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MODELING OF THE SUSTAINABLE DEVELOPMENT OF MULTIFUNCTIONAL FARMS IN UKRAINE

Abstract. Dynamic optimum planning and forecasting of rational combination of agricultural sectors allows to execute transition from traditional to ecological and organic management at the least costs and risks. The gradation of ecological compatibility of agricultural enterprises is shown in the article. It includes main criteria of the model of balanced development of agricultural manufacture. The efficiency of transition to the highest levels of agriculture ecologization was proved with the use of mathematical programming. The automated model of agricultural manufacture development and easures to increase the level of its ecologization were provided. Presented model is universal and may be applied to any enterprise of the Left-bank Forest steppe zone.

Keywords: development, optimization of agricultural sectors, ecological and mathematical model, ecologization of agriculture

MODELOWANIE ZRÓWNOWAŻONEGO ROZWOJU WIELOFUNKCYJNYCH GOSPODARSTW ROLNICZYCH NA UKRAINIE

Streszczenie. Dynamiczne optymalne planowanie i prognozowanie racjonalnego połączenia sektorów rolniczych pozwala przy najniższych kosztach i ryzyku dokonać przejścia od tradycyjnych form działalności do rolnictwa ekologicznego lub organicznego. Artykuł naświetla kwestię gradacji ekologiczności gospodarstwa rolnego, która obejmuje podstawowe kryteria zrównoważonych modeli rozwoju rolnictwa. Za pomocą programowania matematycznego udowodniono skuteczność zwiększenia poziomu ekologizacji. Przedstawiono zautomatyzowany model rozwoju gospodarstwa rolnego oraz sposoby zwiększenia bezpieczeństwa

produkcji. Model jest uniwersalny i może być stosowany w przedsiębiorstwach lasostepu Ukrainy Lewobrzeżnej.

Słowa kluczowe: rozwój zrównoważony, optymalizacja połączenia branż, model ekologiczno-matematyczny, rolnictwo ekologiczne

1. Problem definition

In the market economy conditions at the stage of concentration of efforts on euro-integration processes one of the main issues of the present is decentralization of power. The corresponding political lever provides the opportunity to accumulate both material, and non-material resources, which have direct influence on development of region. The correct organization of agricultural industry is playing not the last role in the balanced regulation. And with taking into account requirements of population of the region and preservation of environment, correct organization of agricultural industry will allow to combine specializations of available enterprises and at the same time to achieve the maximum profit. It is important not only to provide population with the food, but also to preserve national wealth for future generations, to improve ecological situation.

Agricultural activity of agricultural enterprises with the high level of specialization damages environment, exhausts soils, pollutes reservoirs and atmospheric air. Despite the complexity of manufacturing processes and management activity, in diversified agricultures risks in the conditions of uncertainty decrease, there provided the closed production type (production of own fodder, organic fertilizers, seed fund, etc.), there improved the ecological condition of both agricultural ecosystem, and environment in general. Deepening of specialization is reasonable only in the sphere of animal breeding.

Determination of the structure of optimum combination of industries is one of the most important tasks of activity of enterprises and makes it possible to achieve such effects: economic (increase in profit, gross output or reduction of manufacturing costs); social (organization of employment of agricultural population, growth in prosperity of workers) and agro-ecological (improvement of the structure of soils, their agrophysical and phytosanitary condition, air and water conditions, positive balance of humus, development of biogenic elements, ecological characteristics of manufactured products).

Due to the constant optimum planning and forecasting of rational combination of industries it is possible to execute transition from traditional management to ecological and organic at the least costs and risks. As the input data of the following model must be preliminary indicators (crop yields, productive efficiency, balance of humus, material and cash expenses, etc.) of productive activity of enterprise. Crop yields and productive efficiency of animals can't be forecasted for the planning period during transition to the other levels, because indicators either decrease, or efficiency of applied measures is low in the short-term

period. Automation of the optimum combination of industries simplifies planning at the enterprise.

Relevance of development of the automated model of evolution of agricultural production allows: to forecast changes of parameters of soil fertility depending on scenarios of ecologization of agriculture; to calculate the amount of application of organic fertilizers for the surplus balance of humus in the soil; to calculate the amount of application of mineral fertilizers for the deficit-free economic nutrient balance in agriculture; to provide the optimum structure of crop acreage, livestock and fodder production at the existing manufacturing resources and specialization of the husbandry; to forecast the economic efficiency of scientifically-based system of husbandry.

