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## Article

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Amfiteatru Economic Journal

## Provided in Cooperation with:

The Bucharest University of Economic Studies

*Suggested Citation:* Dobrin, Cosmin; Croitoru, Elena Oana; Dinulescu, Ruxandra; Marin, Irinel (2022) : The impact of pesticide and fertiliser use on agricultural productivity in the context of the 'farm to fork' strategy in romania and the european union, Amfiteatru Economic Journal, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 24, Iss. 60, pp. 346-360,  
<https://doi.org/10.24818/EA/2022/60/346>

This Version is available at:

<https://hdl.handle.net/10419/281638>

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## THE IMPACT OF PESTICIDE AND FERTILISER USE ON AGRICULTURAL PRODUCTIVITY IN THE CONTEXT OF THE “FARM TO FORK” STRATEGY IN ROMANIA AND THE EUROPEAN UNION

Cosmin Dobrin<sup>1</sup>, Elena Oana Croitoru<sup>2</sup>, Ruxandra Dinulescu<sup>3\*</sup>,  
and Irinel Marin<sup>4</sup>

<sup>1,2,3,4)</sup> *Bucharest University of Economic Studies, Romania*

### Please cite this article as:

Dobrin, C., Croitoru, E.O., Dinulescu, R., and Marin, I., 2022. The Impact of Pesticide and Fertiliser Use on Agricultural Productivity in the Context of the “Farm To Fork” Strategy in Romania and the European Union. *Amfiteatru Economic*, 24(60), pp. 346-360.

DOI: [10.24818/EA/2022/60/346](https://doi.org/10.24818/EA/2022/60/346)

### Article History

Received: 21 December 2021

Revised: 18 February 2022

Accepted: 18 March 2022

### Abstract

One of the main pillars of the European Green Pact is the “Farm to Fork” strategy. Launched in May 2020, this strategy aims to build sustainable agri-food production and distribution processes. The aim of this research is to estimate the impact of inorganic pesticide and fertiliser use on agricultural productivity and the economy at the national and European level in the context of the implementation of the “Farm to Fork” strategy. The current study outlines two models of analysis that will estimate the correlation between a possible 50% decrease in pesticide use and a 20% decrease in fertiliser use, and the level of agricultural productivity in European countries and, implicitly, Romania.

The originality of the paper lies in the research method used, based on computable general equilibrium modelling, whose results were adjusted with a coefficient obtained by statistical analysis of agricultural productivity from 1991-2019. The results obtained show that the implementation of the strategy regarding the decrease in pesticides and fertilisers will not negatively influence the agricultural productivity of Romania. In addition, the amount of pesticides and fertilisers used in Romania is lower than the European average.

**Keywords:** Pesticides, fertilisers, agricultural productivity, “Farm to Fork”.

**JEL Classification:** D24, Q56, Q57

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\*Corresponding author, **Ruxandra Dinulescu** – e-mail: [ruxandra.dinulescu@man.ase.ro](mailto:ruxandra.dinulescu@man.ase.ro)



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## **Introduction**

Every year, a third, or about 1.3 billion tonnes of food produced for human consumption is lost or wasted along the food supply chain. Identifying the causes and reasons for food loss and wastage is essential to improve long-term resource efficiency (Candel and Pereira, 2017). Some losses are caused by natural phenomena, such as the presence of insects, pests, and mould, as well as the temperature and humidity conditions. The interaction of these factors could have a significant impact on food loss and wastage. However, for many people, farming is both a necessity and a source of income. Because of this, many farmers prefer to use pesticides and fertilisers to prevent crop loss.

The EU's mission is to reduce the environmental impact on food systems, make them more resilient to crises, and ensure that good, low-cost food is affordable for people now and for future generations by reforming the way it is produced and consumed in Europe. Thus, to achieve the above, the EU proposes to develop and implement the Farm to Fork (F2F) strategy. The intention of the F2F strategy is to build a fairer, healthier, and greener European food system, thus being recognized as a cornerstone of the European Green Pact under the European Commission's 2019-2024 mandate. From this point of view, the aim of the paper is to estimate the potential impact of the F2F strategy on agricultural productivity in the European Union countries and, implicitly, in Romania, under the conditions of a 50% reduction in the quantity of pesticides and a 20% reduction in the quantity of fertilisers used in agriculture.

