НОВЫЕ МЕТОДЫ И РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЛАНДШАФТОВ В ЕВРОПЕ, ЦЕНТРАЛЬНОЙ АЗИИ И СИБИРИ

Монография в 5 томах

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NOVEL METHODS AND RESULTS OF LANDSCAPE RESEARCH IN EUROPE, CENTRAL ASIA AND SIBERIA

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This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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ABSTRACT. In the 1990s, a methodology for organization of agroecological monitoring was elaborated as a unified observation system of the state and dynamics of agroecosystems and a component of biosphere monitoring. It allows the environmentally optimal fertilizing systems to be determined experimentally and the role of separate practices in positive and negative environmental impacts to be assessed. Experimental investigations have focused on determining site-specific indicative parameters to characterize the state and dynamics of soil fertility to ensure the application of environmentally sound fertilizer rates for the optimal nutrition of plants with consideration of weather conditions. Comparison of soil agrochemical parameters dynamics in periodical agrochemical soil survey of agricultural lands and in long-term experiments allows to test effective measures for soil fertility control in modern technologies. Strategy of fertilizers application based on long-term research should include the upper limit of permissible fertilizer rates connected with reducing environmental risk of nutrient loss, while the lower limit for the tested management practice connected with the significant decrease in the fertilization efficiency.

INTRODUCTION

Soil fertility monitoring is one of the numerous tools for assessing the fertility of soil and its agroecological potential. Local monitoring on the reference plots, test areas, and plots of long-term experiments run by the Geographical Network, as well as the periodical agrochemical soil survey of agricultural lands and models of soil fertility, are complementary methods within the integral approach to assess the effect of economic activities and natural factors on the agricultural soils [1]. Studies on the development of high-input technologies of crop cultivation and the program of agroecological monitoring have been launched in the Soviet Union in the late 1980s–early 1990s. The studies in the fields of intensive farm systems and agroecological monitoring are mutually related. An advantage of the new monitoring system compared to the existing soil-agrochemical approaches was the implementation of an expanded research program and the unification of methodological approaches and procedures. The organization of agroecological monitoring was considered as a unified observation system of the state and dynamics of agroecosystems and a component of biosphere monitoring. The main
The aim of the agroecological monitoring was to integrate it into the network of regular ground environmental observations in space and time, and the major practical tasks were to create highly efficient and ecologically balanced agrocenoses on the basis of the expanded reproduction of soil fertility, to sustain the essential functions of soil cover, the maximal use natural-climatic resources, and to increase the efficiency of chemicals [2,3].

**MATERIAL AND METHODS**

The field experiment is the most representative method of studying the theoretical and practical principles for reproducing soil fertility, increasing crop yields, and improving crop quality. The network of more than 350 similar long-term experiments simultaneously performed in several geographical and soil-climatic zones according to the standardized procedure form the main scientific basis for adequately assessing the changes in slow processes. Measurements within the geographical network of long-term field experiments supplement the observation design with a new information block: an assessment of variations in the agrochemical soil parameters under the impact of multiple factors.

Long-term field experiments allow the environmentally optimal fertilizing systems to be determined experimentally and the role of separate practices in positive and negative environmental impacts to be assessed. In the 1990s, a methodology for launching new field experiments was developed, which includes the extension of experimental studies in agroecosystems to include information about adjacent environments by organizing a new type of experimental network: agroecological polygons. The organization of polygons allows the effect of intensification factors in agrolandscapes to be studied by taking into account the transfer of water, nutrients, and xenobiotics. The main objective of the polygons was their integration into the network of land observations on the state of arable soils as a component of agrochemical and agroecological monitoring. The experimental treatments were located along the main slopes and allowed the treatments within catenae to be compared by taking into account the geochemical conjugation and the control of soil material, nutrient, and water transfer both within and beyond the experimental plots.

Research in the field of agroecological monitoring involved the development of scientific and technical fundamentals for the creation of an integrated system of remote sensing methods with the selection of the most informative parameters for each zone (e.g., soil moisture for the Nonchernozemic zone, salt content for the irrigated arid areas, and humus content for chernozems).

It was recognized that no common set of parameters characterizing the soil fertility can be proposed for all soils. It is advisable to select indicative parameters for the state and dynamics of soil and soil cover in the area considered, which are controlled on the basis of the realization of different management practices. The parameters were separated into three groups, which allowed performing the early diagnostics on the basis of seasonal dynamics and reflecting the perennial and long-term changes in the state of soils (Table 1) with the possibility of periodical revision and specification.

