Effect of foliar nutrition of nano-fertilizers and amino acids on growth and yield of wheat.

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Abstract. A field experiment was carried out at the Extension farm in Province 41 of Husseiniya, Babylon Governorate to study the effect of foliar nutrition with some of nano-fertilizers and nano-amino acids on growth and yield of wheat cultivar Adana 99. The experiment included 8 treatments of Nano chelated super fertilizer (NCSF), nano-amino acids (AA), nano potassium K (NK), di (NCSF +NAA), tri (NCSF +NK), (NAA+NK), tri (NCSF +NAA+NK) and spray with water only as control for comparison with three replicates in a simple one-way experience using RCBD design. A number of growth criteria in plant and yield (quality and quantity) parameters were recorded. Results indicated that significant response is obvious due to spraying of NCSF followed by the spraying combined of di (NCSF +NAA), (NCSF +NK) and (NAA+NK) tri (NCSF +NAA+NK) treatments respectively in all growth and yield parameters of wheat with an increment of the spray foliar (NCSF) of 81.66 cm, 11.88 cm, 51.99 spad, 118.57, 32.66, 26.33 and 69.43 µg g⁻¹ for plant height, length of spike, total chlorophyll, concentration of Fe, Cu, Zn and Mn in grain respectively compared to control treatment. The same treatment had grain yield and protein of 5.836 Mg ha⁻¹ and 809.93 kg h⁻¹ compared to control, harvest index were in the range (from 35.37 to 44.57 %) for control and tricomination spraying respectively. The highest grain yield and agronomic productivity was achieved when foliar nutrition of tri nano mixture of (NCSF +NAA+NK) (7.036 Mg h⁻¹ and 2570kg kg⁻¹).

1. Introduction

Biofortification strategies exist in enhancing nutritional content of crops and these strategies, according to Stein et al., [1], include agronomic and breeding methods. Under agronomic interventions, the use of fertilizers including inorganic and organic. Inorganic fertilizers usually with sizes more than 100 nm are easily lost due to leaching and volatilization, while organic matter utilization is hampered by its low mineral content and long-period of nutrient release. Numerous attempts to increase the efficiency of nutrient uptake of crops and thus biofortify them have not been so successful. Thus, the time is rife to apply nanotechnology in solving some of these problems. According to recent research works, nanotechnology has the possibility to revolutionize agricultural systems [2,3]. It enables the platform for the use of elegant delivery structure for agrochemicals which is safe, target bound and has easy mode of delivery. Nano-fertilizers, due to their high surface area to...
volume ratio, are more effective than most of the latest polymeric type conventional fertilizers. Their nature could also allow slow release and promote efficient nutrient uptake by the crops. This technology, therefore, offers the platform for sustainable and novel nutrient delivery systems, which will exploit the nano-porous surfaces of the plant parts on plant surfaces. With encapsulated nanoparticles, nanoclays and zeolites, there is increase in the efficiency of applied fertilizer, restoration of soil fertility and plant health and reduction of environmental pollution and agroecology degradation [4,5].

The application of bio-stimulants to improve growth rate and quality of crops is gaining preparations do not harm the environment and may partly supplement the action of nutrients applied. Therefore, previous studies confirmed was conducted to evaluate the performance of several stimulants: an amino acid preparation, liquid fertilizer biostimulant, a multiple natural foliar nano-fertilizer and their combinations on wheat grain yield and quality. The results indicated that these preparations strongly influenced grain yield and baking traits such as falling number, protein content, wet gluten, sedimentation value and bread volume. The best results were obtained on using multiple natural foliar nano-fertilizer+ amino acid preparation, with 20.1% higher yield in 2013 and 22.6% higher yield in 2014 in comparison with the control [6].

The most favourable values of technological features were obtained with multiple natural foliar nano-fertilizer in combination with amino acid preparation. Wet gluten was the highest and the protein content and bread volume were high after spraying wheat with multiple natural foliar nano-fertilizer . The interest in nano-fertilizers and preparations that stimulate plant growth and development is increasing constantly and it may become one of the essential elements of cultivation technology in future. Broadening the knowledge on bioregulators can result in an increase in the effectiveness of agricultural production as well as in the quality of crops [7,8,9].

Amino acids for the production of biostimulants are obtained by chemical synthesis, from plant proteins (e.g., algae, corn, and soybean), as well as from animal proteins by chemical or enzymatic hydrolysis [10]. Amino acids are the basic building blocks of proteins and fulfill multiple functions in the plant-structural, metabolic and transport [11,12].

Nano fertilizers enhance growth parameters (plant height, leaf area, number of leaves per plant) dry matter production, chlorophyll production, rate of the photosynthesis which result more production and translocation of photosynthets to different parts of the plant compare with traditional fertilizers [13,14].

