Scientific Research Publishing

American Journal of Plant Sciences, 2025, 16(4), 485-493
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Effects of Zn, Cu, Mn, and Co on Nitrogen Metabolism of *Cucumis melo* L. Varieties

Durdona Uktamovna Ergashova, Akmal Lapasovich Sanakulov, Noila Shokirovna Jumakulova, Alisher Nuraliyevich Khujanov

Department of Plant Physiology and Microbiology, Samarkand State University named after Sharof Rashidov, Samarkand, Uzbekistan
Email: durdonaokitamovna@gmail.com

How to cite this paper: Ergashova, D.U., Sanakulov, A.L., Jumakulova, N.S. and Khujanov, A.N. (2025) Effects of Zn, Cu, Mn, and Co on Nitrogen Metabolism of *Cucumis melo* L. Varieties. *American Journal of Plant Sciences*, **16**, 485-493.
https://doi.org/10.4236/ajps.2025.164036

Received: December 30, 2024
Accepted: April 12, 2025
Published: April 15, 2025

Abstract

Melon crops occupy an important place in the diet of the population and contain a large amount of vitamins, minerals and organic acids. Melon (*Cucumis melo* L.) has very useful properties and provides the body with substances and elements necessary for human health. In this respect, the use of micro-fertilizers in polyculture, and in particular in the cultivation of melons, is one of the most pressing issues. This is because microelements are involved in many physiological and biochemical processes in the body—from the processes of anabolism and catabolism inside the cell to the reproduction of the organism. As a result of the positive effect of microelements, the amount of chlorophyll in leaves increases, photosynthesis increases, and the assimilative activity of the whole plant increases. The lack of microelements causes defects in the growth and development of crops; their development is delayed, the resistance to adverse conditions is reduced, and they are often damaged by diseases and pests. The article describes the effect of the use of zinc, copper, manganese, and cobalt microelements in the cultivation of melon crops on the formation of male and female flowers and the nitrogen content in the leaves. The effect of microelements increased the nitrogen content in the leaves and the number of flowers. The melon varieties Amiri and Kizil Gulobi were used for the study.

Keywords

Melon, Manganese, Female Flower, Nitrogen Metabolism, Photosystem II, Protein Synthesis

1. Introduction

Meeting the population's demand for food products and ensuring food security are among the most pressing issues today. For this, it is advisable to create scientifically based innovative technologies for the cultivation, storage, and processing of various food products throughout the year. Currently, the demand for melon products is increasing day by day. After all, melon, which is a product of melon crops, has several beneficial properties for human health. Uzbek melons are famous all over the world for their sweetness, unique taste, aroma, and long-term storage [1]. Melon fruits contain a large amount of potassium, calcium, magnesium, iron, sulfur, and some vitamins. The energy value of their fruits is on average 34 kcal, most of which consists of water. The main part of the fruit consists of carbohydrates, the rest of the protein, fat, ash, pectin, and organic acids [2] [3]. The seeds are also rich in biologically active substances (more than 25% fat, sugars, protein, and other compounds).

Currently, more than 160 varieties of melon are distributed in Uzbekistan, which differ from each other in terms of early ripening, yield, resistance to diseases and other adverse conditions, taste, storage, transportability, suitability for processing and drying, etc. The sugar content of melon varieties ranges from 10.4 - 14.9% [4] [5].

Many researchers claim that pre-sowing seed treatment with various methods ensures high yields. In studying the effect of pre-sowing seed treatment on improving melon yield, seed quality is improved by applying additional micronutrients to the soil before planting. Microelements are involved in many physiological and biochemical processes in the body from intracellular anabolism and catabolism to the reproduction of the organism [6].

