No 46 (2020)
P.7
The scientific heritage

(Budapest, Hungary)

The journal is registered and published in Hungary.
The journal publishes scientific studies, reports and reports about achievements in different scientific fields. Journal is published in English, Hungarian, Polish, Russian, Ukrainian, German and French.
Articles are accepted each month. Frequency: 12 issues per year.
Format - A4
ISSN 9215 — 0365

All articles are reviewed
Free access to the electronic version of journal

«The scientific heritage»
Editorial board address: Budapest, Kossuth Lajos utca 84,1204
E-mail: public@tsh-journal.com
Web: www.tsh-journal.com

CONTENT

ECONOMIC SCIENCES

ECONOMIC SCIENCES

РАЦИОНАЛИЗАЦИЯ ИСПОЛЬЗОВАНИЯ ОРГАНИЧЕСКИХ ОТХОДОВ ЖИВОТНОВОДСТВА КАК ДЕТЕРМИНАНТА РОСТА ЭФФЕКТИВНОСТИ СЕЛЬСКОХОЗЯЙСТВЕННОГО ПРОИЗВОДСТВА

Березюк С.В.
к.э.н., доцент кафедры административного менеджмента
и альтернативных источников энергии,
Винницкий национальный аграрный университет
г. Винница, Украина
Зубар И.В.
к.э.н. ассистент кафедры административного менеджмента
и альтернативных источников энергии,
Винницкий национальный аграрный университет
г. Винница, Украина

STREAMLINING THE USAGE OF ORGANIC ANIMAL HUSBANDRY AS A DETERMINANT OF INCREASING AGRICULTURAL PRODUCTION EFFICIENCY

Bereziuk S.
Candidate of Economic Sciences,
Associate Professor of the Administrative Management
and Alternative Energy Sources Department,
Vinnytsia National Agrarian University
Vinnytsia, Ukraine
Zubar I.
Candidate of Economic Sciences,
assistant of the Administrative Management and Alternative
Energy Sources Department,
Vinnytsia National Agrarian University
Vinnytsia, Ukraine

Аннотация

В статье акцентировано внимание на стремительной интенсификации эксплуатационных нагрузок на земли сельскохозяйственного назначения, что вызвано рядом факторов, в частности ростом численности населения и соответственно цен на продовольствие в мире, сокращением мировых площадей сельскохозяйственных земель, ухудшением экологической ситуации и нарастанием негативного антропогенного воздействия в целом.

Определено большое значение органических удобрений в современном земледелии и экспериментальным способом обобщенно методику определения оптимального органико-минерального удобрения сельскохозяйственных культур на примере зерновых.

Проанализировано современное состояние отрасли животноводства, которое характеризуется стремительным сокращения поголовья животных с соответствующими последствиями для общей эмиссии органических удобрений. Проанализирована динамика внесения органических удобрений, что позволило выявить четкую тенденцию к сокращению. На основе этого рассчитан объем потерь питательных веществ в пересчете на эквивалентное количество минеральных удобрений и потенциальный урожай зерновых.

Обоснован наиболее рациональный вариант обращения с отходами животных, который предусматривает предварительную биоферментацию с одновременным выделением биогаза и биоудобрений, что позволит повысить эколого-экономическую эффективность использования животного навоза.

Внесены рекомендации по обеспечению необходимого количества органических удобрений за счет установки минимально допустимого поголовья животных в расчете на единицу площади пашни, также рассчитан мультипликативный эколого-экономический эффект от данного предложения.

Abstract

The article focuses on rapid intensification of operational loads on agricultural land, which is caused by a number of factors such as: population growth and the increasing of world food prices, the reduction of agricultural land in world space, environmental degradation and an increase of negative anthropogenic influence in general.

The significant importance of organic fertilizers in modern agriculture is determined and the method of determining of the optimal organic-mineral nutrition of crops on cereals example is generalized by the experimental way.

The current state of the livestock industry with distinction of trends of rapid reductions in the number of animals with corresponding consequences for the total emission of organic fertilizers is analyzed. The dynamics of organic fertilizers using is studied, which revealed a clear downward trend. On this basis, the amount of nutrient loss was calculated in equivalent amount of mineral fertilizers and a potential grain crop.

The most rational option of animal waste treatment is substantiated, which involves pre-bio-fermentation with simultaneous separation of biogas and fertilizers, which will enhance the ecological-economic efficiency of using animal manure.

Recommendations to provide the required amount of organic fertilizers by establishing a minimum allowable quantity of animals per unit area of arable land have been made, multiplicative ecological and economic effect of this option was calculated.
Ключевые слова: органические отходы, животноводство, урожайность, биогаз, эколого-экономическая эффективность.

Keywords: organic waste, animal husbandry, yield, biogas, ecological-economic efficiency.

