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## Economic effectiveness of use of liquid organic fertilizers

**Scientific problem.** The problem of effective use of fertilizers has always been relevant and acquires special significance in terms of transformation of land relations, one of which is the disparity in prices. Due to the sharp increase in prices of mineral fertilizers in Ukraine in 2013–2015 (According to Ministry of Agrarian Policy and Food of Ukraine during 2013–2015 prices increased: for nitrogen fertilizers – from 3420 to 11502 UAH/t (more than 3.4 times) potash from 2600 to 5300 UAH/t (more than 2 times) and complex (Superagro) – 4200 to 10000 UAH /t (more than 2.4 times) the problem of rational use of fertilizers in agricultural enterprises is even more important and requires proper attention [1, p. 29]. Under these conditions the favorable alternative to expensive fertilizers can be organic fertilizers, including liquid manure of pigs, especially since the pig industry compared to other livestock sectors is developing dynamically.

**Analysis of recent researches and publications** shows that I. M. Bohdevych [2], A. M. Moskalenko [3], O. V. Sendetska [4], O. V. Khodakivska [5], E. Enujeke [6], T. Leah, N. Leah [7], K. Leibold, T. Olsen [8], R. Massey [9], M. Schmitt, G. Rehm [10] pay attention the issue of the effectiveness of organic fertilizers. At the same time the economic aspects of the efficacy of pig liquid organic fertilizer application are not investigated, so it has become the object of study.

**The objective of the article** – to determine prognosis (approximate) indicators of economic efficiency (cost savings) of the use of liquid organic fertilizers of pig production on the example of crops such as corn, winter wheat.

### Statement of the main results of the study.

Research results show some differences in the potential economic efficacy of using organic fertilizer samples from different investigated pig farms, primarily due to varying their agronomic value. According to the economic department of the studied enterprise, the cost of organic fertilizers as of September 2015, depending on the farm ranges from 5 UAH/m<sup>3</sup> to 7.5 UAH/m<sup>3</sup>. The cost price of organic fertilizers depending on the form and method of making ranges from 8 UAH/m<sup>3</sup> to 18 UAH/m<sup>3</sup>. Thus, the cost (including the cost to application) of organic fertilizers depending on the farm and a way of application varies from 13 UAH/m<sup>3</sup> to 25.5 UAH/m<sup>3</sup>.

Given that the weight of 1 m<sup>3</sup> of liquid manure is 950 kg [11, p. 122], the cost of organic fertilizers depending on farm varies from 5.27 UAH/t to 7.90 UAH/t. Accordingly, the cost of organic fertilizers and farm depending on the method of introduction ranges from 8.42 UAH/t to 18.95 UAH/t. Consequently, the cost (including the cost to make) of organic fertilizers depending on the method of ranges from 13.69 UAH/t to 26.85 UAH/t. In the future, for the calculating by the variant approach by the optimistic variant it is taken the manure costs 13.69 UAH/t, and by the pessimistic version – 26.85 UAH/t.

The calculations show that the cost of 1 kg NPK (taking into account the costs of entering with the full assignment of all expenditures for nutrients, ie without subtracting costs of organic matter) contained in the samples of organic fertilizers from different farms varies according to the pessimistic version 4.13 UAH to 8.95 UAH, and the optimistic variant – from 2.11 UAH to 4.56 UAH (Table 1, 2). Thus, the sample from farm number 1 has the lowest estimated cost of 1 kg of NPK, and its highest level is observed in a sample from farm number 6.

## 1. Indicators of nutrient content and its cost in the samples of organic fertilizers from farms on fattening and growing pigs

Indicators	The actual content in the samples from			
	farms on fattening			farms on growing
	1	3	8	2
Content in 1 t dry matter, kg: nitrogen	3.6	3.6	2.8	2.0
phosphorus	0.3	0.3	0.3	0.5
potassium	2.6	2.4	1.6	1.3
NPK	6.5	6.3	4.7	3.8
organic matter	10.2	11.4	7.8	6.0
Pessimistic option				
The cost of 1 kg of NPK, UAH	4.13	4.26	5.71	7.07
incl.: without cost on application	1.22	1.25	1.68	2.08
Optimistic option				
The cost of 1 kg of NPK, UAH	2.11	2.17	2.91	3.60
incl.: without cost on application	0.81	0.84	1.12	1.39

Source: Author's calculations.

