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THEORY OF LANDSCAPE RECLAMATION AGRICULTURE

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SUMMARY

The purpose. The technique of crop production adaptation to reclaimed agricultural landscapes in a landscape reclamation agricultural system was developed to improve the agricultural geosystem productivity and agro-ecological sustainability and crop production profitability.

Methods. Office (based on literature, statistical, and map material) and field (route and stationary survey on agro-ecological testing sites) methods were used to study crop plant adaptive behavior in changing agricultural landscape conditions. Mathematical, cartographo-mathematical, and statistical analysis modeling was applied to sort out areas of the same agro-ecological crop productivity type. The techniques were developed to identify a complex of agrotechnological measures for each type of the abovementioned areas as well as to transfer modeling results in real-life environment.

Results. Based on the research results landscape reclamation agricultural systems were modeled for different hierarchy levels of the geographical envelope (from landscape provinces to concrete farms) within the Non-Black Soil Zone of Russia. The hierarchy of different level models, their roles in the organization of production within various administrative units and in the choice of individual agricultural technologies for different areas was shown.

Conclusion. The models of landscape reclamation agricultural systems were developed by the scientists of the Russian Research Institute for Reclaimed Lands. These models are the results of the latest achievements of Russian geographers, ecologists, agronomists and reclamationists in optimizing farm production and environmental protection. Using the principles of land reclamation agriculture for the production organization helps drastically reduce production and landscape irrigation costs, take into account environmental standards and market demands, improve the aesthetic attractiveness of the surrounding landscapes.

Key words: agricultural geosystem, landscape reclamation agricultural system, plant adaptive behavior.

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ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ЛАНДШАФТНО-МЕЛИОРАТИВНОГО ЗЕМЛЕДЕЛИЯ

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РЕЗЮМЕ

Цель. В статье показаны теоретические основы создания систем ландшафтно-мелиоративного земледелия различных уровней. Описаны принципы разработки приемов адаптации сельскохозяйственного производства к условиям макро-, мезо- и микротерриторий. Определены методы переноса параметров теоретических моделей систем земледелия в условия реальных хозяйств. Сделано сравнение экономических показателей моделей, разработанных для разных типов агроландшафтов.

Ключевые слова: сельскохозяйственная геосистема, ландшафтно-мелиоративная сельскохозяйственная система, адаптация и поведение растений.

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ТЕОРЕТИЧНІ ОСНОВИ ЛАНДШАФТНО-МЕЛІОРАТИВНОГО ЗЕМЛЕРОБСТВА

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РЕЗЮМЕ

Мета. У статті наведені теоретичні основи створення систем ландшафтно-меліоратив-ного землеробства різних рівнів. Описано принципи розроблення прийомів адаптації сільськогосподарського виробництва до умов макро-, мезо- та мікротериторій. Визначені методи переносу параметрів теоретичних моделей систем землеробства в умови реальних господарств. Виконано порівняння економічних показників моделей, розроблених для різних типів агроландшафтів.

Ключові слова: сільськогосподарська геосистема, ландшафтно-меліоративна сільськогосподарська система, адаптація і пристосування до неї рослин.

The human history is currently characterized by the unprecedented intensification of the industrial exploitation of resources. Besides, agricultural lands are lost because of various degradation processes (erosion, salinization, water-logging, etc.) According to the current estimates, about 1.2 bln ha of global agricultural lands, pastures, and forests are severely degraded. The crop production process in the Non-Black Soil Zone of Russia is negatively influenced by erosion, deflation, primary and secondary water-logging, lithological and soil microvariety, accumulation of iron in the soil layers, sharp temporal and space variations of temperature and air humidity, etc. This calls for taking into account the environmental conditions of geographical plots of different scale.

Research Objective. One of the ways of preventing the further biosphere degradation and reclaiming disturbed soils is a Landscape Reclamation Agricultural System (LRAS) or a complex of measures to use the pool of natural and industrial resources of agricultural landscapes efficiently in order to get high and stable harvests and improve natural environment sustainability. The process of the LRAS development consists in analyzing environmental, economical, and market conditions of the area under study with the most sophisticated methodological approaches (GIS, geostatistics, mathematical and statistical analysis modeling). The analysis makes it possible to develop a unique set of agricultural system elements for a specific enterprise and adapt the new (exact, coordinate) technologies of crop farming to environment and economic conditions.

Materials and Methods. The LRAS methodology is based on production process modeling with due consideration of the area landscape peculiarities and plant adaptive behavior. The research showed that the development of LRAS to optimize the controlled natural environment factors and consider the uncontrolled ones during the crop growth depends on the ecological peculiarities of various biosphere hierarchical levels (geographical envelope). Such hierarchical approach is only possible when the LRAS principles are theoretically proved at the macroarea level and their application is practically verified at an agroecological enterprise at the microlevel. The development of various LRAS models for agrogeosystems of different hierarchical levels is a key element of agricultural landscape adaptation.

To take into account the biosphere hierarchical (multilevel) composition the four types of LRAS are used, three of them being developed as models: 1. LRAS taking into account natural and agro-industrial conditions of landscape provinces are referred to as Regional Systems of Agriculture (RSA). They describe the common approaches to adapting the agricultural production to landscape conditions of comparatively uniform large areas. 2. The LRAS base models are hypothetical, landscape adapted agricultural systems developed with the averaged parameters of main genetic types of areas (Belarusian and Ukrainian Polesia, the Valdai Hills, the Vladimir Opolye, etc.), which mosaic alternation shapes the largest geographical regions (e.g., the Russian (East

European) Plain, Scandinavia, the Canadian Shield, etc.). 3. The LRAS typical models are the agricultural systems developed with base model macrodifferentiation. They take into account the conditions of the natural environment of the area genetic types of a specific landscape province. 4. The agricultural systems of specific enterprises developed with transferring typical model parameters in their real-life conditions.

