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MODERN TRENDS IN AGRICULTURE SCIENCE: PROBLEMS AND SOLUTIONS

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The monograph is a collection of the results of actual achievements of domestic agricultural scientists, obtained directly in real conditions. The authors are recognized experts in their fields, as well as young scientists and postgraduate students of Ukraine. Research is conceptually grouped at 7 sections: Plants protection and quarantine; vegetable growing in open and closed ground; horticulture, fruit growing, viticulture; breeding and seed production; agrochemistry and soil science; agriculture and modern agricultural technologies; management and strategies for future development. The monograph will be interesting for experts in plant breeding, economics, plant protection, selection, agrochemistry, soil science, scientific workers, teachers, graduate students and students of agricultural specialties of higher education institutions, and for all those who are interested in increasing the quantity and quality of agricultural products.

Keywords: agriculture, modern technologies, plants protection, quarantine, vegetable growing, horticulture, fruit growing, viticulture, breeding and seed production, agrochemistry, soil, management, strategies, development.

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CHARACTERISTICS OF RESOURCE-SAVING TECHNOLOGY OF AGRICULTURE DEPENDING ON PRODUCTION CHEMISTRY

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The work provides a comprehensive agro-ecological assessment on the study of the features of the interdependence between the toxic-ecological characteristics of the main products of agrocenoses, different levels of agricultural chemicalization and the state of individual components of agro-ecosystems in the economy. The investigated (residues of organochlorine pesticides, heavy metals, nitrates) in the components of agroecosystems pose the greatest danger to the population and the biosphere as a whole, since they are actively included in the biogeochemical cycles of transformations in nature. The role of different levels of agricultural chemicalization can determine the intensity of transformation of pollutants by components of agroecosystems and their specific content in the main products of agrocenoses. On the basis of the biocentric principles of the system-target approach, an ecological assessment was provided and the interdependence between the toxic-ecological characteristics of the main products of agrocenoses, different levels of chemicalization of agriculture and the state of individual components of agroecosystems was clarified.

Key words: *agrocenoses, agroecosystem, heavy metals, resource-saving technology, chemistry, pesticides, nitrates*

Formulation of the problem. At the current stage, the ecological aspects of land use in Ukraine are becoming extremely acute. Most of the environmental problems associated with the use of land resources have a natural basis, but their intensification is caused not so much by the rhythm (cyclicity) of natural phenomena, but by anthropogenic influence, or rather – the consequences of imprudent management, oriented not on the future, but on the current return (Veremeyenko, 2010).

Contamination of agricultural land with heavy metals leads to a decrease in yield and an increase in their content in agricultural products.

Soil pollution by heavy metals occurs more slowly on chernozems, which have (compared to sod-podzolic soils of sandy and loamy granulometric composition) significantly more organic matter and high absorption capacity. Diffusion coefficients of heavy metals in chernozems are 2-3 times lower than in sod-podzolic soils, and therefore chernozems suffer from the effects of pollution much less than podzolic sandy and loamy soils. On chernozems, the crop is less damaged and its quality deteriorates than on other soils.

The study of the above-mentioned aspects is important for overcoming environmental risks in the agricultural sector, improving the food problem and does not lose its relevance.

The purpose of the research was to carry out an ecological assessment and substantiate the principles of regulating the toxic-ecological safety of the main products of agrocenoses at different levels of agricultural chemicalization in growing conditions.

Every year, 193 thousand tons of fluorine, 1.6 thousand tons of zinc, 620 thousand tons of copper, and 622 tons of potassium are added to agricultural land with mineral fertilizers (Lanovenko, 2013). Residual quantities of pesticides and gross forms of heavy metals in the soil and in plant products are at the level of the MPC (maximum permissible concentrations), and in mobile forms in the soil they exceed the MPC by 1.5-2 times.

The crisis situation exists in the territories with the level of radionuclide contamination of Cs-137 in the range of 5-15 Ki/km^2 and Sr-90 -1-3 Ki/km^2, and the residual amounts of pesticides in soils and plants exceed 1.1-1.5 times MPC, the content of gross forms of heavy metals exceeds the MPC by 2-10 times, and in plant products – by 1.1-1.5 times (in mobile forms in soils, it exceeds the MPC by ten times).

The main directions of soil pollution, which are subject to constant field and laboratory control, are determined by the accumulation of residues of plant protection products (pesticides), mineral fertilizers and heavy metals in the soil cover.