Foliar nutrition is the technique of feeding plants by spraying liquid fertilizers directly to the leaves of macro and micronutrients are more effective in term of getting maximum yield and reduce losses [15]. Potassium is a one of special significance because of its active role in bio-chemical functions of plant e.g. activating various enzymes, protein formation, carbohydrates and fat concentration, tolerance to drought and resistance to frost, lodging, pests and disease attack [16,17].

Therefore, our aim was to determine the extent effect foliar spray of Nano Chelated Super Fertilizer (NCSF) and di of NCSF,NAA, NK and tri of them compare with control in some parameters of wheat growth and yield.

2.Materials and Methods

A field experiment of wheat cultivar Adana 99 was carried out at extension farm in Province 41 of Husseiniya, Babylon Governorate in silt clay loam soil (Table 1). The study included the foliar nutrition of nano fertilizers (table 2). Spray of single , dual , tri and control , on some growth parameters with three replicates in a simple one-way experience using RCBD. The process of foliar application was conducted at the start of the flag leaf stage according to spray treatments , scheduling and concentrations (tabe.3) The foliar application was conducted early in the morning through applying 400 liters ha⁻¹ of mixture in 14 days between applications.
Table 1. Some soil properties

| Property                          | Value | Estimated Methods          |
|----------------------------------|-------|----------------------------|
| Particle size distribution (gm kg⁻¹ soil) |       |                            |
| Clay                             | 120   |                            |
| Silt                             | 580   |                            |
| Sand                             | 300   |                            |
| Texture                          | Silt clay Loam | [18]          |
| CEC Cmolc kg⁻¹ Soil             | 25.3  |                            |
| OM gm kg⁻¹ Soil                 | 13.4  |                            |
| Total carbonates gm kg⁻¹ Soil   | 222   | [19]                       |
| pH                               | 7.6   |                            |
| EC (dS m⁻¹)                      | 2.8   |                            |
| Available macronutrients (mg kg⁻¹ soil) |       |                            |
| N                                | 22    |                            |
| P                                | 12    |                            |
| K                                | 210   |                            |
| Bulk density Mg m⁻³              | 1.36  | [20]                       |

Table 2. Nano fertilizer properties

| Type of nano fertilizer       | Symbol | Contains of Nutrients % | Origin     |
|-------------------------------|--------|-------------------------|------------|
| Chelated Super Fertilizer     | NCSF   | N6,P3,K17,Mg3,Ca1,S6,Fe4,Zn 4,Mn2,Cu0.5,B0.5,Mo0.1 | Iranian    |
| Potassium Fertilizer          | NK     | 27                      | Iranian    |
| Amino acids                   | AA     | amino acids 30, N 5     | Turkish    |

Table 3. Treatments

| Tr. N° | Treatments of foliar nutrition | Dates and rates of foliar nutrition treatments combinations (ml or gm in 100 L⁻¹ water) |
|--------|--------------------------------|-----------------------------------------------------------------------------------------------|
|        |                                | 120 DAP | 134DAP                                                                          |
| T₁     | Control (spray with water only) | 0       | 0                                                                               |
| T₂     | Nano (NK)                      | 100     | 150                                                                             |
| T₃     | Nano (AA)                      | 100     | 150                                                                             |
| T₄     | Nano (NCSF)                    | 100     | 150                                                                             |
| T₅     | Nano (AA+NK)                   | 50+50   | 75+75                                                                           |
| T₆     | Nano (NCSF+NK)                 | 50+50   | 75+75                                                                           |
| T₇     | Nano (NCSF+AA)                 | 50+50   | 75+75                                                                           |
| T₈     | Nano (NCSF+AA+ NK)             | 33.33+33.33+33.33 | 50+50+50                                                                      |

Di ammonium phosphate (DAP 18-46-0) was applied at 240 kg ha⁻¹ to all treatments as a starter and source for some N and P. Nitrogen at 150 kg N ha⁻¹ using urea (46%N) and potassium at 100 kg K ha⁻¹ using potassium sulfate (41.5K) were applied in split for better management. All management practices for soil (e.g. land, soil preparation "tillage" and irrigation) and for plants (e.g. pesticides) were done as required. Size of experiment units was 9 m² (3x3 m) and a distance of 1.5 m was left between units and replicates to increase the precision of the trial. Each experimental unit consisted of 15 lines with a length of 3 m at a distance of 20 cm between lines and a depth of 5 cm and seeds were sown at 15th of Nov. 2018 with rate of 120 kg ha⁻¹ using Turkish wheat cultivar Adana 99.

