Journal of Advanced Zoology

ISSN: 0253-7214 Volume **44** Issue **S-6** **Year 2023** Page **391:395**

Response of seedling barley (*Hordeum vulgare*, L.) to foliar fertilization of nano-oxides (Fe, Cu, Mg)

Fatma F Ali [1]*, Ahmed S Buhedma[1], Zohar ashoor[1], Tarq A Nouh[1], Rasha R Atiya [2]

[1]*Faculty of Agriculture, Crop Department, Omar Al-Mukhtar University, Libya.*
[2]*Department of Biology, Faculty of Education, Omar Al-Mukhtar University, Al-Bayda.*

*Corresponding author's E-mail: Fatmaalzhra84@yahoo.com

Article History

Received: 06 June 2023
Revised: 05 Sept 2023
Accepted: 25 Nov 2023

Abstract

Background. *An experiment was conducted at the Grain Technology Laboratory, Crop Department, Faculty of Agriculture, Omar Al-Mukhtar University, during the 2023 season. The experiment utilized a completely randomized design to study the response of barley to foliar application of fine nanoscale iron, manganese, and copper fertilizers. The application was carried out as foliar spray at two different doses, two weeks and one month after sowing, using 3 kg capacity pots with 20 seeds per pot. The experiment included three observations for each treatment, with the nanoscale iron, manganese, and copper oxides applied at a concentration of 1 mol/L. The data revealed the following: Significant positive response of barley shoots to foliar application of nanoscale iron, manganese, and copper fertilizers in various growth indicators, including shoot weight, shoot length, leaf area, crop growth rate, and specific leaf weight. High significant differences were observed in the effect of nanoscale iron, manganese, and copper oxides on the average shoot weight, crop growth rate, and leaf area. Copper oxide and manganese oxide showed the highest means, followed by iron oxide, compared to the control. Iron oxide exhibited the highest specific leaf weight for barley shoots, followed by copper oxide and then manganese oxide, compared to the control treatment.*

Keywords: *Germenation of barley seeds, nano- fertilizers, iron, manganese, copper*

1. Introduction

The global production of agricultural crops is increasingly focused on utilizing large quantities of fertilizers to achieve higher yields per unit area. However, using doses exceeding the optimal fertilizer rate leads to several problems such as environmental pollution (soil, water, and air pollution), reduced efficiency of fertilizer inputs, decreased income from production, and soil degradation. Therefore, it has become imperative to search for alternatives to reduce nutrient losses in fertilization and increase crop productivity within the framework of sustainable agriculture.

Micronutrients are essential elements required by plants in small quantities, such as manganese, iron, and zinc. However, they can affect most physiological and biochemical processes within plant cells and are necessary for their development, growth, and the formation of factors that enhance crop production and quality (Khan & Jamil, 1998). Foliar application is a technique of plant nutrition that involves spraying liquid fertilizers directly onto the leaves (Nasiri *et al.*, 2010). Many researchers have emphasized the importance of foliar nutrition for micronutrients, especially in large areas of crops such as wheat and barley, due to its ability to activate plant physiological processes and facilitate their rapid absorption through the leaves (Jones, 1995). Foliar application is a quick and effective treatment for plants, as it allows for rapid absorption of nutrients, thereby accelerating crop growth, particularly in cases where the soil is deficient in available nutrients (Wojtkowiak *et al.*, 2014).

Due to their unique characteristics, nanoscale fertilizers play a significant role in sustainable agriculture. Nanotechnology involves the manipulation of matter at the molecular or atomic level, typically within the range of 100 nanometers. This promising technology holds potential for improving current agricultural practices by enhancing the management, maintenance, and sustainability of inputs in crop production (El-Ramady *et al.*, 2014).

Over the past two decades, extensive research has been conducted on metal nanoparticles (NPs), such as zinc oxide, copper oxide, and metal chelates, as well as the controlled release of micronutrients (Monreal *et al.,* 2015). Numerous studies have investigated the effects of metal oxide NPs on seed germination and crop growth, particularly focusing on the role of zinc, iron, and copper in plant growth, metabolic processes associated with photosynthesis and chlorophyll formation, root cell development, respiration, water uptake, plant disease resistance, and the activities of enzymes involved in primary and secondary metabolic pathways (Hänsch and Mendel, 2009; Adhikary *et al.*, 2010).

Furthermore, the application of nanoscale foliar fertilizers containing zinc, copper, and iron on grain crops has been found to increase the relative growth indices of wheat compared to other fertilizer sources (Ghorbanpour *et al.,* 2010). Therefore, the objective of this research was to determine the response and impact of nanoscale foliar fertilizers containing iron, manganese, and copper when applied via spraying on selected growth indicators and barley yield.