At the same time, the actual content of harmful substances in the soil is compared with the already mentioned maximum permissible concentrations (MPCs) – the normatively established content of such substances in the soil mass (mg/kg), which guarantees the absence of a negative (direct or indirect) impact on human health and sanitary living conditions of the population.

In practice, one of the main ecological criteria of soil pollution is the accumulation in the soil of various heavy metals that enter the soil from the air or through groundwater (it is enough to mention that, for example, coal ash alone contains up to 70 chemical elements, among which a significant amount can be attributed to the group of heavy metals). At the same time, the leading positions are not even quantitative estimates of heavy metals accumulated in the soil, but their toxicity. However, as noted by S. I. Veremeyenko (2010), clear criteria for the toxicity of each element for different agricultural crops have not yet been developed.

The excessive accumulation of nitrates in the vegetative parts of vegetable crops is a particular danger, since most of them are used by humans for food. In general, more than 30% of agricultural products produced in Ukraine have a nitrate content that exceeds the maximum permissible level (MDR) – 5-13.4.

In special raw material zones intended for growing products for baby and diet food, pesticides and agrochemicals are used according to special technologies that ensure the production of products that meet the sanitary and hygienic requirements for baby and diet food (Fesenko, 2013).

Thus, according to UNEP, the average pesticide load per hectare of arable land in the USA at the end of the 20th century. was 1.5 kg, in Europe – 1.9 kg, in Ukraine 2.5 kg. Recently, the rates of consumption of pesticides have been decreasing. This is connected, firstly, with the use of active substances of new chemical classes, effective at lower consumption rates, and secondly, with the use of biological means of plant protection. In order to protect the components of agroecosystems from the negative impact of pesticides, it is necessary to strictly follow the recommendations for their use, to introduce integrated systems of plant protection, biological methods of protection of agricultural crops, to stimulate the development of new ecologically harmless pesticides of the new generation (Lanovenko, 2013).

Pesticides that have reached the surface of the soil can be washed into deeper horizons and groundwater, enter reservoirs with surface runoff, appear on the surface of the soil during capillary rise of groundwater, pass into the atmospheric air as a result of evaporation or with dust during wind erosion of the soil, through plants to migrate into the body of animals and humans. Intensive pollution of the natural environment is largely a consequence of irrational agricultural production (Degodyuk, 2014).

The use of pesticides leads to the suppression of biological activity of soils and prevents the natural restoration of fertility, causes a loss of nutritional value and taste qualities of agricultural products, increases losses and shortens the shelf life of products, reduces the yield of many crops.

Therefore, it is ecologically important to assess the current state of soil contamination with pesticide residues.

Research results. Cultivation of field crops using the so-called intensive technology is a system of agrotechnical measures that makes it possible to maximally realize the potential of varieties at the genetic level due to the use of modern achievements in breeding, agriculture, and agrochemistry for the use of production processes (Balyuk, 2016). Today, there are significant deviations from the main components of intensive cultivation technologies, as well as a tendency to increase the use of pesticides and mineral fertilizers. This is a consequence of limiting the alternation of crops in crop rotations.

Today, oversaturation of soils with mineral fertilizers, as well as disruption of the circulation of organic substances in the soil, endangers the fertility of all arable lands and the surrounding environment. After such a negative practice, soils lose their structural features for growing grain crops.

Excess application of mineral fertilizers threatens not only human health, but also leads to destabilization of agroecosystems in general.

The search for maximum productivity during the intensification of agriculture leads to oversaturation of the soil with chemical fertilizers, which significantly pollutes agricultural land and the environment.

In connection with the increased rates of application of mineral fertilizers to agricultural plants, the anthropogenic load on the soil cover is increasing (Nazarenko, 2004). Therefore, more and more attention is paid to this issue today. In the works of Prohorov V.M. etc. basic indicators of providing plants with elements of mineral nutrition were developed depending on the degree of their absorption (Prohorov, 1970).

Intensive agricultural production using modern agricultural technologies is impossible without the use of mineral fertilizers.

Thus, the search for maximum productivity during the intensification of agriculture leads to oversaturation of the soil with chemical fertilizers, which significantly pollutes the environment, in particular agricultural land (Antonec, 2010; Tarasova, 2007; Fesenko, 2013).

In agriculture, the introduction of mineral fertilizers into the soil is an extremely important means of managing soil fertility and increasing the productivity of the soil, i.e. agriculture.

