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FEATURES OF THE ACCUMULATION OF HEAVY METALS BY DIFFERENT GENOTYPES OF SPRING WHEAT UNDER CONDITIONS OF SOIL CONTAMINATION WITH COPPER AND LEAD

Abstract. At present, the human impact on the biosphere is global in nature, in connection with which the issues of environmental pollution by many toxic substances, including heavy metals, have become very urgent. The long period of self-cleaning of contaminated soils and the high cost of their technogenic cleaning make mankind look for new ways to solve this problem. The identification of plant objects characterized by a minimal accumulation of heavy metals is the most promising direction in this area. The aim of our study is to determine the tolerance of wheat genotypes to severe metals, priority in the East Kazakhstan region, as well as identification of donors for breeding for metal resistance and promising forms of wheat. The object of research in this work is the genotypes of spring wheat from the collection of the East Kazakhstan Research Institute of Agriculture: GVK (East Kazakhstan genotype) -11/14, GVK-19056, GVK-19055, GVK-19012, GVK-19009.

Key words: heavy metals, spring wheat, soil, harvest.

Risks associated with safety yu food and the environment under the conditions of all the growing pollution by heavy metals, causing the t serious public concern in many countries. Contamination of agricultural soils with heavy metals is becoming serious due to rapid industrialization and urbanization [1]. Thus, n redpriyatiya metallurgical industry annually discarded into the environment of about 155 thousand tons of copper, 89 tons of lead, 122 tons of zinc., Combusting e coal and oil - 3.6 tonnes of lead, 2.1 tonnes. copper, 7.0 thousand tons of zinc. The amount of lead coming from the exhaust gases of vehicles is 250 thousand tons per year [2]. In rural areas of heavy metals through a system of soil-culture can play a dominant role in the effects of heavy metals on the health of a person [3] The imbalance of chemicals in foods and diets is the root cause and the beginning of the emergence and development of many human and animal diseases [4]. High concentrations of heavy x metal s in the environment cause health problems adversely affecting the nervous, hematopoietic, cardiovascular, reproductive and renal systems. Consequences of heavy metal contamination include decreased intelligence, attention deficit and behavioral abnormalities, and a contribution to cardiovascular disease in adults [5] . Some metal s, such as for example, both Cu and Zn harmless in small amounts, but other - mainly Pb, As, Hg, and Cd, even in extremely low concentrations, are toxic and are potent initiators or promoters of many diseases, including an increased risk of cancer [6].

However, it is not easy to remove heavy metals from soils because of their irreversible immobilization in various soil components [7]. The most effective way to reduce contamination of agricultural products is to use metal-resistant varieties of agricultural plants that do not accumulate metals even when they are abundant in the soil. Knowledge of the biological characteristics of agricultural crops helps to solve the problem of rational use of soils with different levels of contamination with heavy metals. It is necessary to take into account the specific and varietal characteristics, commodity the part of the plant. Taking into account all these components, on soils with a low level of pollution, it is possible to obtain a fairly clean crop of grain crops without much risk [2]. Wheat grain production is an important area of ensuring the country's food security. In this regard, agricultural production should produce ecologically clean, high quality grain, in which the content of heavy metals should not exceed the maximum permissible standards [8]. Therefore, the purpose of our study was to study various genotypes of spring durum wheat for their resistance to the accumulation of copper and lead in grain, which is a commercial part of the product.

Growing plants in conditions of natural pollution. The plants were grown in primary seed nurseries of the research and development site of VKNIISH, in conditions of natural pollution, in the suburban area of Ust-Kamenogorsk, East Kazakhstan region, north-east direction, 3 km from the city border. The area of the experimental plot is 5 m^2 in triplicate. Sowing is mechanized, plotting, the seeding rate is 5-6 million germinating grains per hectare. Row spacing 15 cm, inter-plot spaces 50 cm.

The soil cover of the experimental site is represented by ordinary heavy loamy chernozem, widespread in the foothill-steppe zone. The soil of the experimental plot is neutral (pH 7.0). The humus content in the arable horizon averages 2.6%. The soil is moderately supplied with easily assimilable nitrogen (22.6-18.4 mg / kg soil), highly supplied with mobile potassium (390-400 mg / kg soil) and low supplied with mobile phosphorus (16.3-18.5 mg / kg soil).

