Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE EVOLUTION ANALYSIS OF THE EXPENDITURES WITH THE AGRICULTURAL LAND FERTILIZATION, BY ECONOMIC SIZE CLASSES IN THE EU27 AND IN ROMANIA, DURING THE PERIOD 2007-2022

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Abstract

Agricultural land fertilization expenditure has evolved significantly in the European Union (EU27) and in Romania, reflecting economic, technological and regulatory changes in the agricultural sector. Differences in fertilization expenditures, depending on the economic size of farms, are particularly relevant in the analysis of expenditures and profitability in agriculture. The methods and indicators used allow a comprehensive assessment of the performance of agriculture in Romania in relation to the EU27 average. By using these methods, not only general trends can be identified, but also specific aspects that require improvement, such as economic efficiency, agricultural productivity and resource use. The indicators provided are relevant for both short-term and long-term analysis, thus facilitating better strategic planning for the development of the agricultural sector. The analysis of the evolution of expenditure on the fertilization of agricultural land by classes of economic size in the EU27 and in Romania highlights a trend of increasing expenditure, influenced by multiple variables, including the economic size of farms, access to technology, and agricultural policies. To ensure the sustainability and competitiveness of agriculture, it is essential to adopt measures to support small and medium-sized farms in accessing the resources and technologies needed to optimize fertilization expenditure.

Key words**:** *EU27, Romania, evolution, fertilization, expenditures chain, vegetable*

INTRODUCTION

The use of chemical fertilizers is a basic requirement of current agricultural technologies. When they are applied correctly, in relation to the characteristics of the soil, the requirements of the plants, correlated with the phase of vegetation and climatic conditions, they contribute to the continuous increase of productions until the genetic potential of the varieties and hybrids is reached. As natural resources are running out, it is up to a smart agriculture to ensure food security for all of humanity [5].

The economic dimension of fertilizers expenditures is an area that concern very much the farmers, the policymakers and the researchers, the expenditures are not just a matter of purchasing inputs, they are influenced by many factors such as raw material prices, government policies, market dynamics, environmental considerations. Understanding the economic implications of fertilizers expenditures are very important in developing strategies that contribute to agriculture profitability and sustainability [7].

Researchers have explored in various directions the evolution and the impact of the fertilizer's expenditures.

While fertilizers are necessary for achieving high productions, their associated expenditures can impose economic burdens that can be significant over time, especially if are not managed sustainably [11].

In Africa, a study on smallholder farms highlighted the challenges posed by high prices and the importance of the subsidies in affording fertilizers, and also underscores the significant role that government intervention play in mitigating the economic burden of fertilizers on farmers [10].

A cost-benefit analysis of fertilizers' use across different agricultural systems made by Morris et al. [6] illustrate that regional variation in fertilizers expenditures lead to disparities in the agricultural productivity and economic outcome, their analysis being very important for farmers to understand the decision-making processes regarding the use of fertilizers and the economic implications.

Heffer and Prud'homme (2018) analyze the global fertilizers' market with focus on how the price volatility impacts the agricultural costs and economic stability, emphasizing the farmers vulnerability to market fluctuations and the necessity for policies that stabilize the fertilizers 'prices in order to maintain the economic viability in agriculture [4].

In the context of EU27, large farms benefited from economies of scale, which allowed them to purchase fertilizers at more competitive prices and to optimize their use through advanced farming techniques. These farms are often better equipped with precision technologies, which help to reduce expenditures in the long term, even if the initial investments are higher [4]. In contrast, small and medium-sized farms had to allocate a larger proportion of their budget to the purchase of fertilizers, with limited access to such technologies and little financial support [6].

In Romania, the situation is similar, but with specific peculiarities. Small farms predominate and their access to resources and modern technologies is often limited. As a result, fertilization expenditures are a major challenge for smallholder farmers, who often have limited financial resources and limited access to credit and subsidies. In addition, regional variations and traditional farming practices play an important role in determining fertilization expenditure, with significant differences between agricultural regions of the country.

The evolution of these expenditures is also influenced by the EU's common agricultural policies, which have promoted the sustainable use of fertilizers and the reduction of their impact on the environment. These policies have stimulated the transition to greener agricultural practices, but have also created new economic challenges for farmers, especially those on small farms [2].

