UDC 631.11.1

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Conceptual fundamentals of formation of bioenergy agro-ecological systems

The principles of the formation of systems of balanced production of food and bioenergy, which provide an expanded reproduction of the agro-resource potential of agricultural territories, are developed, allow to solve problems of development of the agrarian sector of the economy comprehensively. Modern tendencies of development of the domestic agrarian sector are considered. Promising regional models of agricultural production are developed. The advantages of multidisciplinary specialization and the necessity of using processing and bioenergy capacities for modernization or creation of new agricultural enterprises have been confirmed. The formation of bioenergetic agro-ecosystems in Polissya, Forest-steppe and Steppe for a significant start-up investment provides a high level of profitability and short payback periods.

Key words: strategy, multidisciplinary specialization, agroecosystem, recirculation, bioenergy, modeling.

The modern system of agrarian production in Ukraine, the main component of which is the production of grain, requires the cost of large volumes of mineral fertilizers, pesticides and combustible and lubricants, leads to increased degradation processes in agroecosystems and increased demand for industrial resources and energy. In the conditions of their high cost, renewable energy sources are extremely limited. On the other hand, according to food safety categories, Ukraine ranks 50th in terms of the economic availability of food products, 65th in terms of their physical availability and 42th in quality and safety of food [5].

As of 1990, the density of the livestock population was 0.81 conditional goal / ha, in particular cattle - 0,57 conditional goal / ha; by 2013, these indicators were respectively 0.29 and 0.11 conditional goal / ha. At the same time, the area of forage crops in the structure of coniferous areas decreased from 12.0 to 2.3 million hectares, or from 37 to 8%, and grain and oilseeds - increased from 16.7 to 23.8 million hectares, or from 52 to 84% [7].

As a result of this transformation, the volume of livestock production has changed. Thus, in 1990-1991, Ukraine occupied one of the leading places in Europe for the production of the main types of livestock products. At present, the consumption of milk and dairy products has, from 1990, decreased from 373 to 214 kg, meat and meat products - from 68.2 to 50.6 kg [8].

In the area of cereals and oilseeds 24 million hectares of accumulation of a low-value part of the crop is not less than 2 t / ha, or 50 million tons. The number of cattle in Ukraine as of August 1, 2014 amounted to 4.9 million head, pigs - 8.1 million head, sheep and goats - 1.9 million head, bird - 268.5 million goals. with a total accumulation of livestock waste of about 15 million tons of dry matter [7]. Of this amount of plant and animal waste, biogas plants can receive about 20 billion m3 of methane. Unfortunately, biomass consumption as biofuels is currently 2.3 million tonnes of conventional fuel, 1.2% of total energy consumption, and the annual use of biomass does not exceed 4-6% [9].

Improvement of the conditions of cultivation, changes in the structure of the corn crop area in favor of corn and the overall increase in agro-technology largely affect the increase in gross collections of grain. So, let's say, in 2013 and 2014 more than 63 million tons of grain were received. Each year, with this grain, 2 million tons of nitrogen, phosphorus and potassium are extracted from the soil, or, in terms of the physical weight of mineral fertilizers, 5.6 million tons worth almost 2 billion USD. In this case, the value of the collected grain is about 9 billion USD. According to statistics, in fact, 1.4 million tons of industrial tufts were introduced, the rest of the requirements for the production of crops were covered at the expense of soil reserves. This condition is accompanied by agrochemical degradation of soils and their exhaustion. In

addition, due to the current structure of crops, yields of cultivated crops and the application of organic fertilizers, a negative balance of humus is generated -0.3 - 0.5 t / ha annually [6]. The country's energy intensity is estimated at 300-350 million GJ [3], which is equivalent to 8-10 million tons of oil, indicating significant volumes of organic carbon and energy losses in the agro-industrial sector of Ukraine.

This necessitates the development of agricultural production systems, which will enable to solve problems in the agriculture of Ukraine in a comprehensive way. The Institute of Water Problems and Melioration of NAAS has theoretically grounded and developed the principles of the formation of balanced production of food and bioenergy, which provide an expanded reproduction of the agro-resource potential of agricultural areas and enable to solve the problems of sustainable development of the agrarian sector of the economy in a comprehensive way.

An important objective for the formation of the bioenergetic agro-ecosystem infrastructure is an objective assessment of the potential for bio-productivity agricultural areas. The problem is the significant changes in crop yields and productivity of crop rotation, depending on the specifics of the weather conditions of some years, especially in the context of climate change. However, long-term free-of-field data from field experiments enables us to accurately determine the significance of various factors and their combinations in the optimal realization of the available agro-resource potential by averaged indicators.

In model experiments, prospective variants of distribution of production potential of agro ecosystems between the food part, bioenergy, soil and CO2 emissions were worked out. For plant-livestock specialization, with productivity of crop rotation, 10 t / ha of dry biomass in a balanced infrastructure, the organic matter is transformed into 2.6 t / ha of meat and dairy products, oil and sugar, at 0.8 t / ha of humus and 1.2 t / ha of methane. That is, from 10 t / ha of organic matter synthesized during the process of photosynthesis, about half of it is found on the functioning of the agro-ecosystem itself and half is obtained in an accumulated form. Increasing or reducing the level of implementation of agro-resource potential will accordingly affect these indicators.

