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# RESEARCH ON THE SUSTAINABLE USE OF PESTICIDES AT MACRO-REGIONAL LEVEL AND IN THE DEVELOPMENT REGIONS OF ROMANIA

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***Abstract***

*The paper highlights the quantities of pesticides used in Romania and the evolution of the surfaces on which pesticides were applied, in the period 2015-2017 compared to 2011-2013, a comparison necessary to present the progress that Romania has made in reducing the use of these plant protection products. This period overlaps over the period in which the harmonized risk index was determined at EU level. In the European Union, it is envisaged that in the future, pesticides should be used in a sustainable manner, the impact that this measure will have representing the reduction of risks and negative effects on the environment and human health. The countries of the European Union take into account the proposed objectives, and by including in the National Strategic Plans the quantitative targets related to pesticides, they will constantly monitor the effects established by the implementation of the EU policy. The conclusions highlight that in Romania the quantities of insecticides and herbicides decreased, and those of fungicides increased in the period 2015-2017 compared to the period 2011-2013, and the surfaces on which insecticides and fungicides were applied increased while the ones with herbicides decreased, thus the average quantity of insecticides and herbicides per hectare decreased and the average quantity of fungicides per hectare increased.*

***Key words*****:** *harmony risk, pesticides, Romania, UE*

## INTRODUCTION

Nowadays, it is well known that agriculture is facing a number of challenges, of which the most relevant are: providing agricultural products, on the one hand, for food to the growing population, and on the other hand, for animal feed; reducing production costs in order to maintain the viability of production farms; reducing pollution due to the use of inputs necessary to obtain agricultural production etc. In order to achieve a self-sufficient agricultural production, it is recommended to use chemical fertilizers as well as the widespread use of pesticides [16]. The specialists in the field have identified over the decades of research, both the benefits and the risks of using fertilizers and pesticides [1]. At the level of the European Union there are regulations that stipulate optimal consumption in the categories specified above. European Union legislation on chemicals and pesticides aims both to protect the health of the population and environment and to prevent difficulties in their marketing [6]. Pesticides are those substances that are used in modern agriculture, because they contribute directly to the control of weeds, pests and diseases that can endanger both agricultural production and farmers' incomes [16]. Currently, there are many factors underlying the use of pesticides by farmers [8]. However, it is necessary to specify that we should not neglect the socio-economic variables that may tip the balance in favor of or against the use of pesticides [2]. In the specialized literature there was a clear delimitation of pesticides, taking into account the organism that must be combated, as follows: bactericides; fungicides; herbicides;

insecticides; acaricides; nematocides; moloscocides; raticides and mixed action [13]. In time, it was found that the practice of a conventional agriculture, which implies that sometimes the excessive use of pesticides, contributes directly to the degradation of the environment, to the depletion of resources and the loss of biodiversity [9, 10]. But at the level of the European Union it is clearly desired a sustainable use of pesticides, by reducing with 50% their use [3]. Thus, in order to measure progress regarding the reduction of risks of pesticide use, as well as its effects on the environment and human health, two specific risk indicators have been introduced at EU level, indicators that objectively contribute to the monitoring of the situation in each state. But risk assessment is not a facile method [11]. The risks associated with the use of plant protection products are not homogeneous, they are correlated with the unequal influence of specific factors, such as the active substance existing in their componence, the amount used per hectare, the frequency of application and the time, place and manner in which farmers use them in their own activity. Currently, two harmonized risk indicators, calculated differently, have been introduced at European level: Harmony Risk 1 is established based on sales of active substance and the Harmony Risk 2, based on the number of emergency authorizations granted. In the EU, the introduction of harmonized risk indicators was a necessity, as this determination highlights the use of pesticides in the Member States, while evaluating EU policies in this area. By calculating the risk indicators, the Member States identify the needs for the use of active substances in plant protection products, with an emphasis on those with a high degree of toxicity, in the sense of elimination from agricultural practice. The integrated control of diseases and pests, remains a priority of EU policies, by reducing the dependence on the use of pesticides [5, 7]. At the level of the European Union, Harmony Risk 1 determined for the period 2011-2019, recorded an oscillating evolution, its highest value being recorded in 2011, respectively 111, and the lowest value was 79 (2019). In the countries of the European Union there is also the oscillation of values during the analysis period. For Romania, Harmony Risk 1, recorded values below the European Union average, except for 2012, when the value recorded was 110, and at the European Union level was 97 [4]. But the progress registered by Romania is noticeable from the following year (2013), when this indicator decreased, and in 2014 the decrease in half of the value compared to the previous year was considered a progress. The oscillations recorded in the following years were small, the year 2019 being highlighted with the lowest value for this indicator, namely 38, by 65.46% lower than the maximum value recorded, namely 110, in 2012. It is necessary to remember that Romania is a country where agriculture is an important sector of the economy and where agricultural production is directed both to the internal and external market. The realization of agricultural production is determined by a number of factors: soil type; precipitation level; applied production technologies; quantity of pesticides used etc. [14]. Romania must take into account the directives of the European Union regarding the quantity of pesticides recommended to be used, as well as the types of pesticides allowed for use [15].