In the mandatory rules of 2023 from our country regarding the fertilization of lands and subsidized crops from the Payments and Intervention Agency for Agriculture – APIA it is specified that farmers submitting the single application for area payments must comply with several mandatory conditions involving both the use of a fertilizer application calendar, with periods of prohibitions, and fertilization with a limited amount of nitrogen [1].

In a previous scientific paper, Rădoi et.al [8] analyzed the evolution of expenditure with agricultural land fertilization by economic size classes in Romania during the period 2007-2021 and the conclusion that emerged from the analysis was that there are many variation among the years analyzed, a more homogeneous period was 2014-2021 for the higher expenditures class, meanwhile the inferior economic classes have increased expenditures per ha.

MATERIALS AND METHODS

In order to analyze the performance and the evolution of the agricultural sector in Romania in comparison with the UE27 average, many methods and key indicators were used, each of them having a specific role in evaluating different aspects of agriculture.

The analysis begun with the agricultural surfaces and the value of agricultural production by economic dimension classes, offering an image of the structure of agricultural land and its efficiency.

The Output/Input ratio reflects the economic efficiency of agricultural holdings, being calculated as a ratio between the revenues obtained (outputs) and production costs (inputs). A higher ratio indicates better economic efficiency.

Other indicators used: the NPK chemical fertilizers kg of active substance; expenditures with fertilizers per hectare (Euro/ha); the chemical fertilizer expenditures share in the inputs' total of in the agricultural holding; chemical fertilizers 'expenditures for 100 Euro vegetable production.

To find out the indicators' degree of dispersion over the analyzed period, we used the coefficient of variation:

Cvar(%) =(Standard deviation/Average)*100 .....(1)

The annual growth rate was used to determine the trend of the analyzed indicators, and it was calculated using the formula:

Growth rate (%)= ((geomean(analyzed period)-1)*100.....(2)

The significance of the difference between the calculated averages is given by the t-test which is used to determine whether the observed differences between Romania and the EU27 are large enough to be considered statistically significant, not just random. Its interpretation was for probabilities of 95%, 99% and 99.9% (t cal>t theoretical) [9].

By using these methods, not only general trends can be identified, but also specific aspects that require improvement, such as economic efficiency, agricultural productivity and resource use. The indicators provided are relevant for both short-term and long-term analysis, thus facilitating better strategic planning for the development of the agricultural sector.

All the indicators were calculated being structured on economic size classes, as follows:

First Class - (1) 2,000 - < 8,000 Euro
Second Class - (2) 8,000 - < 25,000 Euro
Third Class - (3) 25,000 - < 50,000 Euro
Fourth Class - (4) 50,000 - < 100,000 Euro
Fifth Class - (5) 100,000 - < 500,000 Euro
Sixth Class - (6) >= 500,000 Euro.

RESULTS AND DISCUSSIONS

1.Comparative analysis of the main technical-economic indicators of agricultural holdings, by economic size classes, at EU27 and Romania's level for the period 2007-2021

(a)*Comparative analysis of the physical size of agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021*

Table 1. The evolution of surfaces in agricultural holdings, in the EU27, by economic size classes for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	ha	ha	ha	ha	ha		ha	%	%
(1)	5.7	5.2	6.0	5.6	Mt	Mt	0.6	11.0	0.4
(2)	15.7	15.3	13.9	14.7	9.2	***	0.9	5.8	-0.9
(3)	35.8	29.4	27.2	30.2	15.4	***	3.3	10.8	-1.9
(4)	60.2	49.8	48.2	52.2	22.0	***	5.1	9.8	-1.6
(5)	105.3	97.6	98.0	99.6	47.4	***	3.8	3.9	-0.5
(6)	316.8	294.7	253.0	283.9	184.3	***	26.1	9.2	-1.6

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE025) Total Utilised Agricultural Area (ha) [3].

From Table 1, it is observed a slight increase in the agricultural areas related to small holdings (2,000 - <8,000 EURO), while the areas related to large holdings (>=500,000 EURO) decreased considerably. This suggests a trend towards land fragmentation or a decrease in land held by large holdings in the EU27.