The predecessor - black fallow after fall plowing - 23-25 cm. When laying the experiments, soil preparation, sowing and plant care were carried out according to the accepted technology of barley cultivation in the foothill steppe zone of East Kazakhstan. Early spring harrowing, cultivation, pre-sowing cultivation. Plant care (rolling, weeding by hand).

Determination of the content of heavy metals in the soil of the root zone and in the grain. The concentration of heavy metals (copper and lead) was determined using an atomic absorption spectrophotometer. The method of atomic absorption spectrophotometry (AAS) is based on the property of atoms of chemical elements formed when the solutions of the substances used are sprayed in a "cold" flame (acetylene-air, propane-air, etc.) to absorb light of a certain wavelength. The radiation intensity of low-pressure gas-discharge lamps after the passage of light through a combustible gas flame and its absorption by the atoms of the investigated element is recorded photoelectrically. Samples of grain and soil in the root zone taken in the field of natural soil contamination with heavy metals were ashed in a muffle furnace. The ash material was treated with nitric and hydrochloric acids and water was added. The atomic absorption of the experimental and control samples was measured using an atomic absorption spectrophotometer [9].

Determination of the coefficient of biological accumulation of metals. One characteristic of reflecting accu- level of heavy metals cultures are biologically rate of accumulation. We have calculated bioaccumulation (coefficient of biological accumulation) as the ratio of the average content of heavy metals in plants to their average content in soils,

$$\mathrm{Ks} = \frac{\mathrm{Ct}}{\mathrm{C\ Wed}}$$

where Ks is the coefficient of biological accumulation; Ct — metal content in the plant, mg / kg; Ssr. - metal content in the soil cover, mg / kg [10].

Determination of vegetative indicators and productivity in conditions of natural environmental pollution

Phenological observations, field and laboratory assessments, and counts were carried out according to generally accepted methods [11].

Observations were carried out for the following developmental phases - seedlings, tillering, renewal of vegetation, tube emergence, heading, flowering, ripeness.

Plants determine the productivity kusti stost. Dug Raste Niya on each option and count the actual number of stems per plant (total, including product GOVERNMENTAL). The arithmetic mean, obtained from dividing the total number and number of productive stems by the number of plants, characterizes the total or productive tillering, respectively, depending on the variety.

Plant survival was determined. Plants were counted in the full germination phase and before harvesting. The number of preserved plants (%) is calculated by the formula:

$$B = \frac{Cx\,100}{B}$$

where: B - the number of plants preserved for harvesting, %; B - the number of plants in the full germination phase, pcs. per m^2; C - the number of plants to be harvested, pcs. by 1 m^2.

The yield was determined by a direct gravimetric method. The grain moisture was determined by the gravimetric method. Since each plot taken about to grain into aluminum cups with a tight lid, weighed, and dried at a temperature of 100 ^{to} - 105 ° C until constant weight is about 4 - 6 hours, then the calculation are according to the formula:

$$X = B{:}H$$

where: X - grain moisture, %; B is the mass of evaporated water, g; H - raw sample, g.

The standard 14% moisture content is calculated using the formula:

$$B = \frac{Yx\,(100 - b)}{100 - c}$$

where: X - yield reduced to standard moisture content; Y is the yield obtained; b - moisture content of the crop (%); c - standard humidity for this object.

In the analysis of plant elements their structures grain crops were collected on 10 plants from each plot of repetitions experience.

Research results and their discussion. First of all, the content of the studied heavy metals in the soil of the root zone of various genotypes of spring barley was investigated, since East Kazakhstan is an industrial center with developed mining and non-ferrous metallurgy and soils can be contaminated with heavy metals. It is known from literary sources that a high concentration of lead in the soil causes its excessive accumulation in plants, which leads to inhibition of the respiration process and inhibits photosynthesis, can also lead to an increase in the intake of cadmium and a decrease in the content of such elements as zinc, calcium, phosphorus, sulfur. The total toxicological effect of pollution of the environment with heavy metals depends not only on the set and level of accumulation of specific elements, but also on the characteristics of their interaction [12]. The unfavorable effect of copper with its increased content in the soil and subsequently in the plant was manifested by a decrease in the accumulation of phytomass, water content of tissues, chlorophyll content, absorption of ions of some other metals and their translocation throughout the plant [13].