Experiments have shown that by ensuring the need of plants for mineral elements, their drought resistance increases sharply. The effectiveness of fertilizers directly depends on the moisture supply of the plant. Therefore, in plants with sufficient water supply, their efficiency increases, as a rule, by 2 - 4 times. The proper functioning of each living cell depends solely on the presence of essential macro- and microelements [7] [8]. Furthermore, the accumulation of dry mass in plants was found to be influenced by alterations in the size of the feeding area and the conditions for providing nutrients [9].

2. Materials and Methods

The experiments were conducted in the conditions of the Samarkand region in 2023-2024. During the research, seeds of the Amiri and Kizil Gulobi melon varieties were used. Before sowing, the field was irrigated, and as the soil matured, pre-sowing tillage was carried out, and seeds of each variety were sown in 4 replicates (field surface (2.5 m × 80 m) 200 m^2). The field was irrigated 3 times (650 - 700 m^3/ha) during the growing season.

In field experiments (5 variants), the following micronutrients were applied to the soil against the background of macro fertilizers ($N_{220}P_{110}K_{70}$ background): copper—10 kg/ha, zinc—20 kg/ha, manganese—15 kg/ha, and cobalt—5 kg/ha. Also, for foliar feeding, solutions of 0.05% copper ($CuSO_4$ * $5H_2O$), 0.01% manganese

($MnSO_4 * 5H_2O$), 0.05% zinc ($ZnSO_4 * 8H_2O$), and 0.01% cobalt ($CoSO_4 * 7H_2O$) were sprayed onto the leaves once during the leaf budding period of the plant. Ammonium nitrate, PS-agro, and potassium chloride were used as mineral fertilizers.

Samarkand region is characterized by very diverse natural and geographical conditions. Various soil types are distributed in the natural and geographical conditions of the region [10]. Typical gray soils with medium and light loamy loams, mainly located in deep layers of groundwater, are widespread in the Samarkand region, and these soils account for 38% of the total area of the region. The rest are almost light gray soils, found in the western and southwestern parts of the region. In addition, meadow, meadow-gray, and gray-meadow soils are also widespread [11].

Before sowing in sand, seeds were soaked in 0.1; 0.05 and 0.005% solutions of various microfertilizers for 12 hours, in which the seeds and solution were taken in a 2:1 ratio. At the same time, the option was used as a control that was soaked in distilled water and sown in soil. In laboratory experiments, each variant was planted in 8 replicates, a total of 100 seeds were sown in sand with a humidity of 70%, and germination energy and germination indices were recorded in a thermostat at 20˚C. Through these laboratory studies, the most favorable concentrations were determined, and field experiments were conducted on this basis.

All observations, analyses, and measurements were carried out based on the "Methodology of State Variety Testing of Agricultural Crops [12]", and field experiments were conducted using generally accepted methods (Methods of Conducting Field Experiments, 2007 [13]; Methodology of Field and Vegetation Experiments with a Cultivator under Irrigation Conditions [14]. In the experiment, the following methodological manuals were used to perform agrochemical and agrophysical analyses: "Methods of agrochemical, agrophysical and microbiological studies in cotton irrigated areas [15]", "Agrochemical methods of soil research [16]. Statistical analysis of the experimental results was carried out according to B.A. Dospechov [17]. In the experiments, the total nitrogen content in the leaves of melon varieties at different developmental phases was taken into account. The total nitrogen content in the plant was determined according to Ermakov [18], Kruglova [19], and Taraz [20].

3. Results and Discussion

Nitrogen (N) is one of the most important mineral nutrients for plant growth and biomass formation and is involved in the synthesis of amino acids, proteins, nucleic acids, lipids, chlorophyll, and various metabolites containing the nitrogen element. Since plants require nitrogen in the largest amount of any mineral element, nitrogen deficiency is a limiting element for plant growth and development [21]. Plant growth and development processes, including root development, leaf development, seed dormancy, and flowering, can be significantly affected by the amount and source of nitrogen supplied to plants. It has also been found that different nitrogen sources available in the rhizosphere significantly affect the amount of macro and micronutrients in leaves, and as a result, affect nitrogen metabolism, photosynthesis, plant growth, and yield in Citrus sinensis [22], cucumber [23], and watermelon [24].

