COLLECTION OF SCIENTIFIC PAPERS

SCIENTIA

21 MAY, 2021

SINGAPORE, REPUBLIC OF SINGAPORE

MODERNIZATION OF TODAY'S SCIENCE: EXPERIENCE AND TRENDS

I INTERNATIONAL SCIENTIFIC AND THEORETICAL CONFERENCE

VOLUME 1

EUROPEAN SCIENTIFIC PLATFORM

DOI 10.36074/scientia-21.05.2021 ISBN 978-1-63848-587-2 00001

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Singapore, 2021

SECTION 12.
BIOLOGY AND BIOTECHNOLOGY

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PHYSIOLOGICAL PROPERTIES OF COPPER IN PLANT METABOLISM

It is necessary to study the importance of micronutrients in plant metabolism, to manage their productivity, and to identify new opportunities, as micronutrients can act as specific and non-specific regulators of metabolism. At the molecular level, micronutrients are actively involved in many life processes that take place in plants. Micronutrients that interact through an enzyme system or are directly bound to plant biopolymers can increase or slow down plant growth, development, and reproductive function.

Treatment with coordination compounds of copper and cobalt leads to an acceleration of the onset of developmental phases and an increase in the number of fully-formed nodules in cotton. An increase in yield of 10-15%, fibre strength and maturity, as well as an increase in the amount of fat in the seeds, were observed. Wetting winter wheat seeds with a solution of copper sulfate (10 mg/l) significantly increased the free tryptophan content. It should be noted that treatment of seeds with a high concentration of the copper solution was less effective, and in several experiments, its negative effect on seed yield was observed [1-4].

Analyzes have shown that barium, copper and molybdenum contribute to the accumulation of carotene, sugar and minerals in carrots. Thus, under the influence of barium, the amount of carotene (depending on soil and climatic conditions) in root crops increased from 0.6 to 2.1 mg%, and the amount of sugar increased to 0.8%.

Thus, there is a relationship between the composition of certain chemical elements in the soil and the proliferation of certain groups of biologically active substances by plants. Plants that produce glycosides choose manganese, molybdenum, chromium; production of alkaloids - copper, manganese, cobalt; saponins - molybdenum, vanadium; terpenoids - manganese; coumarins, flavonoids - copper; vitamins - manganese, copper; polysaccharides - manganese, chromium.

Available in the early stages of growth, molybdenum and zinc increase the amount of carbon, especially sucrose, in corn leaves. Under the influence of molybdenum, the amount of starch, manganese led to a significant increase in the amount of DNA and RNA. Lack of micronutrients in soils affects the decline in productivity and quality of plants. Molybdenum and zinc have proven to be particularly effective in increasing crop yields. Manganese helps glutathione to accumulate more and be converted to a reversible form of ascorbic acid.

The average amount of copper in plants is 2 mg per 1 kg of mass, and it depends on the characteristics of plant species and soil conditions. In a plant cell, 2/3 of the copper may be in an insoluble, bound state. The seeds are rich in copper and the growing parts of the plants are the most vital. 70% of all copper in the leaves is accumulated in chloroplasts. The physiological role of copper is mainly determined by the inclusion of enzymes that catalyze the oxidation of proteins and diphenols in copper and the hydroxylation of monophenols. Copper deficiency leads to growth retardation, chlorosis, loss of turgor and withering of plants, delayed flowering and a sharp decrease in yield. As a result of acute copper deficiency in cereals, the tips of the leaves turn white and spikes do not develop, and in fruit plants, dry twigs appear with copper deficiency [5-9].

Copper fertilizers are most effective in peat, grassy-swampy, marshy soils and soils with light mechanical content. The most demanding plants for copper fertilizers are wheat, oats, barley, flax, millet, sunflower, mustard, sugar and fodder beets, beans, peas, vegetables and fruits. Demand for copper increases with the application of high amounts of nitrogen fertilizers. In the future, it is desirable to meet the needs of the country's agriculture in copper fertilizers at the expense of copper sulfate and copper-potassium fertilizers. Copper fertilizers of local importance are pyrite slags.

They are applied once every 4-5 years at a rate of 500-600 kg/ha during autumn ploughing or spring sowing. 100 kg of seeds is treated with 50-100 g of copper sulfate solution. The amount of copper sulfate per 1 hectare of the crop for leaf processing is 200 - 300 g. Copper sulphate contains 25.4% copper.

For example, copper has a positive effect on the synthesis of amino acids and proteins in legume nodules, protein metabolism, the synthesis of chlorophyll in plant leaves, and reduces its breakdown in the dark. Due to the strong lack of copper, the stems dry out. Such plants do not yield at all or the yield is very low and of poor quality. Sometimes, due to a strong copper deficiency, the accumulation increases due to the drying of the three parts of the plants, and after complete drying, they continue to form new buds. The strong and rapid elongation of barley stalks as a result of copper deficiency contributes to the damage caused by the Swedish fly [10-17]].

