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AGROCHEMICAL ASPECTS OF SULFUR FERTILIZER ON DIFFERENT TYPES OF SOIL (ANALYTICAL REVIEW)

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There is an analytical overview on the content of sulfur in plants and soil, the dynamics of change and the use of sulfur-containing fertilizers. It is shown that their use optimizes the processes of growth and development of plants, the flow of biochemical processes in plants, increases crop productivity.

Sulfur components in soil and plants, sulfates, sulfur fertilizers, plant productivity.

Sulfur in plant nutrition. The presence of sulfur in the composition of plants was found by Liebig in 1859. Its importance as nutrition element became apparent after the development of Sachs and Knop in 1860 the method of plants growing based on salt solution. Sulfur is the ninth of the macronutrients required for plant nutrition [1]. It is absorbed by plants from the soil in the form of oxide − sulfate anion, which are the source of various salts of sulfuric acid [2].

There are two main ways in a small biological cycle of substances in the biosphere conversion of this element: oxidation and reduction. The reduction of sulfate assimilation prevails in plants − the main pathway of sulfur in plant cells, that's why sulfate is the main power source of sulfur occupies a leading position in them [2].

In plants, sulfur content varies from 0,02 to 1,8%. Sulfur is a necessary part of two amino acids: methionine and cystine which it takes a part proteins formation together with. The content of these amino acids in zeyini corn and wheat gliadin is respectively 2,4, 0,9 and 2,3, 2,3% per dry substance. Sulfur is also a part of mustard and garlic oils contained in the seeds of cabbage and garlic. As nucleotides are sulfur-

containing vitamins B1, B2, B6, niacin, and others. Thus, vitamin B1 (thiamin) is a coenzyme halofermenta β-carboxylase . It is involved in the formation of high-energy phosphate bonds and stimulates the biosynthesis of protein forms of phosphorus. Vitamin B6 is involved in the conversion of asparagine and glutamine in the plant. Plant β- amylase is part of the cereal grains and soybeans. Its activity is related to the occurrence of sulfhydryl groups - SH [2].

Rhizosphere microflora is the reason that there are always vitamins B1, B2, B6, B12 pantoteonova , folic , nicotinic acid and other compounds that positively influence the biochemical plants in fertile soil. An average thiamine content in soils is 2 - 3mkh per 100g of soil. Making every kilogram of manure into the soil receives 150 mg of thiamine and other vitamins. [4] According to F. Lipmann [5], compounds containing sulfur, could be responsible for the occurrence of the primary oxidation-reduction potential required for biosynthesis. The thioesters are supposed to be the evolutionary ancestors of "macroergic"ATP [3].

Thus, the sulfur in the cell performs the following biological functions: energy, strukturalnu (consisting of proteins, carbohydrates, lipids, etc.), catalytic (in the active site of enzymes, cofactors part), redox (balance in the cell) initiative (in cell division), Rostov (in the polypeptide chain during protein synthesis). She is also involved in methylation reactions of DNA, RNA and other important compounds [6].

Sulfur is used heavily cultivated plants in the biological cycle and estranged from crop plants. In older leaves of plants the sulfur is very labile and is a source of some amount of the moving sulfur to more sulfur-demanding actively-dividing meristems of young leaves and roots [3].

During sulfur starvation leaves do not die, though it becomes pale. The need for sulfur is different in varies plants. It is carrying out mostly by crop plants from cruciferous (mustard, kale, turnip, turnips and radish) [7, 8]. Plants of the family wormseeds and legumes (beans, peas, soybeans) also alienate sufficient quantity of it form harvest. To a lesser extent, sulfur is carrying out by the harvests of corn, potato, cotton [9]. Sulfur content (calculated as SO_3) in plants is expressed in the following terms (in % on air- dry basis): the grain of winter wheat − 0,02, pea − 0,08, in potato tubers − 0,06, in wheat straw − 0,11, pea − 0,27, tops potatoes − 0,13 [10].

The conditions for plant nutrition are judged on the basis of analyzes of soil and rainfall [11]. With sufficient sulfur nutrition increases plant's resistance to low temperature, drought, diseases, soil salinity [12]. Some researchers propose to consider the diagnosis of total and sulfate sulfur in plants. Studies in the U.S. have shown that the critical concentration of sulfate sulfur in soils for crops is 0.8 mg per 100 g of soil, corn – 0,7-0,8 , alfalfa and clover − 1,2 mg per 100g of soil [13]. For the sulfur content of 0,19% and higher plants do not react to application of it, but the contents 0,15-0,17 % is showing signs of deficiency in sulfur [11]. Along with sulfur the nitrogen is determined and calculated in the ratio of nitrogen to sulfur. This figure for certain crops is relatively stable because both elements are part of proteins in a well-defined quantity, which is typical for each species of plants [13].