Calculations showed because of the lower fertilizing reclamation value the samples of fertilizers from farms-reproducers and farms on growing because they contain very few solid, content of nutrients and organic matter is low, have a higher cost of nutrients than from farms on fattening and economic efficiency of their use is lower.

By calculating the cost of nutrition elements, containing manure, from total costs to subtract the cost of organic matter of 25 %, which makes sense, according to E. V. Skrylnyk and

other scientists [12], the cost of 1 kg NPK is lower in a percentage.

Thus, on the basis of these data, we can make a preliminary conclusion about higher economic efficiency of organic fertilizer usage pig farm than mineral fertilizers because the value of their nutrients are lower than the cost of nutrient fertilizers, which depending on the brand of fertilizers and supplier during January–September 2015 ranged from 18.70 to 33.83 UAH/kg [13], that was 4.5–8.2 times more than this cost.

## 2. Indicators of nutrient its content and cost in the samples of organic fertilizers from farms–reproducers of pig farm

Indicators	The actual content in samples from farm-reproducers			
	4	5	6	7
Content in 1 t of dry matter, kg: nitrogen	2.8	2.8	1.1	1.7
phosphorus	0.3	0.0	0.8	0.1
potassium	1.6	1.3	1.1	1.4
NPK	4.7	4.1	3.0	3.2
organic matter	5.1	4.4	4.5	4.2
Pessimistic option				
The cost of 1 kg of NPK, UAH	5.71	6.55	8.95	8.39
incl.: without cost on application	1.68	1.93	2.63	2.47
Optimistic option				
The cost of 1 kg of NPK, UAH	2.91	3.34	4.56	4.28
incl.: without cost on application	1.12	1.29	1.76	1.65

Source: Author's calculations.

For specific comparative evaluation of the economic efficiency of the use of organic fertilizers with mineral ones as the object of comparison it was chosen one of the most concentrated, nitrogen-phosphorus-potassium fertilizers – Nitroamofoska (N<sub>16</sub>P<sub>16</sub>K<sub>16</sub>), the wholesale price of which as of 01.10.2015 was in the

range 9000–10550 UAH/t. To calculate the price it was taken the cost 9000 UAH/t that is the price of 1 kg of NPK was 18.75 UAH, the cost of application was accepted at a rate of 1350 UAH/t, which together with the cost of fertilizers does not exceed the upper limit of the market price of Nitroamofoska. Using cash-

equivalent method it was defined benchmarks of economic efficiency (cost savings) the use of organic fertilizers of pig production compared

with Nitroamofoska (Table 3), which show substantial economic advantages of manure over mineral fertilizer.

### 3. Prognostic indicators of the economic effectiveness of use of organic fertilizers pig compared to Nitroamofoska (N<sub>16</sub>P<sub>16</sub>K<sub>16</sub>)

Sample number	The market cost of organic fertilizers (by the contents of NPK), UAH/t	Economic benefit (cost savings) from using organic fertilizers instead of Nitroamofoska, UAH			
		Pessimistic option		Optimistic option	
		per 1 kg of NPK	per 1 ton of organic fertilizer	per 1 kg of NPK	per 1 ton of organic fertilizer
1	140.14	17.43	113.30	19.45	126.43
2	81.93	14.49	55.06	17.96	68.25
3	135.83	17.30	108.99	19.39	122.16
4	101.33	15.85	74.50	18.65	87.66
5	88.40	15.01	61.54	18.22	74.70
6	64.68	12.61	37.83	17.00	51.00
7	68.99	13.17	42.14	17.28	55.30
8	101.33	15.85	74.50	18.65	87.66

Source: Author's calculations.