Copper deficiency often results in zinc deficiency, while in sandy soils it is manifested as a result of magnesium deficiency. The introduction of high amounts of nitrogen fertilizers increases the need for copper in plants and leads to an increase in symptoms of copper deficiency. Copper is also involved in protein synthesis. The activity of nitrogen-containing oxidizing enzymes slows down due to copper deficiency. The peculiarity of the effect of copper is that this microelement increases the resistance of plants to fungal and bacterial diseases. Copper reduces the disease of cereal crops, increases the resistance of tomatoes to brown spots. Copper improves the movement of carbohydrates, especially sucrose, from the leaves to the stems and reproductive organs. Lack of copper and zinc leads to a significant increase in the content of free amino acids, which in the absence of these micronutrients disrupts protein synthesis, providing the energy side of the movement of substances.

Copper complex compounds include sugars as well as many other organic compounds. Therefore, they are of great importance in improving the mobility of not only carbohydrates but also other organic substances. It is a starting material for the synthesis of proteins, fats, alkaloids, vitamins, growth stimulants and other organic compounds that play an important role in the metabolism of sugars. Copper passes from the soil to the plants very slowly. A 12-fold increase in the amount in the soil results in a maximum 2-fold accumulation of it in grains, roots, straw and leaves. A. Hodenberg determined the concentration of copper, which is toxic to some plants. Copper is relatively rare in nature. Its average content in the earth's crust is 0.01% by mass. Copper is mainly found in sulfur, iron, oxygen compounds. Copper forms many minerals (such as pyrite, malachite, lazurite, etc.), the most common of which are basic minerals - simple and complex sulfides. They are observed under the influence of weather (especially in acidic environments), along with the formation of copper ions in this environment [18-23].

The element has the properties of forming very strong complex compounds. The microelement is strongly bound to montmorillonite, clay and soil humus. Biological processes, especially microbiological fixation, play an important role in copper migration. The copper content in the soil is closely related to its structure, the amount of organic matter and the amount of absorbed content. The heavier the soil composition and the more the bases are absorbed, the higher the copper content. Copper is a typical element with high agrochemical activity - its consumption ranges from 62 to 84%. Therefore, feeding without the addition of fertilizers can be observed primarily in soils with low amounts of this element [24-27].

Plants accumulate copper at a dry weight of 5–20 μg/g. Reduced copper can easily convert electrons into oxygen and easily return oxidized copper. Therefore, copper ions, like iron, are involved in the transport of electrons during respiration and photosynthesis. For example, one of the components of the electronic transport chain of photosynthesis is a blue protein-containing copper-plastocyanin. Copper, along with iron, is part of cytochrome oxidase, an oxidase enzyme involved in respiration. Most of the copper (75% of the total amount in the leaves) accumulates in the chloroplasts. It promotes the formation of chlorophyll complexes with proteins [28-31]. Copper is also part of diphenol oxidase and ascorbate oxidase. These enzymes are involved in electron binding to phenols or returned ascorbic acid. Ascorbate oxidase contains at least four copper atoms, which are involved in the conversion of O_2 to H_2O. In these enzymes, copper is bound to a protein. In addition, copper activates nitrate reductase and proteases, so it is involved in nitrogen and protein metabolism. Polyphenol oxidase is involved in the synthesis of lignin. Copper also plays an important role in the binding of the hormone ethylene to receptors [27 - 32].

The high reactivity of copper can lead to its toxicity even at low concentrations. Copper stretches the thiol bonds in proteins, which negatively affects the structure of protein molecules. Therefore, the transport of copper through membranes is carried out in conjunction with special proteins, chaperones, which convert copper into a non-reactive form. In the absence of copper, dark green leaves are formed, which may have necrotic spots, usually, these symptoms appear on young leaves. Copper deficiency results in the formation of sterile pollinators, which leads to a decrease in the number of seeds and slows down the synthesis of lignin, sometimes causing the plants to fall asleep.

As a result of copper deficiency, early shedding of leaves is observed, growth slows down. Copper deficiency can halve the rate of photosynthesis. As a result of laboratory experiments with cotton, it was observed that copper and zinc from micronutrients had a positive effect on the initial growth and development of cotton. Bukhara-102 cotton variety was used as the object of research. In all experimental variants, seed germination was high under the influence of micronutrients. The growth of tumours along the neck, the formation of petals intensified. Leaf level, the total water content in leaves, wet and dry weight of shoots, root size, and other indicators were high.

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