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THE USE OF CHEMICAL FERTILIZERS IN ROMANIA'S AGRICULTURE

Agatha POPESCU[1,2,3], Toma Adrian DINU[1], Elena STOIAN[1], Valentin ŞERBAN[1]

[1]University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Marasti Boulevard, District 1, 011464, Bucharest Romania, Phone: +40213182564, Fax: +40213182888, Email: agatha_popescu@yahoo.com
[2]Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu-Sisesti", 61 Marasti Blvd, District 1, 011464, Bucharest Romania, Email: agatha_popescu@yahoo.com
[3]Academy of the Romanian Scientists, 1 Ilfov Street, Bucharest, 030167, Romania, Email: agatha_popescu@yahoo.com

Corresponding author: agatha_popescu@yahoo.com

Abstract

The paper analyzed the evolution of the surfaces where chemical fertilizers were used, total consumption of fertilizers and the average consumption per surface unit in Romania and also by micro-region of development in order to establish the trends in the use of the fertilizers, and its concentration degree in terms of Herfindahl-Hirschman Index, (HHI), Gini-Struck Index (GSI) and Coefficient of Concentration (CC). The empirical data were collected from National Institute of Statistics for the period 2007-2020. Romania's mineral fertilizer consumption accounts for 5% of the EU total consumption, for which the country is ranked the 7th after France, Germany, Poland, Spain, United Kingdom and Italy. Compared to the EU mean of 77.2 kg Nitrogen fertilizer consumed per ha UAA in the year 2018, Romania applied less than 60 kg, a level which is far away from over 100 kg used by Belgium, Netherlands, Czechia and Denmark. In 2020, the average consumption of mineral fertilizer in Romania reached 98.16 kg/ha, which is still lower than in the Western EU countries. In the year 2020, the average consumption in Romania was exceeded, in the descending order, only by the West, Bucharest-Ilfov, North West and South West Oltenia regions. If in 2007, it was observed an uniform consumption of fertilizers among the eight micro-regions of Romania, in 2020, a slight moderate concentration was noticed in terms of HHI, GSI and CC. The regions with the highest share in mineral fertilizer consumption in Romania, in the decreasing order, are: West, South Muntenia, South West Oltenia, North East, South East and North West regions. The EU policy regarding the sustainable development of agriculture reducing the use of chemical fertilizers for protecting environment, biodiversity and ensuring food safety is welcome, but it has to be adapted to the actual average consumption and also taking into account the local needs of each country regarding the growth of productivity, farmers' income and profit.

Key words**:** *chemical fertilizers, consumption, dynamics, regional utilization, Romania*

INTRODUCTION

If the forecast for the globe population is 9.1 Billion inhabitants by 2050, then food production should grow by 70% as estimated by FAO [1].
As long as the globe has a limited agricultural area, farmers have to use modern technologies for producing more food to cover the population's needs.
Chemical fertilizers are a crucial farm input for increasing productivity in conventional agricultural system, but with a negative impact on environment. However, the role of chemical fertilizers must not be denied, because they are a source of nutrients for soil besides oxygen, hydrogen and water [11].
Plants need various nutrients along the growth phases in order to achieve quantitative and qualitative productions and expected productivity per surface unit. For this reason, in conventional agriculture there are used many types of chemical fertilizers, of which: the ones based on Nitrogen, Phosphorus and Potassium are of the highest importance, being followed by other fertilizers which have in their composition other minerals [9].
The Nitrogen-based fertilizer is the most used worldwide as it provides a good plant development, a high resistance to diseases and

pests, a high productivity per surface unit and products of good quality. A similar impact has the use of Phosphate and Potash, which multiply the Nitrogen effect in stimulating photosynthesis, plant metabolism, favouring the growth of roots, flowers, seeds, fruits, water movement into the plant and a high production level [4].

The highest amount of fertilizers is requested by cereals, especially wheat, maize, rice and also oilseed crops [2, 10, 13, 15, 25].

But, a high applied amount of fertilizer could affect soil and water quality due to the spread of minerals. Therefore, the use of chemical fertilizer has become a controversial topic nowadays, because it could increase pollution, affects biodiversity and even human health.

