Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 21, Issue 4, 2021
PRINT ISSN 2284-7995, E-ISSN 2285-3952

PESTICIDES - A PROBLEM IN ROMANIA'S AGRICULTURE?

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Abstract

The paper analyzed the use of pesticides in Romania in the period 2007-2020, based on the official statistical data by type of pesticide, at the national and territorial level, and using fixed and structural indices, concentration indices and time and spatial comparisons. In the year 2020, pesticides were applied on larger surfaces than in 2007 and they accounted for 3.88 million ha for herbicides, 2.39 million ha for fungicides, and 2.34 million ha for insecticides. But, the total consumption decreased by 26% for insecticides and by 23% for herbicides, but it increased by 8.2% in case of fungicides. The national mean consumption of pesticides per ha declined and in 2020 accounted for 0.27 kg a.s. insecticide, 0.75 kg herbicide and 0.76 kg fungicide. Romania comes on the last position in the EU for the smallest average consumption 0.8 kg a.s. pesticide per ha and also for the risk indicator 1 equal to 48. The largest areas where pesticides are applied in the territory are in South Muntenia, West, South East and South West Oltenia micro-regions. Total consumption differs from a region to another as follows: insecticides are much more consumed in South West Oltenia, South Muntenia, North East, South East and West, fungicides are especially applied in South East, North East, Center and West, and herbicides are predominantly utilized in North East, South East, North West, South West Oltenia, and West. The average consumption per ha, over the national mean, is higher in the following regions: insecticides in North West, South West Oltenia, Center and North West, fungicides in the Center, Bucharest-Ilfov, South East and North East and herbicides in North East, North West and Center regions. The values of the concentration indices Herfindahl-Hirschman, Gini-Struck and Concentration coefficient proved that in 2020, Romania was characterized by a relative moderate concentration of the use of pesticides. As a conclusion, pesticides have to be used taking into consideration the local conditions at the regional level and at farm level. Farmers have to evaluate the problems and make the best decision regarding what type of pesticide to use, on what surface, which is the suitable dose per ha, how many treatments are required etc. The EU regulations regarding pesticides imposes a strict control and use of the approved pesticides for compiling with the European the Green Deal.

Key words**:** *pesticides, consumption, dynamics, territorial dispersion, Romania*

INTRODUCTION

The existence of the risk of the diseases and pests in agriculture can diminish yields, harvests, and farmers' income and profit. In general, the use of pesticides provides a higher yield and also reduces the cost of labor, and farmers have to give a response to the question: Is it wise to save a harvest or to lose it? And they are obliged to make the decision "to save", as this is their business!
Also, the use of pesticides prolongs food shelf life [1, 28].
This justifies the development of the chemical industry which produce pesticides.
The chemicals referring to pesticides are of a large variety, depending of their components and, functions: for destroying weeds, for controlling insects and killing the useless ones for agriculture, for combating diseases caused by fungi and bacteria and for preventing and treating the pests attack. About 90% of pesticides are herbicides [3, 29].
Climate change could influence the increase of the incidence of pests and pathogenic agents attack on agricultural crops, but it is

still considered to have a minor role, the main drivers in the use of pesticides being agronomic, economic, environment reasons and social reasons [9, 12].

The widespread use of pesticides and other chemicals like fertilizers has lead to the release and remanence of the toxic residues in the environment polluting air, water, soil, non-target plants, animals, affecting biodiversity, and in food, putting in danger human health and life [8, 10, 27, 30, 32].

That is why the use of pesticides has become controversial, and the reduction or elimination is imposed by policy makers for developing a sustainable agriculture, friendly with environment and for ensuring food safety [13, 15].

Solutions are diversified and could include a careful ecosystem management, the use of crop rotation and of a healthy soil practice which favors the stimulation of the beneficial microorganisms, the application of the integrated systems for combating weeding, and also measures to stimulate useful insects and eliminate the destroying ones, in a word to implement the so called Integrated Weeding and Pest Management. More than this, the farmers could easily use other techniques regarding tilling, planting cover crops and applying a different time, early or late, for starting crops to avoid weeding. And, the existence of non-chemical pesticides could be also another solution [14].

Therefore, we must not deny the use of pesticides which is essential for ensuring the plant protection and food production.