## MATERIALS AND METHODS

The paper highlights the consumption of pesticides in Romania during 2015-2017, compared to 2011-2013. In order to better capture the pesticide consumption, it was necessary to analyze several specific indicators such as: the quantitative consumption of insecticides for the periods considered in the study; the land areas where insecticides were applied; the average amount of insecticides used on the land area where insecticides were utilized; the quantitative consumption of herbicides; the total land areas on which herbicides were applied; the average amount of herbicides used on the land area where herbicides were applied; the quantitative consumption of fungicides; the total land areas on which fungicides were applied; the average amount of fungicides

used on the land area on which fungicides were utilized. The results were presented in tables and graphs. The statistical data underlying the paperwork were taken from the website of the National Institute of Statistics.

## RESULTS AND DISCUSSIONS

In Romania, according to NIS data, the total quantitative consumption of insecticides (kg. s, a) recorded an oscillating trend in the period 2011-2013 and upwards in the period 2015-2017 (Fig. 1).

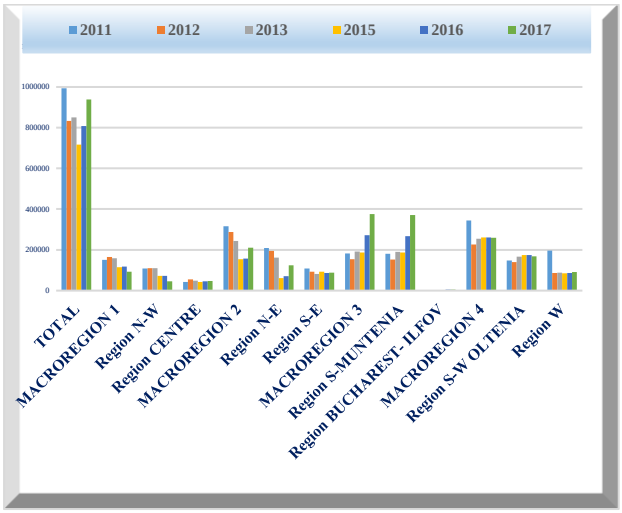


Fig. 1. Amount of insecticides (kg. s.a.) utilised in Romania
Source: [12].

There is a 7.97% decrease in the consumption of insecticides in the period 2015-2017 compared to 2011-2013.


Fig. 2. Average quantity of insecticides (kg. s.a.) used in Romania in the periods 2011-2013 and 2015-2017
Source: [12].

This decrease is due to the situation within the second macro-region, with the North-East regions registering a decrease of insecticide consumption by 54.66% compared to the period 2011-2013 and the South-East Region with a decrease of insecticide consumption by 5.67%. Macroregion One also contributed to this decrease, with North-West Region (42.01% decrease in consumption) and Central Region with a 8.17% reduction. In the Macro-Region Four, South-West Oltenia Region recorded an increase of 13.50% compared to the previous period and the West Region a decrease of 29.01% (Fig. 3).

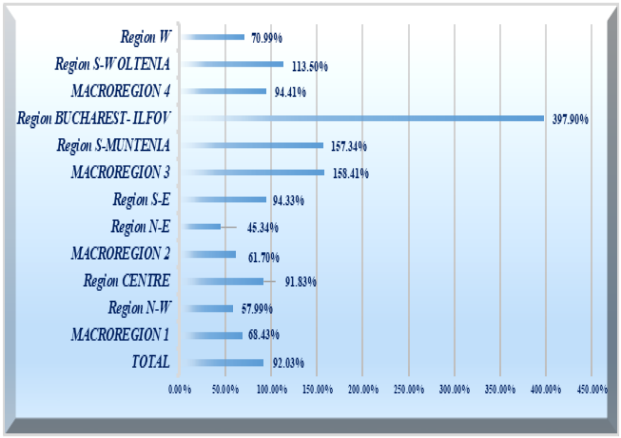


Fig. 3. Dynamics of the average quantity of insecticides (kg. s.a.) used in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