For this reason, the use of chemical fertilizer has to be kept under control, and conventional system of agriculture is more and more in competition with organic agriculture which is an "open door" for ensuring a healthier diet and maintaining life on the Earth.

Farmers have to become more conscious that the applied amount of fertilizer has to be optimized in accordance with the need of nutrients by plants and the reserve of nutrients existing in the soil. The dose of fertilizer per surface unit depends on large range of factors, such as: plant type, its requirements to grow, the reserve of minerals in the soil, the capacity of some plants to produce and fix Nitrogen, expected yield, applied technologies (crop variety and hybrids, soil tillage, forecrop etc), existence or lack of irrigation systems, climate factors etc. [14, 16].

At the global level, the consumption of chemical fertilizer per surface unit varies from a country to another, from zero to more than 200 kg, but the diminishing trend is imposed of the need to protect environment factors and human life [12].

Romania is a special case in among the EU member states due to its peculiarities regarding the huge number of agricultural holdings, small sized farms, low yields in general, and the dominant family farming.

Agricultural output achieved by Romania accounted for Euro 15,290 Million, of which 70.8% crop output [7].

This reflects that agriculture is an important branch of the economy which gives its contribution to GDP and ensure the internal market and export with food products of good quality. It also absorbs an important part of labour force, agriculture being the main occupation and income source for the population living in the rural areas [19, 22, 23].

The area of arable land and permanent crops is 9.9 million ha, but in the country there are also 4.9 million ha grasslands. The companies practicing conventional agriculture represent below 1% of the total number of farms, but they work about 46% agricultural land.

Main agricultural crops cultivated in Romania are cereals (maize, wheat, barley), oilseeds crops (sunflower, rape, soybean), vegetables (tomatoes, cucumbers egg plants), potatoes, grapes etc. [18, 20, 21].

A high amount of fertilizers is requested by wheat, maize, sunflower, soybean, vegetables etc. [3].

In this context, the purpose of the paper was to analyze the dynamics of the surfaces where chemical fertilizers were applied, total consumption of fertilizers and the average consumption per surface unit both at the national level and in the territory by micro-region of development in order to establish the trends in the use of the fertilizers, and in the concentration degree.

MATERIALS AND METHODS

This research claimed empirical data which have been collected from National Institute of Statistics, Tempo Online data base for the period 2007-2020.

The main indicators used to characterize the use of the chemical fertilizer were: the area on which fertilizers were applied, the total amount of used fertilizer, the quantity of fertilizer used per surface unit. The tendencies both at the national level and in the territory by micro-region were emphasized, and also were identified the areas where chemical fertilizers are used in the highest amount.

Polynomial equations were used to reflect the trend line of the indicators along the chronological series.

For assessing the degree of concentration of the use of fertilizers, there were determined the values of the well known concentration indices: Herfindahl-Hirschman Index, Gini-Struck Index and the Coefficient of Concentration.

Comparisons were made by region of development based on the absolute values of the indicators and also on their shares.

The processed data were synthetically presented in tables and the graphics allowed to illustrate the evolution of the chosen indicators.

At the end of the paper, there were exposed the main ideas resulting from this statistical research.

RESULTS AND DISCUSSIONS

The agricultural area where chemical fertilizers were applied in Romania increased by 17.11% after the country adhesion to the EU. If in 2007, 6,423 thousand ha were fertilized, in the year 2020, the surface reached 7,522 thousand ha, representing 51.5% of the 14.6 million ha agricultural area and 80.8% of the 9.39 million ha arable land (Fig. 1).

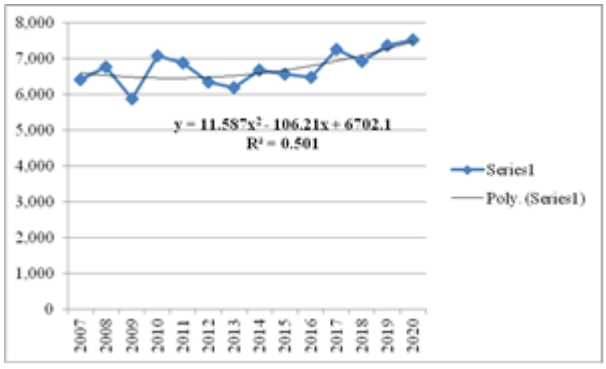

Fig. 1. Dynamics of the agricultural area where the chemical fertilizers were used in Romania, 2007-2020 (Thousand ha)
Source: Own calculation and design based on NIS data, 2021 [17].