2. Analysis of the last researches

According to the world statistics, as of 2014 Ukraine takes the honourable twentieth place among the leading countries of organic movement[1] and became one of the ten European countries, which are characterized by the greatest rate of growth of organic agricultural lands. It is found out that the surplus is equal to 1,9%, which means that the number of lands under organic production has increased on 7364 hectares in comparison with 2013. Total area of lands, which completed organic certification in our country is equal to 400,76 thousand hectares, from them 530,0 thousand hectares are wild crops. The share of certified organic areas among the total amount of lands of Ukraine is equal to 1%. Pursuant to the available area Ukraine takes the 11th place among the European leaders of organic production, but, unfortunately, pursuant to the number of manufacturers – only the 32nd place[2]. Official statistical reviews of IFOAM confirm that when in 2002 in Ukraine were registered 31 husbandry, which received the status of "organic", in 2014 there were 182 husbandry, and in 2015 there were 210 certified organic husbandries[3].

Taking into account the presence of 30,8% of lands with the status of special raw material zones and 4,3% of agricultural enterprises of Poltava region of the total amount at Ukraine, the ratio of organic operators is equal to 0,2% of the total number of enterprises of the region, and special raw material zones – 0,6%. In our opinion, exactly the insufficiency of regulatory and methodological framework for transition of husbandries to organic production and receipt of the status of special raw material zones is the reason of insignificant number of such enterprises. It is important for agricultural enterprises to offer the gradual transition with the optimum manufacturing costs. And we recommend to do it with the use of methods of

[1] Organic in Ukraine. Official website of the Federation of organic movements in Ukraine.
[2] Willer H., Lernoud J. (eds.): The world of organic agriculture. Statistics and Emerging trends 2016. Research Institute of Organic Agricultural (FiBL), Frick, Switzerland and Organic International (IFOAM), Bonn 2016.
[3] Organic in Ukraine…, op.cit.

ecological and mathematical modeling, which provide the opportunity to increase the level of ecologization of agriculture at available resources.

Purpose of research – develop the automated model of the balanced evolution of agricultural enterprise by criterion of ecologization of agriculture.

3. Statement of the main results and their justification

The influence of activity of agricultural enterprises on the balanced development of Poltava region is rather high, as more than 60% of gross output is made by agricultural manufacturers (table 1).

Table 1

Indicators of activity of agricultural enterprises of Poltava region, 2000-2014

Indicators	Years						
	2000	2005	2010	2011	2012	2013	2014
Gross agricultural output (fixed prices in 2010), million UAH	7038,7	10307,6	10999,2	14922,5	13399,8	16022,8	15520,4
including:							
– crop products	4275,7	7380,2	8064,7	11877,2	9959,1	12271,1	11703,0
– livestock products	2763,0	2927,4	2934,5	3045,3	3440,7	3751,7	3817,4
Structure of gross output, %:							
– of crop growing	60,7	71,6	73,3	79,6	74,3	76,6	75,4
– of animal breeding	39,3	28,4	26,7	20,4	25,7	23,4	24,6
Ratio of agricultural enterprises to the total volume of production of gross output, %:							
– of products of agricultural industry	77,8	63,3	64,1	61,1	59,7	63,6	61,7
– of crop products	84,7	68,2	68,5	65,1	62,9	66,9	64,1
– of livestock products	70,4	56,7	48,2	48,6	50,7	50,6	54,7
Profit on sales of agricultural products, million UAH	16,3	76,4	1062,2	1579,6	1482,4	757,4	2553,0
Level of profitability of production of agricultural products, %	2,4	5,6	21,7	27,6	16,1	8,3	23,4

Source: State Statistic Service of Ukraine. Department of Statistics in the Poltava region. Annual publication "Agricultural in the Region in 2014", Poltava 2015, p. 15-185.

In 2014 the volume of manufacture of gross output at agricultural enterprises grew by 2,2 times in comparison with 2010, and respectively to 2010 – by 41,1%. The ratio of crop products in the structure of gross output in 2000 was equal to 60,7%, in 2010 it increased to 73,3%, and in 2014 – to 75,4%. In the sphere of animal breeding during 2000-2014 is observed decrease in the ratio from 39,3% to 24,6%.

In 2000 ratio of agricultural enterprises in the total volume of manufacture of gross output of agricultural industry was equal to 77,8%, and in 2014 – correspondingly 61,7%. Due to uneven rates of reducing of volumes of products manufacture, ratios significantly changed. In 2000-2005 ratio between the crop products and livestock products at agricultural enterprises decreased from 1:0,65 to 1:0,40, and in 2010-2014 it fluctuated, ranging from 1:0,25 to 1:0,36.

In 2014 agricultural activity was performed by 2514 enterprises of various business organizational and legal forms, among which the greatest share is occupied by the farm enterprises – 73,5% (1849 units). The share of business entities is 15,5% (391 units), private enterprises – 7,6% (190 units), production cooperatives – 1,1% (28 units), state owned enterprises – 0,8% (19 units), enterprises of other forms of managing – 1,5% (37 units) from the total number of enterprises.

Direction of industry specialization of enterprises of Poltava region – is cultivation of grain and industrial crops, production of milk and meat (table 2). In terms of agricultural enterprises of various business organizational and legal forms the ratio of mentioned above industries significantly differs. The level of ecologization of agriculture has great influence on the structure of marketed output.