Table 2. The evolution of agricultural areas in agricultural holdings, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	ha	ha	ha	ha	ha		ha	%	%
(1)	4.09	3.46	4.5	4.1	Mt	Mt	0.5	11.4	0.7
(2)	12.95	10.62	12.4	11.1	7.1	***	1.6	14.3	-0.3
(3)	48.2	39.89	33.8	39.6	35.5	***	8.2	20.8	-2.5
(4)	122.91	97.72	77.7	99.8	95.7	***	23.0	23.1	-3.2
(5)	444.64	328.06	285.3	350.5	346.4	***	70.8	20.2	-3.1
(6)	1,554.1	1241.1	1,139.5	1,302.8	1,298.7	***	147.2	11.3	-2.2

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE025) Total Utilised Agricultural Area (ha) [3].

These trends reflect internal restructuring, changes that occur in each country as an effect of the land governance and policies that favour or penalize different types of holdings.
The situation in Romania (Table 2) shows a significant reduction of agricultural areas in the large categories (>=100,000 Euro), indicating a possible restructuring of the agricultural sector, with a greater concentration of land in smaller holdings. This could reflect a deconcentrating in ownership of agricultural land and a loss of competitiveness of large holdings.

Table 3. The significance of the deviations of agricultural holdings areas, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	ha/expl	ha/expl	(+/-)ha/expl	%	
(1)	6	4	2	137.3	***
(2)	15	11	4	132.4	***
(3)	30	40	-9	76.2	***
(4)	52	100	-48	52.3	***
(5)	100	350	-251	28.4	***
(6)	284	1,303	-1,019	21.8	***

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE025) Total Utilised Agricultural Area (ha) [3].

In Table 3, the differences are analysed statistically, highlighting significant differences between the agricultural areas in the EU27 and Romania, especially in the categories of large holdings (>=100,000 Euro), in the EU-27 in class (5) is registered an average of 100 ha/ holding, meanwhile in Romania is an average of 350 ha/holding. For the class (6) the difference is even bigger, 284 ha/holding in the EU-27 compared to 1,303 ha/holding in Romania. These deviations indicate major structural differences between agriculture in Romania and that of the rest of the EU27, where Romania has larger areas in these classes, suggesting a deficit in the economic efficiency. This structure may be the result of different agronomic and economic histories as well as national policies.

(b)*Comparative analysis of vegetable agricultural productions in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021*

Table 4. The evolution of plant agricultural productions value, in the EU27, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	O/I	O/I		O/I	%	%
(1)	1,056	846	1,095	875	Mt	Mt	97.7	11.2	0.3
(2)	1,046	948.8	1,225	979	104	N	86.9	8.9	1.1
(3)	858	876.8	1,134	902	-77	N	98.3	10.9	2.0
(4)	830	913.11	1,192	924	21	N	115.4	12.5	2.6
(5)	1,117	1,193.55	1,408	1175	251	*	98.3	8.4	1.7
(6)	1,588	1,738.98	2,331	1795	620	**	214.6	12.0	2.8

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE136) Total crops output (€/ha) [3].

A constant increase in value of plant agricultural productions is observed (Table 4), after year 2014, especially in the high economic size classes (>=500,000 Euro), at the end of year 2021 the value for this class was 2,331 euro/ha. This indicates high efficiency and continuous optimization of agricultural production in large farms, thanks to advanced technologies and effective support policies. In contrast, Romania presents a much lower average for all classes and a more volatile agricultural vegetable production's value, even if the year 2021 presents a higher amount for all classes (Table 5). For example, the highest value is for class (1) with 1,134 euro/ha indicating lower efficiency and greater sensitivity to external factors (such as weather conditions or international markets). Volatility also indicates possible deficiencies in agricultural risk management.

Table 5. Evolution of value of plant agricultural productions, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha		€/ha	%	%
(1)	717	778	1,134	813	Mt		119.6	14.7	3.3
(2)	768	746	862	793	-20.3	***	68.0	8.6	0.8
(3)	566	651	868	679	-134.1	***	81.7	12.0	3.1
(4)	438	632	902	642	-171.0	***	112.3	17.5	5.3
(5)	467	692	1,025	688	-124.8	***	146.0	21.2	5.8
(6)	409	798	1,083	758	-55.2	***	159.9	21.1	7.2

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE136) Total crops output (€/ha) [3].