Researchers have paid great attention to studying the effect of micronutrients on total nitrogen accumulation in plants. It has been found that manganese, boron, molybdenum, and cobalt increase total nitrogen in most crops. In our experiments, the effect of micronutrients on plant nitrogen content was also studied. As shown in **Figure 1** and **Figure 2**, the total nitrogen content in leaves increased at different stages of plant development under the influence of micronutrients. We also observed a decrease in the total nitrogen content of melon varieties by phase, that is, from the 7-leaf stage to the fruit formation phase. We can say that the reason is the transport of nutrients, including microelements, from vegetative organs to generative organs during the fruit formation period.

According to the data obtained in the experiment, microelements had a significant effect on the total nitrogen content of leaves in different phases of development and on the number of male and female flowers in the plant. It was found that the total nitrogen content in both varieties increased from the 7-leaf stage of the plant to the flowering phase and decreased by the fruit formation period. In particular, the nitrogen content in the Amiri variety in the $N_{220}P_{110}K_{70}$ background variant was 2.48 mg/kg at the 7-leaf stage, 2.73 mg/kg at the flowering phase, and 2.18 mg/kg at the fruit formation period, respectively (**Figure 1**).

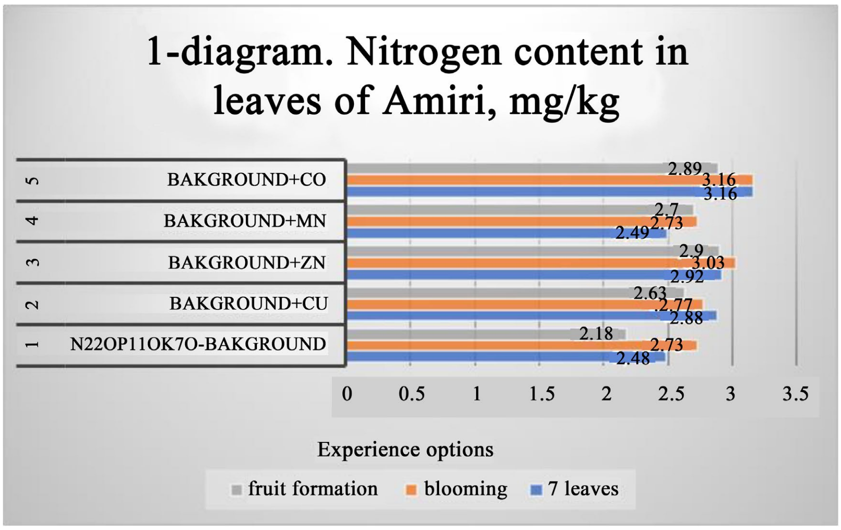

Figure 1. Nitrogen content in leaves of Amiri (mg/kg).

Under the influence of microelements, the nitrogen content in the leaves of the Amiri variety increased compared to the $N_{220}P_{110}K_{70}$ background variant, and the highest nitrogen content was observed in the variant with cobalt application. In particular, the nitrogen content in the 7-leaf stage of the Amiri variety was 2.48 mg/kg in the $N_{220}P_{110}K_{70}$ background, while the highest was 3.16 mg/kg when cobalt was applied and as a result, cobalt increased nitrogen content by 27% in Amiri leaves during that stage of the vegetation period. The same result was observed in the flowering phase of the plant. The positive effect of cobalt on the plant is known from the scientific literature, as it was found that additional treatment with cobalt in cobalt-deficient soils had a positive effect on the total nitrogen content in some crops [25]. According to the research of A. L. Sanakulov, when cotton grown in cobalt-deficient conditions was additionally treated with cobalt, the energy efficiency coefficient increased [26] and this microelement had a positive effect on nitrogen metabolism in the plant [27]. On the contrary, in the 7-leaf stage of the Kizil Gulabi variety, the highest nitrogen content was observed when manganese was applied and was 2.95 mg/kg, respectively. In the flowering phase, the highest nitrogen content was observed when copper was applied, at 3.37 mg/kg and was accounted for 68,5 % increase (**Figure 2**).