The total amount of chemical fertilizer utilized in the country raised by 90.69% from 387 thousand tons active substance (a.s.) in the year 2007 to 738 thousand tons a.s. in the year 2020, reflecting the interest of the farmers to sustain yield performance (Fig. 2).

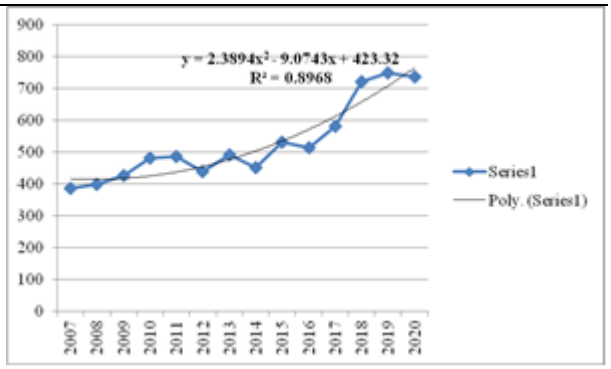

Fig. 2. Dynamics of the total amount of chemical fertilizers used in Romania, 2007-2020 (Thousand tons 100% active substance)
Source: Own calculation and design based on NIS data, 2021 [17].

The amount of chemical fertilizer utilized per ha also recorded an increase by +63.33% from 60 kg a.s./ha in 2007 to 98 ka a.s./ha in 2020. This was a consequence of the growth both in the area where the fertilizers were applied and the quantity used (Fig. 3).

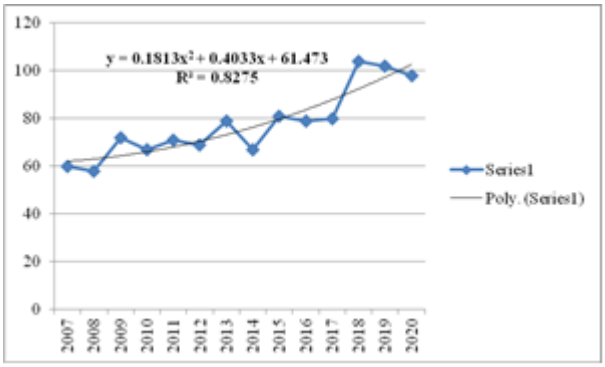

Fig. 3. Dynamics of the quantity chemical fertilizers applied per surface unit in Romania, 2007-2020 (kg a.s./ha)
Source: Own calculation and design based on NIS data, 2021 [17].

Among chemical fertilizers, the most important group used in Romania is based on NPK, of which Nitrogen-based one is consumed in the highest proportion because of the crop structure and expected yields.

In the year 2009, the EU average consumption of manufactured NPK fertilizers was 76 kg nutrients per ha UAA, of which 59 kg Nitrogen, 6 kg Phosphorus and 11 kg Potassium.

Romania had the lowest average consumption of NPK fertilizer accounting for 35 kg, of which 21 kg Nitrogen, 2 kg Phosphorus and 2 kg Potassium per ha UAA. Therefore, the

average consumption in Romania represented 46% of the EU mean [5].

In 2019, according to Eurostat, Romania consumed 456 thousand tons Nitrogen-based fertilizer, coming on the 6th position after France, Germany, United Kingdom, Spain and Poland [8].

In 2018, in the EU-28, it was consumed 10,1691 thousand tons Nitrogen fertilizer, of which France 21%, Germany 14.7%, Poland 11.5%, Spain 10.1%, United Kingdom 10.1%, Italy 5.2% and Romania 4.6%, the last coming on the 7th position.