Even in the organic agriculture which looks to become a strong competitor for conventional agriculture in the way to a healthier environment and food, the use of pesticides is allowed, but taking into consideration only the approved types of pesticides and the limited amount to use.

Therefore, pesticides production and use is under a strict regulation and control nowadays as a response to the need for producing more bio-based products using modern environmentally friendly technologies and healthy food [26].

The EU has developed a long run strategy which provides the reduction of pesticides in agriculture by 50% by 2030 by the extend of organic agriculture from 10% at present to 25% [2, 7].

The application of pesticides differs from a country to another and from a region to another depending on soil and climate conditions, farm size, crop structure, agricultural system utilized etc.

Taking into account the heterogeneity of agronomic conditions, pesticide policy has to respond to the specificity of each country adapted to the local conditions.

However, the EU policy regarding the use of pesticides is justified for creating a harmonized framework of the national policies, so that the pesticides allowed to be used to contain only the approved substances and no new pesticide to enter the market without being authorized by the EU country when it will be used [4, 5, 6, 28].

In this context, the goal of the paper was to analyze the situation of pesticides in Romania during the period 2007-2020, regarding the areas where these chemical substances were used, the quantities consumed and the average consumption per surface unit, the degree of concentration of the pesticide use at regional level as finally to assess in what measure the utilization of pesticides in Romania is a problem and in which way the country to adapt and align to the EU regulations in force.

MATERIALS AND METHODS

A brief presentation of Romania's agriculture

Romania is an EU country where agriculture is an important sector of the economy and plays an important part of the European agriculture. Romania has a fertile soil and in general a favourable climate, a large range of arable crops (cereals, oilseeds crops, technical crops etc) [16, 21] which could be cultivated and also orchards, vineyards and grasslands, and animal sector is represented by cattle, swine, poultry, sheep and goats, beekeeping subsectors which give their contribution to the agricultural output value [11] and GDP [17, 23, 25].

The main characteristics of Romania's agriculture are: the large number of holdings

accounting for about 3.2 millions, for which Romania comes on the 1st position among the EU member states, the small-sized farms of around 3.67 ha, the high share of 78% of the vegetal sector in the agricultural output, and the main products achieved are cereals (wheat, corn, barley, etc) [21, 24], sunflower seeds [22], potatoes, grapes, wine, milk, pork, poultry, eggs, honey [18, 19, 20].

The main agricultural system applied is the traditional one, specific to subsistence and semi-subsistence agriculture, but in the large agricultural holdings, conventional agriculture is applied on a large-scale. Organic farming is still shade, but its importance is increasing.

Family farming is dominant running in very small sized farms, 98% of farms having less than 10 ha and the productivity being below the production potential. Only 1% of the farms are represented by agricultural commercial companies with high performances and they work about 46% of arable land.

The need of agricultural inputs like seeds, seeding materials, fertilizers, pesticides, fuels, equipments etc, is facing more and more with price volatility and the small or lack of financial resources.

The uncertainty of the future harvests due to the climate change, the lack of labour, aging, migration are other problems which transform agricultural business into a high risk goal.

Data collection

The study is based on the official data provided by National Institute of Statistics, Tempo Online data base for the period 2007-2020.

Methodological approach

In this study, there were used the following indicators: the surface where pesticides were utilized, the total consumption of pesticides, and the average consumption per ha.

The analysis is made, on one side, at the national level, and on the other side, in the territory, for studying how pesticides were used in the eight micro-regions.

Fixed basis indices, structural indices, and also the degree of concentration of the use of pesticides in terms of Herfindahl-Hirschman Index, Gini-Struck Index and the Coefficient of Concentration, time and spatial comparisons have been the main procedures involved in this research work

The results were comprehensively displayed in tables and graphics which allow the understanding of the dynamics and correlative relationships between the studied indicators.

The main conclusions were presented at the end of this paper.

RESULTS AND DISCUSSIONS

The surface on which pesticides were utilized

After Romania's entry into the EU in January 2007, agriculture tried to enforce and strengthen its position among the other states. To increase productivity, fertilizers and pesticides were among the main farm inputs to which farmers paid attention.

In consequence, the utilization of pesticides was justified by the need to ensure plant protection and reach the expectations regarding production.

