

THE STATISTICAL ANALYSIS OF THE PRODUCTIVITY AND THE BENEFIT OF PESTICIDES APPLICATION IN THE SOUTH-EAST REGION, ROMANIA

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Abstract

Without doubts, a balance between the application of pesticides, productivity and soil health control is essential for assuring sustainable agricultural performance. Nevertheless, pesticides proceed to be a critical tools for worldwide food guarantee, but their negative consequences should not be ignored precisely when sustainable agriculture is the worldwide target. The purpose of the present article is to present a statistical analysis using a parametric and a nonparametric correlations coefficient in order to study the effect of using three categories of pesticides: insecticides, fungicides, herbicides from 1990 to 2022, in the South-East region of Romania and the productivity of: barley, rape and soybeans. During the studied period, the quantity of pesticides per hectare is the following: insecticides 30.67 kilograms of active substance/ha; fungicides 103.81 kilograms of active substance/ha and herbicides 45.16 kilograms of active substance/ha. The statistical analysis shows that the highest correlation between insecticides and herbicides is that with barley of 0.816 and 0.860, while for fungicides is with rape - 0.683.

Key words: pesticides, statistical analysis, SE Region, Romania.

INTRODUCTION

Agricultural chemical products as fertilizers and pesticides have turn into a significant factor of contemporary agricultural systems within the recent period to provide a substantial increase in crop harvests (Alexandratos and Bruinsma, 2012). It has been valuated that approximately 35-45% harvest production is lost as a result of insufficient crop protection actions contra pest invasion of insects, weeds and diseases (Larsen et al., 2019). During the last fifty years, significant increase in the global economy containing both technical and farming fields generated the gradual grow in the production and application of agriculture-based chemicals compounds that frequently cause devastating repercussions on the environment (Balog et al., 2017).

Inappropriate utilize of pesticides and other chemical pollutants in agricultural lands have devastating subsequent impact (Lampridi et al., 2019). In recent years attempts have been made to find alternatives accessible to manage crop damage attributable to pest attack that might contain the use of several biopesticides (Tudi et al., 2021). However, the utilisation of synthetic

pesticide is still chosen comparing with the majority over all other options to protect harvest from efficiency damage. Currently, over the world about 2 million tonnes of pesticides are used, among them 47.5% are herbicides, 29.5% are insecticides, 17.5% are fungicides and 5.5% are different types of pesticides (De et al., 2014). According to Worldometers in 2020 the top ten pesticide consuming countries in the world are China, the USA, Brazil, Argentina, Canada, Ukraine, France, Malaysia, Australia and Spain (Worldometers, 2020).

Pesticides applied in agriculture has synthetic origin and are assimilated in the ground throughout surface drainage from processed plants. The type of organic mixture, cropping procedures, watering facilities and climatic causes influence the dissipation of pesticides in ground (Kniss, 2017; Möhring et al., 2021; van der Sluijs, 2020).

The remnants of these organochloride compounds moreover contaminate the subsoil water through percolating and successively influencing the characteristic of agricultural harvests (Martin et al., 2013). Pesticides are collected in soils immediately by its utilization in agriculture and household purposes or

incidentally by deposition of aerial pollutants formerly originating from distinct locations or regions (Rossi et al., 2012). Soil has the role of storage segments attributable to larger predilection of biological chemicals with soil (Shattuck et al., 2023). The deposition of natural chemicals or pesticides in ground immediately exposes soil bacteria and in addition rises the hazard for diverse organisms through nutriment and may seriously impact ground habitat, aquatic areas, vegetation and human condition (Sharma et al., 2019; Möhring et al., 2020; Sabzevari et al., 2022).

MATERIALS AND METHODS

With the purpose of analysing the quantities of pesticides applied in the South-East region of Romania, during the period 1990-2022 a series of indicators were used: pesticides (insecticides, fungicides, herbicides) applied per hectare.

The data, collected by the National Institute of Statistics, have been statistically calculated and defined, presenting a clear image of the studied period. During the analysed period, data collection was based on the survey method, with the principal target of obtaining information related to the principal characteristics of agricultural resources. The surveys focus on agricultural holdings that carried out farming activities, either as a main activity or as a secondary activity.

The current study includes an analysis of the main categories of pesticides: insecticides, fungicides and herbicides applied in the South-Eastern region of Romania, more precisely the counties of: Braila, Buzau, Constanta, Galati, Tulcea and Vrancea. From the analysis of the surface of the lands on which pesticides were applied and the quantity of pesticides applied in agriculture, the amount per hectare was calculated in kilograms of active substance/ha.

