# MODERN TRENDS IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTION

## PROBLEMS AND PERSPECTIVES

EDITED BY
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# MODERN TRENDS IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTION: PROBLEMS AND PERSPECTIVES

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The monograph presented for review 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 into 5 sections: modern technologies in crop production and fodder production; economy of the agro-industrial complex; breeding and breeding in the 21th century; protection and quarantine of plants; agrochemistry and soil science. 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: modern technologies, crop production, fodder production, plant protection, quarantine, agrochemistry, soil science, economy of agro-industrial complex.

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# THE PROBLEM OF SOIL FERTILITY UNDER THE CONDITIONS OF FERTILIZER APPLICATION AND WAYS TO SOLVE IT

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*The authors of the article established, that the most vulnerable to the action of liquid forms of mineral fertilizers were structural units of higher orders. The use of mineral fertilizers led to a deterioration in the aggregate composition of the soil. Within the studied forms of mineral fertilizers, ammonia water had the greatest aggressive effect, and forms such as KAS and RSF had a strong effect after their dilution. The most stable were units measuring 0.5 mm and 3–2 mm. The maximum destructive effect was experienced by units of 7–5 mm in size.*

***Key words:*** *typical chernozem, fertilizers, computed tomography*

It is well known that the rational use of fertilizers is the key to preserving soil fertility and a profitable agricultural business. At the same time, the current state of the soil cover, despite the positive dynamics of fertilizer use, indicates an increase in the dehumification of arable soils, an increase in the deficiency of the balance of nutrients, acidification, spraying, compaction and manifestation of blistering (Balyuk, Medvedev, Zakharova, 2013). So, a logical question arises, how urgent is the problem of preserving soil fertility under the conditions of fertilizer use? Of course, for its intended purpose, mineral fertilizers should carry "good" to plants and soils. However, it should not be forgotten that the fertilizers applied significantly improve the nutritional regime of the soil, but at the same time act as a fairly strong agent of chemical influence on soil colloids (Filon, 2011). Perhaps it is here that it is appropriate to recall the proverb of T. Paracelsus " and nothing is devoid of toxicity, it's all about the dose." It all depends on the fertilizer application system.

In addition, different types and forms of fertilizers affect the organic part of the soil in different ways. The most "aggressive" effect is carried out by

nitrogen, individual potash and complex fertilizers. In the range of fertilizers, there are such that 1) intensively peptize organic colloids (am. water, $K_2CO_3$, $(NH_4)_2CO_3$, $(NH_4)_2HPO_4$ ); 2) significantly enhance their mobility ($NH_4H_2PO_4$); 3) practically do not affect the state of soil colloids (KCl, $NH_4NO_3$, $KNO_3$, $NH_4Cl$). Farmers are primarily interested in the impact on soils of fairly common and promising fertilizers, which include anhydrous ammonia, RSF, KAS and ammonia water.

Anhydrous ammonia is one of the promising fertilizers around which there are constant discussions. Today, the largest volumes of liquefied ammonia are used in the USA (Miroshnichenko, 2015), where the proportion of anhydrous ammonia is about 50% of the applied nitrogen fertilizers. Ammonia application is also becoming widespread in Ukraine. First of all, this is due to the presence of the ammonia pipeline "Togliati – Odessa", which passes through the territory of Ukraine, It has 12 distribution stations and provides service to a significant number of farms. At the same time, it should not be hidden that the main reason for the widespread use of ammonia both abroad and in Ukraine is the pricing policy, or rather the profit from its use. Simple calculations show that the cost of nitrogen when applied for winter wheat at a dose of 150 kg / ha is 4552.02 UAH for ammonium nitrate, and 2460.51 UAH for ammonia.With a close cost of fertilizer application, the total costs associated with the introduction of ammonium nitrate will be – 4852.02 UAH/ha, anhydrous ammonia – 2960.51 UAH/ha. Of course, in such scenarios, the agricultural producer will give preference to the latter.As for the preservation of soil fertility, in this respect it is unlikely that anhydrous ammonia can be considered an environmentally safe fertilizer. Our previous research suggests that the direct effect of mineral fertilizers is primarily manifested in the structural and humus state of soils. For an objective assessment of the float of anhydrous ammonia on the structural state of soils, we used computed tomography (CT), which today is one of the modern methods of soil research in an undisturbed state. It allows to obtain data not only on the size of structural units, but also on the shape and their mutual placement (De Gryze et al., 2006; Gibson et al., 2006; Martinez et al., 2010).