Table 2

Structure of the marketed agricultural output of researched agricultural enterprises of Poltava region of various business organizational and legal forms, on average for 2010-2014

Indicators	SE "EH named after 9 January"		PC "Agroecology"		Peasant farm enterprise "Chaus"		Poltava region	
	Thousand UAH	%	Thousand UAH	%	Thousand UAH	%	Thousand UAH	%
Crop products	14376	59,2	10365	15,2	3184,2	70,5	10775	76,0
– grain crops	8453	34,8	8623	12,6	1333,7	29,5	4686	33,1
– industrial crops	5723	23,6	1730	2,5	1833,3	40,6	3303	23,3
– potato, vegetables and cucurbits crop	–	–	–	–	–	–	2114	14,9
– fruits, berries and grape	–	–	–	–	–	–	354	2,5
– fodder crops	200	0,8	–	–	17,2	0,4	312	2,2
– other products	–	–	12	0,01	–	–	21	0,1
Livestock products	9899	40,8	57968	84,8	1334,5	29,5	3398	24,0
– cattle and bird (breeding)	2799	11,5	14430	21,1	454	10,0	1056	7,4
– milk	7046	29,0	43428	63,6	858	19,0	1936	13,7
– eggs	–	–	–	–	8,7	0,2	294	2,1
– other products	53	0,2	110	0,2	20,8	0,5	113	0,8
Products of agricultural industry – total	24275	100,0	68333	100,0	4518,7	100,0	14173	100,0

Source: developed by the authors.

At the enterprises with traditional methods of economic management the dominant industry is crop growing ≈70%, in the special raw material zones – its level is lower than 60%, in organic production the more developed industry is animal breeding.

Degree of influence of agricultural activity on environment depends on the level of ecological compatibility of the husbandries, established by the operating regulatory framework. As of today, two legislative documents, which regulate the rules of performing economic management, grant the corresponding status to the enterprise and classify it to the registers, published on official websites: The Law of Ukraine No. 425-VII "On manufacture and distribution of organic agricultural products and raw materials" of 03.09.2013[4], according to which enterprise after certification by the corresponding organizations may be classified in the Register of producers of organic products (raw materials); Resolution of the Cabinet of Ministers of Ukraine "On approval of Procedure of Granting the Status of Special Zone on Manufacture of the Raw Materials Used for Production of Baby Food Products and Dietary Products" of 03.10.2007, No. 1195[5], according to which requirements enterprises are classified in the Register of special raw material zones.

The issue of development of organic agriculture is regulated additionally in the other regulatory documents. Thus, the State target program of Ukrainian rural development for the period until 2015 has declared the plan of bringing of the share of organic products in the total volume of gross output of agricultural industry to 10%, stimulation of maintenance of principles of organic production, creation of economic conditions for development of alternative agriculture, standartization of maintenance of organic agriculture and production of biofuel, standartization of development of organic agriculture, creation of the system of its certification[6].

In return, "The strategy of development of agricultural sector of economy for the period until 2020", accepted in 2013 as one of the priority directions of achievement of strategic objectives in agro-industrial production of the country, it determines the need in the food security of the country by assistance in development of organic agriculture, first of all in the personal farm and average households[7].

As the main principles of National environmental policy of Ukraine is determined the creation of conditions for widespread implementation of ecologically oriented and organic technologies of management of agriculture and achievement of their use in 2020 at the level of 7% of the total quantity of agricultural lands, which is the double increase in their areas in comparison with basic level[8]. Unfortunately, we state that according to a lot of estimates of accomplishment of this strategy in 2011-2015 especially such its strategic task as development of organic agriculture, isn't observed. Also it is not conducted the monitoring of

[4] The Law of Ukraine. On manufacture and distribution of organic agricultural products and raw materials, No. 425-VII, 03.09.2013.
[5] Resolution of the Cabinet of Ministers of Ukraine, No. 1195, 03.10.2007.
[6] Resolution of the Cabinet of Ministers of Ukraine, No. 870, 15.08.2011.
[7] Ordinance of the Cabinet of Ministers of Ukraine, No. 806, 17.10.2013.
[8] The Law of Ukraine. On manufacture and distribution of organic agricultural products and raw materials, No. 425-VII, 03.09.2013.

the part of agricultural lands, at which are used ecologically oriented and organic technologies of agriculture, and official information about them is absent[9].

It should be noted that today the increase in share of lands, which are used in organic production, occurs only by the initiative of independent entrepreneurs, which testifies the lack of accurate organizational and legal regulation on the part of the state. In Ukraine are not yet developed the corresponding bylaws, domestic manufacturers undergo the procedure of organic certification of their production in accordance with the current international standards, most often they are the regulations of European Union[10].