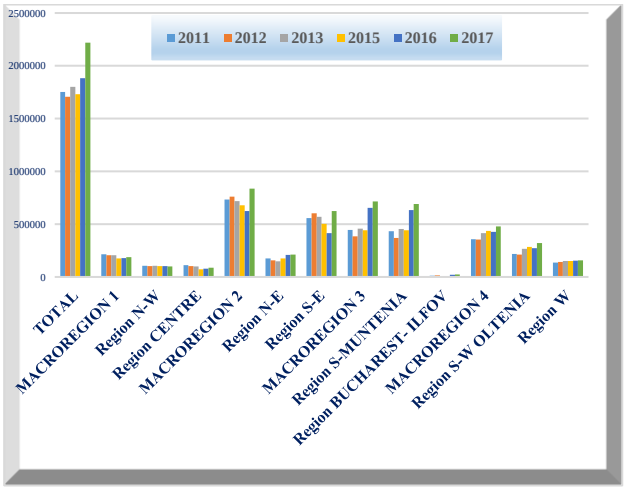


Fig. 4. Surface (ha) on which insecticides have been applied
Source: Own processing [12].

At the opposite pole is the South-Muntenia Region where there were increases in the consumption of insecticides by 57.34% compared to the previous period, and in the

Bucharest-Ilfov Region, the increase was substantial by 297.90% more in the period 2015-2017 compared to the period 2011-2013. On the other hand, the total land area (ha) on which insecticides were applied recorded an oscillating trend in the period 2011-2013 and an upward trend in the period 2015-2017.

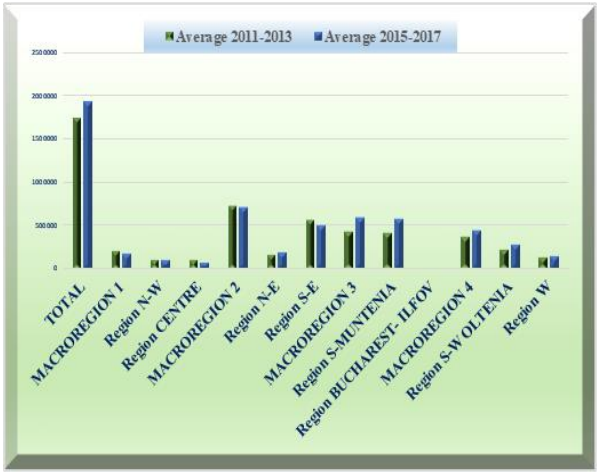


Fig. 5. Average land area (ha) on which insecticides were applied in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].


Fig. 6. Dynamics of the average surface on which insecticides (ha) were applied in Romania in the periods 2011-2013 and 2015-2017
Source: Own processing [12].

We notice the increase of the surfaces on which insecticides were applied by 10.93% in the period 2015-2017 compared to the period 2011-2013. This increase is due to the situation within Macroregion Three, which includes the South-Muntenia Region with an increase of the areas on which insecticides were applied by 40.63% as well as the situation in the Bucharest-Ilfov Region, with an increase of 37.86%.

Also, in the Macroregion Four there were increases in the areas on which insecticides were applied and these increases were due to the situation in the South-West Oltenia Region where on another 26.61% of land were applied insecticides compared to the period 2011-2013, but also in the West Region there was an increase of 7.20%.

At the opposite pole lies Macroregion One, with the North-West Regions (13.79% decrease of the surfaces where insecticides were applied) and the Center Region (3.03% decrease). In Macroregion Two, we noticed the following situation: North-East Region, increase of the areas on which insecticides were applied by 23.01% and South-East Region, decrease of these areas by 10.91%.

Analyzing the average amount of insecticides used on the land surface on which insecticides were applied during the period 2015-2017, it is noted that, in Romania, this decreased was of 0.09 kg a.s./ha, respectively 17.12% compared to the period 2011-2013.

Table 1. The average amount of insecticides used onthe area of land on which insecticides were applied (kg s.a./ha)

| No. Crt. | Macroregions and development regions | Average | | Dynamics Average 2015/2017 at Average 2011/2013 | |
|---|---|---|---|---|---|
| | | 2011-2013 | 2015-2017 | | |
| | | Kg. s.a. | | | |
| 1. | TOTAL | 0.51 | 0.42 | -0.09 | 82.88% |
| 2. | MACROREGION 1 | 0.76 | 0.60 | -0.15 | 79.56% |
| 3. | Region N-W | 1.05 | 0.63 | -0.42 | 59.64% |
| 4. | Region CENTRE | 0.47 | 0.57 | +0.10 | 121.52% |
| 5. | MACROREGION 2 | 0.38 | 0.24 | -0.14 | 63.86% |
| 6. | Region N-E | 1.16 | 0.43 | -0.74 | 36.52% |
| 7. | Region S-E | 0.16 | 0.18 | +0.01 | 108.49% |
| 8. | MACROREGION 3 | 0.41 | 0.45 | +0.05 | 111.32% |
| 9. | Region S-MUNTENIA | 0.42 | 0.46 | +0.04 | 110.32% |
| 10. | Region BUCHAREST-ILFOV | 0.10 | 0.28 | +0.18 | 276.11% |
| 11. | MACROREGION 4 | 0.74 | 0.58 | -0.16 | 78.73% |
| 12. | Region S-W OLTENIA | 0.66 | 0.59 | -0.07 | 89.94% |
| 13. | Region W | 0.87 | 0.57 | -0.30 | 65.25% |

Source: Own processing [12].