Monoliths for computed tomography were selected six months after the introduction of $NH_3$ . Studies have shown that in tapes with the introduction of anhydrous ammonia there is a significant increase in the electrical conductivity of the soil, which in dry summer conditions persisted for a long time. Express determination of soil dispersion according to O.N. Sokolovsky indicate the intensive dispersion of the soil mass in the foci of

ammonia application.

Scanning of monoliths finally confirms the negative changes in the structural state of typical chernozems, occurring under the influence of the introduction of anhydrous ammonia. Thus, on the cut of the monolith from the control version (Fig. 1), structural separations and aggregates of higher orders, rather large interaggregative pores, pores–cracks and pores of biogenic origin are clearly visible. That is, we are faced with a clear picture of the black soil typical in its undisturbed state.

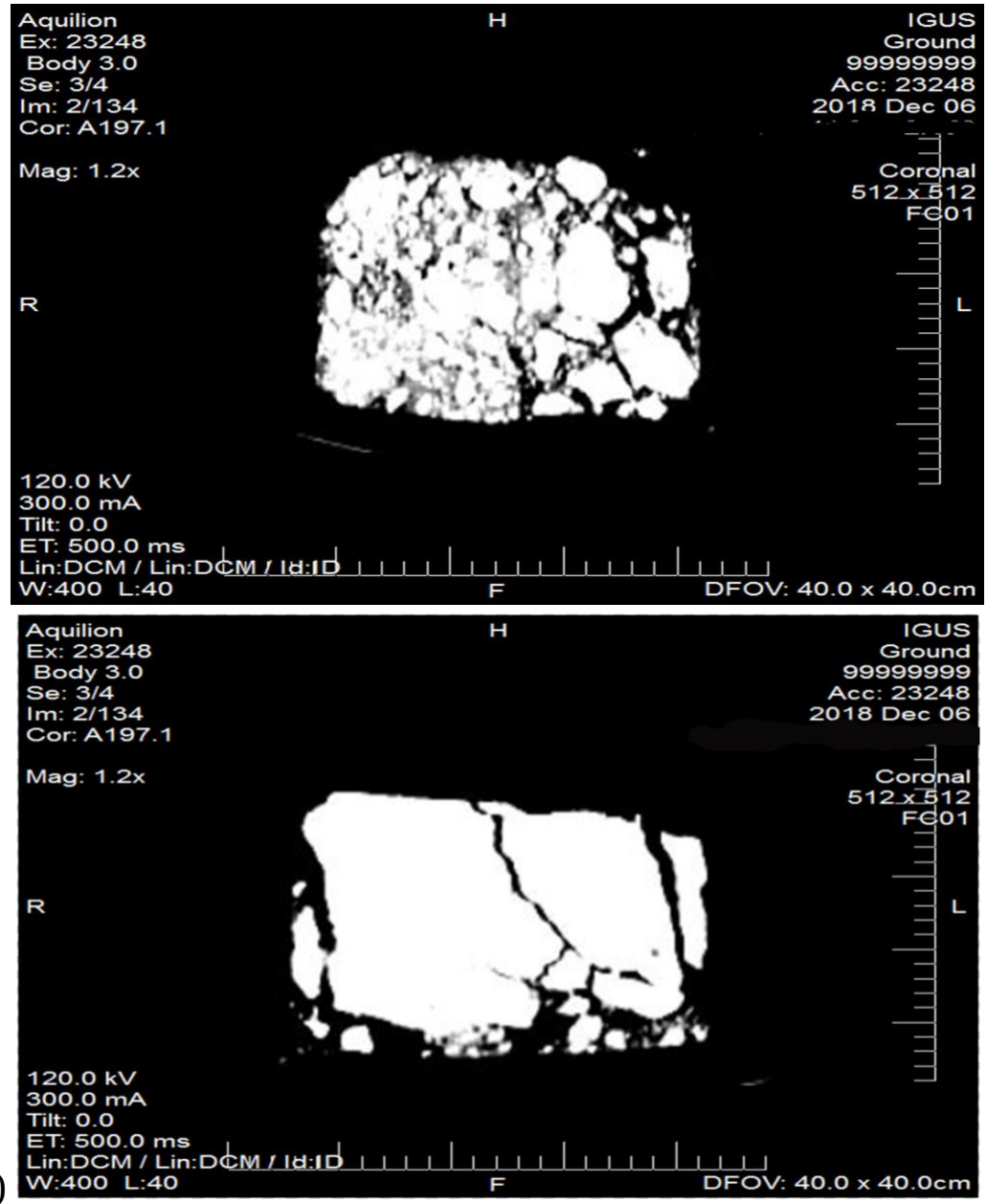


Figure 1 Tomographic sections of monoliths of chernozem typical: a – control (well–structured soil); b – tape with the introduction of anhydrous ammonia (soil compaction)

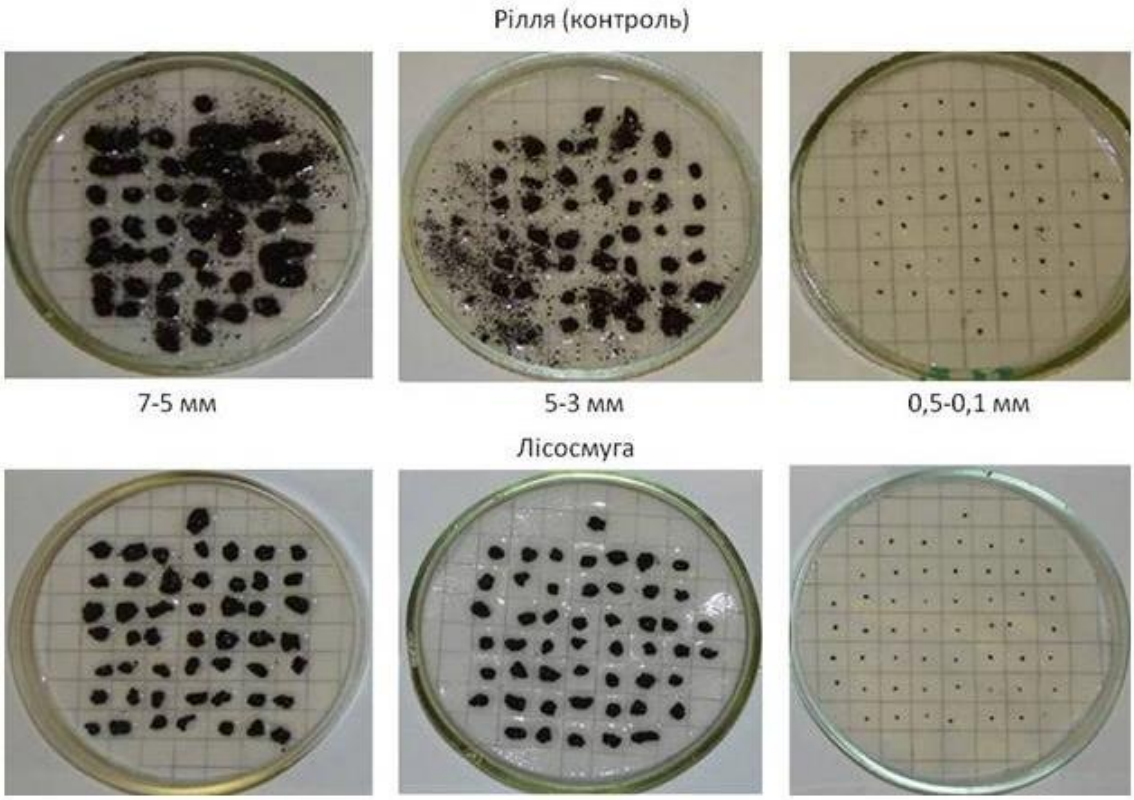


Figure 2 The influence of UAN on the structural units of typical chernozem:
upper row – structural units of arable soil; lower – soil under the forest belt