Based on the available regulatory support of conducting ecologically oriented agricultural activity of enterprises, the known operating regulations of ecologically safe production we produced classification of ecologically oriented development of agricultural enterprises for the zone of Left-bank Forest-steppe, in the basis of which lies the known classification of systems of agriculture by the amounts of application of organic fertilizers and by the ecologization index of agriculture (table 3). The offered classification is the base for gradation of ecological compatibility of agricultural enterprises (Fig. 1) and is the main criterion in agro-ecological model of development of enterprise.

Depending on the level of ecologization of agriculture there possible two ways of transition, which are estimated by mathematical modeling. Taking into consideration operating regulations of production of one or another products: 1) from traditional to ecologically oriented enterprise (from chemical agriculture to its ecologization or ecological agriculture); from ecologically oriented to the special raw material zones (by increasing the ecologization level from descending to accruing or intensive level); 2) from ecologically oriented enterprise to organic agriculture and from special raw material zones to organic agriculture (that is from ecological agriculture to organic).

Table 3

Ecological classification of systems of agriculture by the amounts of application of organic fertilizers and by the ecologization index for the Left-bank Forest-steppe

Ecologization index I_e	**Coefficients of ecologization of agriculture**	**Ratio of organic and mineral fertilizers, t/kg of active ingredient**	**Amount of organic fertilizers, t/hectare**	**Nature of action on agriculture**
0	0,2-1	1:0-1:5	26	Organic agriculture
1-4	0,125-0,2	1:5-1:8	26	Intensive ecologization
5-15	0,067-0,125	1:8-1:15	13-25	Ecologization
16-25	0,033-0,067	1:15-1:30	8-12	Chemicalization
More than 25	0,033	1:30	7	Intensive chemicalization

Source: developed by the authors.

[9] Evaluation of execution of the strategy of National Environmental Policy of Ukraine for the period until 2020 and the National Action Plan for the Natural Environment Protection for 2011-2015 (project).

[10] Organic in Ukraine…, op.cit.

Mathematical models of both methods significantly differ among themselves by restrictions concerning application of mineral fertilizers, which are replaced by biological. There imposed restriction for green manures by shifts of crops, which cost is included in manufacturing cost of the main products. There additionally performed the calculation for the balances of humus and nutrients, in which green manures are put on the same footing as application of fertilizers.

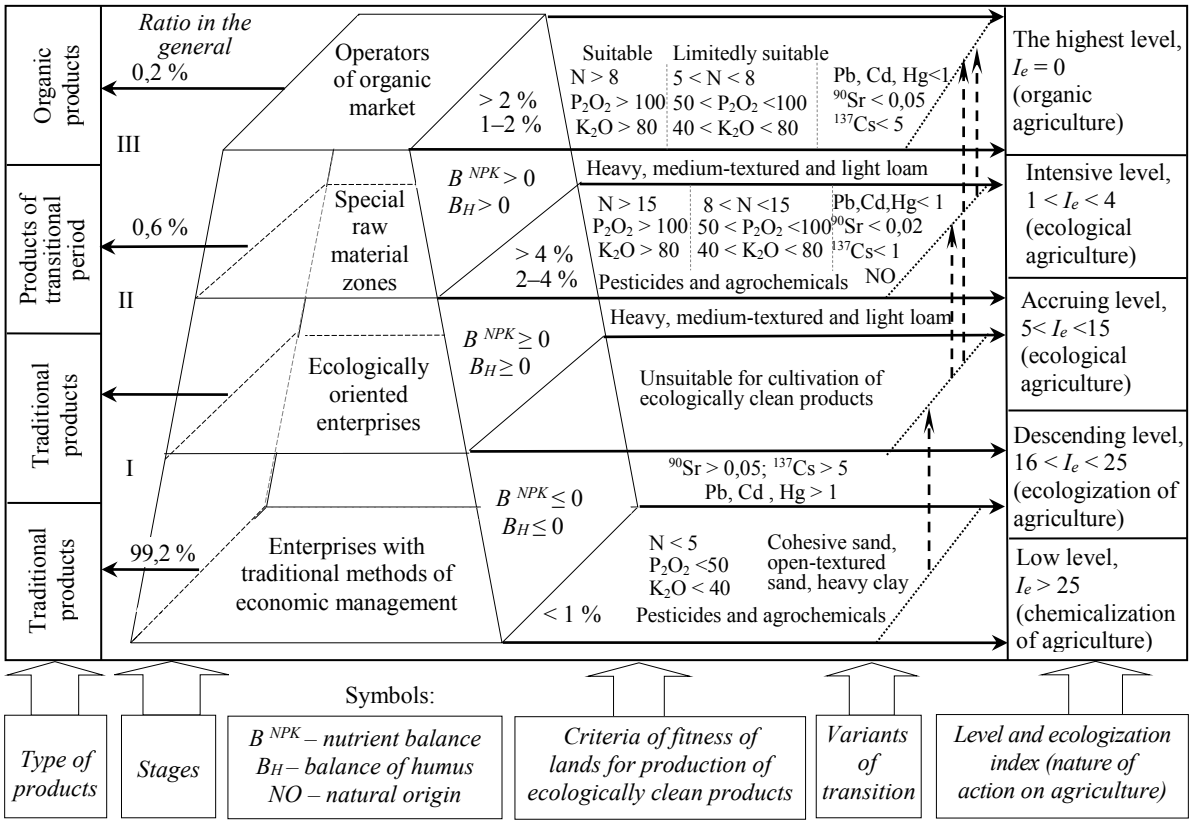
We classified main agrochemical indicators of soil fertility, ecological stability and sanitary and hygienic state of soils (nitrogen for nitrification capacity of soil, labile phosphorus and potassium, humus content in the arable layer, grain-size distribution of soil, density of radionuclide contamination, content of active forms of heavy metals and pesticide residues relatively to the value of maximum allowable concentration) to criteria of gradation of ecological compatibility of the agricultural enterprises[11].