Thus, during the study of plant nutrition of sulfur inevitably raises the question of the need for knowledge of every case of sulfur's metabolism. This may be useful in selecting appropriate doses of sulfur-containing fertilizers, as well as species and varieties of plants that react to the introduction of sulfur. A distinctive feature of higher plants is the ability to use sulfate sulfur in biosynthetic purposes. Therefore, in the plant sulfates are the main source of sulfur supplying and occupy the top spot and largely depend on its accumulation in soils. By adjusting the supplying of sulfur for plants, one can affect the quantity, but moreover the qualitative parameters of agricultural products.

The purpose of research – to conduct an analytical review of national and international experience in the usage of sulfur fertilizers in the nourishment of plants.

The material and methodic of studies. To achieve this goal were analyzed publications of domestic and foreign scholars on the purpose of importance of sulfur in plant's nutrition and the use of sulfur-containing fertilizers to increase plant productivity, synthesis, carried out by using general techniques.

The results of studies. It is known direct and indirect effects of not only sulfur but other fertilizers on the growth and development of plants. Indirect effects related to changes in the availability of nutrients in the soil, and direct evident in the immediate participation of sulfur metabolism in plants. Currently, the most intensive research is being conducted by scientists in this field in China, India, Iran, Canada

and Germany. Despite some research on the influence of sulfur on soil properties and the availability of nutrients this issue today remains poorly studied [14].

By the experiments domestic and foreign scholars it is found a beneficial effect of sulfur on the synthesis of chlorophyll in plants and enzyme activity. In wheat and barley it is observed an increase of productive bushiness, accelerated maturation, improvement of structure of the harvest. Under the influence of sulfur fertilizer the harvest of winter and spring wheat, winter rye, oats, barley growing at 1,0-2,5kg/ha, and in some cases even more. In this case, there was an increase in grain protein content on 0,5-1,6 % [15]. By the research of M. P. Shkel [16] it is found that with the use of sulfur-containing fertilizers it is observed rising of glassiness of wheat and content of all amino acids in grain of barley.

By the investigations of Estonian scientists when inducting in crops of winter wheat liquid fertilizer containing sulfur sulfate (Na), and fertilizer Ahan-1 (2,7% S), Ahan-2 (7% S) sulfur doses of 4 to 26kh/ha it is found an increase in chlorophyll content in leaves of winter wheat, increasing the number of productive stems, grains per ear and grain harvest increase to 29-64% [17].

At the sod-calcareous soils with low amount of available sulfur in crops of winter wheat Ivanic J. [18] applied N_{60} at sowing and N_{60} in feeding. With fertilizers was made 6-12kh/ha of sulfur in the form of Na, and studied the effectiveness of sulfur coming from the fungicide "Thiovit Jet". When applying sulfur in the form of Na increase of harvest was 27-49% of the fungicide - 11-55% (depending on the dose and timing of application). Outside-root sulfur fertilization increased the productive bushiness and number of grains per ear, which favorably affected the formation of the harvest.

As for cultivated crops, there is also marked increase in green fodder, corn, beet roots, potato tubers by 10-20 %, and in some cases even on 30%. Effect of sulfur fertilizer is positive on the quality of the harvest of these crops. Thus, in the grain and green mass of corn increases the amount of protein, fat, tryptophan, valine, threonine [19]. Under the influence of sulfur enhances synthesis of carbohydrates: the roots of sugar beet growing, and in potato tubers − starch [20]. In some experiments established that the sulfur-containing fertilizers contribute to more intense flow of

nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and some trace elements in such plants as corn, sugar beets, potatoes, oilseed rape [21].

The research has established the beneficial effects of sulfur fertilizer on the growth and development of leguminous plants [20] and legumes [22]. Often the positive effect of sulfur was discovered on getting more proteins in leguminous plants than on their overall performance. Thus, on field experiments in Kharkiv's SGI the application of labeled sulfur under barley, clover's predecessor, it increased protein content on 0,7-1,5%, and its collection - at 1,0-1,5kg/ha [23].

The sulfur-containing fertilizers are activating activity of nodule bacteria. Under the influence of sulfur in crop legumes it becomes more, not only nitrogen, but also phosphorus, calcium and some trace elements − boron, zinc and copper [22]. As a part of the protein in grain and peas it is observed the increase in well-absorbing water-soluble and salt-soluble fractions [24]. Sulfur contributes to the accumulation in leguminous plants of valuable amino acids, increases seed germination and increases the activity of enzymes of peroxidase and polyphenol oxidase [22].