The novelty of the paper is the comparison of agricultural productivity between Romania and the rest of the European countries, depending on the impact of the F2F strategy. We believe that the topic proposed for research is of particular importance, as it is imperative to know the extent to which agricultural productivity in European countries, and implicitly in Romania, will be affected by a 50%, respectively, 20% reduction in the level of pesticides and fertilisers.

Next, a review of the specific literature in the field will be addressed, illustrating the theoretical concepts specific to the F2F strategy, the role of pesticides and fertilisers in agriculture, and their impact on human health. The research methodology section presents the research hypotheses and economic models used to estimate the link between agricultural productivity levels in European countries (including Romania) and the reduction of pesticide and fertiliser use by 50% and 20%, respectively. Next, the results of the study and conclusions on which countries will experience a decrease in agricultural productivity as a result of the decrease in pesticide and fertiliser use are presented.

## **1. Review of the scientific literature on the F2F Strategy**

At the heart of the EU's efforts to build fairer, healthier, and greener food systems is the F2F strategy. The F2F aims to create a European food system that ensures food security while having a reduced environmental and climate footprint. Achieving this is possible by promoting sustainable food production, consumption, processing, and distribution and by reducing food loss and waste (Dekeyser and Rampa, 2021). The EU initiative is also the first attempt to address the sustainability of the food system in a comprehensive manner, targeting the entire European food system (Schebesta and Candel, 2020). However, this

attempt to ‘export’ F2F rules is not viewed positively by the United States, which fears that the strategy could create new trade barriers (Wax and Anderson, 2021).

The main objective of the F2F strategy is to increase action towards a sustainable, affordable, and safe food chain characterized by the following:

- Minimal or positive environmental impact;
- Assistance in combating climate change and adapting to its consequences;
- Preventing biodiversity decline;
- Promoting public health and food security, ensuring access to safe, nutritious, and sustainable food for all;
- Providing food at low prices, while increasing the competitiveness of EU suppliers and encouraging fair trade.

The F2F strategy includes many objectives, such as: reducing the impact of food systems on the environment and climate change, competitiveness in terms of sustainability, creating a robust and resilient food system, and exploiting new food opportunities. It is the first time in the history of European food law that the EU has addressed food sustainability from primary production to the consumer in a comprehensive way. This policy contains concrete targets on pesticides, fertilisers, organic farming, and antimicrobial resistance to be met by 2030.

The transition to an organic food system is expected to generate new economic opportunities that will have a positive effect on the profits of agricultural and food companies around the world, including for the European consumers.

## **2. Pesticide and fertiliser use in agriculture in the context of the F2F strategy**

### **2.1. The role of pesticides and fertilisers in agriculture and their impact on human health**

Fertilisers are substances of natural or synthetic origin that are applied to the soil or plant tissue to provide nutrients, while pesticides are chemical compounds used to kill pests, including insects, rodents, fungi, and unwanted plants (weeds).

Organic and inorganic pesticides and fertilisers will continue to play an important role in the broad spectrum of technologies that can preserve and improve the living conditions of the global population. Alternative approaches may be more costly than current agricultural practices, which use many chemicals, but these comparisons generally do not consider the environmental and social consequences of pesticide and fertiliser use. In addition, externality issues related to the consequences of the use of these chemicals on human health and the environment need to be addressed in a concrete way.

The lack of pesticides and fertilisers would lead to a decrease in agricultural productivity and an increase in food costs. This would make it harder for farmers to compete in global commodity markets if their production fell and prices rose (Oerke, 2005). Thus, pesticides and fertilisers have become an essential part of increasing agricultural productivity, providing protection for plants and increasing crop yields.