There are regions where this average amount of insecticides used on the surface on which insecticides were applied has grown and there are highlighted Macro-Region Three, with the South-Muntenia Region and the Bucharest-Ilfov Region, as well as the Center and South-

East Regions. In the other development regions of Romania, there is a decrease in the quantities of insecticides used in the period 2015-2017 compared to the period 2011-2013. The total quantitative consumption of herbicides (kg. s.a) in Romania recorded an upward trend between 2011-2013 and 2015-2017, with a slight decrease highlighted in 2017. There is a 2.74% decrease in herbicide consumption in the period 2015-2017 compared to 2011-2013, taking into account the average consumption of these periods. This decrease is due to the situation within Macroregion One, with the North-West Regions, which recorded a decrease in consumption by 37.09% and the Centre Region with a decrease of 29.91%, as well as the West Region within Macroregion Four, with a decrease in the quantities of herbicides used of 7.82%.

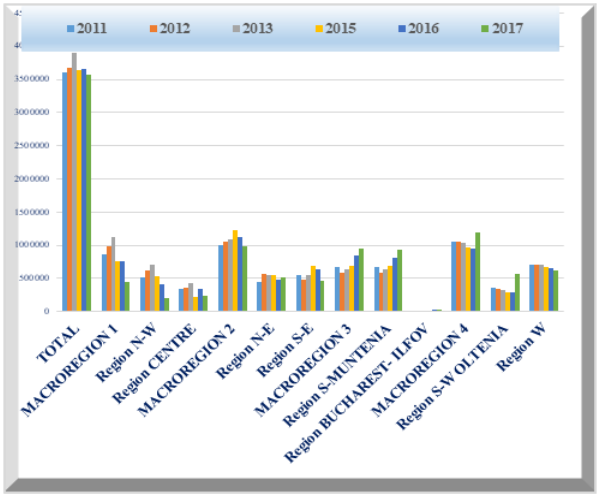


Fig. 7. Quantity of herbicides (kg s.a.) used in Romania
Source: Own processing [12].

At the opposite pole is Macroregion Two, with an increase in the quantities of herbicides used by 5.82%.
This was due to the increase within the South-East Region (12.24%) as well as Macroregion Three, with a total increase of 30.20% in which the South-Muntenia Region contributed with an increase in the quantities of herbicides used of 27.69% and the Bucharest-Ilfov Region stands out with a substantial increase of 783.18 compared to the previous period considered in the study.

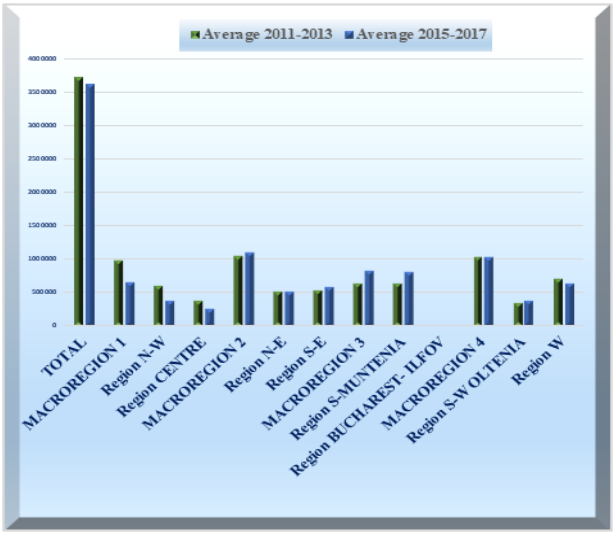


Fig. 8. Average quantity of herbicides (kg s.a.) used in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