The intensive research on the effectiveness of shapes, forms, terms and methods of inducting sulfur fertilizers for rape, being currently making by Canadian scientists. In gray, dark gray forest soils and black soils it is studying granulated sulfur-containing fertilizer (ES-99, ES-95, ES-90 and Biosul-90), suspension Biosul-50 and Na, and Agrium Plus (21,7% elemental S + 18,7% SO_4^{2-}) and Tiger 90 (R) (bentonite with elemental sulfur) for making surface scattered or as outside-root fertilizing. Suspension Biosul-50 and powdered elemental sulfur were similar in performance to the sulfate form of sulfur fertilizers and liquid fertilizers containing sulfur sulfate (Na) were more effective than Tiger 90 (R). Granular shape and elemental sulfur significantly increased the efficiency of the second year, but loses to sulfate forms, suspension and powder [8]. On the black soils it was increased oil content and sulfur in rapeseed and decreased the amount of chlorophyll. Adding Na under predecessor (wheat) provided a residual effect of sulfur on rape, increasing oil content and sulfur in seeds, while reducing its amount of chlorophyll and nitrogen, with those sulfur fertilizer efficiency was not dependant on the method of primary tillage. [9]

German, British and Swiss researchers have found a significant increase in rapeseed plants the content of sulfate, cysteine, glutathione, hlikozinolates. They elucidated the mechanisms of S-induced resistance of rape to fungus Pirenopeziza brassicae [21]. It is found that rape as a precursor may further increase the availability of sulfur in rotation of crops. With an average availability of sulfur in soil, application of sulfur fertilizers in half of the cases led to an increase of oil content in rape [25].

Much attention the scholars of Western Europe, North America and China have given to the problems associated with the cutting out of forests and soil acidification by precipitations. Felling of deciduous forest led during 8 months to acidification of forest soils (pH from 4,5 to 4,0) and lower of content of mobile sulfates. The reason was adsorption fixing of sulfur with increasing acidity. Annual flow of total and sulfate sulfur from the forest floor for 3 years in total decreased by 6,9kg/ha [26].

In the southwestern part of Sweden from 1988 to 1998 it was observed the introduction of ammonium sulfate at planting spruce (100kh/ha N and S 114kh/ha annually). Effects of fertilizer was accompanied by enhanced removal form soil NH_4^+, NO_3^-, SO_4^{2-}, Mg^{2+}, Ca^{2+} and did not affect the removal of K. Herewith, the value of pH in the mineral horizons for the period decreased by 0,4 units. [27].

In studying the regulation of sulfate accumulation in deciduous forests, it was found, that sulfur deficiency has no effect on the growth of poplar, but the content of glutathione in plants decreased. Sulfur deficiency leads to increased levels of ATF sulfate-reductase in mRNA what is an adaptive mechanism of accumulation of sulfate during metabolism [1].

Chinese scientists have found that while earning sulfur with precipitation on red soils in the deciduous forests of South China 69% of its total accounts for sulfates [28].

On the timing and methods of application of sulfur fertilizers it is a lot of information in foreign literature, especially in countries where production of sulfur fertilizers was long-established. In the CIS sulfur fertilizers are applied during autumn plowing in autumn or early spring during pre-sowing cultivation [29]. Fertilizers containing sulfur, marked good effect in making them in small doses at

sowing [23]. In acute deficiency of sulfur it is recommended outside-root plant nutrition 0.5-2.0% by solution of sulfate [13]. The optimal dose of various forms of sulfur fertilizers in Ukraine and Belarus is about 60kh/ha [23]. Latvia has made 60-120kh/ha of sulfur, depending on soil and crops [11].

The conclusion

1. Thus, an analytical review of the literature shows that sulfur is important in the small biological and large geological cycle of substances on Earth. Content and patterns of distribution of the element are studied and understood not in all soils. Most developed countries in agriculture are (USA, France, Japan) began to produce sophisticated and complex fertilizers, balanced not only NPK, but also sulfur, calcium, magnesium and other vital elements for plant nutrition.

2. In the former USSR rush to study the problem of sulfur in the agricultural sector fell from 70 to 80 years of last century. The first successful results in studies of sulfur content in soils and plants were obtained by scientists Baltic countries, Belarus, Ukraine and Russian Federation. Despite the fact that the problem of sulfur became urgent in different regions of the country, industry has not developed production of modern fertilizers, balanced by a large number of elements of nutrition, including sulfur. Therefore, each particular area requires a detailed study of availability of sulfur in the soil; also we must identify needs for sulfur plant nutrition with sulfur and ground the environmental and economic feasibility of sulfur fertilizers.

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