The use of mineral fertilizers improves soil fertility and increases the yield of all grain crops. This is due to the fact that fertilizers enrich the soil with mobile nutrients. They also provide more complete use of nutrients in the soil itself, as they positively affect the development of the root system of field crops and improve its physical properties.

In the economy FG "Alliance" uses resource-saving technology in crop production. During the cultivation of corn, the largest application of mineral elements is applied to the grain, the amount of application is $N_{90}P_{30}K_{30}$.

When growing Doridna winter wheat and Zlatson sunflower, smaller amounts of mineral fertilizers are applied, which are $N_{80}P_{30}K_{30}$ for wheat, and $N_{70}P_{15}K_{15}$ for sunflower.

A smaller amount of mineral elements was added when growing barley of the spring variety Parnas – $N_{30}P_{15}K_{15}$.

When growing winter wheat of the Doridna variety, for the application of $N_{90}P_{35}K_{35}$, it is necessary to apply 200 kg/ha of nitroammophoska and 150 kg/ha of ammonium nitrate, a total of 350 kg/ha. And when growing barley of the spring variety Parnas for use $N_{35}P_{15}K_{15}$. it is necessary to apply 80 kg/ha of nitroammophoska and 50 kg/ha of ammonium nitrate, together – 130 kg/ha.

For the application of $N_{100}P_{40}K_{40}$, 230 kg/ha of nitroammophoska, 80 kg/ha of ammonium nitrate and 60 kg/ha of urea should be used under corn for the grain of the Vera MV hybrid, together – 370 kg/ha. To grow Zlatson hybrid sunflower, you need to apply $N_{75}P_{20}K_{20}$, as well as apply 110 kg/ha of nitroammophoska and 150 kg/ha of ammonium nitrate, in total – 260 kg/ha.

In the economy, when using resource-saving technology, the largest volume of mineral fertilizers is applied to corn for grain of the Vira MV hybrid – 370 kg/ha, a little lower for winter wheat of the Doridna variety – 350 kg/ha, sunflower of the Zlatson hybrid – 260 kg/ha, and the least is applied under spring barley of the Parnas variety – 130 kg/ha.

The composition of mineral fertilizers includes heavy metals that are toxic to agricultural plants, therefore it is very important to take into account their influence on the quality characteristics of the crop.

Research has established that solid waste contains more than 100 names of toxic compounds, including dyes, pesticides, heavy metals, solvents, and formaldehyde (Butko, 1995). According to some scientists' estimates, about 20 % of the country's arable land is contaminated with heavy metals to one degree or another. Black earth soils suffer from pollution less than soils in which illuvial processes take place. But the accumulation of heavy metals in soils of various genesis is safe only up to a certain level, as long as the plant is able to withstand pollution (Polyevoj, 1999).

A significant amount of heavy metals enters the soil and plant cover with mineral fertilizers under the influence of intensification of agricultural production. Taking into account everything mentioned above, an assessment of the content of heavy metals in farm soils was carried out.

Indicators of agrochemical condition of soils include humus content, NPK, calcium content and acidity. In particular, the parameters of the toxic-ecological state of soils are the content of mobile forms of heavy metals, such as Pb, Cd, Zn, Cu, and pesticide residues (γ – HCCG, DDT).

It was established that in the conditions of the farm on soils where intensive cultivation technology is used, the content of humus was in the field, where Zlatson sunflower hybrid, Vira MV corn hybrid, spring barley of the Parnas variety, and winter wheat of the Doridna variety were grown – 0.5 %.

The highest content of hydrolyzed nitrogen was in the soil where the Zlatson sunflower hybrid was grown – 95.0 mg/kg. On the site where spring barley of the Parnas variety was grown, the content of hydrolyzed nitrogen was 2.0 % less, and the hydrolyzed nitrogen content of the Vira MV corn hybrid was 1.8% less, where winter wheat of the Doridna variety was grown – by 2.7% smaller and amounted to 68.0 mg/kg.

The highest content of mobile phosphorus was in the soil where the Vera MV corn hybrid was grown – 315.0 mg/kg. In the area where winter wheat of the Doridna variety was grown, the content of mobile phosphorus was 298.0, where spring barley of the Parnas variety and Zlatson sunflower hybrid were grown, it was 275.0 mg/kg.