Nearly 45% of a country's food supply is lost annually to insect pests, which is why pesticides are becoming necessary for pest control (Abhilash and Singh, 2009). As a result of the rapid growth of the international economy in the latter part of the 19th century, agricultural chemicals have been generated and used in increasing quantities. This can have devastating long-term effects as they can accumulate in plant components, water, soil, air, and biota after being sprayed on crops. The use of biopesticides may be an option for farmers who want to prevent crop losses due to pests. Another way to reduce the need for pesticides and fertilisers is by applying transgenic techniques that can lead to the development of pest-resistant crop types. However, the use of chemicals to protect crops against yield loss remains the most popular method. Approximately 2 million tonnes of pesticides are used worldwide, with herbicides accounting for 47.5% of this total, insecticides 29.5%, fungicides 17.5% and other pesticides 5.5% (De et al., 2014).

According to studies by the European Food Safety Authority (EFSA, 2021), more than 60% of vegetables and 30% of fruits on the market contain pesticides. Furthermore, a pesticide "cocktail" has been found in more than 60% of "summer" fruits. Regulators continue to conduct safety assessments as if people are exposed to a single pesticide, despite EU legislation requiring cumulative and synergistic effects of pesticides and fertilisers to be included in safety assessments over the last 14 years.

EFSA also claims that more than one in four of the fruits examined (about 27.5%) contained one or two pesticide residues. These samples were collected from all EU Member States in 2019. These reports show alarming scores, as these values apply to both fruit and vegetables. For example, 70% of currants and blackberries, as well as 60% or more of cherries, strawberries, lettuce, rockets, and bananas were found to contain at least two pesticide residues.

Researchers have warned for decades that the combined use of certain pesticides and fertilisers could increase their lethal potential compared to their individual use.

Humans are at risk of developing serious diseases (such as cancer or Parkinson's disease) because once in the soil and water, these substances persist in crops and eventually enter the food chain (Sharma et al., 2017; Taylor et al., 2002). Even after certain pesticides such as DDT, hexachlorobenzene and imazalil (E233) have been banned, they are still present in our food (especially meat), creating a constant exposure of humans to these harmful substances. All of these are well-documented health hazards (Gorell et al., 1998).

Consequently, exposure to pesticides has been linked to endocrine, dermatological, gastrointestinal, carcinogenic, and reproductive disorders (Alavanja and Bonner, 2012; Georgescu et al., 2005). These substances are also involved in many cases of occupational poisoning (especially among farmers), raising concerns about their influence on human health (Roberts and Reigart, 2013). Memory loss, slower response to stimuli, impaired motor skills, and decreased visual ability are all neurological effects of pesticide exposure (Sarwar, 2015; Li et al., 2014).

## **2.2. Reducing the level of pesticides and fertilisers**

The European Commission (EC) has published the content of the F2F and biodiversity strategies, which impose constraints on EU agriculture by reducing the use of pesticides and fertilisers. The F2F strategy reflects a significant change in EU food and agricultural

policy, with equally far-reaching consequences for the structure and productivity of the food and farming sector. As the EU is a significant agricultural producer and a participant in international agricultural trade, this policy move is expected to have an impact on agricultural commodity markets and, consequently, on the entire food and farming system.

Through the F2F strategy, the food and farming component of the European Green Pact, the EU intends to accelerate the ongoing sustainable transformation of food systems while providing fair economic rewards to farmers. The strategy includes 27 initiatives to make the whole food chain more sustainable, such as targets for greening our food production, suggestions from the retail sector, food labelling rules for consumers, and more. However, other initiatives, such as a 50% decrease in chemical pesticide use by 2030, have provoked fierce opposition from agribusiness organizations.

The F2F strategy has set two main targets regarding the level of pesticides and fertilisers:

- To reduce the use of fertilisers by up to 20% by 2030.
- To reduce the use of pesticides by up to 50% by 2030.

Maintaining environmental sustainability with a growing population and the need for food is a significant issue (Gereffi and Abdulsaman, 2017). Thus, it is clear that the use of pesticides, and by implication, the occurrence of their effects in water, soil, and air is a global concern (Benton and Bailey, 2019). In this context, adopting solutions to reduce pesticide and fertiliser contamination and improve the quality of life for farmers and consumers become key objectives at the EU level.

Related to the topic of this paper, the farmers' knowledge and perception about the dangers of pesticides and fertilisers are seen as critical issues in adopting protective behaviour against these chemicals (Aldosari et al., 2018). Moreover, while creating initiatives to reduce pesticide and fertiliser hazards, the first step should be to investigate farmers' knowledge, attitudes, and behaviours regarding the use of these substances in agriculture (Koh and Jeyaratnam, 1996).

