

ESTIMATION FOR THE EFFECT OF BALANCED FERTILIZATION SYSTEM ON THE LAND USE EFFICIENCY IN THE AGRICULTURAL INDUSTRY

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Annotation. The article analyzes the importance of the fertilizing system for improving the land use efficiency in the agrarian sector. The concept of "balanced land use" and its features in the field of agricultural activity are studied. The main factors influencing the formation of a balanced land use system in the agrarian sector and their further consideration for optimization of agricultural activity are defined. The importance of balancing the fertilizer system for agricultural crops with the amount of organic and mineral fertilizers introduced for increasing the productivity of agricultural crops and improving the quality of land and resource potential for substantiation of the possibilities for the development of environmentally and economically efficient agricultural production was established. It is substantiated that the priority in the work of agrarian formations is to improve the productivity of agricultural crops by increasing the use of organic elements in their fertilization.

Key words: agrarian production, ecologization, balanced land use, mineral fertilizers, organic fertilizers, impact assessment, fertilizer system, yield, impact factors.

Introduction. These days, due to the intensive land use, the quality of the Ukrainian land fund is constantly deteriorating. In some areas, where land drainage is carried out, there is an uncontrolled decrease in groundwater levels, a decrease in the mass of organic matter; flooding and salinization of soils takes place, degradation of chernozems in areas of irrigation, which leads to negative environmental effects in many regions of Ukraine.

According to research results [1], 10.4 million hectares (26.3%) of Ukraine's agricultural land are sour soils. Solonchic (medium and strong) and saline soils make up 4.7 million hectares (14.3%). In addition, pearled and marshy soils cover an area of 3.9 million hectares (10%), rocky soils - 5.4 million hectares (1.4%).

According to the State Committee for Land Resources of Ukraine, the total area of agricultural land affected by water and wind erosion is 30.7%, deflationary-hazardous soils account for 19.1% of the total area. Today, about 15.0 percent of the total area of irrigated land is subjected to erosion, 1.5 percent - for reloading, more than 4 percent are solonchic and salted. An increase in the groundwater mineralization leads to the secondary salinization of land.

At the same time, humus content decreased by 0.22 percent in absolute terms on average in Ukraine over the past 20 years, which is a significant loss, since a period of 25-30 years is required for its increase in the soil by 0.1 percent in natural conditions (Broshchak et al. 2013).

According to the State Geological Survey of Ukraine, more than 1 million hectares of agricultural land require preservation today, of which about 563 thousand hectares are degraded, more than 475 thousand hectares are unproductive and about 12 thousand hectares are technically contaminated. More than 409 thousand hectares of land require reclamation and improvement.

To overcome the current situation, determining the balanced land use processes in the direction of optimizing the impact of anthropogenic factors on the qualitative state of land is required.

The issue of the balanced land use in the agrarian sector and its development in modern economic conditions was studied by many domestic and foreign scientists, among which are the following: V. Baranovskyi (Baranovskyi V.A. 2004), V. Budziak (Budziak V.M. 2008), T. Hardashuk (Hardashuk T.V.), Yu. Hubeni (Svatosh M., Hubeni Yu. 2008), O. Shubravska (Shubravska O. 2009), M. Andreoli, V. Tellarini. (Andreoli M., Tellarini V. 2000), D. Baldock (Baldock D. 2012), P. Matson, W. Parton, A. Power, M. Swift (Matson P.A., Parton W.J., Power A.G., Swift M.J. 1997), T. Read (Read T. 1997), P. Verburg, P. Schot, M. Dijst, A. Veldkamp (Verburg P.H., Schot P.P., Dijst M.J., Veldkamp A. 2004). However, the problem of assessing the impact of balanced fertilizer system on land use efficiency in terms of increasing crop yields is poorly investigated and requires thorough estimation.

Therefore, the purpose of this study is to assess the impact of the fertilizer system by the mineral and organic components on the yield of agricultural crops based on quality indicators of agricultural land.