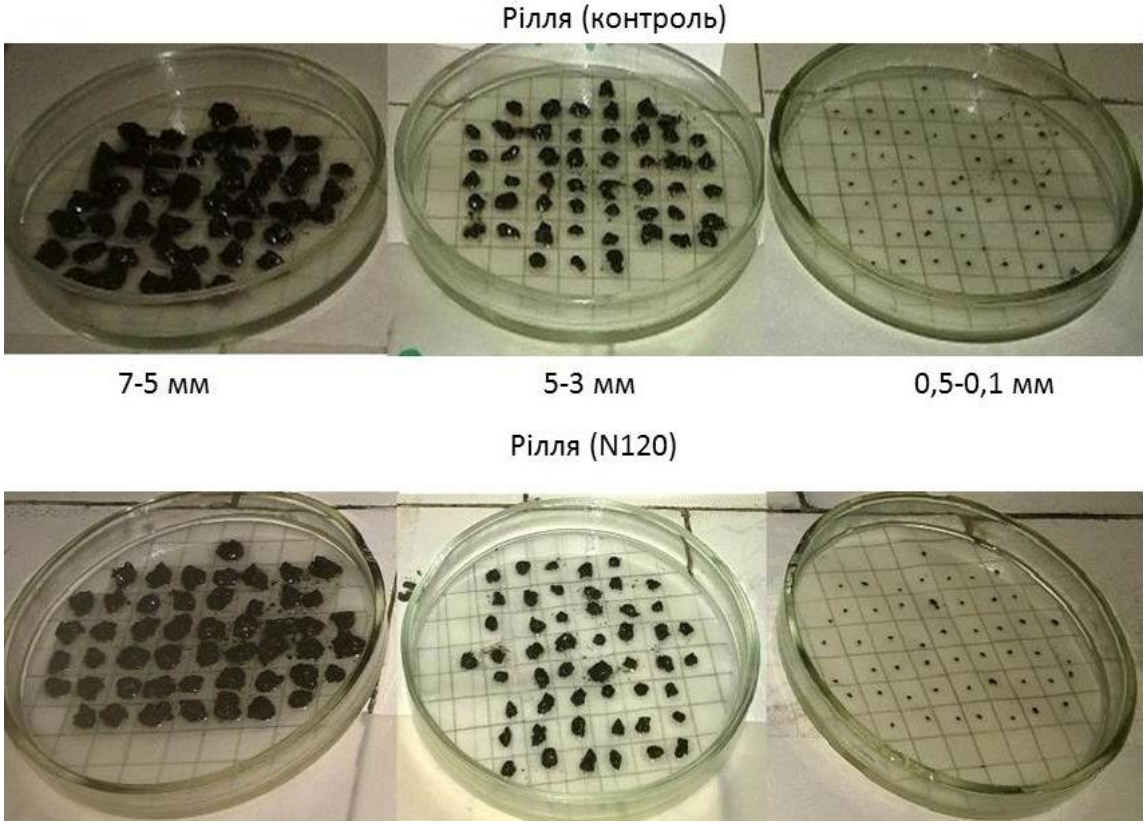


Figure 3 The effect of ammonia water on the structural units of typical chernozem:
top row – structural units of the control version; lower – fertilized version

A monolith tomogram from the variant where ammonia was applied indicates a significant compaction of the soil. Interaggregate pores are present in small quantities, on individual samples they are practically absent. Cracks of drying, blistering of the soil are recorded. Therefore, the use of anhydrous ammonia is an effective and at the same time environmentally hazardous measure that obliges farmers to exercise operational control over soil parameters that are adversely affected by this fertilizer.

To determine the direct stability of agronomically valuable structural units to the effects of agrochemicals, the accounting and statistical method of P.A. Andrianov was used. To this end, different–sized structural units were flooded with fertilizer solutions. In fig. 2 and 3 lts shown zano results of the research. The greatest destruction under the influence of UAN, RCTs and ammonia water was experienced by units of the highest orders (7–5 and 5–7 mm). The units of chernozem, which was selected under the forest belt, turned out to be more resistant to the action of UAN. These units are agronomically valuable, since they determine the air, and indirectly the water regime of the soil. The destructive effect of RCTs on the structural units of chernozem typical was not detected. It is likely that this phenomenon is associated with high concentration and density of the base solution. As for the effects of ammonia water, the largest number of destroyed units is registered on an unfertilized background.