The amount of pesticides/hectares used in agriculture, South-East region, Romania, is represented in Figure 1, the annual values being obtained by reporting the amounts of pesticides per hectare, calculating the total amounts of the three types of pesticides (Insecticides, Fungicides, Herbicides) that were applied in the six counties in the South-East region of the country.

If we discuss Figures 2-4, they contain two types of graphic representations: the amount of pesticides applied in agriculture, by county, South-East region and the surface of the land on which pesticides were applied and for both types of maps, s - they used the total values of the quantities of pesticides applied and of the surfaces on which pesticides were applied in the counties of Braila, Buzau, Constanta, Galati, Tulcea and Vrancea in the period 1990-2022

The production of Barley, Rapeseed and Soy beans in the South-East region of Romania compared to the pesticides applied is represented graphically in Figure 5, where the total values of the three categories of pesticides are represented (kilograms of active substance/hectares) and productivity of barley, rape and soy beans/hectares for the period 1990-2022.

At the same time, by using the SPSS 26 software, the correlation coefficients were calculated analysing the amounts of pesticides per hectare and three types of barley, rape and soy beans crops.

RESULTS AND DISCUSSIONS

Intense long-term utilization of pesticides on cultivated area causes substantial environmental and health concerns. As a pollutant, when applied on ground, pesticides are able to disturb the soil properties because of its contaminant effect and harmful impact on biodiversity. Over entire pesticides utilized for crops, it has been stated that an extremely small percent reaches the target organism whereas the residues of it pollute the surrounding field (air, water, and ground). All these aspects require a permanent monitoring in order to avoid a series of imminent dangers.

In the South-East region of Romania, in the period 1990-2022, an average amount of 179.65 kilograms of active substance/ha was applied.

Among these, if we analyse each category, the situation is as follows: insecticides 30.67 kilograms of active substance/ha; fungicides 103.81 kilograms of active substance/ha and herbicides 45.16 kilograms of active substance/ha.

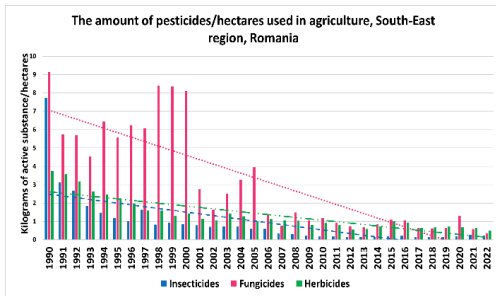


Figure 1. The quantity of pesticides/hectares used in agriculture, South-East region, Romania, 1990-2022

It is obvious that for all the types of pesticides: insecticides, fungicides and herbicides analysed in this study, the quantities applied per hectare decreased. Fungicides represent the pesticide category that decreased the most, from a quantity of 9.14 kilograms of active substance/ha in 1990 to 0.35 kilograms of active substance/ha in 2022. And insecticides registered a very large decrease, from 7.73 kilograms of active substance/ha in 1990 to 0.22 kilograms of active substance/ha in 2022.

Insecticides are crucial for modern agriculture to secure crop protecting and optimally harvests. Despite that, their disproportionate use increases difficulties concerning their negative consequences on agriculture and the ecosystem. Exaggerated insecticide utilization may conduct to the evolution of resistance in focus insects, requiring larger concentrations or stronger chemical substances, being the cause of higher production expenses and perturbation of natural pest control systems. Additionally, non-target organisms, like as useful bugs and watery life, are affected by the accidental repercussions of insecticide application, resulting into environment disparities and potential food cycle pollution.

The current study presents the situation of the use of pesticides in the counties of South-East Romania, analysing distinctly each type of pesticide applied at the county level.

In the period 1990-2022, in the South-East region of Romania, the largest quantities of insecticides applied were in Constanta County 3231535 kilograms of active substance, followed by Braila County 2447605 kilograms of active substance and Vrancea County 2274080 kilograms of active substance. The smallest quantities are those in Tulcea County

1482936 kilograms of active substance and Buzau County 1882068 kilograms of active substance. If we analyse from the point of view of the surfaces on which insecticide-type pesticides were applied, the first place is Constanta County 5702810 hectares, followed by Braila County 2936991 hectares, and the smallest quantities were applied in Vrancea County 990680 hectares and Buzau County 1165877 hectares.