In the period 2007-2020, the surfaces where pesticides were applied increased by +42.9% in case of insecticides, by +52.5% in case of fungicides and by +31.1% in case of herbicides. Therefore, in 2020, the insecticides were used on 2,343 thousand ha, fungicides on 2,395 thousand ha and herbicides on 3,887 thousand ha (Fig. 1).

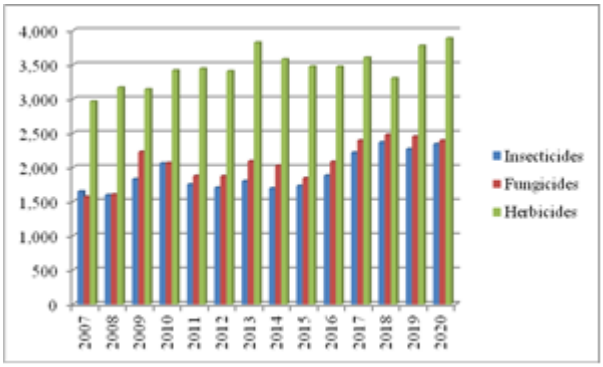

Fig. 1. Dynamics of the agricultural area where the pesticides were used in Romania, 2007-2020 (Thousand ha)

Source: Own calculation and design based on NIS data, 2021 [11].

Plant protection measures were imposed due to the extent of the cultivated area, crop structure, the new technologies in crop farming and the need to adapt to climate

change (droughts, huge rainfalls, pathogenic agents, weeding etc).

The total amount of pesticides utilized reflected the problems which appeared for plant protection in the country in the last 13 years. In the analyzed period 2007-2020, the total amount of insecticides active substance (a.s.) consumed declined by -25.8%, the amount of herbicides also decreased by -23%, but the quantity of fungicides increased by +8.25%. This means that the cultivated areas in the country had less problems with the attack of insects and weeding and more problems with the appearance of diseases caused by fungi.

In 2020, there were consumed the following amounts of pesticides: 641 tons a.s. insecticides, 1,823 tons a.s. fungicides and 2,901 tons a.s. herbicides. Therefore, from this point of view, it is clear that weeding is the biggest problem in Romanian agriculture, on the second position coming the diseases produced by various pathogenic agents and on the third position is the attack of insects (Fig. 2).

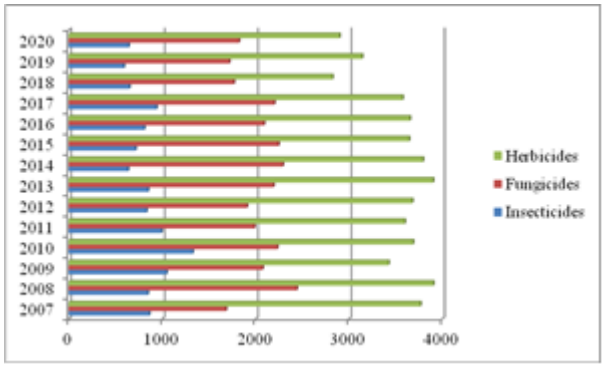

Fig. 2. Dynamics of the total amount of pesticides used in Romania, 2007-2020 (Tons 100% active substance)
Source: Own calculation and design based on NIS data, 2021 [11].

The average quantity of pesticide utilized per ha

In the year 2020, in Romania it was consumed 0.27 kg a.s./ha insecticide, 0.76 kg a.s./ha fungicide and 0.75 kg a.s./ha herbicide, much less than in the year 2007. The reduction in consumption per ha of the level in the year 2007 by type of pesticide was the following one: -48.1% in case of insecticides, -29% in case of fungicides and -41% in case of herbicides. Therefore, we may affirm that the consumption was deeply in a descending trend in Romania (Fig. 3).

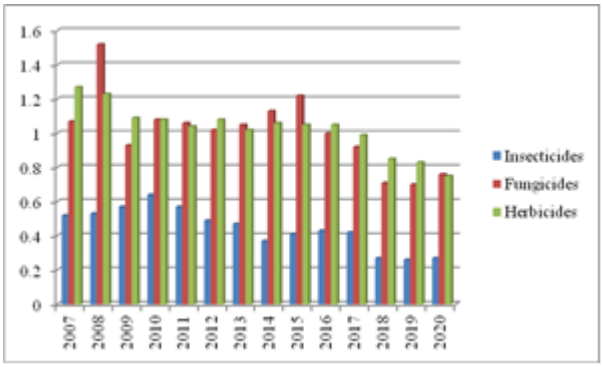

Fig. 3. Dynamics of the quantity of pesticides applied per surface unit in Romania, 2007-2020 (kg a.s./ha)
Source: Own calculation and design based on NIS data, 2021 [11].