Another interesting and relevant question that arises during the discussion of experimental data is how often there are cases of "sawing" of soils due to the use of mineral fertilizers? Firstly, mineral fertilizers applied in ordinary doses make up 1/100000 of the mass of the arable soil layer, and therefore it is rather difficult to notice such changes with the naked eye. Secondly, the accumulation of cells with lost physical properties of the soil requires the systematic application of high doses of fertilizers. The latter, as we will show, is quite possible in modern conditions. Despite this, farmers pay little attention to preserving soil fertility, citing a lack of funds associated with a disparity in prices for fertilizers and agricultural products. Price disparity really existed for a long time (Fig. 4.). This was especially noticeable in 2004 – 2010, when the cost of ammonium nitrate was twice or even three times higher than 1 ton of winter wheat grain. As of 2019. This ratio is about 1.3 and differs little from that in the developed countries of the world. For comparison, we give the ratio of the price of ammonium nitrate and winter wheat grain in the United States, where it is 1.23. Of course, the share of ammonium nitrate among fertilizers applied in the United States is insignificant, but the fact remains. The thesis that at this

stage we apply such doses of fertilizers that are not capable of causing non–negative changes in the physical properties of chernozem soils is also not justified. Far from it.

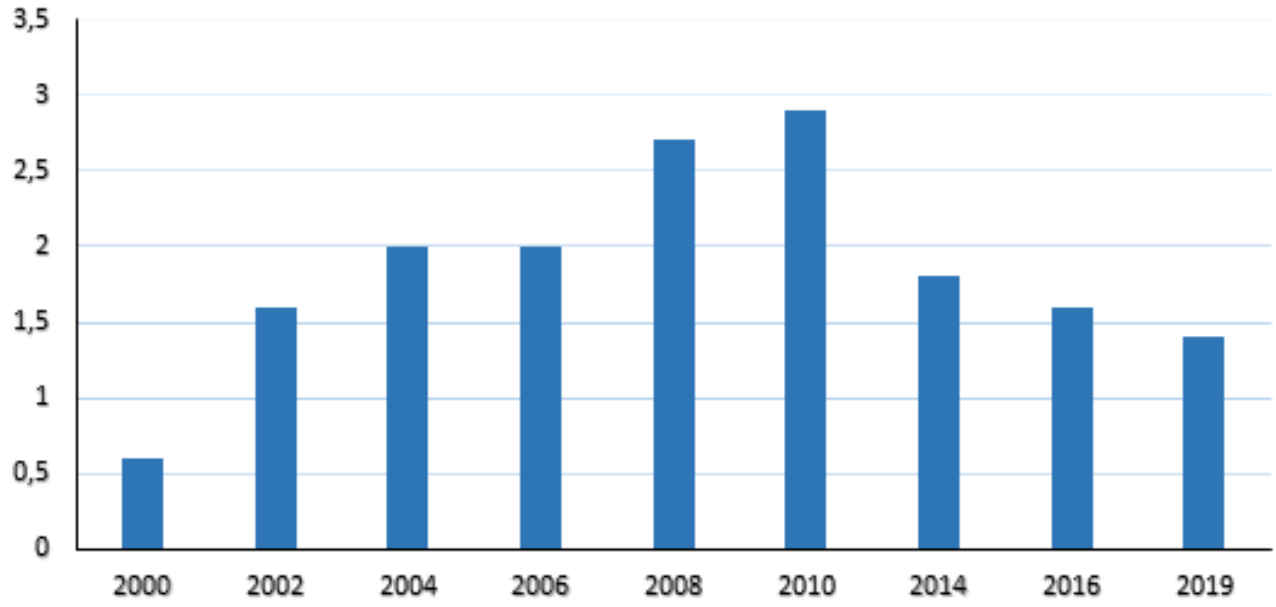


Figure 4. Dynamics of the ratio of prices for ammonium nitrate and winter wheat grain

Since 2004 (Fig. 5) in Ukraine there has been a clear increase in the use of mineral fertilizers. If in 2005 we contributed only 32 kg a.d. NPK, then in 2018. already 105 kg a.d. In other words, the anthropogenic "pressure" on the soil is clearly increasing.