Thus, the economic benefit (cost savings or substitution effect) from the use of organic fertilizers instead of Nitroamofoska in different farms varies according to the pessimistic variant from 12.61 UAH/kg of NPK to 17.43 UAH/kg of NPK, or from 37.83 UAH to 113.30 UAH per 1 t of organic fertilizer and to the optimistic variant – from 17.00 UAH/kg of NPK to 19.45 UAH/kg of NPK, or from 51.00 UAH to 126.43 UAH per 1 t of organic fertilizer. Thus, the use of organic fertilizers of pig farm saves significant costs compared with the use of Nitroamofoska, so the cost is reasonable.

For comparative analysis it is defined the economic efficiency of organic and mineral fertilizers usage on certain crops, based on the assumption that nutrients containing these fertilizers, make equal impact on yields. For this it is used a formula for determining the need for nutrients (NPK) on the planned increase in yield, which has the form [14, p. 190]:

$$d = \sqrt[n_i]{y \div m_j}, \quad (1)$$

where  $d$  – dose NPK, kg active substance;

$y$  – increase in yield, c/ha;

$n_i$  – the estimated rate of recoupment of fertilizers on  $i$ -type of soil;

$m_j$  – the estimated ratio of recoupment of fertilizers by the increments of  $j$ -culture on  $i$ -type of soil.

In our case research was performed using crops such as maize and winter wheat under their cultivation in the area of Forest-Steppe.

To achieve yields of winter wheat at 50 c/ha the need of nutrients was determined by the formula:

$$d_{win.wheat} = 0.7484 \sqrt[y \div 0.4369]{}, \quad (2)$$

where  $d$  – dose of NPK, kg active substance;

$y$  – increase in yield, c/ha;

$n_i$  – the estimated rate of recoupment of fertilizers on chernozem typical – 0.7484;

$m_j$  – the estimated ratio of recoupment of fertilizers by increments of winter wheat on chernozem typical – 0.4369.

Given that the natural yield of winter wheat in the Forest-Steppe zone is 26 c/ha, the increase will be 24 c/ha [50 – 26 = 24 c/ha]. To ensure the growth of winter wheat yield in the amount of 24 c/ha it is necessary to make 211 kg active substance/ha:

$$d_{win.wheat} = 0.7484 \sqrt[24 \div 0.4369]{211} = 211 \quad (3)$$

To obtain corn yield, for example 70 c/ha, the need for NPK was defined by the formula:

$$d_{corn} = 0.7278 \sqrt[40 \div 0.6872]{266} = 266 \quad (4)$$

Considering the natural yield of corn in the Forest-Steppe zone is 30 c/ha, the increase will amount to 40 c/ha [70 – 30 = 40 c/ha]. Thus, to ensure the growth of corn yield of 40 c/ha there is the need to make 266 kg active substance per 1 ha of cultivated area.

Given that the optimum ratio N : P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O for winter wheat is respectively 1.0 : 0.9 : 0.8, and for corn – 1.0 : 0.9 : 0.9 [11, p. 174], let's

determine the need for nutrition element, first by calculating the sum of the coefficients ( $1.0 + 0.9 + 0.8 = 2.7$  – for winter wheat and  $1.0 + 0.9 + 0.9 = 2.8$  – for corn) and the price of each factor in the elements of nutrition ( $211 : 2.7 = 78$  kg/ha for winter wheat and  $266 : 2.8 = 95$  kg/ha for corn). The norms of nutrition elements are: winter wheat – N –  $78 \cdot 1.0 = 78$  kg/ha;  $P_2O_5$  –  $78 \cdot 0.9 = 70$  kg/ha;  $K_2O$  –  $78 \cdot 0.8 = 63$  kg/ha, while for corn – N –  $95 \cdot 1.0 = 95$  kg/ha;  $P_2O_5$  –  $95 \cdot 0.9 = 85.5$  kg/ha;  $K_2O$  –  $95 \cdot 0.9 = 85.5$  kg/ha.