The results of our study first the content of lead in the soil root zone of different genotypes of spring barley indicated that in relation to the MAC lead to soil are exceeded in 1, 6-1,7 times, except for the soil root zone habitat genotype HVA-19056 (Figure 1).

Comparison with MPCs does not always reflect the true pollution situation. Therefore, the ratio of the lead content in the soil of the root zone with the Regional Clark was also determined, in accordance with the opinion that the content of elements in the topsoil should be compared with the background [14]. Regional Clark was taken as the background metal content in the soil.

Figure 1. The content of lead in the soil of the root zone of various genotypes of spring durum wheat in relation to the MPC

Studies have shown that, in relation to Regional Clark, the excess of the metal content is 2, 6 - 2.7 times, except for the soil of the root zone of the genotype GVK-19056, where the excess is 1.6 times. This excess is higher nd than with respect to the MPC (Figure 2).

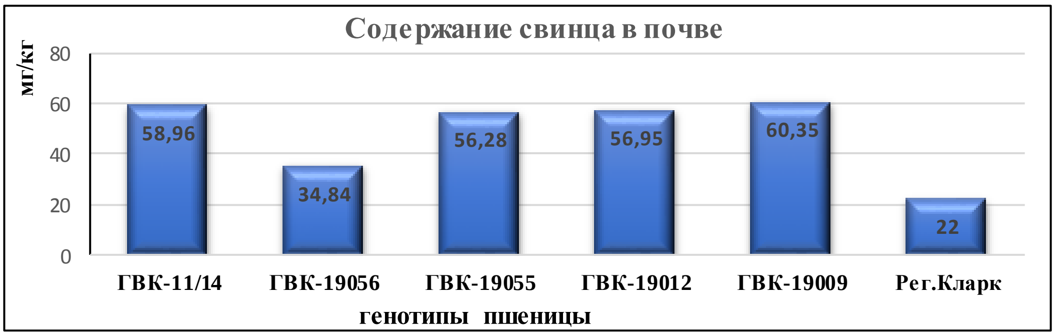

Figure 2. The content of lead in the soil root zone different genotypes YAROVOY minutes durum wheat with respect to the Regional Clark

The copper content in the soil of the root zone of various genotypes of spring barley was also investigated (Figure 3.4). The findings of copper have shown that with respect to the MPC excess copper is observed in the soil in 1 5 - 2.5 times (Figure 3).

Figure 3. The content of copper in the soil of the root zone of various genotypes of spring durum wheat in relation to the MPC

The ratio of the copper content in the soil of the root zone to the Regional Clark was also determined. Studies have shown that, in relation to Regional Clark, an excess of copper content in the soil of the root habitat of spring durum wheat genotypes is not observed (Figure 4).

Figure 4. Copper content in the soil of the root zone of different genotypes of spring barley in relation to Regional Clark

Thus, the study of the content of copper and lead in the soil of the habitat zone of the roots of spring barley showed an increased content of the studied elements, both in comparison with their maximum permissible concentration for soil, and lead in comparison with Regional Clark. In all studied genotypes, they experience stress from the increased content of heavy metals in the soil. At the same time, the content of lead makes a greater contribution to stress, since compared to its natural content in the region, the excess is 2, 6 - 2.7 times a.

Determination of the accumulation of the studied elements in seeds is the most important studied indicator, since wheat grain is used in the food industry.

Our studies have shown that lead ions accumulate in seeds of all genotypes of spring barley and their amount exceeds the MPC for grain by about 4-12 times. According to the amount of lead ions accumulated in the seeds of plants of different genotypes of spring barley, they can be arranged in the following order as they decrease: GVK-19012 > GVK-19055 > GVK-19009 > GVK 11/14 > GVK 19056.

Less likely, compared with the other genotypes, genotype lead ions accumulates HVA-19056, most - GVK19012 remaining spring barley genotypes show intermediate values of the content of the element (Figure 5).

