures ensure balanced nutrition of crops throughout the growth cycle that ultimately improves agricultural production, it is worth noting that increasing the efficiency of the product may encourage farmers to use the product more profitably [14, 15].

1.2. Objectives

The current study aims to evaluate some of growth and yield indicators for maize towards leaf spraying with various fertilizer treatments from Nano NPK, NCM and NAA.

2. Materials and Methods

2.1. Experimental Design

The experiment consisting of two factors was designed according to the Randomized Complete Block Design (RCBD) with three replicates for each treatment [16], the first factor represented by Nano NPK consisted of three treatments: control, NPK (20-20-20) and NPK (12-12-36), while the second factor consisting of four treatments: control, NCM, NAA and NCM + NAA.

2.2. Soil Preparation, Sampling and Analysis

The field soil was prepared prior to planting by plowing, smoothing and leveling operations, and then a soil sample was taken by spade by digging a V-shaped hole with a depth of 0-60 cm from five sites represented by the four sides of the field and the center to be a representative sample of the field soil after being air-dried and ground with ceramic mortar and sieve it (2 mm), and then perform laboratory tests on it according to the methods mentioned by Estefan et al. [17], which included: electrical conductivity (EC) = 4.98 ds m⁻¹; pH = 7.5; Available-N = 26.0 mg kg⁻¹, Available-P = 13.0 mg kg⁻¹, Available-P = 280.0 mg kg⁻¹; Organic matter = 0.15 %; Cation-exchange capacity (CEC) = 26.34 mq 100 g⁻¹; Soil texture = Silt clay loam. The experiment field was divided into three equal blocks separated from each other by a distance of 1 m, and each block was divided into 12 experimental unit, and leaving a distance of 1 m between each of experimental unit and other.

2.3. Cultivation and Crop Management

On 1/ 8/ 2019, the seeds of maize were sown in pits in the upper third of the border at a depth of 5 cm and the distance between one pit to another was 30 cm by 3 seeds per pit. Upon completion of germination, one plant was kept for each pit and the experiment field was irrigated whenever needed to maintain suitable soil moisture until the start of the treatments, as well as manually controlling the bush by weeding whenever necessary and before the fertilization applications.

2.4. Fertilization Applications

2.4.1. Soil Fertilization by Urea Fertilizer

It was added to all treatments by 300 kg h⁻¹ on three batches; The first batch represented a quarter of the quantity (75 kg h⁻¹) and was added a month after the planting process, the second batch represented half of the quantity (150 kg h⁻¹) and was added a month after the first addition, while the third batch represented the last quarter (75 kg h⁻¹) it was added a month after the second addition process for the purpose of supplying plants with nutrients during the different growth stages.

2.4.2. Foliar Fertilization by Nano Fertilizers

NPK (20-20-20), NPK (12-12-36) by (2 g L⁻¹) and Nano Chelated Complete Micro Fertilizer (NCM) by (2 g L⁻¹) were added according to the instructions of the manufacturer of fertilizers (KHARZA, Iran) and Nano amino acids (NAA) (Optimus Plus: agricultural fertilizer manufactured according to nanotechnology containing amino acids 30%, nitrogen 5% and organic nitrogen 3%) by (2 ml L⁻¹) according to manufacturer's instructions. The mentioned fertilizers were added by the method of foliar spray by two sprinkles, the first was 50 days after the date of planting and the second was a week after the first spray.
2.5. Studied Indicators

2.5.1. Chlorophyll Content in Leaves (SPAD unit)
Chlorophyll content was measured by using a portable SPAD-502 chlorophyll meter (MIMOLTA CO. LTD. JAPAN) to obtain a rapid estimate of the leaf chlorophyll content in real time in the field [18].

2.5.2. Plant Height (m)
Plant height measured by tape measure from the soil surface level to the highest plant height at 100 % flowering [19].

2.5.3. Stem Diameter (cm)
Stem diameter measured from the surface area close to the soil surface by using digital vernier caliper.

2.5.4. Biological Yield (ton h⁻¹)
Biological yield was estimated of the harvested plants weight within the specified square meter of each experimental unit after air-drying them until their weight stability, then calculating them to ton per hectare at moisture content of 14% [20].