As we know, the norms of application of liquid manure under agricultural crops are determined by the content of nitrogen. The high-

est norms of organic nitrogen depend on the size distribution of soil: heavy and medium loamy – 250 kg/ha light loamy – 230, loamy and sandy – 200 kg/ha [11, p. 125]. By calculating standards of organic fertilizers it should be noted that according to the Helsinki Commission Recommendations upper limit of manure is set in equivalent to 170 kg/ha nitrogen per year [15]. Calculated higher application rate of nitrogen in winter wheat and corn for grain do not exceed the specified limit restrictions, but due to different content of the nutrition in the samples of organic fertilizers the norm of their application varies significantly (Table 4).

#### 4. Prognostic indicators of the economic effectiveness of use of organic fertilizers of pig farm compared to Nitroamofoska (N16P16K16) on the example of winter wheat and corn

Sample number	The dose of organic fertilizers t/ha		The costs for application of certain standards of organic fertilizers, UAH/ha				Economic benefit (cost savings) of using organic fertilizers instead of Nitroamofoska, UAH/ha			
			Pessimistic variant		Optimistic variant		Pessimistic variant		Optimistic variant	
	Winter wheat	Corn for grain	Winter wheat	Corn for grain	Winter wheat	Corn for grain	Winter wheat	Corn for grain	Winter wheat	Corn for grain
1	21.7	26.4	583	709	297	361	3967	5026	4252	5374
2	39.0	47.5	1047	1275	534	650	3502	4460	4015	5085
3	21.7	26.4	583	709	297	361	3967	5026	4252	5374
4	27.9	33.9	749	910	382	464	3800	4825	4167	5271
5	27.9	33.9	749	910	382	464	3800	4825	4167	5271
6	70.9	86.4	1904	2320	971	1183	2645	3415	3579	4552
7	45.9	55.9	1232	1501	628	765	3317	4234	3921	4970
8	27.9	33.9	749	910	382	464	3800	4825	4167	5271

Source: Author's calculations.

Thus, to obtain the planned yields of winter wheat at 50 c/ha dose of organic fertilizers is in the range 21,7–70,9 t/ha, or in value terms: by the pessimistic variant – 583–1904 UAH/ha, by the optimistic variant – 297–971 UAH/ha and for corn – accordingly 26,4–86,4 t/ha, in value terms it is: by the pessimistic variant – 709–2320 UAH/ha, by the optimistic variant – 361–1183 UAH/ha. However, if these crops' need in the nutrition elements is filled with NPK fertilizer application, the cost in this case will be greater, namely for winter wheat – 4549 UAH/ha, for corn – 5735 UAH/ha. Therefore, the estimated economic impact (cost savings) from using organic fertilizers instead of Nitroamofoska for winter wheat by the pessimistic variant is from 2645 UAH/ha to 3967 UAH/ha, and by the optimistic variant – from 3579 UAH/ha to

4252 UAH/ha; for corn: the pessimistic variant – from 3415 UAH/ha to 5026 UAH/ha, and by the optimistic variant – from 4552 UAH/ha to 5374 UAH/ha. Consequently, the use of organic fertilizers of pig farm is economically justified because it allows saving significant costs compared to using Nitroamofoska.

It should be noted that certain economic benefit is conditional, as the content of other nutrients, particularly phosphorus and potassium in the samples of organic fertilizers significantly varies (and in some cases, such as in a sample number 5 phosphorus is not available), and probably that nutrition factor, which is in the minimum, will affect yields. Therefore, one way to address this issue could be an additional application, in addition to organic fertilizers also mineral fertilizers or mixed application.

For example, in Germany the mixes (liquid manure with addition of certain elements of nutrition according to developed recipes) are widespread. The dose of their application is – 40 m<sup>3</sup>/ha [11, p. 125].

Given this it was made calculation of indicators for targeted economic efficiency of the organic fertilizer usage of pig farm compared with Nitroamofoska (N16P16K16) on the example of studied cultures considering cover of the deficit PK through insufficient content of nutrition elements by taking away correspond-

ing amount of mineral fertilizers (Table 5). Estimated economic impact (cost savings) in this case for winter wheat is by the pessimistic variant from 1715 UAH/ha to 2456 UAH/ha, and by the optimistic variant – from 2082 UAH/ha to 3615 UAH/ha; for corn: by the pessimistic version from 2088 UAH/ha to 3268 UAH/ha, and by the optimistic variant – from 2534 UAH/ha to 4405 UAH/ha. As we expected, the economic impact in this case was 1.5–2 times lower than in the previous case, but it is more objective and likely.

