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THE RESPONSE OF WHEAT TO FOLIAR APPLICATION OF NANO-MICRO NUTRIENTS

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Abstract

Traditional ways of fertilization have more than a single side effect on both plant and soil. Therefore, this study was designed to determine the response of wheat to foliar application of nano- micronutrient (Iron, zinc, and copper) as a single(mono) or in combinations. Treatments of nano-iron, nano-zinc, nano-copper, and their traditional sources additional to a control. A number of plant and yield traits were studied. Results indicate significant response of the combined nano-(Fe+Cu+Zn) followed by the treatments of di and single spraying compared to control treatment with an increase of the triple foliar of 27.47, 28.53, 18.22, 141.23, 33.33 and 57.40 % for plant height, length of spike, total chlorophyll SPAD, concentration of Cu, Zn and Fe ,respectively compared to control treatment. The same treatment (tri) had grain yield and protein yield of 5.84 t ha^{-1} and 830.44 kg ha^{-1} compared to the treatment of triple of traditional fertilizers and control, Which amounted to (4.55 and 3.60 t ha^{-1}) and (571.48 and 443.88 kg ha^{-1}), respectively. Harvest index were 51.05, 46.85, 48.73, 48.84, 40.57, 40.95, 43.71 and 37.89% for tri, di, single, control (Cu + Zn + Fe, Zn + Cu, Zn + Fe, Cu + Fe, Fe, Zn, Cu and control, respectively).

Keywords: wheat, foliar nutrition, nano iron, nano zinc, nano copper.

Introduction

Wheat *Triticum astivum* L. is the main food for more than 35% of the world's population, a major source of plant protein in human food, for its high protein content compared to other major grains (Khaeim, Hussein M. (2013; Safaa *et al.,* 2013). Wheat is a major source of carbohydrates and protein for both humans and animals. It contains starch (60-90%), protein (11.0-16.5%), fat (1.5-2.0%), mineral ions (1.2-2.0%) and vitamins B-complex and E) (Ayala *et al.,* 2011). In addition, wheat is the most important winter crop, and its grain is the staple food for urban and rural communities. Its straw is used as a very important feed for feeding animals, especially during the summer season (Youssef *et al.,* 2013). Micronutrients are important in the production of wheat in terms of quantity, quality, and human health. There are more than 3 billion people in the world suffering from micronutrient deficiencies, especially zinc, iron, and Iodine. It is known that micronutrients are determined primarily for plant growth and product quality in terms of nutrition despite the small quantities needed by crops relative to macronutrients. The availability of different mineral sources and chelates (synthetic and natural - organic) for these nutrients and different methods for application to plants (to the soil and foliar or both), but micronutrients use efficiency generally do not exceed 5-7% (Ali *et al*., 2002 and Ali, Al-Ameri, 2016 and Ali & Salman, 2016).