Under condition of conducting organic and ecological agriculture operators of organic market and special raw material zones must meet the corresponding criteria of fitness of lands. Criteria for the possibility of production of ecologically clean products, concerning provision with the mineral elements, coincide with the standard indicators (Fig. 1), and restriction on the level of fertility of soils in the special raw material zones is increased from 2% to 4%. Fitness of lands for cultivation of ecologically clean products is also determined by grain-size distribution – heavy loam, medium-textured loam and light loam. Limitedly suitable are light clay and sandy loam.

In the special raw material zones such indicators of sanitary and hygienic state of the soil as content of active forms of heavy metals, pesticide residues, contamination density of ^{137}Cs must not exceed 1 Ki/km^2 and of ^{90}Sr – 0,02 Ki/km^2, and in organic agriculture is allowed contamination density of ^{137}Cs and ^{90}Sr to 5 and 0,05 Ki/km^2 correspondingly.

Unsuitable are considered the lands, which consist of cohesive, open-textured sand, heavy clay; content of nitrogen in them by nitrification capacity of soil is less than 8 mg of NO_3/kg of soil, labile phosphorus – is less than 50 mg/kg of soil, mobile potassium – is 40 mg/kg of soil; fertility of soil – is less than 1%. Undoubtedly, the corresponding indicators are characteristic for the low level of ecologization of agriculture, but it should be noted that enterprises with traditional methods of husbandry also may meet the criteria of fitness of lands for production of ecologically clean products, but they can not be considered as the special raw material zones or operators of organic market due to non-compliance of production technologies and the lack of necessary certificates.

[11] Soil quality. Special raw material zones. General requirements: State Standard of Ukraine 7244:2011; The draft resolution of Cabinet of Ministers of Ukraine. On approval of Procedure of Evaluation of Lands (Soils) Fitness for Production of Organic Products and Raw Materials, 26.11.15.



Note. It is offered to differentiate five levels of ecologization of agriculture. The highest level – is organic agriculture, which excludes application of mineral fertilizers. Intensive level – allows to apply 5-8 kg of active ingredient of mineral fertilizers per 1 t of organic fertilizers, and accruing – from 8 to 15 kg. Intensive and accruing levels are characteristic for ecological agriculture. The main feature of ecological agriculture is application of organic fertilizers at the level of 13-26 t/hectare, which is the additional criterion in ecological and mathematical model of optimization of production program. Increase in application of mineral fertilizers from 15 to 30 kg of active ingredient per 1 t of organics indicates that it is the descending level of ecologization, and when it is more than 30 kg – it is the low level, which is characteristic for chemical agriculture, that is conducted in traditional husbandries. Amounts of application of organic fertilizers decrease from 12 to 7 tons and below per 1 hectare of sowing of agricultural crops.

Fig. 1. Gradation of ecological compatibility of agricultural enterprises of the Left-bank Forest-steppe (in-house development)
Source: developed by the authors.

According to the stated above gradation the transition from chemical to ecological agriculture must be accompanied by the change of deficit balance of humus and negative economic nutrient balance on the deficit-free or positive balances of humus and fertilizer elements, from ecological to organic – to occur only with their positive levels.

Based on the earlier the result of conducting agricultural activities of agricultural enterprises are the products, which are divided into 3 types: organic, products of transition period and traditional.

The highest level of ecologization of agricultural production is the system of organic agriculture, in which business activity is executed by operators of organic market, the average (intensive and accruing) – is ecological agriculture, characteristic for enterprises with the status of special raw material zones and for ecologically oriented, the lowest – is the intensive

agriculture, characteristic for the most of enterprises, which are using traditional methods of economic management.