To determine specific biosphere hierarchical levels demanding the development of the LRAS models, the types of the damp zone agrogeosystems were designed. The use of the correlation and path analysis results made it possible to learn that the maximal number of factors actively influencing the crop capacity is at the levels of landscape provinces, typological landscapes, geographic localities, and stows.

Results and Discussion. The RSA main parameters are determined in studying the plant adaptive responses to natural and industrial peculiarities of the landscape province with qualitative and quantitative methods. The main indicator of the plant adaptive response to the natural environment conditions is their capacity (productivity). The data on area crop capacity and a natural and industrial state are obtained from numerous archival, literary, statistical, and map sources. Major agro-industrial parameters being common for the area under study are determined. They include crop collection, main directions of land reclamation, basic principles of allocating agricultural enterprises with different specialization, etc.

The LRAS base models are the main elements of the agricultural industry landscape adaptation. The first stage of the base modeling determines the number of major extrataxonomic groups of geocomplex types forming the area of the country in question (e.g., sand flats, ridged plains on covering silts, etc.), with the expert grid method developed [1].

Although the covering-moranic (characterized by the predominance of covering silts) and terminal moranic landscapes (boulder loams and two-layer drifts) are relatively favorable to agriculture (slightly acidic and relatively fertile soils), they are liable to water-logging, erosion and have a pronounced lithological and soil diversity. Cultivated lands of terminal moraine are marked by lithogenesis. These areas are in need of complex land reclamation aimed primarily at suppression of water-logging and erosion. Layout and improving of fields are also relevant here.

Agricultural lands of Polesye which dominate within gentle sand plains are characterized by weak development of erosion but they are highly acidic soils of low fertility and low water retaining capacity. First of all, integrated efforts on improving soil fertility are required to be done within these lands. Floodplain lands being characterized as the most fertile (humus content is more than 6%) and most suitable for agriculture are subject to annual flooding. They also have a relatively low amount of effective temperatures. Flood protection and thermal reclamation are relevant here [2-5].

Then optimal ratio of meadows, forests, and arable lands is to be determined for every extrataxonomic group. The stage of determining the composition and ratio of lands is divided into two steps: determination of major land categories and determination of their operating modes. Principles of categorizing the cultivated lands are based on recording the regularities of matter and energy movements within a cultivated land, as well as on the location of similar agro-ecological areas. Similar agro-ecological areas are territorial units characterized by a similar degree of crop productivity (or other manifestations of functioning). Their properties are mainly defined by specific location of elementary geochemical landscapes within a tract [6].

The core principle in designing each of the elements of an agriculture model (ratio of agricultural lands, crop rotation, soil treatment, fertilizer formula, plant protection, etc.) arises from a spatially differentiated approach to the use of particular agricultural practices and agroreclamation measures that would enhance adaptive capacity of crops to the specific landscape conditions. Therefore in the process of developing the base models, a special attention is paid to the analysis of micro-landscape soil composition, that is to alternation behavior of special categories of lands – eluvial, transit and accumulative – within major groups of these geocomplexes. Thus, the vegetation peculiarities of crop plants and weeds are empirically studied on agro-ecological test sites of different types (route, stationary and specialized landscaping, etc.). Experimental data serve a basis for the determination of agronomic crop collections, crop rotation, soil treatment, plant nutrition and protection as consistent with micro-landscape features.

Production parameters of the models to a large extent depend on the agro-ecological features of agro-geosystem and related to the agricultural planning. In the context of particular agricultural landscape model, each type of land is characterized by a certain set of arable farming elements; the combination of these sets within the agricultural landscape defines the specificity of the LRAS model.

The economic analysis of the base LRAS models allows us to range them by a profitability level, an economic return, etc. It is found that the best results can be achieved by the agricultural exploitation of floodplain and covering-moranic geosystems, while the highest production costs appear to be within the sandy plains. [7].

Within the framework of multilevel structure of biosphere, elements of the base LRAS model undergo the macro-differentiation procedure – adaptation to the particular conditions of a regional system of arable farming. As a result, a base model is transformed into a typical one. Thereby, the parameters developed for a base model are subject to a certain correction (possible change in the ratio of agricultural lands, the crop collections, the system of ameliorative techniques, the ways of implementation of other agriculture system elements, etc.). The micro-differentiation procedure helps us to transfer the typical LRAS model parameters into real economy, which is the initial step of the farming system development. When the model conditions are similar to the economic conditions, the transferring procedure is performed by the «interpolation» method. If faced with a limited matching, the transfer is carried out by the «extrapolation» method. Methods of transferring the typical LRAS models parameters into terms of specific farms are based on the theory of natural environment forecasting.

It should be noted that the development of LRAS for a specific farm is not limited by a transfer of corresponding typical model parameters. A farming system building which consists in taking into account the whole complex of local conditions is to be performed by home farm specialists with the participation of representatives of the agricultural production planning authority.

CONCLUSIONS

Thus, Landscape Reclamation Agricultural System developed on the basis of abovementioned principles takes into account not only the local landscape and working environment, but the factors of mesic- and macro-environments, which makes it more resistant to degradation processes and agro-ecological stresses.

The LRAS models are developed by scientists of the Russian Research Institute for Reclaimed Lands (FGBNU VNIIMZ). They are the result of the latest achievements of Russian geographers, ecologists, agronomists and reclamationists in optimizing farm production and environmental protection. Farm economy building on the principles of LRAS can dramatically reduce the production costs and the landscape irrigation costs, comply with the environmental regulations, adapt to the market demands, and improve the aesthetic appeal of the surrounding landscapes.

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