The highest content of mobile potassium was in the soil where Doridna variety winter wheat was grown – 236.0 mg/kg. In the area where spring barley of the Parnas variety was grown, the content of mobile potassium was 193 mg/kg, where the sunflower hybrid Zlatson was grown – 165.0 mg/kg, and the corn hybrid Vera MV – 110.0 mg/kg.

The highest calcium content was in the soil where the Zlatson sunflower hybrid was grown – 159.0 mg.eq/kg. And in the area where spring barley of the Parnas variety and corn for grain were grown, the calcium content was 143.0 mg.eq/kg, and where winter wheat of the Doridna variety was grown, it was the lowest and was 114.0 mg.eq/kg.

The highest hydrolytic acidity was in the soil where winter wheat of the Doridna variety was grown – 0.94 mg.eq/100 g. In the area where corn for grain, the Vira MV hybrid and the Zlatson sunflower hybrid, hydrolytic acidity was 0.31 and 0.33 mg .eq/100 g, respectively, and the lowest level where spring barley of the Parnas variety was grown was 0.25 mg.eq/100 g.

The highest saline pH was in the soil where spring barley of the Parnas variety was grown – 7.0 pH.

In the area where the Zlatson sunflower hybrid was grown – 0.5 % less, where winter wheat was grown – by 1.0%, the lowest saline pH was in the soil where the Vera MV corn hybrid was grown, the saline pH was 0.4 %.

So, the soil where Doridna winter wheat was grown had the lowest calcium content, but the highest potassium content.

The soil where sunflower was grown was characterized by the highest content of calcium (4.2 % and 159.0 mg.eq/kg) and high hydrolytic acidity, but the lowest content of hydrolyzed nitrogen, mobile forms of phosphorus and potassium.

The soil on which Parnas spring barley was grown had the lowest value of hydrolytic acidity (0.25 mg.eq/100 g) and the highest pH (7.0).

The plot where corn for grain was grown had the highest content of mobile phosphorus (275.0 mg/kg), and the Zlatson sunflower hybrid had the highest content of hydrolyzed nitrogen (95.0 mg/kg).

When using the resource-saving cultivation technology, the humus content was observed in the soil where Doridna winter wheat, Zlatson sunflower hybrid, Parnas spring barley, and corn hybrid were grown – 0.5%.

The highest content of hydrolyzed nitrogen was in the soil where corn for grain (79.1 mg/kg) and winter wheat of the Doridna variety (78.0 mg/kg) were grown.

The highest content of mobile phosphorus was noted in the soil where corn was grown for a grain of 200.0 mg/kg. In the area where winter wheat of the Doridna variety was grown, the content of mobile phosphorus was 52.0 mg/kg, where the sunflower hybrid Zlatson was grown 163.0 mg/kg, where spring barley of the Parnas variety was grown 85.0 mg/kg and where wheat was grown in the winter variety Doridna, it was the smallest and amounted to 52.0 mg/kg.

The highest content of mobile potassium was in the soil where the Zlatson sunflower hybrid was grown, 93.0 mg/kg. In the area where winter wheat of the Doridna variety was grown, the content of mobile potassium was the lowest and amounted to 45.0 mg/kg.

The highest calcium content was in the soil where winter wheat of the Doridna variety was grown – 94.0 mg.eq/kg. In the plot where the Zlatson sunflower hybrid was grown, the calcium content was 0.4 % lower, and where the Parnas spring barley was grown, it was 2.4 % lower and amounted to 70.0 mg.eq/kg.

The highest hydrolytic acidity was in the soil where spring barley of the Parnas variety was grown – 3.40 mg.eq/100 g. In the area where winter wheat of the Doridna variety and the Zlatson sunflower hybrid were grown, the hydrolytic acidity was 2.7% lower and amounted to (0 .76 and 0.72) mg.eq/100, respectively.

It was established that the soil where winter wheat of the Doridna variety was grown had the lowest content of mobile phosphorus, but the highest content of calcium.

The soil where spring barley of the Parnas variety was grown was characterized by the highest value of hydrolytic acidity, but the lowest content of mobile potassium. The soil on which the sunflower hybrid Zlatson was grown had the highest content of mobile potassium and was 93 mg/kg. The soil on which the corn hybrid Vira MV was grown had the lowest value of hydrolytic acidity of 0.31 mg.eq/100, but the highest value of pH and the content of mobile phosphorus.

After the soil analysis, it should be noted that the MPC of lead in the soil is 6.0 mg/kg, cadmium – 0.70 mg/kg, copper 3.0 mg/kg, and zinc – 23.0 mg/kg.