Nanotechnology is an ingenious treatment of matter at the molecular or atomic level, generally within the limits of 100 nanometers. This technique is promising to improve ongoing agricultural processes through improved management, maintenance, and sustainability of inputs in the agricultural production field. Researches carried out over the last 2 decades focused on the subject of metal nano-particles (NPs) such as zinc oxide, copper oxide, chelates of metal and micronutrients slow release. (Monreal *et al.,* 2015). Nano-fertilizes applications to the soil or foliar in small quantities increased growth and yield of some crops compared to bulky fertilizers of the same elements. Fertilizer use efficiency was almost better due to better penetration ability and translocation with in plant parts (Ghorbanpour *et al.,* 2017). Foliar application is the technique of feeding plants by spraying liquid fertilizers directly to the leaves (Nasiri *et al.,* 2010), which accompanied with batter absorption in the aerial parts. The amount and rate of nutrient absorption limited by type, does of fertilizer, plant type, growing period and time of application. Rate of Foliar micronutrient can be applied in single, di or tri doses for better uptake and use efficiency (Amiri *et al.,* 2008). Roles of micronutrients especially, zinc, iron and copper in plant can include growth and metabolism associated with photosynthesis, chlorophyll formation, development of root and respiration cells, water absorption, resistance to plant diseases, and the effectiveness of enzymes involved in primary and secondary metabolism (Adhikary *et al.,* 2010, Mer and Ama, 2014; Luma Abdalalah *et al*., 2018). Therefore, zinc, iron and copper can control plant growth, grains yield and determine the quality of food consumed by humans and animals. The low micronutrient use efficiency as mentioned above can lead the researchers to think on some alternatives to sole such issue and one of these the use of nonmaterial of metal and oxide metal. Armin *et al*. (2014) revealed that application of nano chelate iron on wheat crop had an effect on the grain yield and yield components with grain yield increment of 5.19% and 9.17%. Foliar nano micro-zinc, copper and iron fertilizers application on grain crops increased growth parameters of wheat relative to other fertilizer sources (Ghorbanpour *et al.,* 2017). Therefore, our aim was to determine the extent of wheat response to foliar micro-nano-fertilizers and effects of splitting application (i.e. mono, di and tri) of iron, zinc and copper in some parameters of wheat growth and yield.

Materials and Methods

A field experiment of wheat cultivar Ebaa 99 was carried out at the Al-Shafeieyah, National Program for Wheat Development in Iraq "NPWD" station in loamy soil (Table 1).

Table 1 : Some soil properties

Particle size distribution (gm kg^{-1}soil)	
330	Clay
350	Silt
320	Sand
loam	Texture
7.7	pH
2.6	EC(1:1) (dS m^{-1})
	Available macronutrients (mg kg^{-1}soil)
20	N
13	P
223	K
	Available micronutrients (mg kg^{-1}soil)
0.22	Cu
0.28	Zn
0.56	Fe
1.29	Bulk density Meg m^{-3}

The study included the response of wheat to foliar application of nano-fertilizers iron, zinc and copper applied in single, double and triple splitting (i.e. Nano-iron, nano-zinc, nano-copper, nano(iron+ copper), nano (iron+ zinc), nano (copper + zinc), tri nano-spray (iron + copper + zinc), tri traditional-spray (iron + copper + zinc)and control.) on some growth parameters with three replicates in factorial experiment using RCBD. The process of foliar nano-micronutrient application was conducted at the start of the flag leaf stage in 1g L^{-1} concentration using chelates nano-micronutrient: Zinc (20% Zn), copper (15% Cu), iron (18% Fe as) for the single di, and tri applications. Equal amounts of the tree micronutrients were applied in combination from traditional source for comparison and foliar application of water only as control. The foliar application was conducted early in the morning by applying 400 liters of nutrient in 14 days between applications.

Di ammonium phosphate (DAP 18-45-0) was applied at 200 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 $9m^2$(3x3m) and a distant 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 sawn at 15^{th} of Nov. 2016 with the rate of 120 kg ha^{-1} using an Iraqi wheat variety called Ebaa 99.

At the stage of grain maturity, some parameters of growth and yield were estimated. Soil analyses were conducted before and at the end of the trial using methods mentioned in Black ,(1965) and Page et al., (1982) for physical and chemical soil properties , respectively. Nutrient concentrations in plants after wet digestion were measured according to Hayens (1980). 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), the weight of 1000 grain were measured too after isolation and removing of straw at 12% humidity (AOAC, 1990). Protein content in grain was calculated from (N%× 5.7). Analysis of variance were analyzed using a simple one-way experiment and a less significant difference (LSD) at (0.05) using Genstate program.

Results

Plant height "cm": As indicated in Table (2) all treatments have significantly increased the height of the plant and the highest height of 91.87 cm for triple micronutrient application compared to 72.07 cm for the control treatment(water only). For single foliar treatments, nano-Fe gave the highest elevation of 83.17 cm compared to zinc, copper (80.17 and 77.03) cm, respectively. As a general observation di nano-spray (Fe + Cu), (Fe + Zn) and (Cu + Zn) and tri (Fe + Cu + Zn) gave values for plant height of (87.07, 88.43, 87.57 and 91.87 cm) ,respectively compared to single spray treatments.