Formulation of the problem. The value of organic fertilizers in modern agriculture is significantly increased due to the increased processes of humus mineralization in soils, which is caused by the increase in crop rotation of the share of cultivated crops, the negative impact of heavy machinery, the increase in the use of agrochemicals while reducing the volume of production. Numerous publications [1, 2] provide data on the decrease in the soil of agricultural use of organic matter and its main component - humus. Therefore, the problem of humus conservation has gained national importance in Ukraine and is being intensively researched today by domestic agrarian scientists.

Proper organization of animal waste management plays a significant environmental role, since organic fertilizers, when optimally applied, improve the structure and quality of soils, enriching their organic component and humus, and when mismanaged, on the contrary, can cause environmental damage. Therefore, the untimely disposal of organic waste, which accumulate in large quantities in the production of livestock products (livestock complexes, poultry farms, etc.), threatens anthropogenic load on the environment in the form of air, water, soil, which is one of the most important.

Currently, science knows a number of ways to use animal manure and other organic wastes [1, 2], among them - the method of anaerobic biological fermentation, which allows to obtain in addition to quality organic fertilizers and alternative gas fuel. At the same time, in the conditions of agricultural enterprises where these technologies can be introduced, the justification of their economic efficiency and the expediency of using organic fertilizers remains insufficient, which has necessitated research on this topic.

Formulating of the goals of the article. The purpose of the article is to substantiate the theoretical, methodological and organizational-economic aspects of livestock waste usage in the economic activities of agricultural enterprises.

Presenting main material. In today's geo-economic space, Ukraine is endowed with a complementary nature of climate and trade and economic conditions. The share of our country in the area of agricultural land in Europe is about 20%, of which 27% is arable land, and the rate of land supply is 0.9 ha per person, which is the highest among the EU countries. The amount of black soil is estimated at 8% of the world's reserves, which opens up opportunities for the domestic agricultural sector to grow the vast majority of crops. All this, together with its powerful human potential, allows Ukraine not only to provide its own food security, but also to become an active player in the global food market, the current state of which can be characterized by the following features:

1. Rapid population growth. In 1990, the world population was 5.327 billion people, and by the beginning of 2020 it was 7.794 billion (+ 46.3% over 30 years) [12]. At the same time, a considerable part of the increase is in the countries of Africa and Latin America (45 newborns per 1 thousand population).

2. Reduction of world acreage of arable land. Each year, the World Land Fund loses about 10 million hectares of farmland through erosion, environmental pollution and rapid agglomeration, which implies their development.

3. Periodic reduction in the supply of agricultural products from some producing countries, due to adverse weather and natural disasters, as well as due to the conversion of a large part of it to biofuels. This direction is actively supported by the US Government, which provides significant subsidies to its farmers and agricultural companies for growing wheat, corn, and rapeseed. The EU foresees an allocation of 4% to 13% of agricultural land for the production of biofuels according to Directive 2003/30 / EU [8].

4. Growth in food consumption in the most populated countries of the world - India and China, accompanied by an increase in household income and consumer demand.

5. The volatility in global financial markets due to the worldwide epidemic of COVID-19 and the threat of defaults, which is why the investment of speculative resources in food is becoming increasingly active [14].

Rising food prices in the world, the attractiveness of the agricultural sector for investment have contributed to an increase in agricultural production in Ukraine. This was made possible by the intensification of agricultural production and the conversion of agriculture to industrial bases [3; 10; 16], which necessitates the strengthening of control over the observance of soil regeneration measures on agricultural lands. In such conditions, against the background of low availability of organic fertilizers, the mineral fertilizer system became popular, which together with the increase of the level of agrarian chemicalisation strengthened the paroxysm of environmental contamination of the environment in the form of soil deterioration, eutrophication of reservoirs and deterioration of the quality of the grown products.

Today, farmers face with the task to provide production of maximum of quality products from each hectare of land while minimizing costs. At the same time, there is a rather high coefficient of correlation of productivity with soil fertility (R = 0.6 - 0.7 depending on the crop) [14]. Accordingly, the integral indicator of soil fertility is crop capacity, which can be expressed in full value, grain or energy equivalents [4]. In order to evaluate soil fertility as the main mean of production in agriculture, it is divided into natural, which is provided by natural processes of soil formation (reserves of humus, nutrients and other properties that affect the growth and development of plants) and artificial (created by man in the process of management by soil cultivation, land reclamation, chemicalisation, and biologicalisation). It is very difficult to separate natural and artificial fertility, sometimes it is almost impossible, because they form the third kind of fertility – economic, which characterizes the potential of the soil - as the main means of production. Its level is characterized by crop yields. Only economic fertility fully and comprehensively reflects the production properties of the land, that means it is responsible for the preservation and efficient use of soils. Thus, the deterioration of the quality of land leads to a decrease in economic indicators of economic activity. The environmental status of soils is fully interrelated with the economic characteristics, so improving environmental performance is seen as fertility reproduction, which allows you to obtain higher quality products and increase the economic performance of the economy by improving soil productivity and preventing its loss in the natural environment. The amount of ecological and economic losses from lost soil fertility is calculated by the sum of the costs necessary for its renovation and the cost of the under-harvested agricultural products as a result of its decrease.