Table 6. The significance of the deviations of the value of agricultural production per hectare, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	€/ha	€/ha	€/ha	%	
(1)	875	813	62	107.6	N
(2)	979	793	187	123.5	***
(3)	902	679	223	132.9	***
(4)	924	642	281	143.8	***
(5)	1,175	688	486	170.7	***
(6)	1,795	758	1037	236.8	***

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE136) Total crops output (€/ha) [3].

Table 6 highlights the significant differences in productivity between the EU-27 and Romania, with the EU-27 having a clear advantage in all economic size classes. These deviations reflect a more efficient use of resources and a greater capacity to generate value per hectare in the EU-27. The differences could be explained by different access to technology, agricultural knowledge, soil quality and agricultural infrastructure.

(c)*The comparative analysis of the Outputs/Inputs (O/I) ratio, in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021*

Table 7. Evolution of the Outputs/Inputs (O/I) ratio in agricultural holdings, in the EU27, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	O/I	O/I	O/I	O/I	O/I		O/I	%	%
(1)	1.45	1.27	1.17	1.221	Mt	Mt	0.105	8.561	-1.521
(2)	1.35	1.22	1.35	1.257	0.036	N	0.047	3.716	0.000
(3)	1.24	1.13	1.25	1.165	-0.091	N	0.042	3.610	0.057
(4)	1.19	1.14	1.26	1.157	-0.009	N	0.046	4.011	0.409
(5)	1.16	1.11	1.2	1.129	-0.028	*	0.036	3.157	0.242
(6)	1.07	1.05	1.12	1.076	-0.053	**	0.038	3.492	0.327

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE132) Total output / Total input (ratio)[3].

At the level of the EU-27, the O/I ratio is relatively stable in the years' evolution and for classes with low variations (c%< 10%), indicating a consistent profitability and efficiency of agricultural holdings, especially in large holdings. The stability of this ratio suggests that EU27 farms are able to maintain a healthy balance between investments (Table 8). In Romania, the O/I ratio shows higher fluctuations (c% > 10%) and lower values, indicating reduced efficiency and variable profitability. However, there is an increase in this ratio in the medium and large categories, which could signal recent improvements in resource management and adaptation to agricultural markets. Table 8 shows significant differences between the economic efficiency of agricultural holdings in the EU27 and Romania, with Romania lagging behind the EU27. This gap is for sure an indicator of the need for investments in technology, agricultural management and other resources to increase the economic efficiency of farms in Romania.

Table 8. Evolution of the Outputs/Inputs (O/I) ratio in agricultural holdings, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	O/I	O/I	O/I	O/I	O/I		O/I	%	%
(1)	1.32	1.52	1.16	1.35	Mt	Mt	0.12	8.80	-0.92
(2)	0.97	1.72	1.31	1.478	0.128	N	0.21	13.94	2.17
(3)	1.02	1.6	1.37	1.430667	-0.04733	N	0.16	11.03	2.13
(4)	0.9	1.49	1.45	1.328	-0.10267	N	0.17	12.61	3.47
(5)	0.93	1.31	1.59	1.245333	-0.08267	N	0.17	13.81	3.91
(6)	0.89	1.28	1.52	1.306667	0.061333	N	0.31	23.80	3.90

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE132) Total output / Total input (ratio) [3].

Table 9. The significance of deviations in the Outputs/Inputs (O/I) ratio, by economic size class, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	O/I	O/I	O/I	%	
(1)	1.350	1.221	0.13	110.6	**
(2)	1.478	1.257	0.22	117.6	***
(3)	1.431	1.165	0.27	122.8	***
(4)	1.328	1.157	0.17	114.8	***
(5)	1.245	1.129	0.12	110.3	*
(6)	1.307	1.076	0.23	121.4	**

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE132) Total output / Total input (ratio) [3].