Under the conditions of resource-saving chemical treatment on all soils, the lead content in the soil was 0.01 mg/kg, which is almost 600 times less than the MPC.

The highest cadmium content was found in the soil where Yariy barley of the Parnas variety and Zlatson sunflower hybrid were grown - 0.07 mg/kg, which is 7.7 times less than the Maximum Permissible Factor, where the Vera MV corn hybrid was grown - 0.02 mg /kg, which is 35 times less than the MPC, and on the remaining options 0.1 mg/kg, which is almost 70 times less than the MPC.

The highest content of copper was found in the soil where the Vira MV corn hybrid was grown – 1.0 mg/kg, which is 3 times less than the MPC. Where the sunflower hybrid Zlatson was grown – 0.85 mg/kg, which is almost 3.4 times less than the MPC, and where winter wheat of the Doridna variety was grown – 0.80 mg/kg, which is almost 3.5 times less than the MPC. Where spring barley of the Parnas variety was grown, the indicator was 0.75 mg/kg, which is 3.7 times less than the MPC.

The highest zinc content was found in the soil where spring barley of the Parnas variety was grown – 6.86 mg/kg, which is 3.2 times less than the MPC. Where the Zlatson sunflower hybrid was grown, the zinc content was 6.4 mg/kg, which is 3.4 times less than the MPC. Where winter wheat of the Doridna variety was grown, the indicator was 3.5 m/kg, which is 6.3 times less than the MPC.

Therefore, the soil where winter wheat of the Doridna variety was grown had the lowest content of cadmium and zinc. Soils where spring barley of the Parnas variety was grown were characterized by the highest content of cadmium and zinc. The soil on which the Zlatson sunflower hybrid was grown had the highest cadmium content.

When using chemical means of plant protection against weeds, diseases, and pests, there is no accumulation of pesticides in grain, which confirms the production of environmentally safe products.

Therefore, in the conditions of resource-saving farming technology, the accumulation of pesticide residues in the dark gray podzolized soils in the conditions of the farm of FG "Alliance" was not detected.

The actual content of nitrates in the grain of winter wheat during the harvesting period, grown under the conditions of resource-saving chemical farming was 11.20 mg/kg, which is 26.7 times less than the MPC, in the grain of spring barley – 17.20 mg/kg, which is 17. 4 times less than the MPC.

The coefficient of accumulation of nitrates is determined by dividing the amount of nitrates in grain and seeds of field crops by the amount of easily hydrolyzed nitrogen in the soil (Tkachuk, 2018).

The lowest coefficient of accumulation of nitrates was in the grain of the hybrid corn on the grain of Vera MV – 0.1, which is the lowest according to the experiment in comparison with other crops. The hazard ratio of nitrates in grain grown under the conditions of resource-saving cultivation technology was the highest in barley of the spring variety Parnas – 0.05, in wheat of the winter variety Doridna – the lowest – 0.04.

Conclusions

Researches carried out in the conditions of farms of FG "Alyans", which use resource-saving cultivation technology, showed that when growing winter wheat of the Doridna variety, 350 kg/ha of physical weight of mineral fertilizers are applied, spring barley of the Parnas variety – 130 kg/ha, hybrid corn for grain Vira MV – 375 kg/ha, sunflower hybrid Zlatson – 260 kg/ha.

When using resource-saving cultivation technology, the content of humus in chernozem typical soils of the experimental farm was 2.8-3.4 %, hydrolyzed nitrogen within 77.0 mg/kg, mobile phosphorus – 52.0–200.0 mg/kg, mobile potassium – 44.0–93.0 mg/kg, calcium content – 70.0–94.0 mg.eq/kg, hydrolytic acidity of dark gray opizolized soil was 0.31–3.40 mg.eq/100 g, saline pH – 5.1-6.5.

After the research, the residual amount of pesticides in chernozems of typical farm soils when growing the main agricultural crops under the conditions of resource-saving agricultural technology was significantly lower than the MPC – less than 0.02 mg/kg γ – HCCG at the MPC of 0.5 mg/kg and less than 0.02 mg/kg of DDT at the MPC of 0.2 mg/kg.

The hazard ratio of nitrates in grain grown under the conditions of resource-saving cultivation technology was 0.05 in the spring barley of the Parnas variety, and 0.04 in the winter wheat of the Doridna variety.

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