### **2.3. The impact of F2F strategy in Romania**

Given the role, impact, and objective of reducing the use of pesticides and fertilisers, it is assumed that the F2F Strategy should take into account the clarifications proposed by regional governments. Firstly, agriculture and food production vary greatly from region to region, which is why measures need to be implemented to provide an approach to the objectives of the Strategy and an effective mechanism for monitoring these measures. For example, it is clear that farmers in Romania will not face the same challenges as those in Germany during this change. In addition, cities and regions have worked for decades to build better food systems through initiatives such as local food policies and plans, and food policy councils.

At the same time, cities and regions have an obligation to ensure that residents of all ages and backgrounds can enjoy the high quality, sustainable, healthy and environmentally friendly food that is at the heart of the European Green Pact. Therefore, the F2F Strategy requires communication and collaboration at the local and regional level. This is why it is essential that the European Commission includes local and regional governments early on

in the dialogue forums and governance structures set up to implement the strategy and ensure its optimal monitoring and evaluation. Otherwise, EU countries will continue to excessively use pesticides and fertilisers in agriculture.

In Romania, the impact of pesticide and fertiliser use on agricultural productivity, and the evidence on environmental pollution and human exposure to pesticides is still limited, with most research focusing on the organochlorine class of pesticides. DDT (dichlorodiphenyltrichloroethane) and HCHs (hexachlorocyclohexanes) have been banned since 1985, while organochlorine pesticides have been banned since 2002. According to IRS (2018), herbicides are the most widely used substances for plant protection (47.5%), followed by fungicides (39.8%), insecticides (8.2%) and other plant protection products (4.5%). Therefore, with the increasing use of pesticides and fertilisers, there is a greater need to study farmers' knowledge, attitudes, and behaviour regarding these chemicals.

### 3. Research methodology

As part of this methodology, an attempt was made to estimate the economic impact of implementing the F2F strategy recommendations using existing historical data on agricultural productivity and quantities of pesticides and fertilisers used. The data analysed is public information and was taken from the Food and Agriculture Organisation of the United Nations website\* and the European Union website.\*\* The period from 1991 to 2019 was analysed. The year 2020 could not be considered because at the time of the research there was not complete data for all EU countries on either of the two sources mentioned. Thus, looking at this timeframe, 1991-2019, it was found that although the F2F directive is new, a significant number of countries have already had significant reductions in pesticide and/or fertiliser use (with reductions occurring before the strategy itself was introduced).

The analysis was performed using data from all EU Member States, and then countries that had at least three years in the past of reducing both fertiliser use, and pesticide use were extracted. In this situation, there were 12 Member States. The choice was made because there is no clear data in the literature on how changing the quantity of pesticides or fertilisers affects agricultural productivity.

If in a country there are increases in pesticide use and decreases in fertiliser use, no correlation can be made with agricultural productivity. The F2F requirement is to reduce both substances, which is why historical data from countries that have already done so, even before the strategy was introduced, have been used to estimate the impact of its implementation in each country. It was noted that the sample of countries is heterogeneous, representing most of the existing climate regions in the EU, which ensured that a fair approximation to reality could be obtained.

Considering the situation in Romania regarding the possibility of reducing the level of pesticide use by up to 50% and fertiliser use by up to 20% in the context of the F2F strategy, two research hypotheses were formulated:

H1: Reducing pesticides and fertilisers by 50% and 20%, respectively, will affect to a certain extent the level of agricultural productivity in Romania and the EU.

\* <https://www.fao.org/faostat/en/#home>

\*\* <https://ec.europa.eu/eurostat>

H2: The reduction of pesticides and fertilisers will affect productivity only in countries with a higher consumption than the target proposed by the strategy (i.e., 1.56 kg/ha of pesticides and 107.67 kg/ha of fertilisers).

The analysis was carried out using data from all EU Member States, including Romania. Malta was excluded, as it is a much smaller country than any other EU Member State. 27 countries were analysed in total, including the UK, which was present in the EU during the analysed timeframe.