Length of the spike: From the data in Table (2), the treatment (Fe + Cu + Zn) was significantly higher in the mean length of the spike, which was 12.30cm compared to the 9.57 cm for control. The di nutrient application also significantly exceeded the comparison treatment with 11.30, 11.50 and 11.33 cm for the nano (Fe + Cu), (Fe + Zn) and (Cu + Zn), respectively. However, these parameters showed no significant differences between them. The superiority of nano-iron on copper was quite clear.

Total chlorophyll (SPAD): The highest concentration of chlorophyll in triple spray treatment (Fe + Cu + Zn) was 53.47 SPAD which was significantly higher than other treatments.

Iron concentration in leaves: Results of the table (2) indicated that single nano iron was superior In the mean percentage of iron in leaves, with 170.67 (mg Fe kg^{-1} dry matter).

Copper concentration in leaves: from Table (2) it can be noted that the treatment of single spray nano copper gave a significant superiority, reaching 12.67 mg Cu kg^{-1} dry matter.

Zinc content in leaves: Table (2) shows that the treatment of spray mono zinc is superior in zinc concentration of 125.67 (mg Zn kg dry matter), which is significantly higher than the other single, dual, triple and control treatments.

Biological yield Mg ha^{-1}: Tri nano-fertilizer (iron + zinc + copper) application gave a biological yield of 11.44 ton ha^{-1}, which was significantly higher than other treatments (Table 3).

Grain yield of Mg ha^{-1}: The single application of nano-copper, zinc and iron fertilizers achieved a qualitative jump of 4.66 and 4.37 and 4.43 Mg ha^{-1} respectively, with a significant difference compared to control 3.60 Mg ha^{-1}(Table 3).

1000 grain weight: from Table (3) it was found that 1000 grain weight was the maximum at the triple application of nano-fertilizers which amounted to (45.7 g) and significantly superior to the tri combination of the traditional fertilizer sources of (42.44 g).

Harvest index%: The status of harvest index was in the range (37.89 to 51.05%) for control and the triple nano composition, respectively, with a significant superiority of the tri-combination on the bilateral and single application and control (Table 3).

Protein%: It is noted from Table 3 that the highest percentage of protein was with triple nano (Cu +Zn +Fe) (14.22%) significantly higher than other treatments,

Protein yield (kg ha^{-1}): It seems that this trait goes in the same direction to the percentage of protein and the superiority of the treatment of spraying of tri nano-fertilizers (830.44 kg h^{-1}) was significant for all treatments.

Table 2: Effect of nano-spray (iron, zinc, and copper) in plant height cm, length of spike cm., total chlorophyll SPAD and concentration of copper, zinc, and iron in the leaves.

Spray Treatment / Characters	Plant height (cm)	Length of spike (cm)	Chlorophyll SPAD	Cu mg Kg^{-1} dry matter	Zn mg Kg^{-1} dry matter	Fe mg Kg^{-1} dry matter
Control	72.07	9.57	45.23	7.5	46.00	92.33
Nano-cu	77.03	9.90	46.93	12.67	47.67	100.00
Nano-Zn	80.17	9.97	46.87	9.75	125.67	92.00
Nano-Fe	83.17	10.43	47.73	10.00	41.33	170.67
Nano(Fe+Cu)	87.07	11.30	49.30	16.55	59.67	156.33
Nao (Fe + Zn)	88.43	11.50	50.03	9.54	86.68	161.00
Nano (Cu + Zn)	87.57	11.33	49.93	14.94	72.00	107.67
Nano (Fe + Zn + Cu)	91.87	12.30	53.47	18.09	61.33	145.33
Tradi (Fe + Zn + Cu)	80.00	9.88	48.55	11.83	53.44	110.83
$LSD_{0.05}$	4.31	1.11	5.92	1.02	4.59	15.43

Table 3 : Effect of spraying with nano-fertilizers (iron, zinc, and copper) in (biological yield and grain yield, ton h^{-1}), 1000 grain weight, harvest index, protein and yield of protein.