In accordance with the set goal, the following tasks were defined:

- to study the main factors influencing balanced land use in the agrarian sector;
- to evaluate the influence of fertilizer system by mineral and organic components on yields of agricultural crops based on the quality indicators agricultural land.

Methods. The research was conducted using the dialectical method estimating the effect of economic laws and a systematic approach to the study of economic phenomena and processes in order to study the balanced land use; monographic method was used during the processing of scientific publications on the study for the essence of the "balanced land use" concept; economics and mathematics methods were applied to study the tightness of the relationship between the indicators of anthropogenic impact and yield of agricultural land; abstract-logical method was used at the theoretical generalizations and formulating conclusions.

Results. In our opinion, balanced land use in the agrarian sector should be interpreted as a system of land use, based on the principles of meeting the growing material needs of the population and the ecologically efficient use of land resources, in which anthropogenic load on land resources and the natural environment as a whole

does not exceed the self-restoration potential of agroecosystems and contributes to its reproduction.

The following components should be included in the general characteristics of balanced agricultural land use:

- 1) the integration of natural and production systems in the process of use, protection and reproduction of agricultural land;
- 2) comprehensive solution for economic, environmental and social tasks;
- 3) obligatory indemnification for the destruction of quality indicators of land;
- 4) the priority of preserving and improving the state of agroecosystems over the production need for one-time economic effects;
- 5) the limited intensification for the use of agricultural land in accordance with their qualitative characteristics and the ability to restore.

In general, in order to achieve a balanced land use system in the agrarian sector, we propose to take into account the following influencing factors:

- the quality of agricultural land and the possibility of their use for the cultivation of the particular crops;
- natural and climatic conditions in a certain territory;
- the level of anthropogenic pressure on agricultural land should be in line with the possibilities for self-restoration of natural ecosystems;
- balancing the use of chemical and organic components in agricultural land use;
- formation of an ecologically safe and economically efficient land use system;
- improving the competitiveness of modern land use through the use of the latest ecologically safe technologies and innovative developments;
- withdrawal of erosion-hazardous agricultural lands from intensive cultivation, preservation of degraded, unproductive and technogenically contaminated lands, reclamation of disturbed lands.

In the current economic conditions, the important role in balanced use of land resources belongs to the fertility of agricultural land that is crucial for achieving high performance indicators of land use. A system of fertilizing agricultural land, which involves the use of organic and mineral fertilizers, is of great importance for improving the land quality and reproduction of land-resource potential. These elements are crucial for improving crop yields and achieving a high level of economic efficiency in agricultural activities.

To assess the impact of nutrients introduced with mineral and organic fertilizers on crop yields, a factor analysis was applied. Since the largest amount of mineral fertilizers, which currently are defining the structure of the fertilizing system, was introduced per 1 ha of crop area in 2016 in Lviv, Volyn, Rivne, Ternopil, Ivano-Frankivsk, Chernihiv, Sumy, Khmelnytsky, Transcarpathian and Vinnitsa regions (120 to 163 kg of fertilizer nutrients), a factor analysis was conducted based on one of these regions, namely the Ternopil. The result of factor analysis is the transition from the set of output variables to a smaller number of new variables - factors. Using the analysis method for the main components, the minimum number of factors that give the largest contribution to the data

variance was defined. These factors are called the main components.

The statistics by the 2016 yield for the major crops and the supply of nutrients to the soil due to the use of organic and mineral fertilizers was used for the analysis.

After the analysis, 7 indicators were identified. The yield of main crops, in centners from 1 hectare, is a dependent variable y . The remaining 6 indicators are independent variables: x_1 and x_2 – the amount of nutrients added to the soil with organic fertilizers, N, P, K, respectively, kg/ha; x_3 and x_4 – the amount of nutrients added to the soil with mineral fertilizers, N, P, K, respectively, kg/ha.