Mineral and organic fertilizers, especially manure, are of great importance in increasing crop yields. The combined usage of organic and mineral fertilizers helps to optimize plant nutrition and increases the productivity of agrocenoses from lower doses of mineral fertilizers [20]. A scientifically proved crop fertilization system in crop rotation is a major factor in increasing their productivity, an effective means of extended soil fertility recovery. It can reduce the cost of crop production by 10-15% and increase the efficiency of fertilizer application by 25-30%. It is possible to evaluate the effectiveness and justify the feasibility of different fertilizer systems in the conditions of their long practical application in rotation. For example, let us use the results of studies of scientists G. Gospodarenko, O. Cherno, A. Cherednyk [3] who compared the performance of mineral and organic-mineral fertilizer system in accordance to yield control values (due to exclusively natural soil fertility) of maize (46.5 c / ha) and winter wheat (44.4 c / ha). Thus, the yield of these crops in the option of exclusively mineral nutrition (N90P90K90) relative to the control, contributed to the increase of corn yield to 69.3 c / ha (+ 49%) and wheat to 64.8 c / ha (+ 46%). In the variant of organic-mineral nutrition (manure 13.5 t + N67P101K54) corn yield increased to 79.6 c / ha (+ 71.2%) and winter wheat - 66.7 c / ha (+50.2 %). Therefore, with an organic-mineral fertilizer system with an optimal dose of organic fertilizers, the average yield over the three years of research was 50-70% higher than the control and mineral system [3]. It should also be emphasized that the systematic using of organic fertilizers in crop rotation contributes to the gradual increase of the total humus content in the soil. The results of such an organic-mineral scheme of fertilizer application discovered by scientists [7] marked the increase of humus content by 0.02-0.03% in the arable layer and by 0.08-0.1% in the basement layers relative to the variant with the mineral fertilizer system. Therefore, to ensure a deficient balance of humus, it is necessary to justify an appropriate amount of organic fertilizer (estimated saturation of 1 ha of arable crop rotation with organic fertilizers).

In determination of rational fertilizer system, it is advisable to refer to the results of M.M. Senchuk's research [16], which substantiated the derivation of an integral index of the ratio between organic and mineral fertilizers. Based on empirical research and systematic observations of scientists [1], [3], we conclude that the most optimal proportion is 16 kg of mineral fertilizer up to 1 ton of manure, i.e. a ratio of 0.06, which should be identified as "humus recovery index" – Igr and is calculated by the formula:

$$I_{gr} = R_o / R_{N+P+K};$$

where R_0– application rate of organic fertilizers, t;

R_{N+P+K}– application rate of mineral fertilizers, kg a.d.

Accordingly, it is possible to justify a rational rate of application of organic fertilizers by the formula:

$$R_o = \frac{\dfrac{H \times C_{(N)} - Q_{S(N)} \times K_{S(N)}}{K_{S(N)}} A_{(N)} + \dfrac{\text{У} \times C_{(P)} - Q_{S(P)} \times K_{S(P)}}{K_{S(P)}} A_{(P)} + \dfrac{\text{У} \times C_{(K)} - Q_{S(K)} \times K_{S(K)}}{K_{S(K)}} A_{(K)}}{\dfrac{1}{I_{gr}} + \dfrac{Q_{O(N)} - K_{O(N)} \times A_{(N)}}{K_{M(N)}} + \dfrac{Q_{O(P)} - K_{O(P)} \times A_{(P)}}{K_{M(P)}} + \dfrac{Q_{O(K)} - K_{O(K)} \times A_{(K)}}{K_{M(K)}}}$$

where *H* – crop yield, c / ha;

$C_{(i)}$– removal of nutrition elements (N, P, K) per 1 c of main and by-products, kg api / ha;

$Q_{S(i)}$– content in soil of mobile forms of nutritional *i* element, kg / ha;

$K_{S(i)}$– coefficient of nutritional element using from soil;

$Q_{O(i)}$– content of nutritional *i* element in organic fertilizer, kg / t;

$K_{O(i)}$– coefficient of using of nutritional element from organic fertilizer;

$K_{M(i)}$– coefficient of using of nutritional element from mineral fertilizer;

$A_{(i)}$– correction coefficients for recommended rates of mineral fertilizers on soils with different levels of nutrient supply of plants, relative units.

Based on the calculations, the best ratio is 11.5 t of manure to $N_{90}P_{16}K_{85}$ of mineral feed.