In 2018, Romania consumed 6.9 thousand tons pesticides for which it came on the 10th position in the EU after France, Spain, Italy, Germany, Poland, Hungary, Greece, Portugal, Netherlands, countries utilize higher amounts of pesticides [31].

Regarding the consumption of pesticides per surface unit for 0.8 kg/ha in average, Romania is situated on the last position in the EU. We could not compare its consumption with the top member states consuming a higher average amount than 3.6 kg/ha, which are, in the ascending order: the following ones; Spain, France, Germany, Portugal, Italy, Ireland, Belgium, Netherlands and Malta, the last one having the highest position for 12 kg/ha [31].

Also, Romania has the lowest risk indicator 1 for pesticides by active substance in the EU, accounting for 48. For this reason, Romania came on the last position compared to the EU average risk indicator which is 83 and which is exceeded by 10 member states with over 84, in the increasing order being: Hungary 84, Lithuania 86, Italy 91, France 100, Slovenia 109, Austria 129, Estonia 131, Cyprus 134, Latvia 140 and Finland 144 [4].

The use of pesticides in the territory of Romania

The dispersion of surfaces where pesticides were used in the territory reflects a different situation from a micro region to another and also from a type of pesticide to another.

(a)Insecticides. In 2007, insecticides were applied on larger surfaces in South East (30.2%), South Muntenia (20.7%), South West Oltenia (17.8%), summing 68.9% of the total agricultural area of 1,649,500 ha where pesticides were utilized.

In 2020, in comparison with the year 2007, a higher surface was used for applying pesticides from the first category, that is insecticides. The highest increase of the surface was noticed in North East (+96.5%), South Muntenia (+85.3%), Bucharest-Ilfov (+189.8%), South West Oltenia (+20.3%) and West (+237.3%).

As a result, in 2020, the highest share in the area where insecticides were used belonged to South Muntenia (27.07%), West (19.3%), South East (17.1%), South West Oltenia (15.1%), totaling 78.7% of the total treated area accounting for 2,343,099 ha.

(b)Fungicides. In 2007, the treatments with fungicides were applied especially in South East, South Muntenia, South West Oltenia, North East, North West, whose share in the total agriculture surface of 1,574,310 ha was: 31.1%, 18%, 12.7%, 11.03% and, respectively, 10.03%.

In 2020, the area where fungicides were utilized increased in North West (+42.1%), Center (+30.3%), North East (+127.9%), South Muntenia (+78.1%), Bucharest-Ilfov (+206%), South West Oltenia (+67.6%), West (+180.2%). Only in South East, it declined by 28.9%.

Therefore, in 2020, the share of various regions in the surface of 2,395,430 ha, where fungicides were distributed, was the following one, in the descending order: South Muntenia (21.08%), West (19.28%), South East (14.56%), South West Oltenia (14.03%), North East (13.6%), summing 82.6%, the remaining belonging to North West, Center and Bucharest-Ilfov.

(c)Herbicides. In 2007, herbicides were applied on 2,963,526 ha, of which the highest weight of the agricultural land belonged to South Muntenia (22.3%), South East (20.7%), West (16.5%), totaling 60%. In other micro-regions like North West, Center and North East, the shares were smaller: 11.37%, 9.52% and 9.01%, while Bucharest-Ilfov had just 0.88%.

In 2020, the agricultural surface where herbicides were utilized increased in North West (+120.6%), South East (+55.2%), South Muntenia (+44.1%), Bucharest-Ilfov (+51.8%), South West Oltenia (+87.5%) and West (+12.9%) (Table 1).