2.5.5. Grains Yield (ton h⁻¹)
Grains yield was estimated of the harvested plants within the specified square meter of each experimental unit by ears remove from the plants and then separating the grains from cob and calculating converting them to ton per hectare at moisture content of 14% [20].

2.5.6. Harvest Index (%)
Harvest index of maize crop was estimated by using formula:

\[
\text{Harvest index (\%) } = \frac{\text{Grains yield}}{\text{Biological yield}} \times 100 \quad [20]
\]

2.6. Statistical Analysis
Results data were statistically analyzed using the Analysis of Variance test within the Analysis ToolPak package included within the Excel add-on [21]. The mean treatments were compared when the differences between them were significant by using the Least Significant Difference (LSD) test at the probability level (P ≤ 0.05) [16].

3. Results

3.1. Chlorophyll Content in Leaves (SPAD unit)
Results in Table (1) indicated the significant effect of Nano NPK fertilizers spray on increasing the mean of chlorophyll content in leaves (SPAD unit) of maize to 54.63 SPAD unit when treated by Nano NPK (12-12-36) compared with 51.08 SPAD unit of control plants. Spraying of NCM and NAA gave the highest mean of chlorophyll content in leaves 56.19 SPAD unit when treated by NCM + NAA compared with 49.22 SPAD unit of control plants. The interaction between the study factors gave the same effect to the single factors by recording the highest mean of chlorophyll content in leaves 58.60 SPAD unit as a result of treatment by Nano NPK (12-12-36) with NCM + NAA compared with 47.76 SPAD unit of control plants.

Table 1. Effect of spray with Nano NPK, NCM and NAA on chlorophyll content in leaves (SPAD unit) of maize (Z. mays L.)

| NPK N (2 g L⁻¹) | Control | NCM (2 g L⁻¹) | NAA (2 ml L⁻¹) | NCM + NAA | Mean - A |
|----------------|---------|---------------|----------------|-----------|----------|
| Control        | 47.76   | 52.33         | 50.80          | 53.43     | 51.08    |
| NPK (20-20-20) | 51.23   | 55.40         | 54.16          | 56.53     | 54.33    |
| NPK (12-12-36) | 48.66   | 55.03         | 56.23          | 58.60     | 54.63    |
| Mean - B       | 49.22   | 54.25         | 53.73          | 56.19     |          |
| LSD (P<0.05)   | A = 0.198 | B = 0.229     |                | AB = 0.397 |          |

3.2. Plant Height (m)
From results of Table (2), it was observed that the significant effect of Nano NPK fertilizer spray on increasing the mean of plant height (m) of maize to 2.14 m when treated by Nano NPK (20-20-20) or NPK (12-12-36) compared with 1.97 m of...
control plants. Spraying of NCM and NAA gave the highest mean of plant height was 2.16 m when treated by NCM compared with 1.95 m of control plants. The interaction between the study factors recorded the highest mean of plant height was 2.28 m from treatment by Nano NPK (12-12-36) with NCM + NAA compared with 1.81 m of control plants.

**Table 2.** Effect of spray with Nano NPK, NCM and NAA on plant height (m) of maize (*Z. mays* L.)

| NPK          | Control | NCM (2 g L⁻¹) | NAA (2 ml L⁻¹) | NCM + NAA | Mean - A |
|--------------|---------|---------------|----------------|-----------|----------|
| Control      | 2.06    | 2.18          | 2.32           | 1.98      | 2.14     |
| NPK (20-20-20) | 2.06   | 2.18          | 2.32           | 1.98      | 2.14     |
| NPK (12-12-36) | 1.99    | 2.23          | 2.05           | 2.28      | 2.14     |
| Mean - B     | 1.95    | 2.16          | 2.11           | 2.10      |          |
| LSD (P ≤ 0.05) |        | A = 0.007    | B = 0.008      | AB = 0.013|

3.3. Stem Diameter (cm)

Results of Table (3) showed that stem diameter increased significantly from 1.86 cm of control plants to 2.01 cm of plants treated by Nano NPK (12-12-36). The stem diameter increased significantly, by the effect of NCM spray to 1.98 cm compared with 1.74 cm of control plants. The interaction between the study factors recorded the highest mean of stem diameter reached 2.06 cm when treating by Nano NPK (12-12-36) with NCM + NAA compared with 1.60 cm of control plants.