Justification of models of bioenergetic agroecosystems with minimal involvement of industrial mineral fertilizers is possible only if the volume of recycle or reusable macro and microelements is used for different specialization or branch structure of agrarian production. For this purpose, the removal of the yield from the soil of biogenic elements and their quantity in products that are sold outside the agroecosystem is compared. For irreversible alienation of the obtained plant biomass, all the biologically active elements extracted from the soil must be compensated by industrial mineral fertilizers. The transition to the bases of bioenergy agrarian production and the adaptation of the sectoral structure to the conditions of specific land use make it possible to ensure the reuse of up to 85-90% of nitrogen from the soil, 90-95% of phosphorus and up to 99% of potassium and trace elements, that is, create the preconditions for the environmentally and energetically sustainable use of the main means of agrarian production - the soil.

For the use of special software for different soil and climatic zones, prospective variants of the sectoral structure of agrarian production in relation to the specificity of specific agricultural enterprises. A balanced infrastructure involves the creation of a specific series of closed technological cycles, where some waste is a valuable raw material for others. It can contain highly productive crop production, modern animal husbandry complexes, feed development modules, bioenergy stations for the processing of plant biomass and utilization of waste with the production of heat, electricity, biogas and organic fertilizers, modular technological complexes for the storage and processing of raw materials from production of sugar, oil, meat and dairy, vegetable and other products, production line of liquid biofuel (methyl ether, bioethanol), irrigation and drainage systems, analytical and information centers for management I have a complex system of interconnected logical technological processes.

The modeling of the agricultural-resource potential adapted to the existing agro-resource potential of the sectoral structure of a particular agricultural enterprise is carried out with the help of special software that enables to carry out simulative computer modeling of various models of agrarian development. Examples of promising variants of bioenergy infrastructure are based on an agricultural enterprise - a branch of the State Enterprise "Seagull" located in the Kozeletsky district of Chernihiv oblast. Considered such variants of its development [2]:

№ 1 «Modern practice» - the area of arable land is 2,5 thousand hectares, pigs - 5 thousand heads, cattle - 900 heads, milk productivity - 6,6 thousand kg per year, for feed not 25% of plant biomass is used, processing of meat products is 82 tons, sales of live weight - 520 tons, whole milk - 2 thousand tons;

№ 2 "The number of livestock corresponding to the feed base"; № 3 «Option number 2 + complete processing of milk and meat»;

№ 4 «Option number 3 + highly productive crop rotation»;

№ 5 «Option 4 + + Bioenergy installation»;

№ 6 «Option number 5 + development of animal husbandry at the expense of pig breeding»;

№ 7 «Option number 6 + restoration of drainage and humidifying system».

According to the current practice of production activity and conditions for the use of all surplus by-products for fertilizers, nitrogen recirculation is 75%, phosphorus-83 and potassium-94%. Implementation of adapted to existing agro-resource potential infrastructure will allow to increase these indicators to 92, 91 and 100%.

Given the size and structure of crop production, manure production does not provide a deficit-free humus balance. Extension of the livestock in accordance with the existing forage base allows to achieve the level of production of organic fertilizers, which provides increased reproduction of the soil's humus soil. At the same time, for biogas plant use in the process of manure processing approximately half of organic carbon is transferred to biogas, and the second half remains undiluted in the form of the so-called biohumus. The coefficient of its humification is 0.40-0.43, and this amount of organic fertilizers is sufficient to restore the soil's humus and energy.

The analysis of the economic efficiency of the investigated variants of the infrastructure of agrarian production showed that the development of dairy cattle breeding with the sale of raw materials (whole milk and live weight) has a long payback period of capital expenditures, and with the attraction of credit resources is unprofitable (table). The processing of livestock products locally is a powerful means to increase the profitability of the enterprise. The introduction of bioenergy infrastructure into the infrastructure for significant additional capital expenditures, however, allows us to increase net profit by almost 1.3 times. For the restoration of the operation of the drainage and irrigation system with the corresponding changes in the capacity of the other components of the infrastructure, the expected level of profitability will be 70 thousand UAH / ha.

In the course of processing various variants of the sectoral structure of the enterprise with a sufficiently developed infrastructure, it is established that the most significant increase in its economic efficiency is ensured by fully utilizing the existing potential of bioproductivity with the corresponding adaptation of capacities to the feed base.

It is highly effective to increase the productivity of the dairy herd, fat and protein content of milk. This is due to a decrease in the amount of fodder per unit of production and a significant increase in the volumes of production of finished dairy products, without substantially increasing the volumes of current production and, especially, capital financing costs.

In the system of bioenergy agrarian production, in terms of profit, the advantage of dairy cattle breeding over pigs is noted. This is mainly due to the ability of cattle to contrast from pigs to transform into meat and dairy products, in addition to concentrated feeds, practically all plant waste (straw, stem, butyl, etc.), as well as rough feeds, obtained on natural forage land.