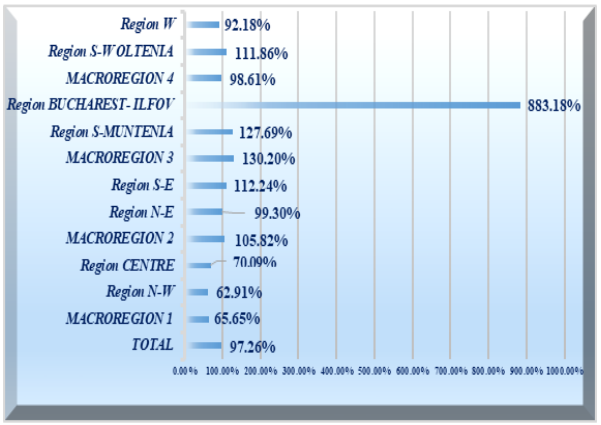


Fig. 9. Dynamics of the average amount of herbicides (kg. s.a.) used in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

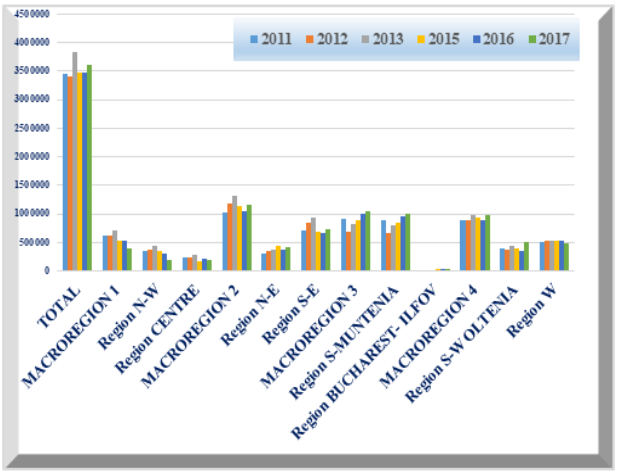


Fig. 10. Surface (ha) on which herbicides were applied
Source: Own processing [12].

On the other hand, the total area of land (ha) on which herbicides were applied recorded an oscillating trend in the period 2011-2013 as well as in the period 2015-2017.
It is noted the decrease of the areas on which herbicides were applied by 1.12% in the period 2015-2017 compared to the period 2011-2013.

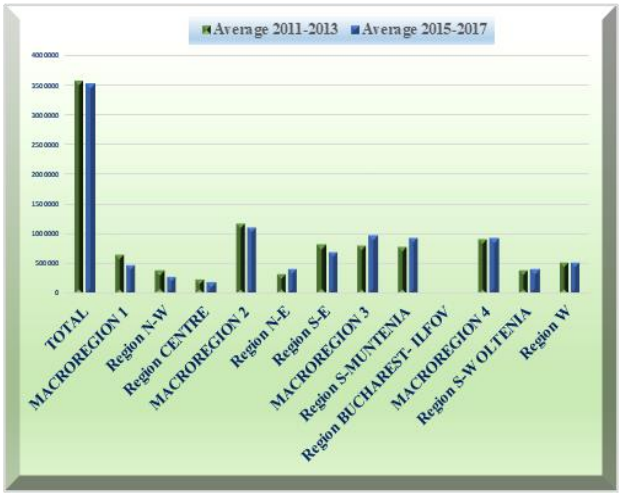


Fig. 11. Average area on which herbicides (ha) were applied in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

This decrease is due to the situation within Macroregion One, where the North-West Region has decreased in the areas on which herbicides were applied by 25.91%, and the Center Region which has decreased by 20.93% in the areas on which herbicides were applied and also Macroregion Two, with the South-East Region where these areas decreased by 16.23%.

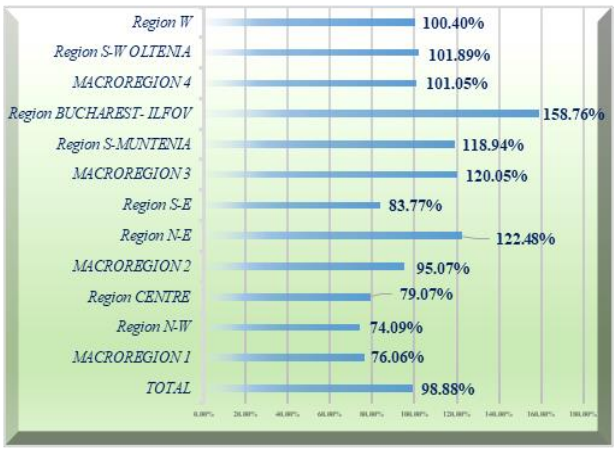


Fig. 12. Dynamics of the average area on which herbicides (ha) were applied in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

A At the opposite pole are the areas on which herbicides were applied in the South Muntenia Region with an increase of 18.94% compared to the previous period and the Bucharest-Ilfov Region, with an increase of 58.76%. And in Macroregion Four, there was a slight 1.05% increase in the areas on which herbicides were applied.
nalysing the average amount of herbicides used on the land area on which they were applied during 2015-2017, it is noted that, at the level of Romania, there was a decrease of 0.02 kg s.a./ha, respectively 2% compared to the period 2011-2013.