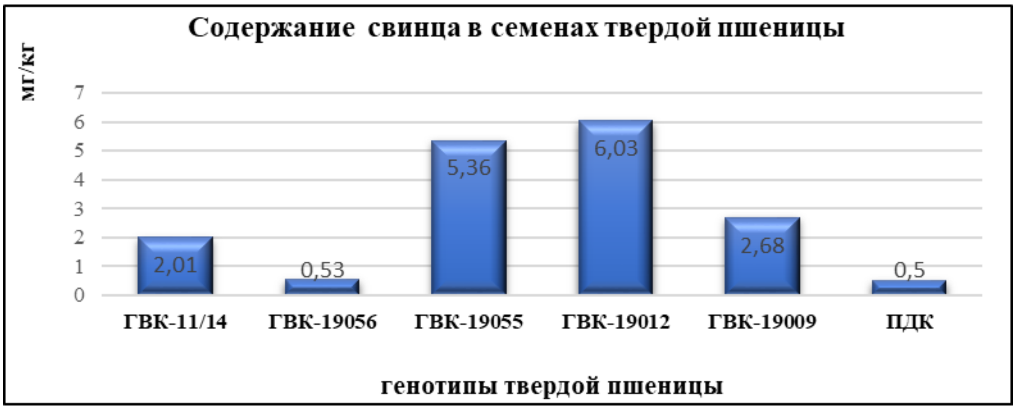

Figure 5. Lead content in seeds of various genotypes of spring durum wheat in relation to MPC

Determination of biological accumulation showed that accumulates the least lead genotype HVA-19056, most - GWC - 19012 (Figure 6)

Figure 6. Coefficient of biological lead accumulation in seeds of various genotypes of spring durum wheat

The study of the content of copper ions in seeds of durum spring wheat showed that this metal accumulates little and its amount does not exceed the MPC for grain for all studied genotypes. At the same time, there are differences between the genotypes of spring durum wheat in terms of the content of copper in seeds (Figure 7).

Figure 7. The content of copper in the seeds of different genotypes of spring barley in relation to the MPC.

According to the number of copper ions accumulated in the seeds of plants of different genotypes of spring barley, they can be arranged in the following order as they decrease: genotype GVK-19009 > GVK-11/14 > GVK-19055 > GVK-19012 > GVK-19056. The smallest quantity of copper in seeds contain and T genotype HVA-19056, the largest - genotype HVA-19009 .

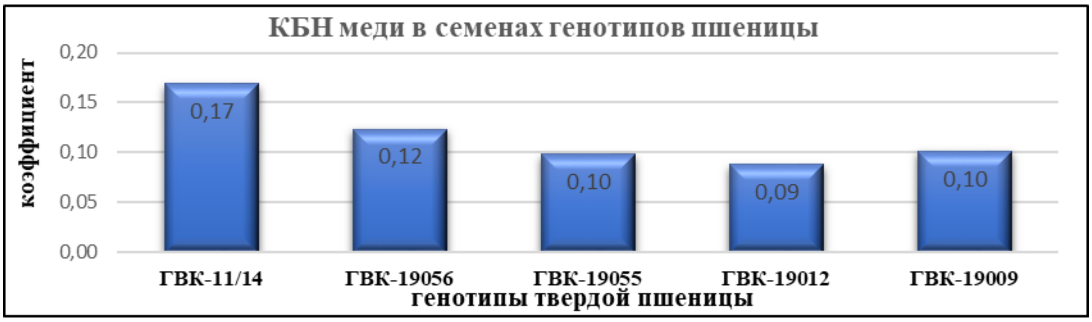

Figure 8. Coefficient of biological accumulation of copper in seeds of various genotypes of spring durum wheat

Determination of biological accumulation (Figure 8) showed that less accumulates all copper genotype HVA-190 of 12, b olshe only accumulate copper seed genotype YAROVOY minutes durum wheat HVA-11/14.