2. Materials and Methods

A laboratory experiment was conducted at the Faculty of Agriculture, Omar Al-Mukhtar University, during the 2022 season using a completely randomized design to study the response of barley (Tisa variety) to nanoscale foliar fertilizers (iron, manganese, and copper) and their impact on selected growth indicators of barley seedlings. The experiment utilized pots with a capacity of 3 kilograms, with 20 seeds per pot. Three observations were made for each treatment, and nanoscale foliar fertilizers containing iron, manganese, and copper oxides were sprayed on the leaves at a concentration of 1 cm^3 per liter from a one-molar nanoscale fertilizer solution. The foliar application was carried out twice, two weeks and one month after sowing.

The studied traits:

1. Root and shoot length (cm): Three random samples of natural seeds were taken, and the length of the root was measured after detachment from the point of attachment to the seed, while the shoot was measured after detachment from the point of attachment to the central embryo axis. Measurements were conducted using a ruler (AOSA, 1983).
2. Seedling dry weight (g): It was calculated using a sensitive balance.
3. Crop growth rate (CGR): According to (Watson ,1952), CGR is calculated as follows:

$$CGR = (W2 - W1) / SA(t2 - t1) \text{ g/m2/day}$$

Where W2 and W1 are the dry weights at time t2 and t1, respectively, t2 and t1 are the initial and final times, and SA is the ground area covered by the plant.

4 Plant leaf area = Leaf length × Leaf width from the middle * 0.95.

5. Specific leaf weight (SLW): g/cm2, as indicated by (Norman and Arkebaucer ,1991). It represents the dry weight per unit area of the leaf and is denoted by the symbol SLW. It is calculated as the number of square centimeters per gram of the leaf's dry weight. SLW reflects the thickness of the leaf, where higher values indicate greater leaf thickness.

$$SLW = LW / LA$$

Where LW = Dry weight of the leaves in grams

LA = Leaf area of the plant in square centimeters. Leaf area (cm2) of the plant: According to (Thomas,1975)

Statistical analysis:

Statistical analysis: All collected data were subjected to statistical analysis using the GenStat software to test for significance and compare the means using the Least Significant Difference (L.S.D.) at a significance level of 5% (Gomez and Gomez, 1984).

3. Results and Discussion

Effect of copper, manganese, and iron nanoparticles on barley shoot length:

The results in Table 1 showed no significant differences in the effect of nanoparticle oxides on the average shoot length of barley plants, except for copper oxide, which resulted in the highest mean length of 26.33 cm, followed by iron oxide (24.73 cm). These increases can be attributed to the roles of the added trace elements through foliar spray solutions in various physiological processes, such as increasing chlorophyll content in leaves necessary for enhancing photosynthetic efficiency and the formation of the essential amino acid Tryptophan for cell elongation (Cakmak *et al.,* 1998). These findings are consistent with (Hänsch & Mendel ,2009), who indicated the important role of copper in metabolic processes despite its low quantity in plants, as it affects enzyme activities, protein and carbohydrate processes, and activates peptidases. They also align with the findings of (Focus ,2003), which highlighted the role of iron in protein synthesis, increased leaf area, enhanced efficiency of photosynthesis and respiration, and plant activity in water and nutrient absorption.

Effect of copper, manganese, and iron nanoparticles on barley shoot weight:
The results in Table 1 showed significant differences in the effect of nanoparticle oxides on the average weight of barley shoots. Manganese and copper oxides resulted in the highest shoot weights of 0.4603 g and 0.4457 g, respectively, followed by iron oxide with a weight of 0.4137 g. In contrast, the control group had a lower average weight of 0.3267 g. These findings are consistent with (Ghorbanpour *et al.,* ,2017), who reported that the application of fine zinc, copper, and iron nanofertilizers on grain crops increased relative growth indicators compared to other fertilizer sources. Additionally, (Adhikary *et al.,* 2010) indicated that iron and copper aid in growth, metabolic processes associated with photosynthesis and chlorophyll, root cell formation and development, respiration, nutrient absorption, and plant disease resistance, as well as the efficacy of enzymes involved in primary and secondary metabolic processes.

Effect of copper, manganese, and iron nanoparticles on barley stem length:
The results in Table 1 showed significant differences in the effect of copper, manganese, and iron nanooxides on the average stem length of barley plants. Copper oxide exhibited the highest average length of 20.23 cm, followed by iron oxide (16.77 cm), while manganese oxide had the lowest average length of 16.53 cm. In comparison, the control group had a decreased average length of 12.60 cm. Nanofertilizers improve growth parameters such as plant height, leaf area, number of leaves per plant, dry matter production, chlorophyll production, and photosynthetic rate, resulting in increased productivity and transportation of photosynthetic building materials to different plant parts compared to traditional fertilizers (Singh, 2017).