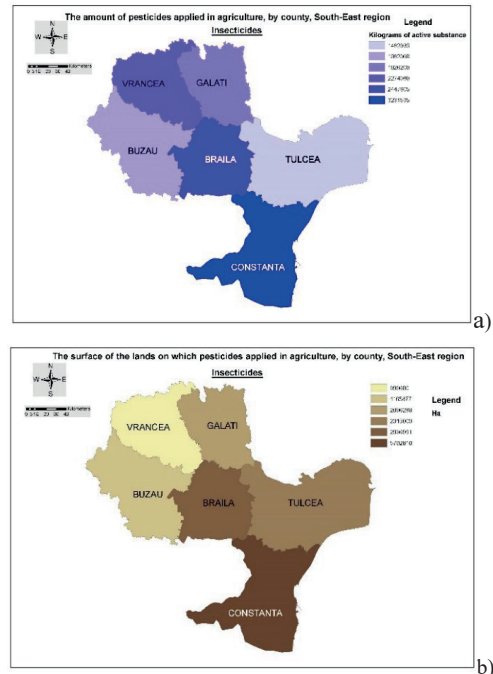


Figure 2. a. The quantity of insecticides used in agriculture, South-East region, Romania
 b. The surface of the lands on which insecticides were applied, South-East region, Romania

Fungal diseases are well-known to impact yield property on majority crops and to generate serious economic global damage. The application of fungicides has been for a long period the principal method to manage various fungal pathogens. During the past few decades, higher public interest on food safety and ecological effect of farming activities has conducted authorities to assume extremely rigorous standards on the appraisal and license of plant protection goods, particularly for toxicological and ecosystems adverse side consequences associated to their apply.

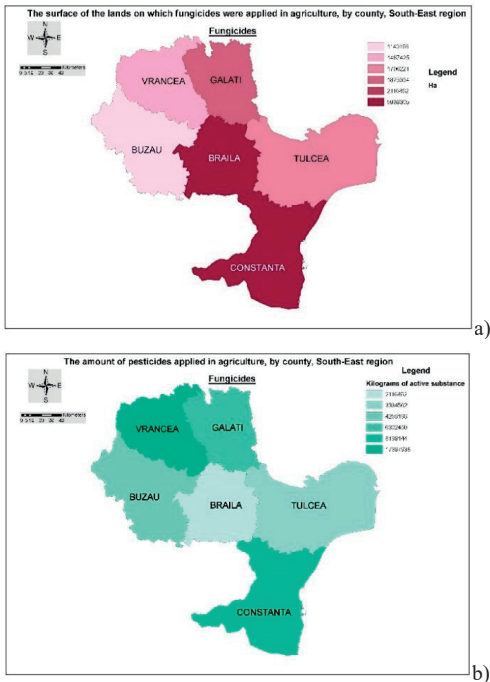


Figure 3. a. The quantity of fungicides used in agriculture, South-East region, Romania
 b. The surface of the lands on which fungicides were applied, South-East region, Romania

Fungicides are used both on seeds or directly on harvest. Most of the seed-treated agro-chemical have integral action and could be absorbed into plant tissues protecting contra pests and microorganism equivalent to their insecticidal counterparts.

From the study of the quantities of fungicides applied in the counties of South-Eastern Romania, it is obvious that in the counties of Vrancea 17397938 kilograms of active substance Constanta 8199144 kilograms of active substance and Galati 6302450 kilograms of active substance the highest quantities were applied, while in the counties of Braila 2116862 kilograms of active substance and Tulcea 3334562 kilograms of active substance the lowest were applied quantities.

The areas in the South-East region on which the largest amounts of fungicides were applied between 1990 and 2022 are those in the counties of Constanta 5939305 hectares and Braila 3308517 hectares, and the least areas were those recorded in the counties of Buzau 1140169 hectares and Vrancea 1487425 hectares.

Herbicides are synthetics applied in order to manage or control undesired plants. Herbicide utilization appear mostly regularly in cultivated crop farming, where they are used formerly or within planting to maximize crop productivity by minimizing other vegetation. They also may be applied to crops in the fall, to improve harvesting herbicides applied with the major goal of maximising productivity and economic returns potentially act at the expense of ecosystem functions. Although not immediately, but these ecosystem services also contribute to crop health by supporting crop stubble yield, pathogen inhibition, nutrient cycling and conservation of soil structure.