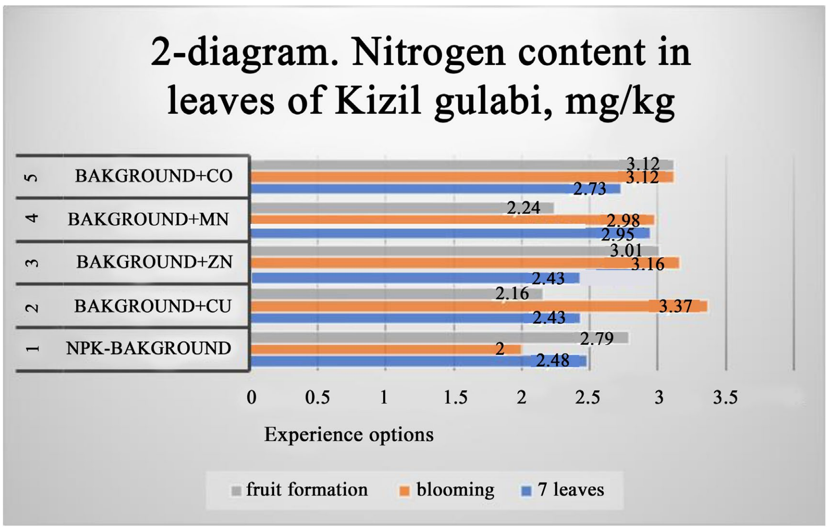

Figure 2. Nitrogen content in leaves of Kizil Gulabi (mg/kg).

In the Amiri variety, the highest nitrogen content during fruit formation was determined in the variant where the zinc microelement was applied—2.90 mg/kg which was made up 33 percentage of growth in nitrogen content. In the Kizil gulabi variety, the highest nitrogen content in the leaves was observed in the variant where cobalt was applied and was 3.12 mg/kg that resulted for 11,82 % rising in nitrogen content during fruit formation. In general, according to the experimental results, we can see that the zinc microelement had a positive effect on the nitrogen content in the leaves. The scientific literature also highlights the existence of a mutual relationship between zinc and nitrogen in the development of crops. According to the experiments of Meng Li *et al.*, zinc application helps in the accumulation and assimilation of nitrogen. It was found that zinc application increased the activity of nitrate reductase and glutamine synthetase in wheat, millet, and rice and enhanced the assimilation of NH_4^+, and as a result, the concentration of amino acids and proteins increased [28]. On the contrary, zinc deficiency has been reported to cause disturbances in nitrogen metabolism, including decreased protein and free amino acid production and accumulation of amides in rice meristem tissues [29].

The number of flowers, including female flowers, formed in the melon plant is noteworthy. The results show that the Amiri variety formed the most male flowers under the influence of the cobalt microelement, 302.4 pieces, while the female flowers formed the most when manganese was applied and amounted to 18.2 pieces (**Figure 3**). The Kizil gulabi variety formed the most male flowers when zinc and manganese were applied, and amounted to 309.7 and 309.2 pieces, respectively. Similarly, the zinc and cobalt microelements affected the formation of the most female flowers, and 21.0 and 21.2 pieces of female flowers were formed, respectively (**Figure 4**). In the variants where manganese and zinc were applied, flowers, including female flowers, were formed in large numbers. Based on the result of the research, yield depends on the number of female flowers produced by the plant. For that reason, increasing the number of female flowers is vital to acquire the yield [30].