Effect of copper, manganese, and iron nanoparticles on barley root length:
The results in Table 1 showed no significant differences in the effect of nanoparticle oxides on the average root length of barley plants, with observed lengths of 7.30 cm, 7.07 cm, and 7.63 cm for copper, manganese, and iron oxides, respectively, compared to the control group, which had a length of 6.10 cm. These findings are consistent with (Jaberzadeh ,2013), who observed enhanced root elongation in soybean plants when $Fe2O3$ nanoparticles were applied through foliar spray or soil application. Additionally, Wang *et al.,* (2010) noted a significant contribution of iron oxide nanoparticles to root elongation.

Effect of copper, manganese, and iron nanoparticles on crop growth rate in barley:
The results in Table 1 revealed significant and highly significant differences in the effect of nanoparticle oxides (iron, manganese, and copper) on the average crop growth rate compared to the control group. Manganese and copper oxides exhibited the highest crop growth rates of 0.0171 g/day and 0.0145 g/day, respectively, surpassing the effects of iron oxide and the control group, which had growth rates of 0.0086 g/day and 0.0068 g/day, respectively. Iron, manganese, and zinc are considered vital micronutrients that play crucial roles in plant metabolism by influencing the activities of activated plant hydrogenase enzymes, carbohydrate metabolism, maintenance of cell membranes, protein synthesis, auxin synthesis, and alleviating environmental stresses in plants (Hafeez *et al.,* 2013).

Effect of copper, manganese, and iron nanoparticles on leaf area in barley:
The results in Table 1 demonstrated significant differences in the effect of iron, manganese, and copper nanoparticle fertilizers on the average leaf area in barley, measured in square centimeters (cm^2), with manganese and copper oxides showing higher averages (16.01 cm^2 and 17.59 cm^2, respectively) compared to manganese oxide and copper oxide. Iron oxide had an average leaf area of

14.07 cm², while the control group had a reduced leaf area of 13.59 cm². Leaf area index is an important trait that influences yield and its components, positively impacting the final production as it represents the dry matter manufactured. The efficiency of a leaf can be determined by the rate of growth per unit weight

in the plant through leaf area, and thus, it can be utilized to enhance the final yield (Yan, 1998; Wallace *et al.*, year unknown).

Effect of Copper, Manganese, and Iron Nanoparticles on Specific Leaf Weight in Barley:

The results from Table 1 showed no significant differences in the effect of nanoparticle oxides on the average specific leaf weight in barley, although iron oxide exhibited the highest averages of 0.0300, followed by copper oxide at 0.0277, and manganese oxide nanoparticles at 0.0260, compared to the control group, which had a lower average of 0.0240. Nanoparticle fertilizers have been reported to improve growth parameters such as plant height, leaf area, and leaf count per plant compared to traditional fertilizers (Singh, 2017). This is consistent with the findings of (Sheykhbaglou *et al.*, 2010), who indicated that organic iron nanoparticles fertilizers have high absorption capacity and enhance photosynthetic processes and leaf surface area expansion. In another experiment, iron oxide nanoparticles increased the dry weight of soybean roots and leaves (reference missing).

Table 1: Effect of Iron, Manganese, and Copper Nanoparticles on Selected Growth Traits in Barley

Characteristics / Treatment	Leaf area (cm2)	Seedling dry weight (g)	Shoot length (cm)	Root length (cm)	Crop growth rate, g/day	Seedling length (cm)	Specific weight of leaves (g/cm2)
Control	13.59b	0.3267c	12.60b	6.10	0.0068b	19.83	0.0240
Copper	16.01ab	0.4457a	20.23a	7.30	0.0145a	26.33	0.0277
Manganese	17.59a	0.4603a	16.53b	7.63	0.0171a	23.50	0.0260
Iron	14.07b	0.4137b	16.77b	7.07	0.0086b	24.73	0.0300
F	N.s	**	**	N.s	**	*	N.s
$LSD_{0.05}$	-	0.05916	4.678	-	0.00674	5.123	-

4. Conclusion

The study recommends conducting multiple field experiments with the addition of various minor elements at different concentrations to confirm their effect on the growth and productivity of barley crops.

References:

Adhikary, B.H.; Shrestha, J. and Baral, B.R. (2010). Effects of micronutrients on growth and productivity of maize in acidic soil. Int. Res. J. Appl. Basic Sci. 1:8-15.4.