2.The comparative analysis of the main technical-economic indicators of the use of chemical fertilizers in agricultural farming, by economic size classes, at EU-27 and Romania's level for the period 2007-2021

(a)The comparative analysis of the quantities of chemical fertilizers used per hectare of agricultural land at the level of the EU27 and Romania for the period 2007-2021

In Romania, the doses of chemical fertilizers per hectare increased significantly between 2007 and 2021, from 42.4 kg s.a./ha in 2007 to 120.4 kg s.a./ha in 2021, with an average of years of 60.5 kg s.a./ha being much below the EU27 average of 118.6 kg s.a./ha (Table 10).

Table 10. Quantitative evolution of chemical fertilizer doses in the EU27 and Romania for the period 2007-2021

Area/MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	Kg sa/ha	Kg sa/ha	Kg sa/ha	Kg sa/ha	Kg sa/ha		Kg sa/ha	%	%
UE27	134.1	120.5	120.4	118.6	Mt	Mt	9.5	8.0	-0.8
Romania	42.4	49.1	102.6	60.5	-58.1	ΘΘΘ	17.8	29.3	6.5

Source: Own calculation based on data from FAOSTAT, 2023 [4].

It reflects an intensification of agriculture in Romania, although the use of fertilizers is still at a lower level, which is a result of financial accessibility or more traditional agricultural practices.

(b)The comparative analysis of expenditures per hectare of agricultural land with chemical fertilizers in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021

The analysis continues with tables regarding the chemical fertilizers expenditures evolution in agriculture, both at the level of the European Union (EU27) and in Romania, over a period of 14 years (2007-2021).

Table 11 shows that at the level of EU27 an overall increase in expenditure per hectare is observed from 2007 to 2021, with annual growth rates varying by economic size classes. Larger farms (>500,000 Euro) have significantly higher expenses in 2021 compared to small farms (2,000-8,000 euro).

Table 11. Evolution of expenditures per hectare of agricultural land with chemical fertilizers, at EU27 level, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Abat	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha		€/ha	%	%
(1)	64.7	78.2	99.3	77.5	Mt	Mt	8.5	10.9	3.1
(2)	72.3	91.8	98.3	86.3	8.8	*	7.2	8.4	2.2
(3)	75.6	101.9	111.9	95.5	18.0	**	9.8	10.3	2.8
(4)	84.6	111.7	116.6	103.3	25.7	***	9.3	9.0	2.3
(5)	102.6	145.5	141.8	132.4	54.8	***	13.2	10.0	2.3
(6)	111.9	162.3	172.4	151.4	73.9	***	16.8	11.1	3.1

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

For example, from 2007 when the expenditures/ha were 64.7 euro/ha increased until 2021 at 99.3 euro/ha for class 1, ad for higher classes sums 141.8 euro/ha (class 5) and 172.4 euro/ha (class 6).

Expenditures per hectare have increased in Romania in all categories, but the values are lower than the EU27 average (Table 12).

Table 12. Evolution of expenditures per hectare of agricultural land with chemical fertilizers, at the level of Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha		€/ha	%	%
(1)	43.52	64.74	98.90	67.2	Mt	Mt	15.1	22.5	6.03
(2)	42.63	64.88	90.53	66.1	-1.2	N	12.9	19.6	5.52
(3)	41.08	63.60	82.30	62.6	-4.6	N	11.2	18.0	5.08
(4)	64.53	70.61	84.36	69.0	1.7	N	10.6	15.4	1.93
(5)	50.57	83.62	103.41	81.2	13.9	N	15.0	18.5	5.24
(6)	49.89	100.43	108.01	90.6	23.4	*	16.1	17.7	5.67

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

For example, farms with small economic sizes in Romania had expenses of €90.5/ha in 2021, compared to €98.3/ha at the EU level, but the real difference is observed at higher economic classes, for class 5 in Romania the expenditures were 103,4 euro/ha, in EU27, 141.8 euro/ha, at class 6 108 euro/ha for Romania and 172.4 euro/ha for EU27.