There is a direct correlation between the humus recovery index and the degree of humification of organic fertilizers: the higher is the value of the first, the higher is the second, ie, the faster is the reproduction of humus and potential soil fertility. Table 1 summarizes the humus recovery index.

The problem of soil nutrient regimes is compounded by the fact that farms do not appeal to scientifically substantiated nutrient ratios, thus violating the physical and chemical properties of soils. The poor ratio between the formation of humus and its mineralization is due to the lack of organic fertilizers. We take animal manure as the basis of organic nutrition - the main organic fertilizer, one of the most ancient fertilizers used by humans. It consists of solid and liquid excrement of animals mixed with litter. From here it is obvious that the composition of the manure depends on the species of animals, the quality and quantity of the litter, as well as the method and shelf life. Improvement of soil properties as a result of application of sufficient amount of organic matter causes decreasing of density, increasing of water resistance of soil structure, improvement of water, air and thermal regimes, positive influence on humus and microbiological state, creation of favorable ratio between organic and mineral fertilizers, when effectiveness of fertilizers is growing. 13-15 t / ha of organic fertilizers needs to be applied to ensure a non-deficit humus balance, however, the decline of the livestock industry has led to a sharp curtailment of manure production, together with the high costs of transporting it to the destinations it have reduced the economic attractiveness of this valuable organic fertilizer.

Table 1

The value of the humus recovery index with different organic-mineral balance of fertilizers

Organic-mineral balance of fertilizers, t / kg of active substance	Humus recovery index	Type of agriculture	Impact on soil properties
1:0-1:5	1-0,2	Organic farming	Optimum soil density; intensity of humus regeneration
1:5-1:8	0,2-0,12	Intensive biologization	Optimum soil density; less intense humus regeneration
1:8-1:15	0,13-0,06	Biologization	Close to optimal soil density; slow growth of humus content in soil
1:15-1:30	0,07-0,03	Chemicalization	Suboptimal soil density, forming of dens; processes of dehumification and decalcification
1:30	0,03	Intensive chemicalization	High level of density, dehumification, decalcification.

Source:[16]

Analyzing the current state of the livestock industry, we note the rapid decline in livestock (Table 2). It should be noted that during the studied period the number of cattle decreased by almost 8 times, pigs - three times, the number of poultry decreased by only 13%.

Table 2

Livestock dynamics of farm animals for the period 1990-2020, thousands of heads

Kind of farm animals	Years					
	1990	2000	2010	2015	2019	2020*
Cattle	24623,4	9423,7	4494,4	3 884	3 333	3 144
Pigs	19426,9	7652,3	7922,2	7350,7	6025,3	5735,45
Poultry	246104	123722	230290	213336	211654	214210

*-forecast

Generalized by authors according to data [10]

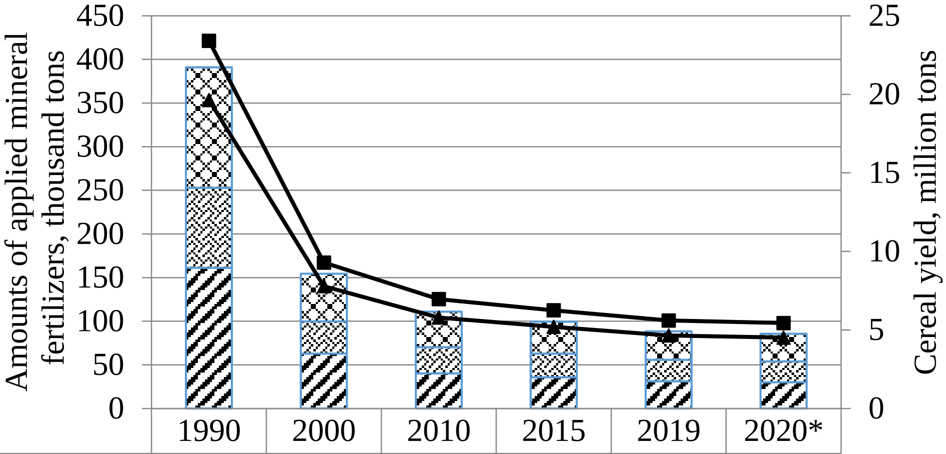
The reduction of animals numbers accordingly affected the total emission of organic fertilizers in terms of nutrients (NPK) (Table 3).