To reach the appropriate level of ecological compatibility of agricultural production, besides compliance to the certain criteria, agricultural enterprises must undergo the corresponding procedures and confirm their level by certification of activity.

To determine the optimum strategy of the balanced development of agricultural production in ecologically oriented direction, it is offered to use mathematical models of combination of industries. There conducted analysis of ecological compatibility of agricultural production of the Left-bank Forest-steppe, which allows to assert that the most urgent is the development of mathematical models for average, that is the accruing level of ecologization. The system of unknown mathematical model includes the areas of agricultural crops and livestock of farm animals, and also attraction of insignificant additional resources, which don't require essential capital investments. Modeling of production processes for enterprises, which must update material and technical support in accordance with operating regulations, should be performed according to mathematical models of the other type, which are taking into account the investment projects and the planning of their payoff period.

Thus, depending on specialization of researched husbandry, there constructed the main mathematical model, which determines the options of combination of main branches of crop growing and animal breeding, taking into account edaphoclimatic, agro-ecological, zootechnical, agrotechnical, economical and other conditions, which concern organization of production processes, according to operating regulations of production of traditional, ecological and organic products. The model allows to forecast various scenarios of the balanced development of agricultural enterprise.

We suggest to model scenarios of development of agricultural production in accordance with the main principles of formalization of mathematical models: reflection of mathematical relations in the quantitative expression, which describe operating conditions of agricultural ecosystem and form the unified system; interconnectedness of working conditions by the certain regularities; establishment of connections between working conditions in the system of economy; abstracting from insignificant properties of agricultural production; availability of alternative scenarios of development of agricultural production.

Modeling of the scenario of development of agricultural production is performed in accordance with the algorithm, which includes the definition of the problem by the certain optimality criterion, the analysis of its main parameters, structuring of information, determination of the method of solution, formalization of the structural mathematical model, development of numerical model and its solution in software environment, conduction of analysis of received results[12]. Upon necessity of change of results, there conducted adjustment of the model and its solution. The last stage is the execution of eco-economic analysis of

[12] Braslavets M.E., Kravchenko R.G.: Mathematical modeling of economic processes in agricultural industry. Publishing house “Kolos”, Moskov 1972, p. 15-28.

various options of implementation of models and the choice of the best scenario of development.

Problem definition lies in imitation of the process of functioning of agricultural production in accordance with the maintenance of scientifically based system of economy with taking into account the ecological restrictions. The most effective implementation of such system is the optimum combination of existing industries in agricultural production, which must provide the balanced use of land resources, fodder base for animal breeding industry, receipt of high productivity indexes of agricultural ecosystem in general. The main criterion is the receipt of clear profit under ecologization of agriculture, which acts as the additional criterion. In the model there also taken into account the conditions of keeping of the positive balances of humus and nutrients, the balanced application of organic and mineral fertilizers, erosive danger of agricultural crops.

For soil fertility recovery there offered to apply the number of agrotechnical actions, main of which is the increase of input of organic substance and justification its amount of application for certain cultures. The corresponding condition is reached by the expansion of seeding of perennial grass, replacements of complete fallows with the sown fallows, gradual implementations of catch crops in the crop rotations, use of secondary products of crop growing and expansion of production of animal breeding industry (in the majority of livestock of cattle). Besides the maintenance of a humus condition, it is offered to increase fertility by means of nutritional adjustment of the soil, in general by means of agrotechnical measures of direct impact (system of fertilization).

According to formalization of mathematical models, there determined the set of all types of activity; the set of methods of replenishment of resources; the set of conditions, which reflect production processes concerning the functioning of agricultural ecosystem.

As the information component of automated model of development of agricultural production serve the reference statutory, scientifically based indicators, determined for the corresponding natural and climatic zones, the data of researched economy and the balance calculations, and also the expanded main model and formed results of optimization model (Fig. 2).

The agro-ecological model of development of economy is intended for the most of traditional enterprises of Poltava region and is developed for the purpose of increase in the level of ecologization of agriculture with the optimum expenditure of resources. The corresponding model doesn't require considerable capital investments, concerning enhancement of industries, whereas transition to organic agriculture without gradual transition – isn't possible without additional expenditures on updating (replenishment) of the capital assets, which require operating regulations of economic management by the organic principles.