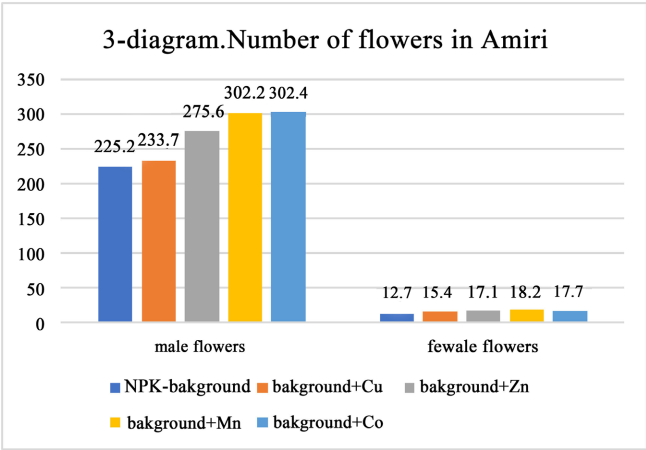

Figure 3. Number of flowers in Amiri.

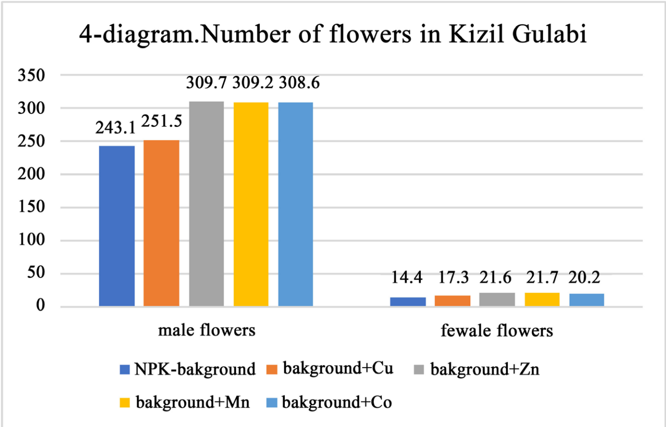

Figure 4. Number of flowers in Kizil Gulabi.

Manganese is an important component of the catalytic center that carries out the oxidation of water in photosystem II (PS II) and is necessary for the formation of energy and ATP required for CO_2 assimilation. In addition, manganese is necessary for the activation of phosphoenolpyruvate carboxykinase [31] and lipid metabolism. It was found in experiments that when maize seedlings were treated with manganese, the net mass of one plant increased by 27.49%, while in conditions of manganese deficiency, the net mass of the plant decreased by 45.62% compared to the control [32]. It can also be seen that the effect of the trace element zinc on the plant was also significant during the experiment. Zinc is an essential trace element and plays an important role as a cofactor in many enzymatic reactions involved in protein synthesis, carbohydrate, nucleic acid, and lipid metabolism [33]. This indicates that adequate levels of zinc are crucial for maintaining optimal growth and development in plants. Further research is needed to explore the mechanisms through which zinc influences these metabolic processes and to determine the optimal concentrations required for different plant species.

4. Conclusion

Thus, in the conditions of the Samarkand region, the application of microelements to the soil and foliar feeding in the cultivation of melon varieties has a positive effect on the accumulation of nitrogen in the leaves of the plant, as well as on the formation of flowers (male and female) in the plant. For instance, by copper treatment, a 68,5 % increase was observed in nitrogen content in Amiri leaves during the flowering period. In the copper-applied option, 11,8% growth was indicated in the nitrogen content of Kizil gulabi leaves in fruit formation while there was a 33 % rise in nitrogen content of Amiri leaves during fruit formation when zinc was applied. As a result, a favorable nutritional regime is created for the plant, the yield increases and its quality improves. In general, according to the experimental results, we can see that the zinc, copper and manganese had a positive effect on the nitrogen content in the leaves.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Mavlyanova, R., Rustamov, A., Khakimov, R., Turdieva, M. and Padulosi, S. (2005) Melons of Uzbekistan. 206 p.