Table 3

Average content of nutrients in organic fertilizers

Kind of farm animals	Oriented manure output	Manure out-put in terms	Average content of nutritional elements in organic fertilizers						Total volume of nutritional elements per year, t		
			In % on absolutely dry matter			Per animal per year, kg					
			N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Cattle	13	35	3,1	1,7	3,3	141,1	77,35	150,2	443,5	243,2	472,1
Pigs	3	30	4,6	2,6	3,4	41,4	23,4	30,6	237,4	134,2	175,5
Poultry	0,12	28	5,8	4,9	2,7	1,9	1,6	0,9	417,5	352,7	194,
Total	-	-	-	-	-	-	-	-	1098,4	730,1	841,9

Generalized by authors according to data [5],[9] Analyzing the dynamics of organic fertilizer using for the period 1990-2020 (Fig. 1) to abstract the scale of lost benefits, we calculate the nutritional value of manure in the equivalent amount of mineral fertilizers by nutrient elements and determine the volume of grain yield provided by them. Thus, in 1990, 260.7 million tonnes of manure were applied, equivalent to 161.23 thousand tonnes of potassium magnesium, 91.77 thousand tonnes of superphosphate and 137.97 thousand tonnes of ammonium nitrate. According to the calculations, this amount of fertilizers can provide nutrients for 19.64 million tonnes of wheat and 23.41 million tonnes of corn, since the average nutrient demand (kg. of active substance / 1 ton of yield) according to data [5] is wheat – $N_{30}P_{11}K_{25}$, maize – $N_{22}P_9K_{25}$, barley – $N_{27}P_{11}K_{22}$. Considering the reduction of organic inputs, the forecast for 2020 is the equivalent of potassium magnesium to be 30.02 thousand tonnes, superphosphate - 24.00 thousand tonnes, ammonium nitrate - 31.63 thousand tonnes and the volume of crops grown on organic fertilizers will decrease to 4.5 million tons of wheat and 5.44 million tons of corn. Therefore, for grain it will be universal nutrition $N_{30}P_{15}K_{25}$, for corn with a yield of 8 t / ha should be used $N_{240}P_{120}K_{200}$, the rate of manure application in the amount of 11.5 t / ha will provide $N_{150}P_{104}K_{115}$, the rest should be added by mineral fertilizers in amount $N_{90}P_{16}K_{85}$, that will povide humus recovery coefficient in 0.06.



	1990	2000	2010	2015	2019	2020*
Ammonium nitrate, thousand tons	137,97	54,7	40,69	36,56	32,61	31,63
Superphosphate, thousand tons	91,77	36,86	30,05	27,13	24,58	24
Potassium magnesium, thousands t	161,23	62,89	40,17	35,73	31,27	30,02
Wheat, million tons	19,64	7,79	5,79	5,2	4,65	4,51
Corn, mln t	23,41	9,29	6,96	6,25	5,6	5,44

Fig. 1. Dynamics of application of organic fertilizers in terms of mineral and their volume of grain yield
Generalized by authors according to data [10], [13]

The approach to the problem of processing livestock farm wastes, especially litter manure, which accumulates in piled up manures, which is a traditional component of the manure application system for most livestock farms in Ukraine, should be based primarily on environmental protection requirements, which include:

- elimination of the emission of unpleasant odors during generation and storage of waste;
- improvement of ecological status due to isolation from the environment of waste and the processes that take place in it, obtaining a safe final product, as well as waste processing at the place of its formation;
- realization of the energy potential of organic waste in the form of biogas;
- production of industrial volumes of valuable organic fertilizers in the short term due to the transition of nitrogen and phosphorus into easily digestible forms for plants;
- development of ecologically clear and organic farming;
- prevention of contamination of products, infection of humans and animals with pathogens;
- prevention of overload of soil, water and plants with harmful substances [18].

Taking into account the complex of the described problems, we consider it advisable to turn the vector of scientific intention towards the search for alternative approaches to the complex utilization of manure. We consider anaerobic methane digestion technology used for biogas production as the most relevant for using. Biogas is a gas that is released during anaerobic fermentation of organic waste and contains up to 75% of methane. The calorific value of biogas from 5000 to 8000 kcal / m3, which in fact responds to the gas mixtures used in everyday life. The calorific value of 1 m3 of biogas is equivalent to 0.6 m3 of natural gas, 0,643 l or 0,566 kg of diesel fuel, 0,856 kg of conventional fuel. With 1 m3 of biogas in the cogeneration unit it is possible to generate 2 kW of electricity. Such gas can be used as fuel to produce heat, steam, electricity or automotive fuel. The biogas output depends on the dry matter content and the type of raw material, so from 1 ton of fresh cattle manure 28 m3 of biogas with methane content of 50% can be obtained. Biogas production technology makes it possible to additionally produce high quality organic fertilizers, thus organic livestock waste can provide innovative prospects for agricultural enterprises. It was found that the cost of producing 1 ton of fertilizer is: 0.4-0.6 machine hours, labor - 0.6-0.8 man-hours, electricity - 0.14-0.23 kW/h. (energy costs for the production of 1 ton of fertilizers are 525-575 MJ, including technological - 240-280 MJ). The cost of processing is 60-95 UAH / t, the cost of finished products ranged from 165 to 280 UAH / t.