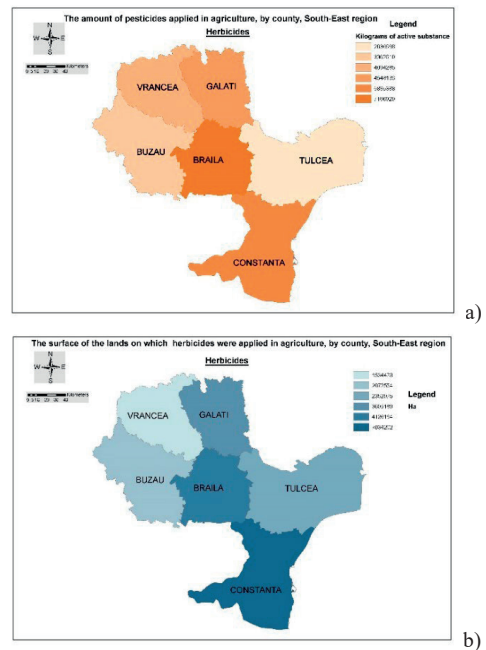


Figure 4. a. The quantity of herbicides used in agriculture, South-East region, Romania
 b. The surface of the lands on which herbicides were applied, South-East region, Romania

A detailed analysis of both the quantities and the surfaces on which herbicides were applied is necessary for the purpose of tracking the production per hectare, therefore the resulting advantages, but also to observe the potential disadvantages arising especially in soil pollution and not only.

Over the analysed period, 1990-2022, the largest amounts of herbicides were applied in the counties of Braila 7166929 kilograms of active

substance, Constanta 5885388 kilograms of active substance, and the smallest amounts in Tulcea County 2636698 kilograms of active substance and Buzau County 3362610 kilograms of active substance.

If we consider the areas on which herbicides were used, the first place is Constanta County 7034202 hectares, the second place is Braila County 4126194 hectares and with a significant difference on the last places are Vrancea County 1534478 hectares and Buzau County 2072554 hectares.

Considering that in the South-Eastern region of Romania the surfaces are cultivated with the main crops: barley, rapeseed and soy beans, in the present article we proposed to study if there is a correlation between these types of crops and the pesticides applied in the form of insecticides, fungicides and herbicides in the period 1990-2022.

The graphic representation shows that there is no interdependence between the productivity per hectare and the quantity of pesticides applied in the analysed period.

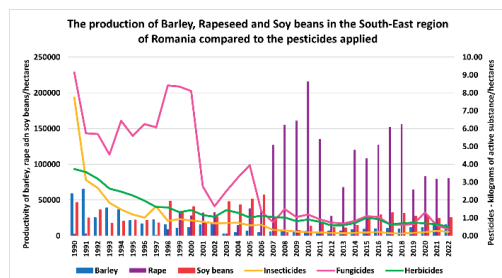


Figure 5. The production of Barley, Rapeseed and Soy beans in the South-East region of Romania compared to the pesticides applied, South-East region, Romania

It is obvious that the largest amounts of pesticides were applied until 2007, the decrease of fungicides from 9.15 kilograms of active substance/hectares in 1990 to 0.76 kilograms of active substance/hectares in 2007 is essential.

The statistical analysis of parametric correlation indicated that there are insignificant or moderately significant correlations in most of the studied situations.

Table 1 indicates the Pearson correlation coefficient for Insecticides and production for the 3 types of surfaces cultivated with barley, rape and soy beans.

Table 1. Pearson correlation coefficient for Insecticides and production for the 3 types of surfaces cultivated with barley, rape and soy beans

		Insecticides	Barley	Rape	Soy beans
Insecticides	Pearson Correlation	1	0.816	-0.481	0.281
	Sig. (2-tailed)		0.000	0.004	0.108
	N	34	34	34	34
Barley	Pearson Correlation	0.816	1	-0.486	0.024
	Sig. (2-tailed)	0.000		0.004	0.892
	N	34	34	34	34
Rape	Pearson Correlation	-0.481	-0.486	1	-0.395
	Sig. (2-tailed)	0.004	0.004		0.021
	N	34	34	34	34
Soy beans	Pearson Correlation	0.281	0.024	-0.395	1
	Sig. (2-tailed)	0.108	0.892	0.021	
	N	34	34	34	34

According to the statistical analysis, the most important correlation is that between insecticides and barley, of 0.816, and the lowest is the correlation coefficient between insecticides and soybeans of 0.281.