Table 13. The significance of the deviations of chemical fertilizer expenditures per hectare of agricultural land, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	€/ha	€/ha	€/ha	%	
(1)	77.5	67.2	10.3	115.3	*
(2)	86.3	66.1	20.2	130.6	***
(3)	95.5	62.6	32.9	152.5	***
(4)	103.3	69.0	34.3	149.7	***
(5)	132.4	81.2	51.2	163.0	***
(6)	151.4	90.6	60.8	167.1	***

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

For small and medium farms (2,000 - 50,000 euro) the deviations are relatively small, which suggests that small farms in Romania have relatively similar costs to those in the EU27, probably due to a more homogeneous level of available resources and technologies.

For the higher economic dimension classes , the biggest deviations are observed here, indicating that large farms in Romania invest significantly less in fertilizers per hectare compared to those in the EU27, with a difference of up to 167.1% for class 6(>€500,000). This can be explained by differences in technology, access to financial resources, the excellent soil conditions, and perhaps a more efficient use of limited resources.

(c)Comparative analysis of the costs of chemical fertilization to obtain 100 Euro of plant production in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021

In EU27, expenditures ranged from an average of 8.93 euro /100 euro for small farms to 8.49 euro/100 euro for very large farms, with some significant variation over time (Table 14).

Table 14. Evolution of expenses with chemical fertilizers to obtain 100 Euro of plant production, at EU27 level, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/100€	€/100€	€/100€	€/100€	€/100€		€/100€	%	%
(1)	6.10	9.24	9.07	8.93	Mt	Mt	1.15	12.92	2.88
(2)	6.93	9.68	8.02	8.85	-0.08	N	0.80	9.08	1.05
(3)	8.82	11.62	9.86	10.62	1.69	**	0.85	8.00	0.80
(4)	10.18	12.23	9.79	11.27	2.33	**	1.11	9.82	-0.28
(5)	9.19	12.19	10.07	11.31	2.38	**	1.22	10.83	0.66
(6)	7.04	9.33	7.40	8.49	-0.45	N	0.92	10.85	0.35

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

It is interesting to see that the classes that range between 25,000 euro and 500,000 euro have an average between 10.62 euro/100 euro and 11.31 euro/100 euro production, so the smallest farms and the biggest one have the less investments/ more efficiency to produce the plant productions.

Table 15. Evolution of expenses with chemical fertilizers to obtain 100 Euro of plant production, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/100€	€/100€	€/100€	€/100€	€/100€		€/100€	%	%
(1)	6.04	8.31	8.72	8.3	Mt	Mt	1.2	15.0	2.66
(2)	5.60	8.66	8.98	8.2	0.0	N	1.4	16.6	3.43
(3)	7.25	9.76	9.48	9.2	1.0	N	1.3	14.3	1.93
(4)	14.74	11.18	9.35	10.8	2.6	**	1.5	13.8	-3.19
(5)	11.07	12.07	10.09	11.9	3.7	***	1.2	9.9	-0.66
(6)	12.52	12.58	9.98	12.2	3.9	***	1.6	12.8	-1.61

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

From Table 15, it can be seen that expenditures were generally lower than in the EU27 but with a similar upward trend.
So, the smallest amount can be observed at the classes 1 and 2, the highest at the larger farms, economic classes 5 and 6.
Averages range between 8.2 euro/100 euro plant production to 12.2 euro/100 euro plant production.
The year 2021 for classes 3 to 6 show a decrease in the expenditures compared to previous years.

Table 16. The significance of the deviations of the expenses with chemical fertilizers to obtain 100 Euro of vegetable production, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	€/100€	€/100€	€/ha	%	
(1)	8.9	8.3	0.7	108.2	N
(2)	8.9	8.2	0.6	107.6	N
(3)	10.6	9.2	1.4	115.2	**
(4)	11.3	10.8	0.4	104.2	N
(5)	11.3	11.9	-0.6	94.7	N
(6)	8.5	12.2	-3.7	69.7	ΘΘΘ

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

Comparing the expenditures/ 100 euro plant production, the deviations are moderate for small farms, but increase significantly for large farms, indicating a more efficient cost in Romania at this level (Table 16).
Small farms: Moderate deviations indicate slightly higher efficiency in Romania in achieving plant production with the same fertilizer expenditures, suggesting that these farms manage to maximize production even with more limited resources.
Large farms: The deviations increase significantly for large farms, which shows that Romania has a higher efficiency in using fertilizers to generate production. This may indicate better management of resources and adaptation to specific conditions that allow comparable or superior returns to be obtained with lower investment.
(d)Comparative analysis of the share of expenditures with chemical fertilization in the total inputs in agricultural holdings by classes

of economic size in the EU27 and Romania for the period 2007-2021

The share of expenditure at the level of EU27 increased slightly across all categories, with larger variations in small and medium-sized farms (Table 17).