Table 1. Surface where pesticides were applied by micro-region of Romania in 2020 compared to 2007

	Insecticides		Fungicides		Herbicides	
	2007	2020	2007	2020	2007	2020
Total Romania (Thousand ha)	1,649.5	2,343.0	1,574.3	2,395.4	2,963.5	3,887.3
Share (%) of the micro-region						
North East	9.29	4.47	10.03	9.61	11.37	8.32
Center	4.79	4.25	7.84	6.72	9.52	6.33
North East	8.32	11.52	11.03	13.68	9.01	15.15
South East	30.28	17.11	31.13	14.56	20.72	16.63
South Muntenia	20.74	27.07	18.00	21.08	22.33	24.54
Bucharest-Ilfov	0.52	1.06	0.51	1.04	0.88	1.02
South West Oltenia	17.88	15.15	12.74	14.03	9.62	13.75
West	8.18	19.37	8.72	19.28	16.55	14.26

Source: Own calculation based on the data from NIS, 2021 [11].

As a result, the share of the micro-regions in the total surface of 3,887,385 ha where herbicides were used, became as follows: South Muntenia (24.5%), South East (16.6%), North East (15.1%), West (14.2%), South West (13.7%) totaling 84.3%, the difference

belonging to North West, Center and Bucharest-Ilfov (Table 1).

The concentration indices regarding the surface where pesticides were utilized obtained the following values:

- Herfindahl-Hirschman Index, HHI, varied between 0.15 and 0.25 showing a moderate concentration for all the types of pesticides and in all the micro-regions.

-Gini-Struck Index, GSI, had values below 0.3, also reflecting a relative concentration of the agricultural land treated with pesticides, no matter the type of pesticide or the micro-region.

-Concentration Coefficient had higher values than HHI and GSI, taking into consideration the relationship existing among these indicators from a mathematical point of view. Therefore, its values reflected the same idea.

Comparing the values of the concentration indices resulting in 2020 with the values recorded in 2007, we noticed that HHI registered lower values in case of the surface treated with insecticides and fungicides, and that in case of the area treated with herbicides the values of these indicators was higher. Similar tendencies were noticed in case of GSI and CC (Table 2).

Table 2. Concentration degree of the surfaces treated with pesticides in Romania in 2020 compared to 2007

	Insecticides		Fungicides		Herbicides	
	2007	2020	2007	2020	2007	2020
Herfindahl-Hirschman Index	0.1908	0.1798	0.1813	0.1547	0.1592	0.1698
Gini-Struck Index	0.2742	0.2502	0.2536	0.1842	0.1977	0.2025
Concentration Coefficient	0.3133	0.2870	0.2898	021.05	0.2259	0.2314

Source: Own calculation.

Dispersion of total consumption of pesticides by micro-region

(a)Insecticides. In 2007, in Romania it was consumed an amount of 863,108 kg a.s. insecticides in agriculture. The biggest amounts were applied in South West Oltenia (23.3%), South East (19.09%), South Muntenia (17.1%), North East (14.7%) and North West (10.8%) summing 85.1%. Smaller quantities were utilized in the Center and Bucharest-Ilfov.

In 2020, the insecticides were used in a smaller amount, accounting for only 640,945 kg, meaning by 25.8% less than in 2007.

However, in the territory, the quantity of used insecticides increased only in the West region (+18.1%), while in the other regions it declined as follows: North East (-37%), Center (-11.3%), North East (-35%), South East (-59%), South Muntenia (-37%), Bucharest-Ilfov (-58.9%) and South West Oltenia (-3.3%).

In the year 2020, the regions with a higher consumption of pesticides were: South West Oltenia (30.4%), South Muntenia (14.6%), North East (12.9%), South East 912.7%), West (12.09%), summing 82.69%. In North West and Bucharest Ilfov, the shares of the used insecticides were smaller than in the other regions.

(b)Fungicides. Of the amount of 1,683,848 kg a.s. fungicides used in 2007, the largest quantity was consumed in North West (23.3%), South East (22.1%), Center (13%), South Muntenia (10.9%), North East (10.9%), South West Oltenia (9.9%) and West (9.5%). In Bucharest-Ilfov, it was used only 0.24%, an insignificant amount.

In the year 2020, the consumption of fungicides increased especially in North East (+111.5%), West (+43%), the Center part of the country (+36.1%), South East (+22.4%), and Bucharest-Ilfov (+792%).