Let us determine the approximate volumes of potential production of biogas within Ukraine (Table 4). We used statistical data of livestock availability of cattle, pigs and poultry as of 01.01.2020 for calculating estimated volume of biogas production in the agricultural sector [10]. The calculations used data on the production of biogas by one head of different species of animals and poultry.

Table 4

Estimated output of organic livestock and biogas wastes in Ukraine in 2020

Kind of farm animals	The output of organic waste			The output of biogas		Bio fertilizer output, million tons
	daily from one head, kg	total in a year, million tons	technically achievable total, million tons	m^3/t	total, million m^3	
Cattle	40	45,902	27,541	28	616,928	9,639
Pigs	8	16,748	10,049	54	434,095	3,015
Poultry	0,25	19,547	11,728	41	384,678	3,284
Total	-	82,197	49,318	-	1435,702	15,938

Generalized by authors according to data [6], [10]

The calculation of the theoretically possible potential for biogas production from animal waste is estimated from the calculation of the potential production of biogas, taking into account the livestock of all animals and birds in agricultural enterprises and households, minus 20% of the volume of biogas production to maintain temperature regime in the methane tank. The technically possible biogas potential is calculated by adjusting the theoretical potential by a factor that takes into account the inability to collect and use waste when, for example, cattle is in pastures, or when waste collection is complicated by other factors. This coefficient for all animals except birds is 0.6. The economic potential of biogas production takes into account the estimation of biogas production from animal waste only by agricultural enterprises [2].

Researches of Sereda L.P. and Chernyavsky M.M. indicate that fermentation residues (biofertilizers) are valuable because in addition to nitrogen, potassium, and phosphorus, which are in synthetic mineral fertilizers, they contain nutrients such as protein, cellulose, and lignin,. These substances cannot be replaced with artificial ones, because they are the basis for the development of microorganisms, responsible for the transfer of nutrients to the plant accessible form [17]. Drukovanyi M.F. in his studies has determined the effect of these fertilizers on the yield of maize, which increased by 25% using biological organic fertilizers [4].

New generation organic fertilizers obtained from organic waste by method of biological fermentation do not contain pathogenic microflora and are environmentally friendly, odorless, with high content of humic acids and mobile forms of basic nutrients, depending on the raw material having dark brown or brown color, loose, small structured with a particle size of 2-5 mm. By its agrochemical properties it is a complex fertilizer containing all macro- (nitrogen, phosphorus, potassium, calcium) and trace elements (copper, zinc, boron, magnesium) and other plant nutrients. 1 ton of fertilizers contains an average of 55 kg of active ingredient $N_{20}P_{15}K_{20}$, and the presence of calcium in the composition helps to reduce the acidity of the soil. Depending on the nutrient content of unprocessed manure, the rate of biohumus application should be calculated based on a coefficient of 0.66, if the optimal dose of manure was calculated at the level of 11.5 t / ha, rate for biohumus - 7.6 t / ha (at humidity 60%). Considering a fact that the available livestock for 2020 will produce 15.938 million tonnes of biohumus, this would allow only 2.1 million hectares of arable land to be fertilized (6.5%). In order to provide the required volume of animal organic fertilizer, a minimum livestock population per hectare of arable land should be established. For simplicity of calculations, we take this figure in the conditional heads according to the established coefficient, which is: for cattle = 1, pigs - 0,28, poultry - 0,011. We consider as appropriate option to keep minimum 1 conditional head per 1 hectare, that equals to: 1 adult cattle head, 4 pig heads or 90 bird heads. Accordingly, to provide the necessary doses of organic fertilizers, the livestock population should be increased by 17,012 million cows, 31,264 million pigs and 759,046 million birds (Table 5).

Table 5

Multiplicative ecological and economic effect of fertilizer system optimizing by expanding of the farm animals livestock population

	Requires livestock, thousands of heads	Livestock deficit, thousands of heads	The volume of organic matter, million tons	Biomethane volume, million m3	Volume of biofertilizers, million tons	Substitution min. fertilizers (ammonium nitrate / superphosphate / potassium magician), thousand tons
Cattle	23036	-17012	179,68	2414,85	62,89	36,56/31,45/44,92
Pigs	42285	-31264	76,11	1972,86	22,83	13,27/11,42/16,31
Poultry	973256	-759046	116,79	2298,44	32,70	19,01/16,35/23,36
Total	-	-	372,58	6686,16	118,42	68,85/76,97/108,27

Economic effect

The cost of biomethane, billion UAH	The cost of regenerated biohumus, billion UAH	The cost of mineral fertilizers substituted with biohumus, billion UAH	The cost of an additional grain crop
38,537	1,701	2,872	84,8

Source: calculated by the authors

Considering the fact that the weighted average humus content in the soil of Ukraine is 3.17%, it can be calculated that its content in the physical mass is 105 kg / ha in the arable layer, and considering the annual rate of recovery + 0.02%, it makes 21 g / year on one hectare. Scientists estimate the cost of humus at 2.5 thousand UAH / t, so the cost of its annual regeneration can be estimated at 52.5 UAH / ha, which is within the total arable land will make 1.701 billion UAH.