In Table 2 is presented the Pearson correlation coefficient for fungicides and production for the 3 types of surfaces cultivated with barley, rape and soy beans.

Table 2. Pearson correlation coefficient for Fungicides and production for the 3 types of surfaces cultivated with barley, rape and soy beans

		Fungicides	Barley	Rape	Soybeans
Fungicides	Pearson Correlation	1	0.565	-0.683	0.359
	Sig. (2-tailed)		0.001	0.000	0.037
	N	34	34	34	34
Barley	Pearson Correlation	0.565	1	-0.486	0.024
	Sig. (2-tailed)	0.001		0.004	0.892
	N	34	34	34	34
Rape	Pearson Correlation	-0.683	-0.486	1	-0.395
	Sig. (2-tailed)	0.000	0.004		0.021
	N	34	34	34	34
Soy beans	Pearson Correlation	0.359	0.024	-0.395	1
	Sig. (2-tailed)	0.037	0.892	0.021	
	N	34	34	34	34

There are two moderately significant correlations between fungicides and barley 0.565, respectively rape -0.683, which indicates

that the application of this type of pesticide does not significantly influence production per hectare.

Table 3 indicates the Pearson correlation coefficient for herbicides and production for the 3 types of surfaces cultivated with barley, rape and soy beans.

Table 3. Pearson correlation coefficient for Herbicides and production for the 3 types of surfaces cultivated with barley, rape and soy beans

		Herbicides	Barley	Rape	Soy beans
Herbicides	Pearson Correlation	1	0.860	-0.617	0.211
	Sig. (2-tailed)		0.000	0.000	0.231
	N	34	34	34	34
Barley	Pearson Correlation	0.860	1	-0.486	0.024
	Sig. (2-tailed)	0.000		0.004	0.892
	N	34	34	34	34
Rape	Pearson Correlation	-0.617	-0.486	1	-0.395
	Sig. (2-tailed)	0.000	0.004		0.021
	N	34	34	34	34
Soy beans	Pearson Correlation	0.211	0.024	-0.395	1
	Sig. (2-tailed)	0.231	0.892	0.021	
	N	34	34	34	34

The third statistical correlation analysis indicates the highest degree of interdependence among the three types of pesticides analysed, namely the Pearson coefficient of 0.860 between herbicides and barley, and in the case of herbicides and turnip of -0.617, being a negative correlation.

CONCLUSIONS

The application of pesticide is one of the fundamental actions of modern agricultural practices in protecting the harvests from various pests. Fertilizers and in particular insecticides are particularly essential inputs and integral constituent of crop production system. Simultaneously these inputs are highly significant in linking the yield gap that exists among the feasible production and the yield obtained at the farm level.

In the period 1990-2022, the most used types of pesticides in the South-Eastern region of Romania, in terms of total quantity, were fungicides 41610152 kilograms of active substance, and if we discuss from the point of view of surfaces, then herbicides were applied

on a surface of 20725592 hectares. The trend of pesticide application is a decreasing one, with significant variations from 20.62 kilograms of active substance/hectares in 1990 to only 1.07 kilograms of active substance/hectares in 2022. In the 34 years in which the study was carried out, in the South-Eastern region of Romania, the largest quantities of insecticides were used in Constanta County 3231535 kilograms of active substance, and there is also the largest total area on which this was applied type of pesticides around 5702810 hectares.

Fungicides were applied predominantly in Vrancea county 17397938 kilograms of active substance and in Constanta County they were applied on the largest surfaces of 5939305 hectares, as the amount in the analysed period.

If we refer to the quantity, the third category of pesticides, herbicides were applied in Braila County 7166929 kilograms of active substance and Constanta County 7034202 hectares is in first place in terms of the surfaces on which herbicides were applied.

The study of the interdependence between the quantity of pesticides kilograms of active substance/hectares and production of barley, rape and soy beans indicate that there are no significant correlations, but in general the Pearson correlation coefficient varied from 0.565 between fungicides and barley and of 0.860 between herbicides and barley.

Among the three types of production analysed, in the case of barley, it has the most important influence resulting from the application of pesticides.

Therefore, for the purpose of controlling pesticide utilisation, innovative approaches and methods are needed in evaluating the impact of widespread use of pesticides on ecosystem and different actions should be done to ensure consciousness between community to reduce the utilization of damaging pesticides. To take advantage of biopesticides should be promoted over chemical pesticides

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