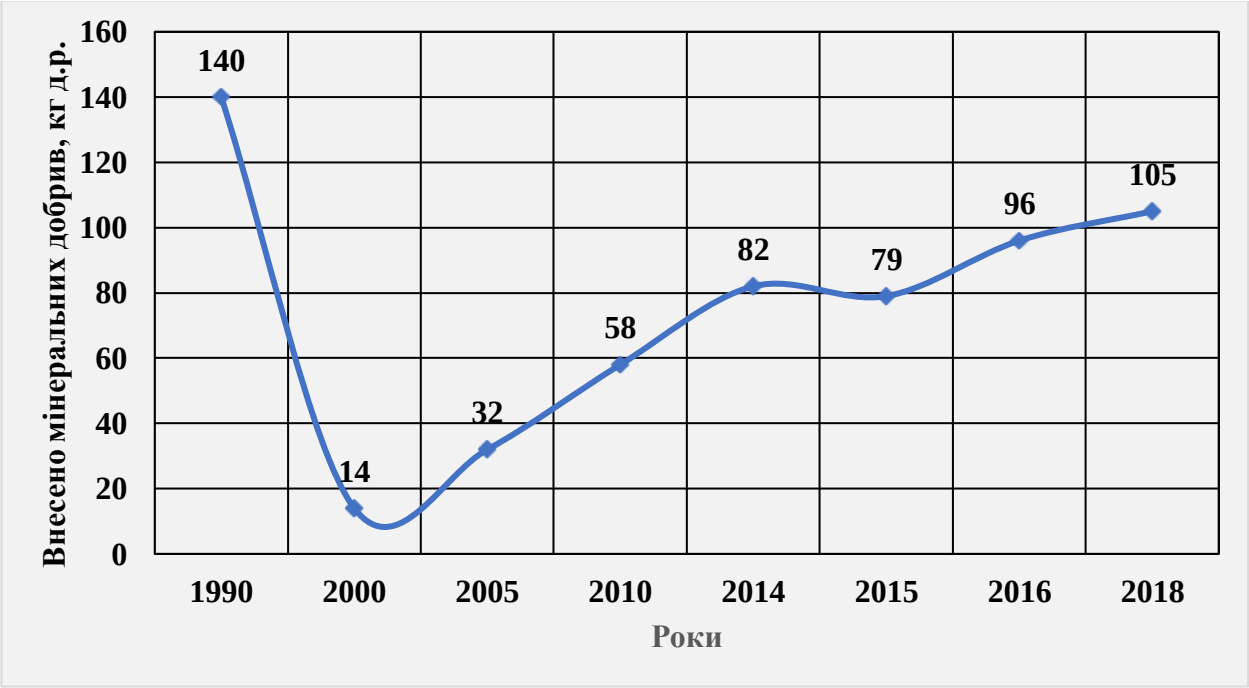


Figure 5. Dynamics of mineral fertilizers application in Ukraine

All this is aggravated by the fact that the ratio of N:P:K remains far from optimal (Table 1). If in the 90s it was 1.0:0.7:0.7, in 2016 it was 1.0:0.2:0.2.

Table 1

**Dynamics of N:P:K ratio in fertilizers applied**

| Years | 1990 | 2000 | 2005 | 2010 | 2016 |
|---|---|---|---|---|---|
| Correlating N:P:K | 1,0:0,7:0,7 | 1,0:0,1:0,2 | 1,0:0,2:0,3 | 1,0:0,2:0,2 | 1,0:0,2:0,2 |

Unilateral application of nitrogen fertilizers can significantly increase crop yields but at the same time enhances their destructive effect on soil structure. To confirm this conclusion, we present the data of a long stationary experiment of the Department of Agrochemistry of KhNAU. V.V. Dokuchaeva. As can be seen from the data of Table 2, the unilateral use of nitrogen fertilizers leads to spraying and the appearance of soil blistering. Thus, the content of the units <0.25 on the variant with the introduction of nitrogen fertilizers was 4.6%, on the variant with full fertilizer – 3.8%. The number of units over 10mm on the variant with the introduction of nitrogen fertilizers was 33.8%, while on the variant with the introduction of NPK only 14.76%.

Table 2

**The effect of long–term application of nitrogen and full mineral fertilizer on the structural and aggregate composition of typical chernozem, %**

| Variants of the experiment | Size of units, mm | | | | | | |
|---|---|---|---|---|---|---|---|
| | >10 | 7–5 | 5–3 | 3–1 | 1–0,5 | 0,5–0,25 | <0,25 |
| Control | 15,1 | 11,6 | 12,1 | 22,4 | 17,6 | 18,7 | 2,5 |
| N | 33,8 | 12,5 | 8,2 | 18,7 | 13,0 | 9,1 | 4,6 |
| NPK | 14,7 | 11,3 | 7,8 | 22,2 | 19,9 | 20,3 | 3,8 |
| $NIR_{05}$ | 4,7 | F $f<F_{05}$ | F $f<F_{05}$ | 1,2 | 1,3 | 2,3 | 1,2 |

It has been experimentally shown that the joint application of manure and mineral fertilizers eliminates the negative manifestation of the latter, especially with regard to the structure, reaction of the soil solution and soil

microflora. From figs. 6 it can be seen that until 1990 nothing threatened our soils. The increase in the use of mineral fertilizers was accompanied by an increase in production and doses of organic fertilizers applied. From 2005 to the present, there has been an increase in doses of mineral fertilizers applied with meager doses of manure applied. Therefore, monitoring of soil fertility should be carried out at the state level.