Table. 2. The average quantity of herbicides used on the area of land on which herbicides were applied

| | Macroregions and development regions | Average | | Dynamics Average 2015/2017 at Average 2011/2013 | |
|---|---|---|---|---|---|
| | | 2011 - 2013 | 2015-2017 | | |
| | | Kg. s.a. | | | |
| 1. | TOTAL | 1.05 | 1.03 | -0.02 | 0.98% |
| 2. | MACROREGION 1 | 1.53 | 1.32 | -0.21 | 0.86% |
| 3. | Region N-W | 1.57 | 1.33 | -0.24 | 0.85% |
| 4. | Region CENTRE | 1.48 | 1.31 | -0.17 | 0.89% |
| 5. | MACROREGION 2 | 0.90 | 1.00 | +0.10 | 1.11% |
| 6. | Region N-E | 1.53 | 1.24 | -0.29 | 0.81% |
| 7. | Region S-E | 0.64 | 0.85 | +0.21 | 1.34% |
| 8. | MACROREGION 3 | 0.78 | 0.85 | +0.07 | 1.08% |
| 9. | Region S-MUNTENIA | 0.80 | 0.86 | +0.06 | 1.07% |
| 10. | Region BUCHAREST-ILFOV | 0.09 | 0.52 | +0.43 | 5.56% |
| 11. | MACROREGION 4 | 1.13 | 1.10 | -0.03 | 0.98% |
| 12. | Region S-W OLTENIA | 0.85 | 0.93 | +0.08 | 1.10% |
| 13. | Region W | 1.35 | 1.24 | -0.11 | 0.92% |

Source: Own processing [12].

There are regions where this average amount of herbicides used on the surface on which herbicides were applied has increased and Macroregions Two, Three and Four are highlighted, the most significant increase being in the Bucharest-Ilfov Region 0.43kg s.a//ha.
The total quantitative consumption of fungicides (kg.s.a.) in Romania recorded an oscillating trend both in the period 2011-2013 and in the period 2015-2017. It is noted the 7.37% increase in the consumption of

fungicides in the period 2015-2017 compared to the period 2011-2013, taking into account the average amount used during these periods.

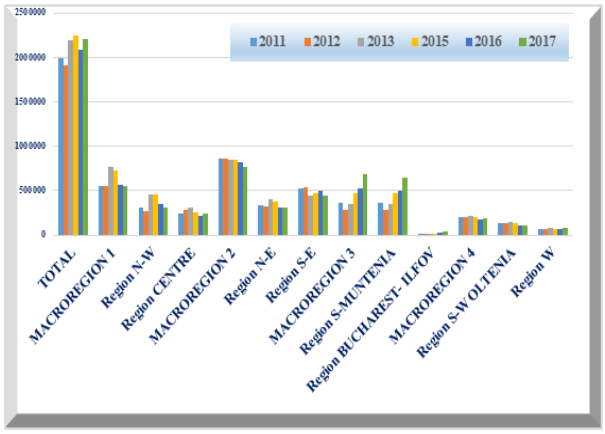


Fig. 13. Amount of fungicides (kg.s.a.) used in Romania
Source: Own processing [12].


Fig. 14. Average amount of fungicides (kg s.a.) used in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

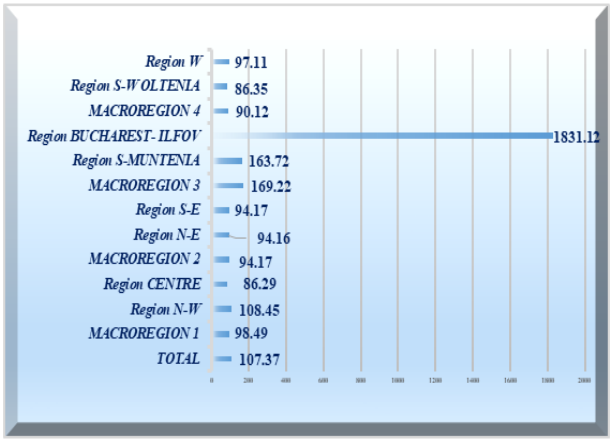


Fig.15. Dynamics of the average amount of fungicides (kg s.a.) used in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

This increase is due to the situation within Macroregion Three, in which the South Muntenia Region which recorded an increase in the consumption of fungicides by 63.72% compared to the period 2011-2013 and the Bucharest-Ilfov Region with an obvious increase of 1,831.12% compared to the previous period. And in the North-West Region of Macroregion One, the increase in fungicides consumption was highlighted with 8.45% compared to 2011-2013. At the opposite pole is Macroregion One, with a decrease of 1.51% due to the decrease in the use of fungicides quantities recorded in the Center Region (13.71%) and Macroregion Two, with a 5.83% decrease in the use of fungicides compared to the previous analysis period.