It can be assumed that there are many causal relationships between these indicators that can give rise to the multicollinearity phenomenon. To avoid this, it is expedient to replace such a set of indicators with fewer uncorrelated indicators.

Table 1

Correlation matrix for the relationship between indicators *

Indicator	y	x_1	x_2	x_3	x_4	x_5	x_6
y	1	0.64	0.64	0.64	0.23	0.41	0.62
x_1		1	0.99	0.99	0.09	-0.1	-0.02
x_2			1	0.98	0.09	-0.1	-0.02
x_3				1	0.09	-0.1	-0.02
x_4					1	0.83	0.68
x_5						1	0.93
x_6							1

* Source: calculated by authors

As it can be seen from Table 1, the hypothesis of the existence of close interactions between the individual indicators affecting yields is confirmed. In particular, there is a close correlation between all the indicators for nutrients introduced with organic fertilizers, as well as among all the indicators for nutrients introduced with mineral fertilizers.

The next step in the study is to reduce the number of independent variables and to identify the main components explaining the causal mechanisms of increasing yields.

Factor analysis was carried out by the method of the main components, followed by the inversion of the found load matrix by the Varimax method. The package of Statistica 10 applications was used for statistic analysis.

Initial data before conducting a multivariate statistical analysis is preliminary reduced to standard conditions. In this case, the condition is that the number of observations (11 crops) is 2-3 times more than the number of independent variables (6 indicators). Based on 6 independent variables, the table of eigenvalues for the correlation matrix was calculated (Table 2).

Table 2

Own values and total component variances *

Component number	Own values	Share of total dispersion, %
1	3.02	50.37
2	2.62	43.70
3	0.32	5.37
4	0.03	0.56
5	0.00	0.00
6	0.00	0.00

**Source: calculated by authors*

As it can be seen from the Table 2, the first two components are obtained, which in aggregate account for 95.07% of the total dispersion for the output variables, indicating a high degree of factorization. In addition, the eigenvalues of these components are greater than 1, thus, the first two components can be attributed to the main ones.

For a visual confirmation for the correct selection of the main components, the criterion of "rocky collapse" was used. According to this criterion, there is a line close to the straight parallel to the abscissa, on the graph (Fig. 1) of the eigenvalues, beginning with the third component. It means that the first two components have the greatest impact on yields.

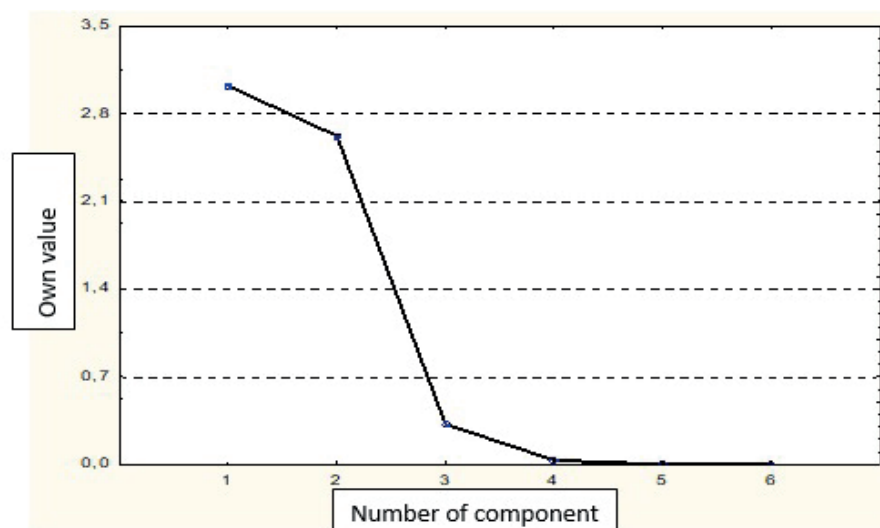


Fig. 1. Own values of the main components *

** Source: calculated by authors*

To interpret the first two main components, the matrix of factor load on the main components is presented (Table 3). Key component 1 includes indicators , , , and

component 2 includes indicators x_4, x_5, x_6 .