In consequence, the highest share in the total consumption of 1,822,965 kg a.s. belonged to South East (25.03%), North East (21.3%), followed by Center (16.3%) and West (12.6%).

(c)Herbicides. In 2007, there were consumed 3,767,126 kg a.s. herbicides. The highest

shares in this quantity belonged to North West (19.3%), West (19.4%), South Muntenia 918%), South East (17%), summing 73.7%. Smaller amounts were utilized in the other micro-regions.

In 2020, the amount of herbicides declined accounting for 2,90,538 kg a.s. meaning by 23.1% less than in 2007. In the territory, the utilized amount of herbicides increased in North East (+89.9%), Bucharest-Ilfov (+184 times), South West Oltenia (+36.8%).

In the other regions, the amount of applied herbicides decreased as follows: in North West (-46%), Center (-17%), South East (-30%), South Muntenia (-50%) and West (-68%).

As a result, in 2020, the highest weight in total consumption belonged to: North East (25%), South East (15.5%), North West (13.6%), South West Oltenia (12.6%), South Muntenia (11.7%), and West (10.6%) (Table 3).

Table 3. Total consumption of pesticides by micro-region of Romania in 2020 compared to 2007

	Insecticides		Fungicides		Herbicides	
	2007	2020	2007	2020	2007	2020
Total Romania (kg)	863,108	640,945	1,683,848	1,822,965	3,767,126	2,900,538
Share (%) of the micro-region						
North East	10.81	9.26	23.31	6.89	19.33	13.66
Center	5.87	7.10	13.00	16.35	8.66	9.39
North East	14.75	12.96	10.90	21.30	10.37	25.59
South East	19.09	12.78	22.12	25.03	17.00	15.52
South Muntenia	17.12	14.62	10.96	8.98	18.08	11.74
Bucharest-Ilfov	1.40	0.78	0.24	2.05	0.03	0.82
South West Oltenia	23.34	30.41	9.92	6.78	7.12	12.65
West	7.62	12.09	9.55	12.62	19.41	10.63

Source: Own calculation based on the data from NIS, 2021 [11].

The concentration indices regarding total consumption of herbicides had the following values:

- The values of Herfindahl-Hirschman Index varied between 0.15 and 0.25 reflecting a relative moderate concentration for all the types of pesticides and also by micro-region.

-Gini-Struck Index and Concentration Coefficient showed higher values than Herfindahl-Hirschman Index which also reflected the same relative moderate concentration.

Table 4. Concentration degree of the consumption of pesticides in Romania in 2020 compared to 2007

	Insecticides		Fungicides		Herbicides	
	2007	2020	2007	2020	2007	2020
Herfindahl-Hirschman Index	0.1627	0.1748	0.1628	0.1646	0.1595	0.1577
Gini-Struck Index	0.2075	0.2385	0.2078	0.2127	0.1985	0.1933
Concentration Coefficient	0.2371	0.2725	0.2374	0.2430	0.2268	0.2209

Source: Own calculation.

-In 2020 compared to the year 2007, the values of Herfindahl-Hirschman Index, Gini-Struck Index and Concentration Coefficient registered an ascending trend for the consumption of insecticides and fungicides,

while for herbicides it was noticed a decreasing tendency (Table 4).

Average consumption of pesticides in the territory by micro-region

Analyzing the situation of average consumption per surface unit, we noticed that in the year 2007, the mean at the country level was exceeded only in Bucharest-Ilfov (more than double), in North East, South West Oltenia, Center, North West, but in the other region it was below the national mean.

In the year 2020, the country average accounted for 0.27 kg a.s./ha insecticide, which was exceeded only in North West and South West Oltenia, having the top consumption of 0.57 kg/ha and 0.55 kg/ha, and the lowest consumption was 0.15 kg/ha in South Muntenia.

In 2007, the average consumption of fungicides was higher in North West, Center, North East, while in the other regions was smaller. In 2020, the country mean declined to 0.76 kg a.s./ha, and it was exceeded in the Center, Bucharest-Ilfov, South East, and North East, while in the other regions it was much lower.

Regarding the average consumption of herbicides per ha, in 2007 compared to the country mean of 1.27 kg a.s./ha, in the West part and North West it was consumed more than double and in North East a little more, while in the other regions it had a very low level. In 2020, the country mean of 0.75% herbicide a.s/ha was exceeded only in North East, North West and Center, while in the other micro-regions the levels were smaller (Table 5).