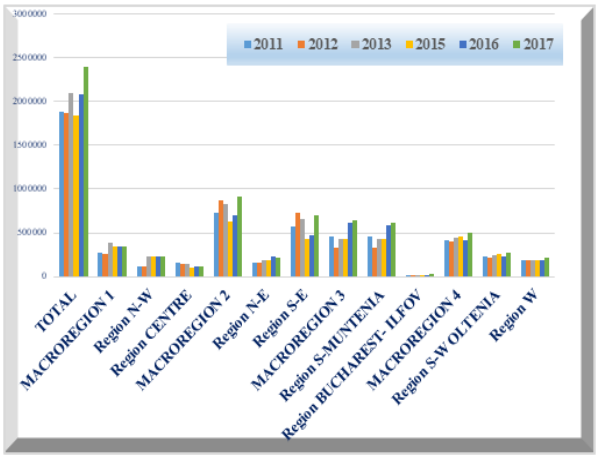


Fig. 16. Surface (ha) on which fungicides were applied
Source: Own processing [12].

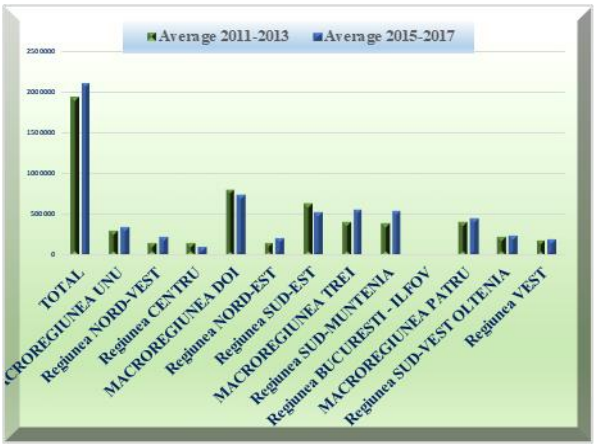


Fig.17. Average area on which fungicides (ha) were applied in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

The land areas on which fungicides were applied increased by 8.23% in the period 2015-2017 compared to the period 2011-2013. This increase is due to the situation within all Romanian Macroregions, with the exception of the Center Region and the South-East Region (the decrease of the areas on which fungicides were applied being of 24.81% and 17.63%, respectively).

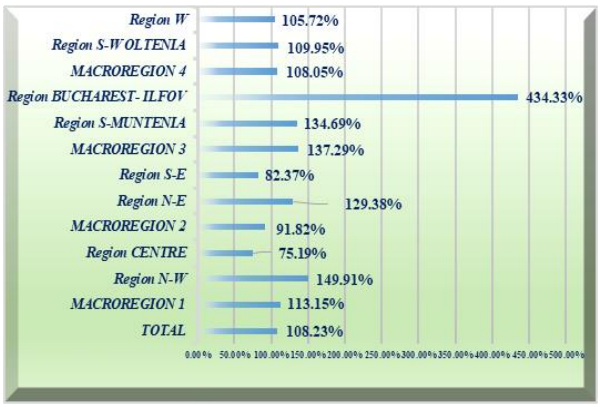


Fig. 18. Dynamics of the average area on which fungicides (ha) were applied in Romania during 2011-2013 and 2015-2017
Source: Own processing [12].

Analyzing the average amount of fungicides used on the land area on which fungicides were applied during 2015-2017, it is noted that, in Romania, it increased by 1.28 kg s.a./ha, respectively 2.22% compared to the period 2011-2013.

Table. 3. The average amount of fungicides used on the land area on which fungicides were applied

| No. Crt. | Macroregions and development regions | Average | | Dynamics Average 2015/2017 at Average 2011/2013 | |
|---|---|---|---|---|---|
| | | 2011-2013 | 2015-2017 | | |
| | | Kg. s.a. | | | |
| 1. | TOTAL | 1.04 | 2.32 | +1.28 | 2.22 |
| 2. | MACROREGION 1 | 2.05 | 4.19 | +2.14 | 2.05 |
| 3. | Region N-W | 2.22 | 3.58 | +1.36 | 1.61 |
| 4. | Region CENTRE | 1.87 | 5.46 | +3.59 | 2.92 |
| 5. | MACROREGION 2 | 1.06 | 2.62 | +1.56 | 2.48 |
| 6. | Region N-E | 2.18 | 3.83 | +1.65 | 1.76 |
| 7. | Region S-E | 0.78 | 2.14 | +1.36 | 2.76 |
| 8. | MACROREGION 3 | 0.81 | 1.79 | +0.98 | 2.20 |
| 9. | Region S-MUNTENIA | 0.82 | 1.80 | +0.98 | 2.21 |
| 10. | Region BUCHAREST-ILFOV | 0.31 | 1.40 | +1.09 | 4.52 |
| 11. | MACROREGION 4 | 0.51 | 1.05 | +0.54 | 2.07 |
| 12. | Region S-W OLTENIA | 0.31 | 1.40 | +1.09 | 4.52 |
| 13. | Region W | 0.51 | 1.05 | +0.54 | 2.07 |

Source: Own processing [12].