The accumulation of chemical elements by plants does not always correspond to the degree of their accumulation in soils, since the input of elements depends on the biological characteristics of the plant organism and the geochemical characteristics of the habitat [15, pp.3-24]. The direct dependence of the content of heavy metals in plants on their amount in the soil is often violated due to the ability of plants to selectively absorb the element s [16, pp.37-97]. P asthenia differ with respect to the ability to accumulate metal. Thus, it was found that the content of heavy metals in wheat flour is determined by varietal characteristics [17, pp.10-12]. The penetration of heavy metals from the soil in the plant depends on the ability to overcome the I internal barriers plant body, its physiological and biochemical mechanisms of self-defense [18, pp.144-159]. Availability of heavy metals to the plant is determined by the following biological characteristics of plants: variation of accumulation of different metals from - for the species characteristics of plants; species and varietal differences of agricultural plants; age differences in cultures in accumulation; species differences in organs that accumulate different amounts of heavy metals [19].

Communication information available in the literature ide ments that revealed a significant positive correlation between the concentration of heavy metals in the grain and genotype varieties showing a possibility of removing the low-potential accumulation of heavy metals. For example, different varieties of spring wheat showed significant differences in storage properties in relation to heavy metals; varieties with high and low content of heavy metals were identified. The latter are less sensitive to industrial pollution and agricultural metal-containing fertilizers. The authors come to the opinion that this is especially characteristic of the most toxic metals - cadmium and lead [20].

Stable agricultural production requires varieties that make the most of the natural resources of the environment, capable of producing stable yields in a changing environment. To recommend metal-resistant varieties and genotypes for production, it is necessary to investigate their yield and resistance to climatic environmental conditions. Determining the survival rate in the spring-summer growing season, the yield of barley and its elements will reveal the most promising forms for cultivation in conditions of pollution.

In order to identify the survival of plants were carried out by counting the number of plants germinating, and the remaining amount before harvesting plants YAROVIT th firmly th of wheat per unit area. By the difference between these indicators, one can judge the survival rate of plants during the spring-summer growing season. The research shows that the number of plants during the growing season decreases in all genotypes of spring wheat (Figure 9).

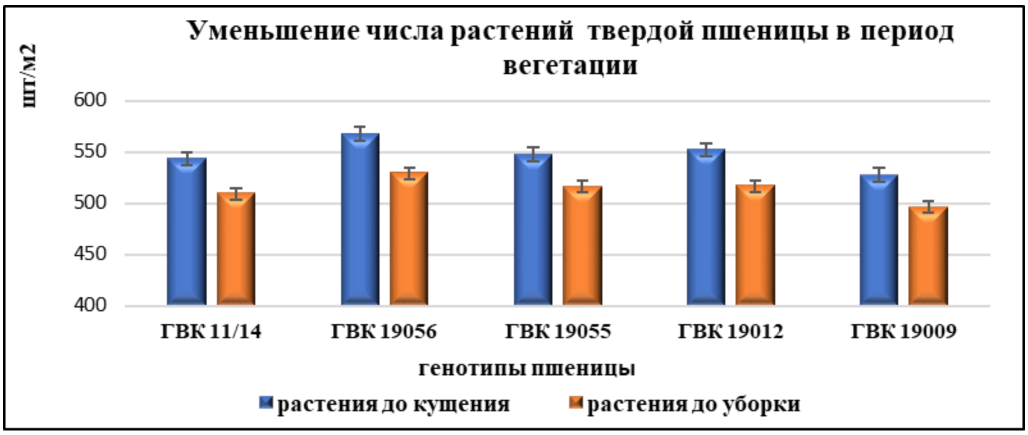

Figure 9. W The number of plant genotypes spring durum wheat germination phase until slaughter p ki

Analysis of the data allows us to conclude that the largest number of dead plants during the spring-summer growing season is observed in the GVK-19056 genotype (6.8%), which indicates their low adaptive ability to external environmental factors. An average reduction in the number of plants was revealed in the GVK-12/14 and GVK-19012 genotypes (6.3% and 6.5%, respectively). The smallest losses in the number of surviving plants during the spring-summer growing season belong to the genotypes GVK-10955 and GVK-19009, the seedlings of which decreased only by 5.7 and 5.9%, respectively (Figure 10).