On the organogenic soils of Polissya, effective measures to increase the efficiency of utilization of agro-resource potential are the restoration of air-conditioning regime on reclaimed land and the replacement of traditional crops in the crop rotation in less productive crops in the region. For low crop yields throughout the land, it is expedient to grow fodder crops, and to concentrate feeds in other regions, which is especially important for territories with radioactive contaminated soils. Expected net profit at the same time is 100-110 thousand UAH / ha.

In the Forest-Steppe the profitability of agrarian production at the level of 40 thousand UAH / hectare is ensured by the involvement of animal feed in the composition of the bioenergy infrastructure of sugar and oil production capacities and the use of all recycled wastes (barley, molasses, pulp, hives). It is important that, in addition, derived from these wastes, the livestock production value is not inferior to the income from the sale of the main products - sugar and oil [4].

In Stepy, even for privileged lending, it is problematic to restore irrigation systems under modern grain specialization farms because of significant production costs to achieve acceptable crop productivity and long payback period of capital investments. The most adapted to the agro-resource potential of the irrigation zone is the infrastructure for growing vegetables for the simultaneous use of waste from their cultivation and processing for cattle feed, followed by the processing on the spot of all raw material produced, bringing to the final consumption products, and organic waste - on bioenergy and fertilizers. Irrigation restoration of such infrastructure allows to increase net income by 1.5 times - up to 90 thousand UAH / ha [1].

The formation of bioenergetic agroecosms requires a significant start-up capital of 10-40 thousand UAH / ha, and on reclaimed land with the restoration, reconstruction or construction of reclamation systems - up to 100 thousand UAH / ha. These costs are also largely determined by the potential of agroecosystem bioproductivity - the more raw biomass output, the more powerful and expensive the infrastructure for its processing and storage. However, the introduction of a model adapted to the specific conditions of agrarian production ensures a high level of profitability and short terms of its payback.

Other important advantages of bioenergetic agroecosystems are their energy independence and high levels of biogenic element recirculation, which enables to provide enhanced reproduction of soil fertility without significant costs of chemical, man-made, energy and financial resources with the transition to the principles of organic production. These advantages lead to the dynamic development of the production of competitive high-quality and affordable crop and livestock products.

So, on the one hand, the systematic processing and decontamination of wastes, the observance of the optimal alternation of crops in crop rotation, ensuring the deficit of the balance of macro- and microelements and organic carbon will be accompanied by a steady increase in agro-ecosystem bioproductivity due to the improvement of the phytosanitary state of the environment, the engagement of biogenic elements in the closed loop and the activation of nitrogen fixation. On the other hand, the high profitability of the introduction of bioenergy systems of agrarian production allows systematically to increase their area by 50% annually without attracting external borrowings.

Indicators of economic efficiency of different variants of the sectoral structure of agricultural production

If, say, agricultural enterprises of state ownership occupy an area of 500 thousand hectares, provided that investment resources are invested in amounts that will ensure the development of bioenergy infrastructure on an area of 100 thousand hectares, then after implementation lending commitments, net profit will allow this area to be extended to 500 thousand hectares over 5 years without attracting foreign origin funds. At the same time, if the initial capital expenditures are taken at the level of 20-30 thousand UAH per hectare, for 100 thousand hectares - 2-3 billion UAH, then after implementation of such a project with an area of 500 thousand hectares to the state budget each year will receive at least 15 - 20 billion UAH.

The benefits of bioenergy agroecosystems include solving social problems in the countryside, in particular the creation of a significant number of additional jobs, and the improvement of the environmental state of the environment. From the standpoint of ecology and economics, bioenergy agroecosystems also provide optimal adaptation to climate change through significant reductions in greenhouse gas emissions, in particular, CO2 - 8-10 t / ha.

Conclusions

Implementation of bioenergy agrarian production projects in the broad practice will ensure independence from external sources of chemical and man-made and energy resources, will allow to significantly reduce the cost price, increase the competitiveness of products, increasing net income from the modern 1.0-1.5 thousand. UAH / ha to 50 - 70, and on land reclaimed land - up to 100 - 110 thousand UAH / ha. At the same time, the payback period of capital costs will be 1-3 years. In the state land fund, agricultural land occupies 42.3 million hectares, which gives an idea of the potential of food and bioenergy production and the possibility of forming financial resources in the agrarian sector of the Ukrainian economy.

In order to implement the agrarian sector development strategy based on state-owned agricultural enterprises, in particular the National Academy of Agrarian Sciences, it is proposed to create experimental operational zonal bioenergy production systems. This will enable the development of sufficient legal and

regulatory framework in the area of land relations, financial and regulatory policy, the development of specific sectors of the agricultural sector and the rational use of natural resources. Together with the creation on their example of systems of training and retraining of personnel and informational and consultative support of small, medium and large agribusiness, the preconditions for a new, integrated development of the agrarian sphere, strengthening of energy independence, increase of food security and export- the potential of Ukraine.

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