Table 5. Average consumption of pesticides by micro-region of Romania in 2020 compared to 2007 (kg a.s./ha)

	Insecticides		Fungicides		Herbicides	
	2007	2020	2007	2020	2007	2020
Total Romania (kg)	0.52	0.27	1.06	0.76	1.27	0.75
Average consumption of pesticides by micro-region						
North East	0.61	0.57	2.48	0.55	2.16	1.22
Center	0.64	0.46	1.77	1.85	1.15	1.11
North East	0.93	0.31	1.27	1.18	1.46	1.26
South East	0.33	0.20	0.76	1.31	1.04	0.70
South Muntenia	0.43	0.15	0.65	0.32	1.03	0.36
Bucharest-Ilfov	1.41	0.20	0.51	1.50	0.005	0.60
South West Oltenia	0.68	0.55	0.83	0.37	0.94	0.69
West	0.49	0.17	1.00	0.49	2.56	0.55

Source: Own calculation based on the data from NIS, 2021 [11].

CONCLUSIONS

This study pointed out that in Romania during the period 2007-2020, the surface where pesticides were applied increased and accounted for 3.88 million ha for treatments against weeding, 2.39 million ha for treatments against fungi and 2.34 million ha for treatments against insects.

But, the total amount of pesticides utilized declined by 26% for insecticides and by 23% for herbicides, but it increased by 8.2% in case of fungicides.

As a consequence, the average consumption of pesticides per surface unit declined and in 2020 accounted for 0.27 kg a.s. insecticide, 0.75 kg herbicide and 0.76 kg fungicide at the national level.

For an average consumption of 0.8 kg a.s./ha, Romania comes on the last position in the EU. Also, for the lowest level of the agri-environment indicator in terms of "the risk indicator 1" equal to 48, Romania is also situated on the last position among the EU member states.

Based on the territorial analysis at the regional level, we identified that the largest areas where plant protection measures are required, in the decreasing order, are: South Muntenia, West, South East and South West Oltenia. In the other micro regions, pesticides are utilized on smaller surfaces. Also, the total consumption of pesticides depends on the type of pesticide suitable to solve specific problems in plant protection and on the micro-region, because of the geographical disparities among regions regarding soil and climate conditions, crop mapping, farm types and size, technologies applied etc.

Insecticides are much more consumed in South West Oltenia, South Muntenia, North East, South East and West where the temperatures have higher average levels and droughts are frequently a big problem and favor a higher incidence of insect attack.

The highest amount of fungicides is used in South East, North East, Center and West where the incidence of diseases caused by fungi is higher than in other regions.

Higher quantities of herbicides are used in North East, South East, North West, South West Oltenia, and West where the risk of damages caused by weeding is very high.

The highest average consumption of pesticides per ha, over the national mean, is differentiated by type of pesticide and also by region. From this point of view, the highest level of insecticides used over the national mean was found in North West, South West Oltenia, Center and North West. The highest level of fungicide per ha and over the national mean was applied in the Central part, Bucharest-Ilfov, South East and North East. And the highest amount of herbicide per surface unit, and over the national mean was consumed in North East, North West and Center regions.

The values of the concentration indices Herfindahl-Hirschman, Gini-Struck and Concentration coefficient proved that in 2020, Romania was characterized by a relative moderate concentration of the use of pesticides.

Therefore, the application of pesticides reflects that the strategic measures for plant protection have to take into consideration the local conditions at the regional level and also within the regions at the level of each farm where the farmer is the only person who knows the problems the best. Farmers have to evaluate the problems and make the right decision regarding the complex of plant protection measures regarding what type of pesticide to use, on what surface, which is the suitable dose per ha, how many treatments are required etc.

Farmers have to be aware of that the development of a sustainable agriculture involves more production and products of higher quality, and also environment protection and food safety. For this reason, the EU regulations regarding pesticides imposes a strict control and use of the approved pesticides for compiling with the European the Green Deal which aims, among other goals, a modern, resource-efficient and competitive agriculture called "to ensure food security, to diminish the environment and climate footprint of the food system, to confer a competitive sustainability from farm to fork".

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