For this purpose, data on the use of pesticides (fungicides, bactericides, herbicides, insecticides, acaricides, etc.) and fertilisers (nitrate, phosphorus pentoxide – P<sub>2</sub>O<sub>5</sub>, potassium oxide – K<sub>2</sub>O) in EU countries were analysed, as well as the results of agricultural production per hectare for four main crop categories: cereals, fruit, root and tuber crops, vegetables. The data were processed using Excel, Excel Solver, and Excel QM.

From a methodological point of view, two models were designed and analysed to implement the recommendations:

- Model 1, in which all EU Member States reduce their use of pesticides and fertilisers by the percentages in the F2F strategy;
- Model 2, which assumes that only those Member States with higher pesticide and fertiliser consumption above the average amounts targeted (mentioned above) will implement measures to reduce the per hectare consumption of pesticides and fertilisers.

For both models, results were obtained for each individual EU Member State. In the study of the two proposed models, a descriptive analysis of the data used as input data (standard deviation, dispersion range, distribution, coefficient of variation) has previously been made. It was observed that the analysed historical data are symmetrically arranged around the mean value, and the mean value is near the median for both fertilisers and pesticides. The values analysed also have a homogeneous distribution within the dispersion range.

**4. Research results**

As an analysis methodology, the maximum value in a data set was mathematically computed. Thus, the year in which the highest quantity of pesticides or fertilisers was used was identified for each country, and the difference between those amounts and the amounts used in 2019 (the last year for which data were collected) was then calculated. The results are shown in Tables no. 1 and 2.

**Table no. 1. Number of countries that have reduced pesticides/ha**

Substances for which the quantity used was analysed	Number of countries having reduced the amount used per ha	Range of decrease in quantities used
Pesticides	22	0.32% - 76.64%
Fertilisers	18	1.48% - 56.85%
Pesticides and fertilisers	12	12,08% - 46.89% (pesticides) 1.48% - 56.85% (fertilisers)

*Source: Data processed by the authors based on information from EUROSTAT*



As a general trend, a decreasing trend in the use of fertilisers and pesticides, or at least one of them, was observed in most EU countries. When analysing all EU member countries, it was observed that 12 of them showed a decrease in both pesticides and fertilisers and even achieved an increase in the use of substances in at least three of the four crop categories analysed. The other countries had either increases in the use of both substances, or decreases in one and increases in the other. This makes it impossible to find a correlation function between the productivity achieved and the use of pesticides and fertilisers.

Table no. 2 shows the amounts used per hectare and the decrease in the period before 2019 for the 12 countries mentioned above. They form a relatively heterogeneous sample, representing most of the climatic regions within the EU. This is also evident from the analysis of the values of the coefficient of variation computed for the quantities of pesticides and fertilisers used and for the degree of reduction in their use in the 12 states.

**Table no. 2. Quantity of pesticides and fertilisers used in the EU in 2019**

Country	Pesticides used in 2019 (kg/ha)	Absolute decrease in pesticides by 2019 (kg/ha)	Pesticide decrease (%)	Fertilisers used in 2019 (kg/ha)	Absolute decrease in fertilisers by 2019 (kg/ha)	Fertilisers decrease (%)
Belgium	6.96	-4.35	-38.46%	289.91	-34.41	-10.61%
Croatia	1.74	-0.78	-30.95%	194.29	-255.95	-56.85%
Cyprus	9.98	-7.83	-43.96%	146.17	-39.93	-21.46%
Finland	0.60	-0.17	-22.08%	95.07	-29.38	-23.61%
France	4.46	-1.42	-24.15%	158.14	-85.67	-35.14%
Italy	5.21	-3.44	-39.77%	94.87	-35.31	-27.12%
Luxemburg	2.33	-0.32	-12.08%	239.66	-16.09	-6.29%
Netherlands	8.88	-4.88	-35.47%	249.98	-211.78	-45.86%
Portugal	4.81	-4.07	-45.83%	103.71	-20.57	-16.55%
Slovenia	4.15	-3.45	-45.39%	197.44	-110.51	-35.89%
Sweden	0.58	-0.38	-39.58%	97.56	-1.47	-1.48%
Great Britain	3.16	-2.79	-46.89%	243.17	-91.29	-27.29%

*Source: Data processed by the authors based on information from EUROSTAT*

When analysing the data in Table no. 2 and correlating them with changes in agricultural productivity, it appears that in most cases pesticides and fertilisers are overused (i.e., above the F2F target values mentioned in Table no. 3) and their reduction to some extent does not affect agricultural productivity. This trend of excessive use is also confirmed by the scientific literature (Skevas, 2012).