At the stage of grain maturity some parameters of growth and yield were estimated. N, P and K nutrients concentrations in grain after wet digestion were measured according to Hayens [21]. and Fe,
Mn, Zn and Cu digestion in di-acid mixture and further estimation using atomic absorption spectrophotometer (AAS) Jackson [22]. Total chlorophyll was measured using (SPAD). Biological yield ton ha\(^{-1}\) was estimated for all plants in 3 lines with a length of 50 cm from each experimental unit weighing the entire plants (grains + straw), weight of 1000 grain were measured too after isolation and removing of straw at 12% humidity (AOAC, 2000) [23]. Protein content in grain was calculated from \((N\% \times 5.7)\) and Agronomic efficiency \(AE = (Y-Y_0)/F\) (Ali, 2011) [24].

Analysis of variance were analyzed using a simple one-way experiment and a less significant difference (LSD) at (0.05) using Genstat program.

3. Results
Nano K, amino acids and chelated super fertilizer significantly enhanced plant growth parameters and nutrient content in grain wheat. Foliar spray of mixtures of NK, AA and NCSF \(T_8\) significantly increased plant height, spike length, Chlorophyll, N, P, K, Fe, Cu, Zn and Mn content in grain (90.43 cm, 13.00 cm, 61.22 spad, 2.53, 0.48, 2.23%, 128.39, 36.44, 26.99 and 7.16 \(\mu g\) g\(^{-1}\)) respectively on all di, mono combination and control treatment.

Table 4. Effect of foliar nutrition of Nano-fertilizers and amino acids in plant height cm, chlorophyll SPAD and concentration of N, P, K, Mn, Zn, Cu and Fe in the grains

| Tr. No | Plant height (cm) | Length of spike (cm) | Chlorophyll SPAD | Concentration of some of macro and micro nutrients in grains % | N | P | K | Fe | Cu | Zn | Mn |
|-------|------------------|---------------------|-----------------|---------------------------------------------------------------|---|---|---|----|----|----|----|
| \(T_1\) | 70.12 | 8.44 | 40.33 | 1.83 | 0.30 | 1.33 | 98.65 | 24.33 | 20.11 | 60.32 |
| \(T_2\) | 74.48 | 10.00 | 45.55 | 2.16 | 0.33 | 1.88 | 103.53 | 25.22 | 21.62 | 62.82 |
| \(T_3\) | 78.23 | 10.90 | 47.84 | 2.28 | 0.35 | 1.55 | 106.42 | 27.32 | 23.34 | 64.33 |
| \(T_4\) | 81.66 | 11.88 | 51.99 | 2.44 | 0.40 | 1.76 | 118.57 | 32.66 | 26.33 | 69.43 |
| \(T_5\) | 81.44 | 11.66 | 51.33 | 2.38 | 0.39 | 2.00 | 113.66 | 30.00 | 24.00 | 66.88 |
| \(T_6\) | 84.55 | 12.11 | 54.11 | 2.45 | 0.43 | 2.21 | 120.54 | 33.42 | 25.77 | 72.34 |
| \(T_7\) | 87.40 | 12.76 | 57.51 | 2.50 | 0.46 | 2.10 | 124.32 | 34.76 | 26.22 | 74.32 |
| \(T_8\) | 90.43 | 13.00 | 61.22 | 2.53 | 0.48 | 2.23 | 128.39 | 36.44 | 26.99 | 77.25 |
| LSD\(_{0.05}\) | 0.498 | 0.136 | 0.894 | 0.059 | 0.023 | 0.138 | 0.874 | 0.542 | 0.606 | 7.16 |

Further foliar nutrition of NCSF showed significant response on these traits. However, spray of higher content 12 essential nutrients \(T_4\) recorded maximum plant parameter growth compare with nano K, amino acids and control, While di spray mixtures treatments gave the best growth criteria (Table 4). Higher biological yield (15.435 Mg ha\(^{-1}\)) and grain yield of (7.036 Mg ha\(^{-1}\)) were identified in wheat grown at spraying of triple spray effect \(T_8\). The grain yield ranged from 4.466 to 7.036 Mg ha\(^{-1}\), the highest grain yield was obtained in \(T_8\). Binary combinations \(T_7\) outperformed single spraying and comparison in both biological yield 14.700 Mg ha\(^{-1}\), grain yield 6.596 Mg ha\(^{-1}\), weight of 1000 grain 49.28 g and Yield of Protein 938.20 Kg ha\(^{-1}\) respectively. The highest protein yield and agronomic efficiency were achieved when spraying treatment \(T_8\) was reached 1016.26 Kg ha\(^{-1}\) and 2570 Kg Kg\(^{-1}\) respectively (table 5).
Table 5. Effect of foliar nutrition of Nano-fertilizers and amino acids in (biological yield and grain yield, Mg ha\(^{-1}\)), 1000 grain weight g, harvest index%, % protein and agronomic efficiency (Kg Kg\(^{-1}\))