The average N fertilizer consumption at the EU level was 77.2 kg/UAA, ranging between the lowest level reached in Romania, being below 60 kg/ha and the highest level of over 100 kg in Belgium, Netherlands, Czechia and Denmark. Therefore, Romania has a lower consumption of Nitrogen fertilizer per surface unit than the EU mean and if we compare the figures for the consumption practiced by the farmers from Belgium, Netherlands, Czechia and Denmark which apply over 100 kg/ha, we may affirm that Romania consume by 50% less N fertilizer than the top EU member states regarding this indicator [6].

Romania is also far away from the world average consumption of Nitrogen fertilizer which in the year 2018 accounted for about 200 kg/ha, and for this reason, the country is placed on the 105 position at the global level [24].

The use of chemical fertilizer in the territory of Romania by micro-region of development

Regarding the dispersion of the surfaces where chemical fertilizers are applied at the regional level, we may affirm that it is closely linked to soil fertility, crop structure, yield level, applied technologies, farms size, farmers' financial resources etc.

From an empirical point of view, in the year 2007, the largest surfaces chemically fertilized were in South Muntenia (19.3%), West (15.5%), North West (15.1%), North East (14.6%0, South East (13.1%) and South West Oltenia (12.9%), all these regions together summing 71.46% of the 6,422,910 ha where mineral fertilizers were utilized. The application of this sort of fertilizers but on smaller surfaces was practiced in the Central part of the country and in Bucharest-Ilfov area.

Table 1. Distribution of chemical fertilization in the territory of Romania by micro-regions of development, 2007-2020

	Fertilized surface (Thousand ha)		Amount of fertilizer used (Tons a.s)		Amount of fertilizer applied per surface unit (kg a.s./ha)		Absolute difference, 2020-2007 (kg a.s./ha)
	2007	2020	2007	2020	2007	2020	
Total Romania	6,422.9	7,522.2	387,216	738,453	60.28	98.16	+37.88
Share of the micro-region in the country level (%)							
North West	15.17	9.52	12.92	10.74	51.32	110.76	+59.44
Center	7.65	9.01	9.16	7.34	72.19	79.96	+7.77
North East	14.63	15.46	13.56	13.72	55.86	87.23	+31.37
South East	13.17	13.27	12.78	11.28	58.66	83.42	+24.76
South Muntenia	19.37	21.15	20.73	17.63	64.51	81.84	+17.33
Bucharest Ilfov	1.52	0.67	1.09	0.86	43.18	127.27	+84.09
South West Oltenia	12.97	15.86	12.62	17.11	58.62	105.98	+47.36
West	15.56	15.60	17.14	21.32	66.51	138.75	+72.24

Source: Own calculation based on NIS data, 2021 [17].

In the year 2020, it was registered an increase of the fertilized surface in the Central region, North East, South East, South Muntenia, South West Oltenia and West, while in North

West and Bucharest Ilfov, it was noticed a decline.

Also, in 2020, it was observed a slight concentration of the fertilized land in the following micro-regions; South Muntenia (21.1%), South West Oltenia (15.8%), West 915.6%), North East (15.4%) and South East (13.2%), accounting for a total of 81.34% of the 7,522,224 ha area where the mineral fertilizers were utilized at the country level (Table 1).

Of the total amount of chemical fertilizers used in Romania in 2007, accounting for 387,216 tons a.s., the highest quantity was applied in the following micro-regions; South Muntenia (20.7%), West (17.1%), North East (13.5%), North West (12.9%), South East (12.7%) and South West Oltenia (12.6%), summing 89.75%.

In the Central region and Bucharest Ilfov, it was used the smallest amount of fertilizer. In the year 2020, of the amount of 738,453 tons a.s. mineral fertilizers, in the territory, its consumption was as follows: the regions with the highest shares in the total consumption, in the descending order, were: West (21.3%), South Muntenia (17.6%), South West Oltenia 917.1%), North East (13.7%), South East (11.2%) and North West (10.7%), totalling 91.8%, and the remaining amount was used in the Central and Bucharest-Ilfov zones (Table 1).

The average quantity of mineral fertilizer applied in Romania was 60.28 kg a.s./ha, with variations from a region to another. The largest amount of fertilizer/ha was applied in the Central area (72.19 kg), followed by West area (66.51 kg), South Muntenia (64.51 kg), South East (58.66 kg), South West Oltenia (58.62 kg), North East (55.86 kg), and North West (51.32 kg) and, the lowest amount was utilized in Bucharest-Ilfov zone (43.18 kg).