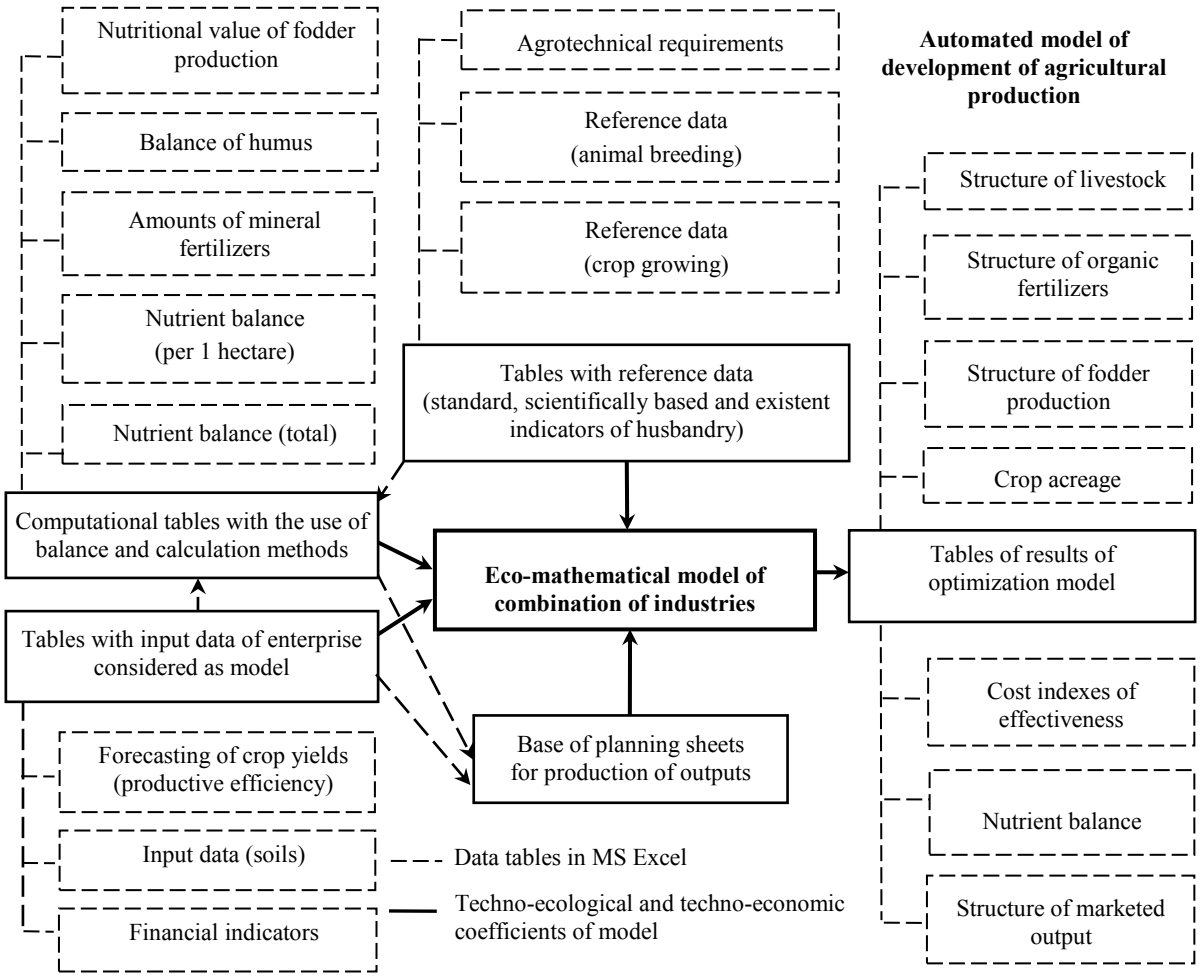


Fig. 2. The automated model of the balanced development of agricultural production
Source: Minkova O.: The optimum combination of industries at different level of ecologization of arable farming. Publishing house "Simon", Poltava 2016.

As the offered model makes it possible to perform transition from intensive (chemical) agriculture to ecological, that's why the use of pesticides and agrochemicals is excluded from the system. At the bottom of modeling of the strategies of development of agricultural ecosystems lies the principle of balanced state of organic substance in combination with efficiency of economic activity. The level of balanced state of agricultural ecosystems is based on cultivation of crops exhausting the soils, to acceptance limits for the purpose of earning the profit and with simultaneous provision of expanded soil fertility recovery, and also the necessary fodder production. For the purpose of increase of organic fertilizers there happened increase in the livestock of cattle and increase in the share of crops with the maximum production volume of sideline products.

The optimized industry structure of enterprises with the accruing level of ecologization doesn't significantly change the specialization of economy, but at the same time it directs production to expansion of the industry of animal breeding for the purpose of its approach to the closed type.

Agro-ecological evaluation of model husbandry includes provision of the positive balance of humus and mineral elements by means of application of 13 t of organic and 72 kg of mineral fertilizers. At such resource saturation we may speak about the optimum level of intensity of nutrient balance for development of plants, with taking into account the low supply of soils with the nitrogenous nutrition. Economic efficiency is characterized by increase in profitability by 4,4%, by increase in production of gross output – by 37,8%, generally due to the growth in commercial share of the corn, milk and meat[13].