[2] Azimova, S.S. and Glushenkova, A.I. (2012) *Cucurbita ovifera* L. In: Azimova, S.S. and Glushenkova, A.I., Eds., *Lipids, Lipophilic Components and Essential Oils from Plant Sources*, Springer, 307-309. https://doi.org/10.1007/978-0-85729-323-7_949

[3] Benvenuti, S., Bortolotti, E. and Maggini, R. (2016) Antioxidant Power, Anthocyanin Content and Organoleptic Performance of Edible Flowers. *Scientia Horticulturae*, **199**, 170-177. https://doi.org/10.1016/j.scienta.2015.12.052

[4] Ostonakulov, T., Sanaev, S. and Khamdamova, E. (2016) Samarkand Melons. 39 p.

[5] Sanakulov, A.L. and Khoshimov, F.H. (2014) Biogeochemistry Copper (Cu) in the

Soils of the Zarafshan Valley. *The Way of Science International Scientific Journal*, **1**, 53-57.
https://scholar.google.com/citations?view_op=view_citation&hl=en&user=RCvdadoAAAAJ&citation_for_view=RCvdadoAAAAJ:M3NEmzRMIkIC

[6] Tilavov, K.H., Ostanakulov, T. and Amanturdiev, I. (2018) Suitability of Melon Varieties for Drying. *Agriculture of Uzbekistan*, No. 10., 31-32.

[7] Khoshimov, F.H. and Sanakulov, A.L. (2017) Improving the Micronutrient Composition of Zarafshon Valley Soils and the Effectiveness of Microfertilizers in Cotton Cultivation. Turon Iqbal, 288 p.

[8] Zeng, W., Huang. J., Wu, J. and Xu, C. (2013) Modeling Soil Salt and Nitrogen Transport under Different Fertigation Practices with Hydrus-1D. *Advance Journal of Food Science and Technology*, **5**, 592-599.
https://doi.org/10.19026/ajfst.5.3133

[9] Zokirov, K., Ergashova, D., Yuldasheva, R., Komilov, A., Kadirova, D. and Abdullayev, D. (2024) Biometric Characteristics of Watermelon Plants. *BIO Web of Conferences*, **149**, Article No. 01037. https://doi.org/10.1051/bioconf/202414901037

[10] Uzokov, P.U. and Ortikov, T.K. (2008) Efficiency of Fertilizers in Growing Cotton on Hydromorphic Soils of the Zarafshan Oasis with Different Levels of Development and Productivity. Problems in the Development of Farms and Their Solutions. *Collection of Materials of the XVI Scientific and Practical Conference of Professors and Teachers*. Samarkand, 30 April-2 May 2008, 9-13.

[11] Kuziev, R.K., Sektimenko, V.E. and Ismonov, A.J. (2010) Atlas of Soil Covers of the Republic of Uzbekistan. State Committee "Ergeodezkadastr", 45 p.

[12] (1983) Methodology of State Variety Testing of Agricultural Crops. Third Issue, 184 p.

[13] (2007) Methods of Conducting Field Experiments. UzPITI, 147 p.

[14] (1981) Methodology of Field and Vegetation Experiments with Cotton under Irrigation Conditions. SoyuzNIHI, 140 p.

[15] (1963) Methods of Agrochemical, Agrophysical and Microbiological Studies and Irrigated Agricultural Areas. SoyuzNIXI, 440 p.

[16] Yudin, F.A. (1980) Methodology of Agrochemical Research. Edited by M.: "Kolos", 336 p.

[17] Dospekhov, B.A. (1985) Methodology of Field Experiment. M.: "Agropromizdat", 352 p.

[18] Ermakov, A.I. (1972) Methods of Biochemical Study of Plants. Kolos, 456 p.

[19] Kruglova, E.K. (1973) Methodology for Determining Forms of Microelements Available to Plants in Carbonate Soils and Plants. In: *Methods of Microbiological Studies and Determination of Microelements*. Agrochemistry, 51.