Foliar Treatment / Characters	Biologial yield Mg ha^{-1}	Grain yield Mg ha^{-1}	Weight of 1000 (g)	Harvest index (%)	Protein (%)	Yield of protein (kg ha^{-1})
Control	72.07	9.57	45.23	7.5	46.00	92.33
Nano-cu	77.03	9.90	46.93	12.67	47.67	100.00
Nano-Zn	80.17	9.97	46.87	9.75	125.67	92.00
Nano-Fe	83.17	10.43	47.73	10.00	41.33	170.67
Nano(Fe+Cu)	87.07	11.30	49.30	16.55	59.67	156.33
Nao (Fe + Zn)	88.43	11.50	50.03	9.54	86.68	161.00
Nano (Cu + Zn)	87.57	11.33	49.93	14.94	72.00	107.67
Nano (Fe + Zn + Cu)	91.87	12.30	53.47	18.09	61.33	145.33
Tradi (Fe + Zn + Cu)	80.00	9.88	48.55	11.83	53.44	110.83
$LSD_{0.05}$	4.31	1.11	5.92	1.02	4.59	15.43

Discussion

The increase in plant height, total chlorophyll, concentrations of iron, zinc, and copper in leaves at foliar of tri nano-fertilizers are attributed to the role of these nutrients in stimulating plant growth. These nutrients are required for healthy and ideal growth of the plant to complete its life cycle (Ali, 2012). It plays a role in many of its physiological functions in plant growth and development. These functions include the synthesis of chlorophyll and thylakoid and the development of chloroplasts (Masoud *et al.,* 2012). 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 (Ali, 2012). The concentration of iron in plant tissues is sufficient if it is about 50-250 g kg^{-1} dry matter (Cakmak, 2010). For crop products to be healthy and safe for consumption, iron concentrations should be more than 50 g kg^{-1} dray mater (Graham, 2007). The foliar application is a quick and effective treatment for plant nutrition, it allows for rapid uptake of nutrients during the fast-growing period of crop especially if the soil was deficient in available of soil nutrients (Wojtkowiak *et al.,* 2014). Copper plays an important role in the metabolism of nitrogen and zinc compounds of micronutrients important for metabolic activities in plants. Although its quantity is very low in plants, it has a role in the activities of enzymes and processes of protein and carbohydrate and the activation of peptidases (Hänsch and Mendel, 2009). Zinc has been found to play an important role in protecting plant cells against oxidative stress (Sheikh, 2009). The average zinc concentration in whole wheat grains ranges from 20-35 g kg^{-1} dry matter (Cakmak *et al*., 2004 and Seilsepour, 2007) and that the growth of wheat roots significantly improved with foliar applied Zn which led to an increase in the absorption of micronutrients.

The increment in protein % and yield of protein can be due to the improvement in the growth and grain yield as a result of treatment applications (Masoud *et al.,* 2012 and Boorboori *et al.,* 2012 and Havlin *et al.,* 2014 and Khanday *et al.,* 2017). The single and common spraying of micro-nano-elements increased the yield and yield components of wheat crop (Armin *et al*., 2014, Zain *et al*., 2015) due to its stimulating role (Mer and Ama, 2014). On the contrary Afshar *et al*. (2014) found that when compared to the same quantity of zinc oxide nano-fertilizers was significantly superior to all growth parameters.

Conclusion

From the above results, we can see the importance of nano-element application especially with Fe, Zn, and Cu applied in combinations. However, with the rise of awareness of nanoparticles toxicity and environmental concerns which is related to soil, plant and nonmaterial, further researches should be contacted and carefully evaluated before a final recommendation made to farmers for agricultural and food uses.

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