Cakmak, I., Torun, B., Erenoglu, B., Ozturk, L., Marschner, H., Kalayci, M. and Ekiz, H. (1998). Morphological and physiological differences in cereals in response to zinc deficiency. Euphytica, 1000: 1-10.

El-Ramady HR, (2014). Integrated Nutrient Management and Postharvest of Crops, Sustainable Agri Rev, 13 :163–274.

Focus. 2003. The importance of micro-nutrients in the region and benefits of including them in fertilizers. AgroChemicals Report, 111(1): 15-22.

Ghorbanpour, M.; Manika, K. and Varma, A. (2017). Nanoscience and Plant-Soil Systems. Springer International Publishing.

Gomez, K.A. & A.A. Gomez., (1984). Statistical procedure for agricultural research. John Wiley and Sons.

Hafeez, B. M. K. Y., Khanif, Y. M., & Saleem, M. (2013). Role of zinc in plant nutrition-a review. American journal of experimental Agriculture, 3(2), 374-391

Hamdia, M.A.; D. Mustafa and K.N. Al-Hakim (2017). The Combined Action Strategy of Two Stresses, Salinity and Cu++ on Growth, Metabolites and Protein Pattern of Wheat Plant. American Journal of Plant Sciences, 8, 625-643

Hänsch, R. and Mendel, R.R. (2009). Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). Current Opinion of Plant Biology 12: 259-266

Jaberzadeh A, Moaveni P, Moghadam HRT & Zahedi H,(2013). Influence of bulk and nanoparticles titanium foliar application on some agronomic traits, seed gluten and starch contents of wheat subjected to water deficit stress, Not Bot Horti Agrobo, 41 . 201–207.

Jones, E. R. (1995). A grower's guide to the foliar feeding of plant. Washington and Oregon Farmer, 28: 13-17.

Khan, M.Q. and Jamil, I.M. (1998). Effect of trace elements and their concentrations in soil and wheat leaves. Sarhad J. of Agric. (Pakistan), 14 (2): 121-125.

Makarem, H., El-Far, I. A., Ali, E. A., & Said, M. T. (2019). Response of three bread wheat cultivars to foliar spray by some micro-nutrients Nano-Particles. Assiut J. Agric. Sci, 50(4), 9-21

Monreal, C.M.; DeRosa, M.; Mallubhotla, S.C.; Bindraban, P.S. and Dimkpa, C. (2015). The Application of Nanotechnology for Micronutrients in Soil-Plant Systems VFRC Report. Washington, D.C., USA

Available online at https://jazindia.com

Nasiri, Y.; Zehtab-Salmasi, S.; Nasrullahzadeh, S.; Najafi, N. and Ghassemi-Golezani, K. (2010). Effects of foliar application of micronutrients (Fe and Zn) on flower yield and essential oil of chamomile (Matricaria chamomilla L.). J. Med. Plant. Res., 4(17): 1733-1737.

Norman J.M. and J.T. Arkebauer, (1991). Predicting Canopy photosynthesis and light use efficiency from characteristics. In: Boote, K.J. and R.S. Loomis (eds.) Modeling crop photosynthesis from biochemistry to Canopy. Am. Soc. of Agron. Madison, WI, pp. 75-94.

Sheykhbaglou, R., Sedghi, M., Shishevan, M. T., & Sharifi, R. S. (2010). Effects of nano-iron oxide particles on agronomic traits of soybean. Notulae Scientia Biologicae, 2(2), 112-113.

Singh M D . (2017). Nano-Fertilizers is a new way to increase nutrients use efficiency in crop production. international journal of agriculture. review article. International Journal of Agriculture Sciences. 9(7): 3831-3833.

Thomas , H. (1975). The growth response to weather of simulator vegetative swards of a single genotype of Lolium perenne. J. Agric. Sci. Camb. 84 : 333-343.

Wang H, Kou X, Pei Z, Xiao JQ, Shan X & Xing B, Physiological effects of magnetite (Fe3O4) nanoparticles on perennial ryegrass (Lolium perenne,L.) and pumpkin (Cucurbita mixta) plants, Nanotoxicology. 10:3109/17435390 (2010) 489206

Watson, D. J. (1952) : The physiological basis of variation in yield. Adv. Agron. 4, 101-145.

Wojtkowiak, K.; Stepien, A.; Warechowska, M. and Raczkowski, M. (2014). Content of copper, iron, manganese and zinc in typical lightbrown soil and spring triticale grain depending on a fertilizationsystem. Journal of Elementology 19

Yan, W. and Wallace, D. H. (1998). Plant Breeding and Whol System Crop Physiology CAB intl., 198 Mad. Are. N. Y. USA

Available online at https://jazindia.com