In the article we showed only possible changes in the soil under the conditions of fertilizer use. We hope that the introduction of the land market and the emergence of real owners of land shares will lead to a rethinking of attitudes towards the preservation of soil fertility. Total chemicalization will be replaced by technologies aimed at improving the soil and obtaining environmentally friendly products. It should be noted that the first and serious steps in this direction are already taking place. This is an expansion of the range of fertilizers, including special ones, the introduction of precision farming technology, the technology of organic and ecological agriculture, the use of biological products built on the use of beneficial microflora, etc.

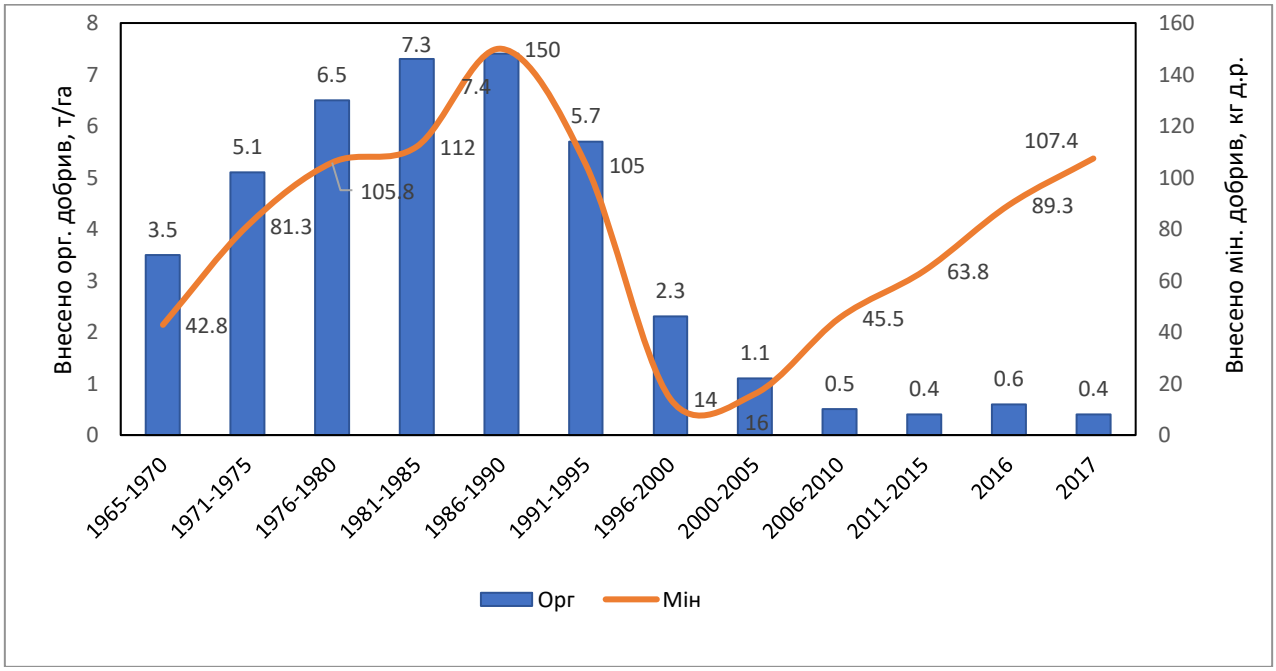


Figure 6. Dynamics of organic and mineral fertilizers

## Conclusions

Consequently, the most vulnerable to the action of liquid forms of mineral fertilizers were structural units of higher orders. The use of mineral fertilizers led to a deterioration in the aggregate composition of the soil. Within the studied forms of mineral fertilizers, ammonia water had the greatest aggressive effect, and forms such as KAS and RSF had a strong

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