### 5. Prognostic indicators of the economic effectiveness of use of organic fertilizers usage of pig farm compared to Nitroamofoska (N16P16K16) on the example of winter wheat and corn considering cover of PK deficiency

Sample number	PK will come from adding organic fertilizers, kg/ha		PK deficiency, that will come with organic fertilizers, compared to norm (winter wheat – 133 kg/ha, corn – 171 kg/ha)				Economic benefit (cost savings) from using organic fertilizers instead of Nitroamofoska considering cover of the PK deficit, UAH/ha			
			Deficiency of PK, kg/ha		PK deficiency cost, UAH/ha		Pessimistic variant		Optimistic variant	
	Winter wheat	Corn for grain	Winter wheat	Corn for grain	Winter wheat	Corn for grain	Winter wheat	Corn for grain	Winter wheat	Corn for grain
1	62.9	76.6	70.1	94.4	1511	2036	2456	2990	2741	3337
2	70.2	85.5	62.8	85.5	1354	1843	2148	2616	2661	3241
3	58.6	71.3	74.4	99.7	1604	2150	2362	2876	2648	3224
4	53.0	64.4	80.0	106.6	1725	2298	2075	2527	2443	2973
5	36.3	44.1	96.7	126.9	2085	2737	1715	2088	2082	2534
6	134.7	164.2	-1.7	6.8	-37	147	2682	3268	3615	4405
7	68.9	83.9	64.2	87.2	1383	1879	1934	2355	2538	3091
8	53.0	64.4	80.0	106.6	1725	2298	2075	2527	2443	2973

Source: Author's calculations.

Thus, the calculation results strongly suggest that the use of organic fertilizers of pig farm from the economic point of view is more effective than the use of NPK fertilizer as it allows saving significant financial resources.

**Conclusions.** The study determined the forecast (approximate) indicators of economic efficiency (cost savings) of applying liquid organic fertilizers of pig farm on example of crops such as maize and winter wheat, which proved their economic advantages over mineral fertilizers (Nitroamofoska N16P16K16). It is defined higher economic efficiency of organic fertilizer application of pig farm than mineral fertilizers because the cost of their nutrients is lower than the cost of the nutrient of fertilizers, which, depending on the brand of fertilizer and supplier in January-September 2015 ranged from 18.70 to 33.83 UAH/kg, that was 4.5–8.2 times more than the NPK prime cost in or-

ganic fertilizers. Economic benefit (cost savings or substitution effect) from the use of organic fertilizers from different farms instead of Nitroamofoska varies according to the pessimistic variant from 12.61 UAH/kg NPK to 17.43 UAH/kg NPK, or from 37.83 UAH to 113.30 UAH per 1 t of organic fertilizer and to the optimistic variant – from 17.00 UAH/kg NPK to 19.45 UAH/kg NPK, or from 51.00 UAH to 126.43 UAH per 1 ton of organic fertilizer. Estimated economic efficiency (cost savings) from the use of organic fertilizers as compared to Nitroamofoska for winter wheat is by the pessimistic version 1715 UAH/ha to 2456 UAH/ha, and by the optimistic variant – from 2082 UAH/ha to 3615 UAH/ha; for corn: by the pessimistic variant 2088 UAH/ha to 3268 UAH/ha, and by the optimistic variant – from 2534 UAH/ha to 4405 UAH/ha.

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## Аналітична оцінка виробництва кормів в аграрних формуваннях Вінниччини

**Постановка проблеми.** Відродження і розвиток тваринництва в державі неможливі без належної кормової бази, яка на 60% формує продуктивність тварин. Найважливішою передумовою розвитку тваринництва в аграрних формуваннях різних форм власно-

сті є створення в кожному з них міцної кормової бази. Від цього безпосередньо залежать можливості збільшення поголів'я худоби та підвищення її продуктивності, а це в свою чергу визначає темпи зростання й рівень виробництва продукції тваринництва [6, с. 73-75].

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