| Tr. N\(_0\) | biological yield Mg ha\(^{-1}\) | grain yield Mg ha\(^{-1}\) | weight of 1000 g | harvest index % | Protein % | Yield of Protein (Kg ha\(^{-1}\)) | A E (Kg Kg\(^{-1}\)) |
|-------------|-------------------------------|-----------------------------|------------------|-----------------|----------|-------------------------------|------------------|
| T\(_1\) | 12.649 | 4.466 | 40.78 | 35.37 | 10.44 | 466.46 | 0 |
| T\(_2\) | 13.352 | 5.033 | 42.55 | 37.70 | 12.33 | 620.40 | 567 |
| T\(_3\) | 13.518 | 5.375 | 44.56 | 39.78 | 13.00 | 698.71 | 908 |
| T\(_4\) | 13.694 | 5.836 | 46.99 | 42.62 | 13.88 | 809.93 | 1370 |
| T\(_5\) | 13.941 | 5.718 | 46.44 | 41.02 | 13.55 | 774.64 | 1252 |
| T\(_6\) | 14.352 | 6.206 | 48.63 | 43.25 | 13.95 | 866.23 | 1742 |
| T\(_7\) | 14.700 | 6.596 | 49.28 | 44.87 | 14.22 | 938.20 | 2129 |
| T\(_8\) | 15.435 | 7.036 | 50.43 | 45.59 | 14.44 | 1016.26 | 2570 |
| LSD 0.05 | 0.039 | 0.100 | 0.550 | 1.245 | 0.101 | 16.26 | 100.4 |

4. Discussion

Foliar fertilization has the ability to improve the efficiency and rapidity of utilization of a nutrient urgently required by the plant for maximum growth and yield [6]. Foliar applications of nutrients also and other biostimolitors can provide for a more rapid material utilization and permits the correction of observed deficiencies in less time than can be accomplished by soil applications. The main advantage of foliar fertilization is the immediate uptake of applied nutrients. Under problems of soil fixation, foliar fertilization is the most effective ways of fertilizer placement [25,26], and usually necessitates using smaller quantities of nutrients comparing with soil application. The most important use of foliar nutrition is the application of micronutrients in small amounts as well as macronutrients (e.g., nitrogen, phosphorus, or potassium) without causing any phytotoxicity [27].

Foliar fertilization also could be used under farming conditions as (1) a quick remediation for unexpected deficiencies, (2) for late supply of N during advanced growth stages, (3) as a preventive measure against unsuspected (hidden) deficiencies, and (4) to overcome fixation of nutrients in soils e.g. Cu, Fe, Mn and Zn [25]. The increase in plant height, total chlorophyll, concentrations of N, P, K,Fe,Cu,Zn and Mn in grains at foliar nutrition of Nano chelated super fertilizer(NCSF), di combination (NCSF) with nano K fertilizer and nano amino acids bi are attributed to the role of these nutrients in stimulating plant growth. These essential elements are required for optimum growth of the plant to complete its life cycle [28]. Macronutrients nutrients are N, P and K are one of the chief importance in enhances quality and productivity of wheat [15].These functions include the photosynthesis and thylakoid and the development of chloroplasts [29,30]. It also plays a role in the transfer of energy within the plant, and in many enzymatic activities and photosynthesis as well as respiration and synthesis of proteins therefore has a key role in plant growth [28].

Roles of micronutrients in plant can include growth and metabolism associated with photosynthesis, chlorophyll formation, development of root and respiration cells and the effectiveness of enzymes involved in primary and secondary metabolism [31,32,33].Foliar spray nano amino acids improve plant growth parameter therefore, the application of ready for uptake amino acids allows plants to save energy and increase the pace of their development or reconstruction, especially in critical times of plant development [11,34]. deficiency of K in wheat causes so many problems and shows many deficiency symptoms in plants growth such as weaker straw, increased lodging and decrease in growth therefore, foliar nutrition of potassium enhance growth and yield of wheat [35]. Nano fertilizers, due to their high surface area to volume ratio, are more effective than most of the latest polymeric type conventional fertilizers. Their nature could also allow slow release and promote efficient nutrient uptake by the crops [36]. This technology, therefore, offers the platform for
sustainable and novel nutrient delivery systems, which will exploit the nano porous surfaces of the plant parts on plant surfaces [5,37].

5. Conclusions
Foliar nutrition of Nano Chelated Super Fertilizer at the rate of 1 kg ha\(^{-1}\) was optimum for growth, yield, nutrient uptake and agronomic efficiency, the results in this study showed that there maximized effect of combined dual and tri nutrients and bistimulator supply on growth and yield parameters of wheat in Iraqi conditions compared with control.

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