Figure no. 1 shows a sharp decrease in pesticide use and an increase in fertiliser use in Romania. However, the quantities involved are lower than the EU average, i.e., 3.13 kg/ha of average pesticide use and 134.59 kg/ha of average fertiliser use. At the same time, there is a consistent increase in production per hectare.

According to a study in which the modelling method used was based on the “Computable general equilibrium” principle (Beckman et al., 2020), if the F2F policy were to be applied only by EU countries, there would be a 12% decrease in agricultural productivity at EU level. This value was further used as an input for the current modelling.

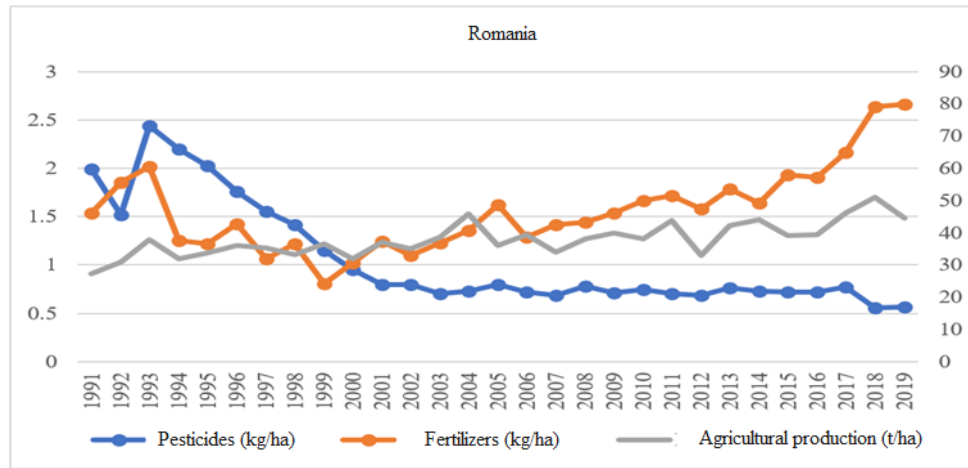


Figure no. 1. The quantity of pesticides, fertilisers, and the level of production for the period 1991-2019

Source: FAOSTAT, authors

Next, a tolerance coefficient was derived to estimate and model the potential effect of pesticides and fertilisers on agricultural productivity. For this analysis, the average of the decreases in consumption per hectare was performed and the standard deviation was calculated. Two coefficients were obtained by taking the least favourable alternative and subtracting the standard deviation. These coefficients will represent the tolerance value expressed in absolute value (kg), which can be considered in the case of the decreases pursued by the F2F strategy.

Next, the tolerance coefficient was considered for the two models listed above in order to estimate the evolution of agricultural productivity.

The results for each country are presented in Tables nos. 4 and 5. The use of the average value per hectare in the EU-27 for 2019, shown in Table no. 3, has been considered.

Table no. 3. The quantity of pesticides and fertilisers used in 2019, compared to the amount obtained following the application of the F2F strategy

EU (27)	Quantity of pesticides (kg/ha)	Quantity of fertilisers (kg/ha)
2019	3.13	134.59
2030 (F2F target)	1.56	107.67

With the introduction of pesticide F2F strategy, pesticide use is expected to decrease to 1.56 kg/ha and fertiliser use to an average of 107.67 kg/ha by 2030. The F2F strategy does not mention how this reduction will be achieved.

In this study, two models were proposed to simulate the effects of pesticide and fertiliser reduction, detailed in the methodology section of the research. When analysing the data obtained in Table 4, it appears that the application of the two models has different effects.