Therefore, the Central region, West, South Muntenia exceeded the average consumption per ha, while South East, South West Oltenia, and North East areas utilized a lower amount than the country mean, while North West and mainly Bucharest Ilfov consumed much smaller quantities. In the year 2020, at the national level, the mean consumption of chemical fertilizers reached 98.16 kg a.s./ha, a level which was exceeded only in the West region (138.75 kg), Bucharest-Ilfov (127.27 kg), North West area (110.76 kg), South West Oltenia (105.98 kg). In the other micro-regions, the fertilization level was smaller than the country mean. In the Central part, it accounted for only 79.96 kg/ha (Table 1).

Of course, in the consumption structure, the Nitrogen-based fertilizer is the most required, followed by Phosphorus and Potassium. However, regarding the consumption in the EU countries, in Romania the level is much smaller, because chemical fertilization is made mainly by the commercial agricultural holdings which have financial resources, taking into account the price of mineral fertilizer which increased year by year. In the small holdings, natural fertilizer is usually utilized.

The degree of the concentration of chemical fertilization in Romania

The calculated values for the concentration indices were small in general and varied in limited thresholds from 2007 to the year 2020. *Herfindahl-Hirschman Index (HHI)* had a smaller value than 0.15 in the year 2007 both for the fertilized surface and the quantity applied, reflecting that in Romania it was a relatively uniform distribution among micro-regions.

Table 2. Values of the concentration indices for the fertilized surface and amount of used chemical fertilizer in the year 2020 compared to the year 2007

	Fertilized surface		Fertilizer amount applied	
	2007	2020	2007	2020
Herfindahl-Hirschman Index	0.1461	0.1527	0.1477	0.1539
Gini-Struck Index	0.1552	0.1779	0.1610	0.1817
Concentration coefficient	0.1773	0.2033	0.1839	0.2076

Source: Own calculation.

In the year 2020, the values of HHI increased, ranging between 0.15 and 0.25, but being much closer to 0.15, they reflected a slight moderate concentration both regarding the fertilized surface and the amount applied (Table 2, Fig. 4).

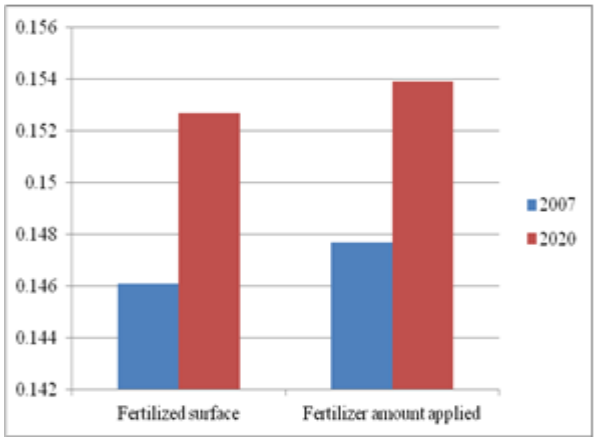

Fig. 4. Evolution of concentration degree of fertilization in Romania in terms of Herfindahl-Hirschman Index
Source: Own calculation and design.

Gini-Struck Index reflected a similar situation, the agricultural surfaces looked to be uniformly fertilized in the territory, without substantial gaps among micro-regions of development. Therefore, we did not notice any spot of concentration in 2007. But, in the year 2020, it appeared a slight tendency of concentration both in case of the fertilized areas and the quantity of utilized fertilizer.

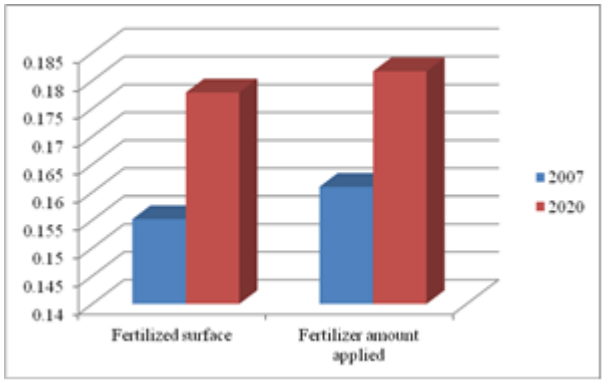

Fig. 5. Evolution of concentration degree of fertilization in Romania in terms of Gini-Struck Index
Source: Own calculation and design.