Figure 10. Survival of plants of various genotypes of spring durum wheat during the growing season

The analysis of the structure of the yield of spring durum wheat from the collection of VK NIISH and the relationship of its elements is carried out. By the structure of the crop, it is possible to identify the main factors and judge the nature of their influence on the formation of the crop. Productivity is the most important and complex quantitative trait, the sum total of the result of plant development during the growing season. In the course of our study, important economically valuable traits associated with the yield of wheat genotypes were analyzed. It is known that pollution of the environment with heavy metals and subsequent pollution of plants cause changes in physiological parameters, development, productivity and quality of grain. For example, contamination of wheat plants with metallurgical dust leads to an increase in the rate of oxygen uptake and carbon dioxide emission [21]. P asthenia I grown e on soils contaminated with heavy metals, characterized Hard of hand cycle and development setbacks second or full th loss m phenophases [22]. Crops grown on soils contaminated with emissions of metallurgical production, characterized by low their quality m grain nak about Square HAND straw in iron, zinc, and lead. When comparing the productivity of wheat grown on contaminated soils within the radius of influence of a metallurgical enterprise with the harvest in the background plots, the maximum decrease in wheat productivity was revealed . The influence of ferrous metallurgy enterprises is expressed in an increase in the degree of contamination of grain crops, as well as in a decrease in the content of gluten and underdevelopment and grains [23].

And hav e information about soil contamination by heavy metals impact on productivity and its components in grains. So, when studying the grain productivity of wheat and its elements under conditions of soil contamination with heavy metals, it was revealed that lead contamination leads to a decrease in the grain weight, the number of grains and the weight of 1000 grains significantly decreased. The combined effect of cadmium and lead had the most toxic effect on plants, it caused the most significant decrease in productivity compared to the control - the weight of grain and straw were lost. In experiments with spring wheat and spring barley under conditions of soil contamination with cadmium, lead and nickel, separately and in certain combinations, a significant effect on plant productivity, elements of the crop structure, correlations between grain productivity and its individual elements, the intake and distribution of these elements in plants was shown. At the same time, the nature of changes in the above signs under the influence of heavy metals was determined by the level of soil contamination with metals, the nature of the interaction between them, and the varietal characteristics of plants. Soil contamination with a high dose of lead led to the loss of a high correlation between productive tillering and grain productivity in cereals [24].

Conclusions:

1. When soil is contaminated with lead and copper ions in the grain of different genotypes of spring wheat and lead ones accumulate in the seeds of all genotypes of spring barley and their amount exceeds the MPC, while copper ions accumulate little and their amount does not exceed the MPC for grain for all studied genotypes.
2. Genotype HVA-190 12 YAROVOY minutes durum wheat can be recommended for use in breeding and genetic research as resistance donor to copper, since this genotype has the lowest value of the coefficient b iologicheskogo accumulation.
3. The main role in the formation of productivity in conditions of polymetallic soil pollution is played by the survival of plants during the spring-summer growing season.

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ОСОБЕННОСТИ НАКОПЛЕНИЯ ТЯЖЁЛЫХ МЕТАЛЛОВ РАЗЛИЧНЫМИ ГЕНОТИПАМИ ЯРОВОЙ ПШЕНИЦЫ В УСЛОВИЯХ ЗАГРЯЗНЕНИЯ ПОЧВЫ МЕДЬЮ И СВИНЦОМ

Аннотация. В настоящее время воздействие человека на биосферу носит глобальный характер, в связи, с чем весьма актуальными стали вопросы загрязнения окружающей среды многими токсичными веществами, в том числе тяжелыми металлами. Большой период самоочищения загрязнённых почв и дороговизна их техногенной очистки заставляют человечество искать новые пути решения данной проблемы. Выявление растительных объектов, характеризующихся минимальным накоплением тяжелых металлов, является наиболее перспективным направлением в данной области. Целью нашего исследования является определение толерантности генотипов пшеницы к тяжелым металлам, приоритетным в Восточно-Казахстанском регионе, а также выявление доноров для селекции на металлоустойчивость и перспективных форм пшеницы. Объектом исследования в данной работе являются генотипы яровой пшеницы из коллекции Восточно-Казахстанского научно-исследовательского института сельского хозяйства: ГВК (генотип восточно-казахстанский)-11/14, ГВК-19056, ГВК-19055, ГВК-19012, ГВК-19009.

Ключевые слова: тяжелые металлы, яровая пшеница, почва, урожай.