**Table 3.** Effect of spray with Nano NPK, NCM and NAA on stem diameter (cm) of maize (*Z. mays* L.)

| NPK          | Control | NCM (2 g L⁻¹) | NAA (2 ml L⁻¹) | NCM + NAA | Mean - A |
|--------------|---------|---------------|----------------|-----------|----------|
| Control      | 1.60    | 1.96          | 1.93           | 1.93      | 1.86     |
| NPK (20-20-20) | 1.70    | 1.83          | 1.96           | 1.96      | 1.86     |
| NPK (12-12-36) | 1.90    | 2.03          | 2.03           | 2.06      | 2.01     |
| Mean - B     | 1.74    | 1.94          | 1.97           | 1.98      |          |
| LSD (P ≤ 0.05) |        | A = 0.006    | B = 0.007      | AB = 0.012|

3.4. Biological Yield (ton h⁻¹)

Results of Table (4) showed that biological yield of maize increased significantly to 29.66 ton h⁻¹ by Nano NPK (12-12-36) compared with 28.81 ton h⁻¹ of control plants. Biological yield significantly increased by the effect of NCM, NAA and their combination to 30.29 and 30.27 ton h⁻¹ for each of the control treatments of NCM + NAA, respectively, compared with 24.64 ton h⁻¹ of control plants, while the control treatment of NCM + NAA as well as Nano NPK (12-12-36) with NCM + NAA achieved the highest means of biological yield 30.06 and 30.01 ton h⁻¹, respectively, compared with all other treatments except above mentioned.

**Table 4.** Effect of spray with Nano NPK, NCM and NAA on biological yield (ton h⁻¹) of maize (*Z. mays* L.)

| NPK          | Control | NCM (2 g L⁻¹) | NAA (2 ml L⁻¹) | NCM + NAA | Mean - A |
|--------------|---------|---------------|----------------|-----------|----------|
| Control      | 24.64   | 30.27         | 30.29          | 30.06     | 28.81    |
| NPK (20-20-20) | 28.80   | 29.51         | 29.42          | 29.09     | 29.21    |
| NPK (12-12-36) | 29.84   | 29.30         | 29.48          | 30.01     | 29.66    |
| Mean - B     | 27.76   | 29.69         | 29.73          | 29.72     |          |
| LSD (P ≤ 0.05) |        | A = 0.065    | B = 0.075      | AB = 0.130|

3.5. Grains yield (ton h⁻¹)

Table (5) shows a higher significant mean of maize grains weight reached 12.87 ton h⁻¹ by treatment with Nano NPK (12-12-36) compared with 11.48 ton h⁻¹ of control plants. The treatment of NCM recorded the highest mean of grains yield reached 12.91 ton h⁻¹ compared with 10.48 ton h⁻¹ of control plants. The interaction recorded the significantly highest mean of
grains yield when treating by Nano NPK (12-12-36) with NCM + NAA reached 13.47 ton h\(^{-1}\) compared with 9.17 ton h\(^{-1}\) of control plants.

Table 5. Effect of spray with Nano NPK, NCM and NAA on grains yield (ton h\(^{-1}\)) of maize (\(Z\). mays L.)

| Nno NPK (2 g L\(^{-1}\)) (A) | Control | NCM + NAA (B) | Mean - A |
|-----------------------------|---------|---------------|----------|
| Control                     | 9.17    | 12.23         | 12.36    | 11.48    |
| NPK (20-20-20)              | 11.40   | 12.51         | 12.65    | 12.37    |
| NPK (12-12-36)              | 11.96   | 12.89         | 13.15    | 12.87    |
| Mean - B                    | 10.84   | 12.55         | 12.66    | 12.91    |
| LSD (P ≤ 0.05)              | A = 0.048 | B = 0.055     | AB = 0.096 |

3.6. Harvest Index (%)

Results in Table (6) indicated the significant effect of Nano NPK spray on increasing mean of harvest index of maize plants to 43.40 % when treating by Nano NPK (12-12-36) compared with 39.73 % of control plants. Spraying by NCM + NAA gave the highest mean of harvest yield reached 43.47 % compared with 38.97 % of control plants. The interaction between the study factors gave the combination of Nano NPK (12-12-36) with NCM + NAA the highest mean of harvest index reached 44.90 % compared with 37.20 % of control plants.