The values of GSI were higher in 2020 than in 2007 and varied between 0.1552 and 0.1779 for the surface where the chemical fertilizers were applied and 0.1610 and 0.1817 in case of the amount of used fertilizer (Table 2 and Fig. 5).

The Concentration Coefficient registered values below 0.3 both in the year 2007 and in 2020, which reflects a lack of concentration in the first year of the analysis and a slight moderate concentration in the last year, both for the fertilized land and the applied amount of fertilizer (Table 2 and Fig. 6).

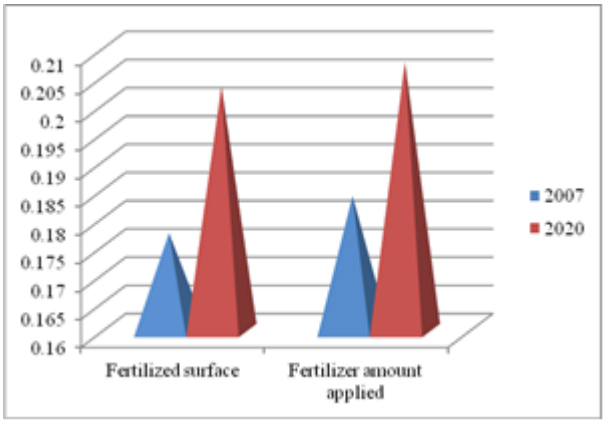

Fig. 6. Evolution of concentration degree of fertilization in Romania in terms of Concentration Coefficient
Source: Own calculation and design.

CONCLUSIONS

Chemical fertilization is still important for Romania's agriculture because the yield level is lower than in other EU countries, and for increasing productivity, income and profit, the farmers practicing conventional agriculture needs to acquire fertilizers besides other farm inputs like certified seed, fuel, pesticides etc.
In 2018, Romania's consumption of mineral fertilizer represented about 5% of the EU total consumption, for which the country is situated on the 7th position after France, Germany, Poland, Spain, United Kingdom and Italy.
In 2018, compared to the EU average consumption of Nitrogen based fertilizer accounting for 77.2 kg per ha UAA, Romania consumed less than 60 kg/ha UAA, being situated on the last position. More than this, Romania is far away from Belgium, Netherlands, Czechia and Denmark which consume more than 100 kg Nitrogen fertilizer per ha UAA,
In 2020, the consumption of mineral fertilizer in Romania accounted for 98.16 kg/ha.

Therefore, Romania has a lower consumption of Nitrogen fertilizer per surface unit than the EU mean and if we compare the figures for the consumption practiced by the farmers in the Western countries, we may affirm that Romania consume by 50% less N fertilizer than the top EU member states regarding this indicator.

In the year 2020, in the territory of Romania the average consumption of chemical fertilizers of 98.16 kg a.s./ha was exceeded, in the descending order, by the West, Bucharest-Ilfov, North West and South West Oltenia regions.

The analysis made in the territory proved that, a slight moderate concentration was noticed in terms of Herfindahl-Hirschman Index, Gini-Struck Index and Concentration coefficient in the year 2020 compared to the year 2007. Therefore, there are a few micro-regions of development were the consumption of fertilizer is a little higher than in other areas. In 2020, about 91.8% of the total consumption of manufactured fertilizer was utilized by West, South Muntenia, South West Oltenia, North East, South East and North West regions.

The EU Regulations regarding the sustainable development of agriculture by reducing the consumption of chemical fertilizers in order to protect environment, preserve biodiversity and ensure food safety are justified, but they have to be applied in a different manner from a country to another depending on its actual use of mineral fertilizers per ha UAA, yield level of agricultural crops and the need to increase productivity, farmers' income and profit.

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