There are no regions where this average amount of fungicides used on the surface on which fungicides were applied has registered a decrease, the smallest increase was recorded in Macroregion Four, West Region and the most significant increase was registered in the Bucharest-Ilfov Region, respectively 4.52 kg s.a./ha.

## ACKNOWLEDGEMENTS

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## CONCLUSIONS

Analyzing the quantitative consumption of pesticides on its components, insecticides, herbicides, fungicides as well as the land areas on which they were applied, in Romania, in the period 2015-2017 compared to the period 2011-2013, we note the following:
*Quantitative consumption of insecticides* decreased in 2015-2017 by 7.97% compared to the period 2011-2013, a decrease mainly due to the limitation of the use of these products in Macroregion One by 31.57%, Macroregion Two by 38.3% and Macroregion Four by 5.59%. In Macroregion Three the consumption of insecticides increased significantly, by 58.41%, noting the Bucharest-Ilfov Region with an increase of 97.90%.
*The areas of land on which insecticides were applied* increased in the period 2015-2017 compared to the period 2011-2013 by 10.63% but the quantitative consumption of insecticides in the same period decreased by 7.97%. The increase in the areas on which insecticides were applied is particularly evidenced by the increase in Macroregions

Three by 40.55% and Macroregion Four by 19.18%. In Macroregion One, the areas of land on which insecticides were applied decreased by 13.79% also in Macroregion two, by 24.51%.

*The average amount of insecticides used on the land area on which insecticides* were applied in the period 2015-2017 decreased by 0.09 kg s,a,/ha, respectively 17.12% compared to the period 2011-2013.

- *Quantitative consumption of herbicides* decreased in the period 2015-2017 by 2.74% compared to the period 2011-2013, a decrease due in particular to the limitation of the use of these products in Macroregion One by 34.35% and Macroregion Four by 1.39%, in Macroregion Three the consumption of herbicides increased significantly, by 30.20%, noting the Bucharest-Ilfov Region with an increase of 783.18% compared to the reference period, 2011-2013, but also to the situation in Macroregion Two, with an increase of 5.82% due to the 12.24% increase in the South-East Region.

*The land areas on which herbicides were applied* decreased by 1.12% in the period 2015-2017 compared to the period 2011-2013, a decrease due to the situation within Macroregion One, with the North-West Regions (-25.91%) and the Center Region (-21.93%) and in Macroregion Two, with the South-East Region (-16.23%). The South-Muntenia Region registered an increase (+18.94%) as well as the Bucharest-Ilfov Region (+58.76%). A slight increase of these areas can be also noticed in Macroregion Four (+1.05%).

*The average amount of herbicides used on the area of land on which herbicides were applied* decreased by 0.02 kg s.a./ha, respectively 2% compared to the period 2011-2013, but there are areas (Macroregions Two, Three and Four) where there were recorded increases, the most significant increase being registered in the Bucharest-Ilfov Region (+0.43 kg s.a//ha).

*The average amount of fungicides* increased by 7.37% in the period 2015-2017 compared to the period 2011-2013, an increase due to the situation within Macroregion Three, South-Muntenia Region (+63.72%), Bucharest-Ilfov Region (significant increase 1831.12%), as well as the North-West Region within Macroregion One (+8.45%). In Macroregion One, the average amount of fungicides decreased (-1.51%) due to the decrease recorded in the Center Region (-13.71%) but also in Macroregion Two (-5.83%) compared to the previous period of analysis.

- *The land areas on which fungicides were applied* increased (+8.23%) in the period 2015-2017 compared to the period 2011-2013, an increase due to the situation within all Romanian Macroregions, except for the Center Region and the South-East Region (-24.81%, respectively -17.63%),
- *The average amount of fungicides used on the land area on which fungicides were applied* increased by 1.28 kg s.a./ha, respectively 2.22% compared to the period 2011-2013, the smallest increase was recorded in Macroregion Four, West Region (+0.54 kg s.a./ha) and the most significant increase was recorded in the Bucharest-Ilfov Region (+4.52 kg s.a./ha).

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