Table 3

Factor load on the main components *

Indicators	Load not reversed		Load back with the VariMax procedure	
	Component 1	Component 2	Component 1	Component 2
x_1	- 1	- 0.09	1	- 0.01
x_2	- 1	- 0.09	1	- 0.01
x_3	-1	- 0.09	1	- 0.01
x_4	- 0.01	- 0.9	0.1	0.89
x_5	0.19	- 0.97	- 0.09	0.98
x_6	0.11	- 0.93	- 0.02	0.93
Share of total dispersion, %	0.5	0.44	0.5	0.44

* Source: calculated by authors

Comparing factor loads, the following conclusions can be drawn:

- the first component is closely related to all the indicators characterizing the amount of introduced N, P, K in the soil with organic fertilizers;
- the second component has the closest connection with all the indicators characterizing the amount of introduced N, P, K in the soil with mineral fertilizers.

After reducing the dimension and obtaining two main components, the correlation analysis for the dependent variable of the main crops productivity with the obtained factors was conducted (Table 4). The correlation coefficient between the yield and the first component has high and positive value - 0.63, which indicates a significant degree of influence for N, P, K in organic fertilizer applied in the soil on the yield of crops.

Table 4

Correlation between the dependent variable and the main components*

Name	Crop yield	Component 1	Component 2
Crop yield	1	0.00	0.63
Component 1		1	0.45
Component 2			1

*Source: calculated by authors

To estimate the dependence for the yield of certain types of agricultural crops on the nutrients introduced into the soil with organic and mineral fertilizers, econometric models, which are given in Table 5, were constructed.

As it can be seen from the results of the simulation, all coefficients in the variable are positive, indicating the positive impact of the mineral fertilizers introduction on the yield of crops. Coefficients in the variable for models have different signs indicating

the positive and negative effects of applying organic fertilizers to certain crops. This situation can be the result of the imbalance in the fertilizer system by the organic and mineral components and the lack of nutrient input through organic fertilizers, which reduces the effect of their use.

Table 5

Dependence of crop yields on the inputs of soil nutrients with organic and mineral fertilizers *

Types of crops	Regression equation, x_1 - nutrients from organic fertilizers, kg/ha, x_2 - nutrients from mineral fertilizers, kg/ha
Cereals and legumes	$y = 26,99 - 4,93x_1 + 0,2x_2$
Winter wheat	$y = 21,11 - 2,17x_1 + 0,18x_2$
Corn	$y = 1,34 + 0,4x_1 + 0,47x_2$
Potato	$y = 174,56 - 6,78x_1 + 0,17x_2$
Vegetables	$y = 130,19 + 0,01x_1 + 0,47x_2$
Fodder corn	$y = 165,52 + 0,4x_1 + 1,07x_2$
Cultivated forag herbs	$y = 55,02 + 0,1x_1 + 0,14x_2$

*Source: calculated by authors

Thus, the priorities in the work of agrarian units to improve yields should be primarily to increase the use of organic elements in the fertilization of crops, which form the very first component. As a result, agricultural producers will be able to achieve significantly better crop yields and a synergistic integrated effect from the use of a balanced fertilizer system.

Conclusions. Thus, a promising direction in improving the efficiency of land-resource potential use is the further balancing in the use of mineral and organic fertilizers for fertilizing crops, which will increase the economic and ecological efficiency of land use. That is, the further development of the agrarian sector should be focused on increasing the use of organic elements to improve the yield of crops.

The result of balancing the fertilizer system is also the improvement of the environment due to the optimization in the use of chemical elements to improve the quality characteristics of the land. It will also help to further balance the land use system and improve the quality characteristics of agricultural products.

In the long run, the balance of the fertilization system for agricultural land and land use, in general, will become one of the prerequisites for improving the ecological state of land, addressing the problems of rational use of land-resource potential and improving the well-being of citizens living in rural areas.

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