[20] Taraz (2002) Methods for Determination of Macro and Microelements in Plants, Soil and Water. AKVA, 91 p.

[21] Krouk, G., Crawford, N.M., Coruzzi, G.M. and Tsay, Y. (2010) Nitrate Signaling: Adaptation to Fluctuating Environments. *Current Opinion in Plant Biology*, **13**, 265-272. https://doi.org/10.1016/j.pbi.2009.12.003

[22] Ni, X., Quisenberry, S.S., Heng-Moss, T., Markwell, J., Sarath, G., Klucas, R., *et al.* (2001) Oxidative Responses of Resistant and Susceptible Cereal Leaves to Symptomatic and Nonsymptomatic Cereal Aphid (Hemiptera: Aphididae) Feeding. *Journal of Economic Entomology*, **94**, 743-751. https://doi.org/10.1603/0022-0493-94.3.743

[23] Schachtman, D.P. and Shin, R. (2007) Nutrient Sensing and Signaling: NPKS. *Annual Review of Plant Biology*, **58**, 47-69. https://doi.org/10.1146/annurev.arplant.58.032806.103750

[24] Roosta, H.R. and Schjoerring, J.K. (2007) Effects of Ammonium Toxicity on Nitrogen Metabolism and Elemental Profile of Cucumber Plants. *Journal of Plant Nutrition*, **30**, 1933-1951. https://doi.org/10.1080/01904160701629211

[25] Mengel, K. and Kirkby, E.A. (2001) Principles of Plant Nutrition. Kluwer Academic Publishers, 849 p. http://dx.doi.org/10.1007/978-94-010-1009-2

[26] Sanakulov, A.L. (2016) Bioenergetic Efficiency of the Use of the Microelement Cobalt in Growing Cotton in the Conditions of the Zarafshan Valley-World Science: Problems and Innovations. 145-147.

[27] Sanakulov, A.L. and Khoshimov, F.X. (2016) The Effect of Cobalt on the Removal of HPK during Cotton Cultivation in the Conditions of the Zarafshan Valley. *Conference*: *Fundamental and Applied Scientific Research*: *Current Issues*, *Achievements and Innovations*, 158-163.

[28] Li, M., Wang, S., Tian, X., Zhao, J., Li, H., Guo, C., *et al.* (2015) Zn Distribution and Bioavailability in Whole Grain and Grain Fractions of Winter Wheat as Affected by Applications of Soil N and Foliar Zn Combined with N or P. *Journal of Cereal Science*, **61**, 26-32. https://doi.org/10.1016/j.jcs.2014.09.009

[29] Kitagishi, K. and Obata, H. (1986) Effects of Zinc Deficiency on the Nitrogen Metabolism of Meristematic Tissues of Rice Plants with Reference to Protein Synthesis. *Soil Science and Plant Nutrition*, **32**, 397-405. https://doi.org/10.1080/00380768.1986.10557520

[30] Prohens, J. and Nuez, F. (2008) Vegetables I: Asteraceae, Brassicaceae, Chenopodiaceae, and Cucurbitaceae. Springer. https://doi.org/10.1007/978-0-387-30443-4

[31] Marschner, H. (1995) Mineral Nutrition of Higher Plants. 2nd Edition, Academic, 324-333.

[32] Gong, X., Qu, C., Liu, C., Hong, M., Wang, L. and Hong, F. (2011) Effects of Manganese Deficiency and Added Cerium on Nitrogen Metabolism of Maize. *Biological Trace Element Research*, **144**, 1240-1250. https://doi.org/10.1007/s12011-011-9105-y

[33] Broadley, M.R., White, P.J., Hammond, J.P., Zelko, I. and Lux, A. (2007) Zinc in plants. *New Phytologist*, **173**, 677-702. https://doi.org/10.1111/j.1469-8137.2007.01996.x