Table 6. Effect of spray with Nano NPK, NCM and NAA on harvest index (%) of maize (\(Z\). mays L.)

| Nno NPK (2 g L\(^{-1}\)) (A) | Control | NCM + NAA (B) | Mean - A |
|-----------------------------|---------|---------------|----------|
| Control                     | 37.20   | 40.40         | 41.10    | 39.73    |
| NPK (20-20-20)              | 39.60   | 42.40         | 44.40    | 42.35    |
| NPK (12-12-36)              | 40.10   | 44.00         | 44.60    | 43.40    |
| Mean - B                    | 38.97   | 42.27         | 42.60    | 43.47    |
| LSD (P ≤ 0.05)              | A = 0.103 | B = 0.119     | AB = 0.205 |

4. Discussion

Nutrition plays an essential role in plant growth and development, and increased nutrients stimulate the plant to increase its yield and the synthesis of active substances [22]. On the other hand, the unbalanced fertilization and the decrease in the organic matter of the soil have a negative effect on plant yield and its chemical content, as well as the effect of excessive application of nitrogen and phosphorus fertilizers on plant structure and its environment in terms of soil and irrigation water, and the occurrence of these cases along with the fact that the use efficiency of conventional fertilizers is about 20 - 50% of nitrogen and 10 - 25% of phosphorus, which means large losses of added fertilizer amounts compared to little benefit by plants [23]. Whereas, the use efficiency of Nano fertilizers from nitrogen and phosphorus is very high, rapidly releases and absorbed by plants, which reduces nutrient loss and avoids the interaction of nutrients with soil, microorganisms, water, and air [24].

The effect of Nano fertilizers of macro and micro elements, and Nno amino acids or mixture between them, all the growth and yield indicators increased significantly, and the reason for this is due to the containment of traditional nitrogen fertilizers on size particales exceeding 100 nm, which makes them difficult to absorb by plants. Which leads to a decrease in the fertilizer use efficiency, especially nitrogen utilization efficiency (NUE) by plants, and therefore the increase in the fertilizer use efficiency by plants is carried out by Nano fertilizers, which are characterized by being single-unit materials ranging from 1 to 100 nm in size at least one dimension [25], and is characterized by a high degree of interaction due to the more accurate surface area and greater density of interactive regions and the greater interaction of these regions on the surfaces of particles, making it easier for the plant to absorb easily [26, 27]. The difference between the multiplications of Nano fertilizers from the traditional in terms of affecting plant characteristics is that Nano fertilizers because an increase in nutrient use efficiency, reduce soil toxicity, reduce the potential negative effects associated with increasing the dose and reducing the frequency of application by providing it with specific regulation and response in nutrient delivery to plants. That is, it is released regularly according to the plant's need without leaching or infiltration [28] compared with traditional fertilizers that are leaching or infiltration in the soil as a result of rapid release regardless of the plant response it [29, 30].
The increase in the vegetative growth and yield characteristics of maize plant by the effect of the interaction between Nano NPK with NCM or NAA may be due to its physiological role stimulating the porphyrin molecules present in important metabolic compounds such as chlorophyll pigments and cytochrome, which are essential in photosynthesis and respiration as well. Coenzymes that activate phosphorus and are necessary for the function of many enzymes and the production of amino acids used in protein synthesis [31, 32, 33]. Likewise, potassium is primarily responsible for the enzymatic efficacy and stability of protein structures [34]. Accordingly, nitrogen plays an important role in synthesis of plant components along with phosphorus, potassium and other micronutrients that complement the role of major elements as well as amino acids by activating the action of various enzymes and proteins synthesis [35] which is reflected positively on growth and yield indicators of maize. These results were consistent with results obtained by Ahmed et al. [36]; El-Gizawy [37]; Vinh et al. [38]; Al-Gym and Al-Asady [39] on maize, and Al-Juthery et al. [40] on wheat, results of their studies indicated that Nano fertilizers treatments were significantly superior in increasing target characteristics, and significantly improved from the characteristics of growth and yield for their plants.

**Conclusion**

The most important findings of the current study on the evaluation of spraying by Nano NPK, NCM and NAA on maize plant that the fertilizer combination consisting of Nano NPK (12-12-36) with NCM + NAA achieved the highest means of the studied indicators which among the most important is grains yield (ton h⁻¹) which is the main and most important characteristic of maize plant.

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