Biomethane by parameters of calorific value is equivalent to natural gas, so its value can be calculated at the market price, which as of 01.01.20, according to the stock quotes [15] was 5763,78 UAH / thousands m^3, so the cost of the obtained biomethane will be 38.537 billion UAH.

Estimating the prospects for growing strategic cereals, according to the 2019 harvest, wheat was harvested - 28.1 million tonnes, maize - 30.8 million tonnes, barley - 8.9 million tonnes [13], it is possible to predict a 25% increase in yield. Accordingly, it is 7 million tonnes of wheat, 7.7 million tonnes of corn and 2.2 million tonnes of barley. Estimating additional yield at the weighted average exchange prices [11], its value will make 84.8 billion UAH. Thus, the multiplicative economic effect of optimizing the fertilizer system, due to the expansion of livestock farming, is estimated at UAH 137.545 billion per year.

Therefore, the proposed restrictions related to a minimum of 1 conditional head of agricultural animals per 1 ha of arable land for working agricultural enterprises and also introduction of bio-fermentation technology of animal waste will lead to financial independence of prices for fertilizers for enterprises, reduce of energy dependence, intensification of production through internal reserves, solving environmental problems and the transition to a high culture of organic farming, increasing of crop yield. In addition, in the context of European integration processes, there is a need to adapt domestic agricultural policy to EU standards and CAP. The gradual adaptation of the proposals will allow the agricultural development vector to be directed towards rural renewal, environmental protection and food security, it will be possible to stimulate agricultural development in Ukraine, increase the standardi of living of the rural population and to be ready for EU membership.

Conclusions and suggestions. Effective functioning of agro-industrial complex of Ukraine and economy in general implies the rational use of its resource potential. It is worth noting that agriculture, which is integral component of agroindustrial complex, is actually waste-free production if rationally implemented. Livestock industry, which purpose of functioning is the production of high quality food and valuable raw materials for food and light industry, is a powerful source of nutrients for plant growing. Livestock wastes, including manure that is generated in a consequence of the physiological processes of animals and poultry, and is not actually the main product of this industry, today is an invaluable source of nutrients and highly liquid commodity. Only in case of inefficient management the manure is treated as a waste and becomes a source of environmental pollution.

In the context of European integration processes, to prevent growth of ecological crisis the state must develop and implement an effective environmental crisis an economic incentive mechanism that should be aimed at raising the interest of landlords and land users (especially tenants) in preserving soil fertility and protecting land from negative effects from production activity. These measures should be adapted to the requirements of «cross compliance» of the EU Common Agricultural Policy [8], providing:

- prevention of misuse of agricultural lands with no difference if agricultural production is carried out or not on these lands;
- protection of the environment, appropriate conditions for keeping animals, avoiding harm for human health, flora and fauna;
- introduction of scientifically substantiated volumes of mineral and organic fertilizers, implementation of anti-erosion measures, compliance with storage requirements and use of agricultural waste.

Adherence to the EU Common Agricultural Policy will allow:

- to reduce the negative impact of agricultural production on the environment, increase crop yields and to raise the culture of agriculture in general;
- to implement new agricultural production technologies, that maximize environmental requirements and are geared toward achieving ecological balance;
- to produce biofuels and energy from raw materials obtained from agriculture, which will increase efficiency of economic activities and energy independence of agricultural enterprises;
- to receive payments by agricultural producers for keeping the rules of conduct for agriculture activity recommended by the relevant EU directives.

In general, the efforts at the state level to solve the problems of improvement of agro-ecological conditions of agriculture functioning in Ukraine will contribute to the improvement of the state of natural resources involved in agricultural production, increase of export potential of environmentally friendly products, meeting the needs of population in a clean environment and quality products, increasing profitability and raising corporate social responsibility and more.

References

1. Berezyuk S., Zubar I. Suchasni ekonomiko-ekolohichni aspekty zastosuvannia dobryv u roslynnytstvi [Modern economic and environmental aspects of fertilizer application in crop production]. Economika APK. 2019. Vol 10. Pp. 34-43. [The Economy of Agro-Industrial Complex. 2019. Vol 10. Pp. 34-43].

2. Biohaz: vchora, sohodni, zavtra [Biogas: yesterday, today, tomorrow]. URL: http://zorg.ua/ua/biblioteka/biogaz-vchora-sogodni-zavtra

3. Gozhayenko G., Cherno O., Cherednik A. Znachennia orhanichnykh dobryv u systemi udobrennia kultur polovoi sivozminy. [The value of organic fertilizers in the system of fertilization of crop rotation crops]. Visnyk Lvivskoho natsionalnoho ahrarnoho universytetu. Seriia : Ahronomiia. 2019. Vol. 23. Pp. 184-190. [Bulletin of Lviv National Agrarian University. Series: Agronomy. 2019. Vol. 23. Pp. 184-190].