It was planned to use the monitoring data for improving the zonal farming systems and assessing the capacities of different soils to sustain a specific productivity level depending on the natural and climatic conditions, management practices, the deviation of soil properties from the optimum level, and the control of the environmental status of lands. The fertilizing system was considered as a combination of not only agronomical solutions, but also organizational and economic ones to ensure the observance of environmental requirements. On the basis of present-day terminology, principles were developed for the sustainable farming, the adaptive management in farming systems and plant nutrition, and the utilization of the bioclimatic potential of the territory for ensuring the long-term improving of land quality.

The practical implementation of this task revealed a number of contradictions because of the differences in the requirements for the organization of long-term experiments and monitoring. The implementation of monitoring implies as wide as possible range of all soil-environmental conditions typical for the studied landscape. The main requirement for the establishment of long-term experiments is, on the contrary, the maximum reduction of the initial heterogeneity of the studied properties, and the studies were performed on small plots of 50–100 m² in area. A significant spatial heterogeneity of the standard agrochemical parameters was revealed on the established polygons.

<p>| Table 1. Control parameters in soil-ecological monitoring (after [4], with amendments) | 240 |</p>
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This problem was solved, in particular, by the involvement of special techniques for the statistical treatment of experimental results (geostatistics methods and the analysis of local trends), which allowed characterizing the spatial heterogeneity of the studied parameters [5]. It can be taken that the mandatory use of agroecological approaches became a general rule in the analysis of the farm systems described [6]. We present some examples to illustrate the above statements.

RESULTS AND DISCUSSION
Effective control of soil fertility in modern technologies
Nutrient mining and decrease of fertility can be revealed based on the decrease of available phosphorus and potassium content, decline of pH and soil organic carbon, especially on albeluvisols with a low natural productivity level. In Republic of Komi dynamics of the relevant agrochemical parameters was compared with the results of 30-year trial with fodder crop rotation. In 1966-2008 weighted average content of available phosphorus based on periodical agrochemical soil survey of agricultural lands had the maximum of 188 mg·kg⁻¹ with decrease to 160 at the end of the period, and for available potassium the same tendency was traced. It coincides with a sharp decrease in applied fertilizer rates: from 153 kg·ha⁻¹ at the end of 80-s to 14 kg·ha⁻¹ in 2008. Weighted average pH value also decreased from 5.3 in 1993 to 4.8 in 2008. The results of the trial demonstrate possibility to stabilize pH at 5/7 at the expense of high rates of peat and FYM compost and available phosphorus at 380-400 mg kg⁻¹ level with a positive trend for potassium (Fig.1).
Assessment the efficiency of fertilizers with consideration of weather conditions

The analysis of databases of the Geographical Network for assessing changes in fertilizer efficiency as affected by fertilization rates showed that the uncertainty at low application rates is relatively high because of variation of weather conditions. This is true for both the Nonchernozemic and Chernozemic zones of the European Russia (Fig. 2). In an experiment with winter wheat on soddy-podzolic soil when N application rates were above 60 kg/ha, the range of fertilizers efficiency variation in treatments having different soil fertility was comparable with the effect of weather conditions. Below this application rate, the efficiency of fertilizers can decrease by more than two times. In a long-term experiment on ordinary chernozem in 9-course cereals-row crops rotation with black fallow, an analogous tendency was observed at NPK rates below 150 kg/ha; a significant decrease in variation occurred at rates of 190–280 kg/ha. Hence, application strategy should include the upper limit of permissible fertilizer rates connected with reducing environmental risk of nutrient loss, while the lower limit for the tested management practice is the significant decrease in the fertilization efficiency because of the variation in weather conditions.

**Figure 1.** Trends of pH\textsubscript{KCl} in the Republic of Komi (a) weighted average for arable lands in 1966-2008 based on periodical agrochemical soil survey of agricultural lands; (b) in a long-term trail with organic and organic-mineral fertilization, PFC – peat-farm manure compost.

**Figure 2.** Agronomic efficiency of fertilizers for N fertilization under winter wheat, experimental data of Central Experimental Station of the Pryanishnikov Research Institute of Agrochemistry, Moscow oblast, 1963–1991.
CONCLUSIONS

1. Integration of long-term field experiments run by the Geographical Network in the system of agroecological monitoring allows to develop principles of sustainable farming, the adaptive management in farming systems and plant nutrition, to access utilization of the bioclimatic potential of the territory for ensuring the long-term improving of land quality.

2. Site-specific indicative parameters were proposed characterize the state and dynamics of soil fertility and the environmental state of soils to ensure the application of environmentally sound fertilizer rates for the optimal nutrition of plants with consideration of weather conditions.

3. Under the conditions of low-cost agriculture information derived from long-term experiments allows confidently using the obtained data for extensive farming technologies and changes in the structure of conventional crop rotations, as well as for the high-input methods providing that financial investments into the agriculture will increase. Moreover, it allows assessing the interchangeability of different approaches with consideration for environmental restrictions of the used technologies.

REFERENCES