Table 17. The evolution of the share of chemical fertilizer expenditures in the total inputs at the farm level, in the EU27, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	%	%	%	%	%		%	%	%
(1)	5.94	7.54	8.22	7.32	Mt	Mt	0.63	8.67	2.35
(2)	6.63	8.69	8.80	8.31	1.00	**	0.64	7.75	2.05
(3)	6.63	8.69	8.80	8.31	1.00	**	0.64	7.75	2.05
(4)	6.78	7.87	8.30	7.77	0.45	N	0.43	5.56	1.46
(5)	5.40	6.81	6.62	6.58	-0.73	*	0.51	7.76	1.46
(6)	3.70	4.58	3.87	4.22	-3.09	**	0.41	9.65	0.32

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

At first economic class the share increased from 5.94% in 2007 to 8.22% in 2021, the next 2 classes have a share of 8.8% in the same year and the smallest share has the upper economic dimension class, 3.87% in year 2021.

Table 18. Evolution of the share of chemical fertilizer expenditures in the total inputs at the farm level, in Romania, by economic size classes, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	%	%	%	%	%		%	%	%
(1)	3.65	5.98	6.36	5.7	Mt	Mt	0.9	16.2	4.06
(2)	1.82	7.15	7.34	6.3	0.6	N	1.3	20.7	10.47
(3)	1.55	9.26	7.52	7.4	1.7	*	1.9	25.5	11.97
(4)	5.02	11.95	9.44	10.0	4.3	***	2.0	19.7	4.62
(5)	5.83	14.21	14.35	12.8	7.0	***	2.5	19.3	6.64
(6)	4.57	12.59	12.48	9.8	4.0	**	2.9	29.8	7.45

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

In Romania significant increases in the share of chemical fertilizer expenditure are observed, especially on medium and large farms (Table 18).

If for the lower economic classes, the shares in year 2021 are between 6.36% and 7.52%, for the medium size classes are at 9.44%, increases for class 5 at 14.35% and 12.48% for class 6.

The deviations are high for small and medium farms, indicating a difference in cost structure and fertilizer use between the EU27 and Romania (Table 19).

Small farms: The large deviations for small and medium farms suggest that, in Romania, fertilizers have a lower share of total inputs compared to the EU27.

This could reflect a lower reliance on or access to fertilizers compared to other inputs (eg manual labor or other technologies).

Large farms: For large farms, deviations indicate a significantly lower share of fertilizer expenditure in Romania compared to the EU27.

Table 19. The significance of the deviations of the chemical fertilizer expenditures shares in the total farm inputs, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	%	%	%	%	
(1)	7.32	5.73	1.58	127.58	***
(2)	8.31	6.30	2.01	131.91	***
(3)	8.31	7.39	0.92	112.48	N
(4)	7.77	9.99	-2.22	77.80	ΘΘΘ
(5)	6.58	12.75	-6.17	51.62	ΘΘΘ
(6)	4.22	9.77	-5.55	43.21	ΘΘΘ

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

This may suggest that large farms in Romania are able to use other inputs or technologies that offset the need for intensive fertilizer use, or that access to fertilizers is more limited and

therefore resort to alternative strategies.

CONCLUSIONS

Agriculture in Romania and the EU27 experienced an increase in costs related to chemical fertilizers, reflecting changes in the agricultural sector and the impact of market factors. However, the relatively higher efficiency of Romanian farms in the use of these inputs suggests a capacity to adapt and optimize resources, even in the context of lower costs per hectare. The structural differences between Romania and the EU27 indicate opportunities to improve the economic performance of Romanian farms, especially regarding the adoption of technologies and practices that allow a more efficient use of fertilizers.