4. Drukovanyy M., Dyshkant L., Tekhnolohichna liniya po vyrobnytstvu biohazu ta biolohichno orhanichnykh dobryv dlya vyroshchuvannya ekolohichno chystoyi silskohospodarskoyi produktsiyi. [Technology line for the production of biogas and organic fertilizers for the production of environmentally friendly agricultural products]. Zbirnyk naukovykh prats instytutu bioenerhetychnykh kultur ta tsukrovykh buriakiv. 2014. Vol 9. Pp.139-143. [Proceedings of the Institute of Bioenergy Crops and Sugar Beet. 2014. Vol 9. Pp.139-143].

5. Zinchenko O. Kormovyrobnytstvo. [Feed production]. Navchalne vydannya. 2-e vyd., dop. i pererob. K.: Vyshcha osvita, 2005. 448 P. [Educational edition. Type 2, Ext. and recycling. K.: Higher Education, 2005. 448 P.]

6. Kaletnik G., Zdyrko N., Fabianskaya V. Biohaz v domohospodarstvakh – zaporuka enerhonezalezhnosti silskykh terytoriy Ukrayiny [Biogas in households is a guarantee of energy independence of rural territories of Ukraine]. Ekonomika. Finansy. Menedzhment: aktualni pytannya nauky i praktyky. 2018. Vol 8. Pp. 7-22. [Economy, Finances, Management: topical issues of science and practical activity. 2018. Vol 8. Pp. 7-22]

7. Olifir Y., Gabriel A., Kachmar O. Vplyv riznykh vydiv orhanichnykh ta orhano-mineralnykh dobryv na rodyuchist siroho lisovoho poverkhnevo ohleyenoho gruntu. [Influence of different types of organic and organo-mineral fertilizers on the fertility of gray forested surface soil]. Okhorona rodyuchosti gruntiv, Vol. 8. 2012. Pp. 100-107 [Soil fertility protection, Vol. 8. 2012. Pp. 100-107].

8. Official Website SIA «International Center for Quality Certification – ICQC». URL: https://www.icqc.eu/

9. Official Website State Poultry Research Station of the National Academy of Agrarian Sciences of Ukraine. URL: http://avianua.com/ua/

10. Official Website of the State Statistics Service of Ukraine. URL http://www.ukrstat.gov.ua.

11. Official Website of the Electronic Cereal Exchange of Ukraine https://graintrade.com.ua/

12. Official Website International help platform «Worldometer». URL: https://www.worldometers.info/

13. Official Website Ministry of Agrarian Policy and Food of Ukraine. URL http://www.minagro.gov.ua

14. Official Website National Institute for Strategic Studies. URL: http://old2.niss.gov.ua/

15. Official Website of the Ukrainian Energy Exchange. URL: https://www.ueex.com.ua/

16. Senchuk M. Vykorystannya kontseptsiyi biolohizatsiyi zemlerobstva v systemi orhanichnoho zemlerobstva. [The use of the concept of biological biology of agriculture in the system of organic farming]. Ahrobiolohiya. 2017. Vol 1. Pp. 61-68. [Agrobiology. 2017. Vol. 1. S. 61-68].

17. Sereda L., Chernyavsky M. Perspektyvy vykorystannya mobilnoyi biohazovoyi ustanovky dlya vnesennya ridkykh orhanichnykh dobryv. [Prospects for the use of mobile biogas plant for the application of liquid organic fertilizers]. Zbirnyk naukovykh prats Vinnytskoho natsionalnoho ahrarnoho universytetu. Vol. 12. 2013. Pp. 172-179. [Collection of scientific works of Vinnytsia National Agrarian University. Vol. 12. 2013, Pp. 172-179].

18. Shelimanova O., Lyashenko A., Mikhalevich V., Korbut N., Stetsyuk V. Kompleksna pererobka vidkhodiv silskoho hospodarstva z vyrobnytstvom enerhonosiyiv, orhanichnykh ta orhanomineralnykh hranulovanykh dobryv. [Complex processing of agricultural waste with the production of energy carriers, organic and organomineral granular fertilizers]. Naukovyy visnyk Natsionalnoho universytetu bioresursiv i pryrodokorystuvannya Ukrayiny. Seriya: Tekhnika ta enerhetyka APK. 2016. Vol. 256. Pp. 191-199. [Scientific Bulletin of the National University of Life and Environmental Sciences of Ukraine. Series: APC Engineering and Energy. 2016. Vol. 256. Pp. 191-199].