For the purpose of comparison of the scenarios of development of agricultural ecosystems at various levels of ecological compatibility and business organizational and legal forms, it is proved that the greatest ecological efficiency is achieved at agricultural enterprises with developed animal breeding industry (especially at the enterprises with the status of special raw material zones), and economic efficiency – at the farm enterprises with the prevalence of crop products. The simultaneous combination of eco-economic effect is achieved in organic system of agriculture.

4. Conclusions

Thus, results of the optimum production program demonstrate that to increase ecologization of agriculture it is necessary: to increase the share of perennial grasses and leguminous crops in the structure of seeds; to increase the quantity of relative livestock by means of cattle; to use as much as possible the crop residues and sideline products as organic fertilizers; to provide the optimum combination of amounts of organic and mineral fertilizers; to expand specialization of enterprise; to increase the production of livestock products in the structure of marketed output.

The use of ecological and mathematical modeling allows to combine most effectively the zone conditions and productive capacities of enterprise, to find out the most effective methods of organization of production, to promptly perform the analysis of possible scenarios of development of agricultural ecosystems, to increase the accuracy of forecast of direct and indirect consequences of influence on agricultural ecosystem. The application of optimum programming in the practice of agricultural production will help in provision of the balanced development of industry, both on the regional, and local levels, and will provide with the opportunity to implement the measures for increase in efficiency of agricultural enterprises.

[13] Minkova O.G.: Model of optimum combination of industries at agricultural enterprise by the criterion of ecologization of development strategies. Scientific reports NUBEE of Ukraine, No. 4 (61), 2016.

Bibliography

1. Braslavets M.E., Kravchenko R.G.: Mathematical modeling of economic processes in agricultural industry. Publishing house “Kolos”, Moskov 1972.
2. Evaluation of execution of the strategy of National Environmental Policy of Ukraine for the period until 2020 and the National Action Plan for the Natural Environment Protection for 2011-2015 (project), http://www.menr.gov.ua/press-center/news/150-news28/3362-otsinka-vykonannia-stratehii-derzhavnoi-ekolohichnoi-polityky-ukrainy-na-period-do-2020-roku-ta-natsionalnoho-planu-dii-z-okhorony-navkolyshnoho-pryrodnoho-seredovyshcha-na-2011-2015-roky.
3. Minkova O.G.: Model of optimum combination of industries at agricultural enterprise by the criterion of ecologization of development strategies. Scientific reports NUBEE of Ukraine, No. 4(61), 2016, http://journals.nubip.edu.ua/index.php/Dopovidi/article/view/6953/6751.
4. Minkova O.G.: The optimum combination of industries at different level of ecologization of arable farming. Publishing house “Simon”, Poltava 2016.
5. Ordinance of the Cabinet of Ministers of Ukraine, No. 806, 17.10.2013, On approval of the Strategy of Development of Agricultural Sector of Economy for the period until 2020, http://zakon4.rada.gov.ua/laws/show/806-2013-%D1%80#n7.
6. Organic in Ukraine. Official website of the Federation of organic movements in Ukraine, http://www.organic.com.ua/uk/homepage/2010-01-26-13-42-29.
7. Resolution of the Cabinet of Ministers of Ukraine, No. 1195, 03.10.2007. On approval of Procedure of Granting the Status of Special Zone on Manufacture of the Raw Materials Used for Production of Baby Food Products and Dietary Products, http://zakon4.rada.gov.ua/laws/ show/1195-2007-п.
8. Resolution of the Cabinet of Ministers of Ukraine, No. 870, 15.08.2011. On approval of the National Target Social Program on Development of Production of Baby Food Products for 2012-2016 (edition of 02.11.2012), http://zakon4.rada.gov.ua/laws/show/870-2011-%D0%BF.
9. Soil quality. Special raw material zones. General requirements: State Standard of Ukraine 7244:2011 [Acting of 2012-01-01]. State Standard of Consuming of Ukraine, Kiev 2011 (National Standard of Ukraine).
10. State Statistic Service of Ukraine. Department of Statistics in the Poltava region. Annual publication “Agricultural in the Region in 2014”, Poltava 2015.
11. The draft resolution of Cabinet of Ministers of Ukraine. On approval of Procedure of Evaluation of Lands (Soils) Fitness for Production of Organic Products and Raw Materials, 26.11.15, http://minagro.gov.ua/uk/regulatory?nid=19482.

12. The Law of Ukraine. On manufacture and distribution of organic agricultural products and raw materials, No. 425-VII, 03.09.2013, http://zakon4.rada.gov.ua/laws/show/425-18.
13. The Law of Ukraine. On the Basic principles (strategy) of the National Environmental Policy of Ukraine for the period until 2020, No. 2818-VI, 21.12.2010, http://zakon4.rada.gov.ua/laws/show/2818-17/page.
14. Willer H., Lernoud J. (eds.): The world of organic agriculture. Statistics and Emerging trends 2016. Research Institute of Organic Agricultural (FiBL), Frick, Switzerland and Organic International (IFOAM), Bonn 2016.