(1) Regarding the evolution of agricultural areas it is found that during the period 2007-2021, in the EU27 and Romania are different trends. In the EU27, small holdings have seen a slight increase, while large ones have decreased, suggesting a potential fragmentation of farmland. In Romania, this decrease is more pronounced for large holdings, indicating either a redistribution of land to smaller holdings, or a loss of competitiveness of the large ones. The agricultural structure in Romania is different, with a greater concentration of land in larger holdings. This may be the result of a tradition of extensive agriculture and national policies that favoured the formation of large holdings.

(2) Analysing the agricultural productivity showed that the value of agricultural crop production in Romania is significantly lower than in the EU27, with large deviations against Romania. This suggests that Romanian agriculture does not exploit the available resources as efficiently and produces a lower economic value per hectare. The differences can be attributed to limited access to modern technology, inefficient resource management and lack of investment in agricultural infrastructure.

Also, in Romania, agricultural production is more volatile, which indicates an increased sensitivity to external factors, such as climatic conditions and international markets. Volatility can also be a sign of less sophisticated farming practices and insufficient risk management.

(3) In terms of economic efficiency the Output/Input ratio (O/I) in Romania is lower and more fluctuating compared to the EU27, indicating a reduced economic efficiency of Romanian agricultural holdings. This suggests that Romanian farmers obtain less profit for each unit of resource invested, which is the result of inefficient practices, insufficient use of technology and high input costs.

Although the O/I ratio remains below the EU27 average, there is an upward trend in the medium and large economic size categories in Romania, which indicates possible improvements in resource management and adaptation to market conditions. This positive trend could be a signal of a gradual maturation of the Romanian agricultural sector.

(4) In the use of chemical fertilizers, Romania recorded a significant increase per hectare between 2007 and 2021, which suggests an intensification of agricultural practices. However, utilization remains below the EU27 average, which may indicate a historical underutilization of these resources or financial constraints preventing Romanian farmers from widely adopting modern agricultural technologies.

Although the expenditures on chemical fertilizers are lower in Romania than in the EU27, they have increased significantly, suggesting a gradual convergence towards European standards. This may reflect a gradual adaptation of Romanian farmers to the demands of the European market, but may also indicate additional financial pressures on them.

(5) The idea of convergence with the EU27 finds persistent differences. The significant differences between Romania and the EU27 in terms of agricultural areas, productivity, economic efficiency and resource use indicate that Romania is still in the process of aligning itself with European standards. These persistent differences underline the need for national policies to support the modernization of agriculture, increase competitiveness and improve rural infrastructure.

In order to reduce the gaps with the EU27 average, Romania must continue to invest in

agricultural technology, professional training for farmers and rural infrastructure. Investments should also focus on developing sustainable agricultural practices that maximize productivity without compromising natural resources in the long term.

(6) In the period 2007-2021, the expenditures per hectare with chemical fertilizers increased both at the EU27 level and in Romania. This trend reflects rising prices of agricultural inputs, as well as possible increased use of fertilizers to achieve higher yields. Expenditures per hectare in Romania are generally lower than the EU27 average. However, the percentage deviations show that the larger farms in Romania have a different cost structure compared to those in the EU27, with significantly lower expenditures per hectare.

(8) Expenditures for obtaining 100 Euro of crop production are lower in Romania than in the EU27, suggesting that, despite lower expenditure per hectare, Romanian farms may be more efficient in using fertilizers to achieve agricultural production.

(9) The share of expenditure on chemical fertilizers in total agricultural inputs has increased both in the EU27 and in Romania, indicating a growing dependence on these inputs for agricultural production. This may reflect both an intensification of agriculture and an adaptation to market conditions.

(10) The deviations between the EU27 and Romania in terms of the share of expenditure and costs per hectare suggest that there are structural differences in agriculture between the two regions. These are influenced by factors such as access to technologies, average farm size, and agricultural policies.

(11) The evolution of expenditures and their efficiency varies significantly depending on the economic size of the farms. Large farms, both in the EU27 and in Romania, generally have higher costs per hectare, but manage to maintain a relatively high level of efficiency in relation to the production obtained.

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