BIOLOGICAL ASPECTS OF CROPS FERTILIZING SYSTEMS


Rational fertilizing system is a basic element in the formation of optimal soil agroecological features (trophic, sanitary, etc.), their stable fertility, obtaining high level of productivity and quality of crop production. But the existing fertilizing systems are aimed mainly at restoring the productive (trophic) functions and do not fully take into account agroecological functions of soils, the laws of their change under the influence of fertilizers.

In this regard, topical is the grounding of fertilizing systems, the use of which provides, on the one hand, a sufficient level of performance of agrocoenosis and the disclosure of bioproductive potential of crops, and on the other – contributes to increasing of environmental sustainability, obtaining biologically valuable harvest and preserving the environment. Solving these problems is possible by taking into account not only agrochemical, but biological indicators that comprehensively characterize the direction of soil processes under the influence of fertilizers.

This started to be paid attention recently, with the advent of numerous soil state problems, sharp decline of humus content and fertility in general, water pollution and so on. Particular attention is paid to such macrolelement as nitrogen, due to the fact that nitrogen fertilizers are, on the one hand, one of the most powerful factors of influence on the formation of crop productivity and the synthesis of amino acids and proteins, and on the other – the source of nitrates capable of accumulation in crops and flowing to groundwater and surface water in concentrations harmful to humans and the environment in general. Moreover, the excessive amount of nitrates in the soil leads to greater emission of N₂O which relates to greenhouse gases.

Today the calculations of amounts of nitrogen fertilizers, required for a specific crop growing technology, are often made on the planned yield based on the results of previous soil diagnosis and coefficients of use of active ingredient from fertilizers by plants. There are different versions of this method, which take into account regulatory costs on yield formation, soil agrochemical indexes, possible coefficients of assimilation of fertilizers by plants, after-effect of fertilizing of previous in rotation crops, nitrogen content in crop debris etc., but their principle essence is to assess element removal with planned harvest [1-3].

In case of 100% use of fertilizers by cultivated plants the method would be ideal. But given the low level of assimilation of active ingredient from fertilizers by plants [4; 5], the use of these methodological approaches leads to planning the greater part of calculated norms for environmental pollution.

In this regard, the Institute of Agricultural Microbiology and Agroindustrial Manufacture of NAAS grounded methodological principles and developed the method for determination of physiologically appropriate norms of nitrogen fertilizers (they can be equated with environmentally acceptable) [6; 7], based on consideration of peculiarities of the process of nitrogen fixation and N₂O emissions in agrocoenosis under various agrochemical load. Having defined nitrogen fixation activity in dynamics during the growing season and having compared with the performance of the control variant (without fertilizing), appropriate can be considered the norms, the use of which will not reduce the studied indicator. An additional criterion for environmental regulation of nitrogen fertilizers are N₂O emission indicators. Norms of phosphate and potash fertilizers thus can be calculated by the well-known principle of balancing to the level of determined nitrogen ones.

Complete correction of norms of nitrogen fertilizer required for complete crops production process can also bring the use of microbial agents in agricultural technologies, since their use promotes the growth of coefficients of assimilation of active ingredient from fertilizers by plants. [8]

The objective of this study is the justification of crops fertilizing systems in case of complementation of agrochemical solutions by the results of biological tests. 

Materials and methods. The study was conducted during 2012-2015 in the stationary
field experiment on black leached light-loamy soil on loess-like sediments (rHsoil = 5.30, humus content – 2.12%, slightly-hydrolized nitrogen – 95.2 mg/kg, phosphorus mobile forms (P₂O₅) – 226 mg/kg (by Chyrikov), exchangeable potassium (K₂O) – 108 mg/kg (according to Kirsanov)) of research field of the Institute of Agricultural Microbiology and Agroindustrial Manufacture of NAAS (short-rotation crop succession) as follows:

<table>
<thead>
<tr>
<th>Crop succession</th>
<th>Fertilizing system</th>
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<tbody>
<tr>
<td>1. Potatoes;</td>
<td>Without fertilizer</td>
</tr>
<tr>
<td></td>
<td>(control);</td>
</tr>
<tr>
<td>2. Spring barley;</td>
<td>Organic (manure);</td>
</tr>
<tr>
<td>3. Peas;</td>
<td>Mineral low;</td>
</tr>
<tr>
<td>The same – with</td>
<td>Mineral intensive;</td>
</tr>
<tr>
<td>inoculation</td>
<td>Organic and mineral.</td>
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In case of organic fertilizer system in crop succession manure was applied at the rate of 40 t/ha once per rotation before autumn ploughing (for potatoes).

Mineral fertilizer systems included the use of nitrogen, phosphate and potash fertilizers at the rate of 40, 80 and 120 kg/ha of active ingredient for potatoes; fertilizers were used in the doses of 30, 60 and 90 kg/ha for peas, barley, and wheat.

Organic and mineral system of crop fertilization included the application of manure at the rate of 40 t/ha and mineral fertilizers (80 kg/ha of nitrogen, P₂O₅ and K₂O) once per rotation (for potatoes). For the following crops in rotation – barley and wheat, the after-manure effect in combination with the effect of mineral fertilizers applied in high doses, for peas – in low ones, was studied.


Research plot area – 86.4 m² (7.2 x 12.0) the repetition of the experiment is quadruple.

In rhizospheric plant soil the potential activity of nitrogen fixation and N₂O emission processes was studied in dynamics [9]. Harvest recording was implemented, specific quality products parameters were determined.

Comparative economic evaluation of technologies was conducted by the following criteria: costs, revenue from sales and profit at the rate of 1 ha of crop rotation area, the level of manufacture profitability, the cost of 1 ton of grain crops, return of extra costs by extra profit.

The calculations of process and expenditure parts were done on a methodical basis [10; 11] taking into account the specific features of studied technologies and resource provision. Prices for resources and agricultural products were accepted at the rate of average actual for 2014.

The comparison of the results of environmental diagnosis and economic calculations allows to ground the feasibility of crop fertilizing systems in the experiment.

Therefore, organic fertilizing system, in case of which the optimization of agronomically valuable microbial communities and the course of processes they carry out is observed, is advisable to be considered feasible. The efficiency of microbial agent in the year of manure application is largely offsetted. The use of pre-seed bacterization of the following in rotation crops, in case of their cultivation on the background of manure after-effect, is highly effective.

Low mineral fertilization system ensures environmental requirements as for the state of agroecoses and the highest economic performance among the studied systems with the use of mineral fertilizers. Costs return, incurred under these conditions for the use of biological agents, is the highest. But barley growing is economically unprofitable even in case of low mineral fertilization system, so low mineral fertilization should be combined with pre-seed bacterization for this crop that can increase manufacture profitability.

Average mineral fertilization system as a whole meets the environmental requirements as for the state of agroecosis, but in view of economic performance it needs clarification. In particular, on black leached soil it is appropriate to use N₈₀P₈₀K₈₀ for potatoes, grow barley on the background of N₃₀P₃₀K₃₀, apply N₃₀P₃₀K₃₀ for
peas and to use the norms of fertilizers that do not exceed $N_{60}P_{60}K_{60}$ while growing winter wheat. For these agricultural backgrounds it is recommended to apply microbial agents.

Using the studied organic and mineral fertilization system an unfavourable ecological situation is formed in agrocoenosis, indicating the need for a significant reduction of mineral nitrogen in it. Intensive mineral fertilization system does not meet environmental requirements and shows the lowest economic indicators. Due to this we do not recommend its use.