According to the first model, which assumes that the reduction was applied proportionally by all EU countries, productivity decreased by 3.14% in each investigated country. In the second model, the reduction is only applied by countries using quantities above the EU

average and the productivity decrease was higher, i.e., 3.77%. At the same time, countries that currently use lower amounts of pesticides and fertilisers than the EU average will not experience a direct negative impact due to the F2F strategy. While model 1 is more theoretical, as there are large discrepancies between different countries in the use of the two types of substances, model 2 is more likely to be implemented in practice. It provides a balance across the EU, ensuring homogeneity in the quality of agricultural products, regardless of which country they come from.

**Table no. 4. The level of fertilisers' rate following the application of the two models**

Country	Use of fertilisers 2019 (kg/ha)	Tolerance decrease (kg/ha)	Model 1 (kg/ha)	Model 2 (kg/ha)	Productivity reduction model 1	Productivity reduction model 2
Austria	112.82	10.74	90.26	83.92	3.14%	3.77%
Belgium	289.91	27.61	231.93	215.64	3.14%	3.77%
Bulgaria	130.12	12.39	104.10	96.78	3.14%	3.77%
Croatia	194.29	18.5	155.43	144.51	3.14%	3.77%
Cyprus	146.17	13.92	116.94	108.72	3.14%	3.77%
Czech Republic	162.59	15.49	130.07	120.93	3.14%	3.77%
Denmark	134.66	12.83	107.73	100.16	3.14%	3.77%
Estonia	90.32	0	72.26	90.32	3.14%	0.00%
Finland	95.07	0	76.06	95.07	3.14%	0.00%
France	158.14	15.06	126.51	117.62	3.14%	3.77%
Germany	171.2	16.31	136.96	127.34	3.14%	3.77%
Greece	93.49	0	74.79	93.49	3.14%	0.00%
Hungary	140.42	13.37	112.34	104.44	3.14%	3.77%
Ireland	200.01	19.05	160.01	148.77	3.14%	3.77%
Italy	94.87	0	75.90	94.87	3.14%	0.00%
Latvia	104.85	0	83.88	104.85	3.14%	0.00%
Lithuania	134.94	12.85	107.95	100.37	3.14%	3.77%
Luxembourg	239.66	22.83	191.73	178.26	3.14%	3.77%
Netherlands	249.98	23.81	199.98	185.94	3.14%	3.77%
Poland	172.09	16.39	137.67	128.00	3.14%	3.77%
Portugal	103.71	0	82.97	103.71	3.14%	0.00%
<b>Romania</b>	<b>79.93</b>	<b>0</b>	<b>63.94</b>	<b>79.93</b>	<b>3.14%</b>	<b>0.00%</b>
Slovakia	127.49	12.14	101.99	94.83	3.14%	3.77%
Slovenia	197.44	18.8	157.95	146.86	3.14%	3.77%
Spain	110.99	10.57	88.79	82.55	3.14%	3.77%
Sweden	97.56	0	78.05	97.56	3.14%	0.00%

*Source: Data processed by the authors based on information from FAOSTAT*

The data in Table 5, which shows the modelling of the decline in pesticide use, maintains the same trends as in Table 4, i.e., an overall decline of 3.07% in Model 1 and 3.25% or 0% in Model 2.

**Table no. 5. The level of the pesticide rate following the application of the two models**

Country	Use of pesticides 2019 (kg/ha)	Tolerance decrease (kg/ha)	Model 1 (kg/ha)	Model 2 (kg/ha)	Productivity reduction model 1	Productivity reduction model 2
Austria	3.56	0.87	1.78	1.67	3.07%	3.25%
Belgium	6.96	1.70	3.48	3.26	3.07%	3.25%
Bulgaria	1.84	0.45	0.92	0.86	3.07%	3.25%
Croatia	1.74	0.42	0.87	0.81	3.07%	3.25%
Cyprus	9.98	2.43	4.99	4.67	3.07%	3.25%
Czech Republic	1.54	0.38	0.77	1.54	3.07%	0.00%
Denmark	1.09	0.27	0.55	1.09	3.07%	0.00%
Estonia	0.91	0.22	0.46	0.91	3.07%	0.00%
Finland	0.6	0.15	0.30	0.60	3.07%	0.00%
France	4.46	1.09	2.23	2.09	3.07%	3.25%
Germany	3.8	0.93	1.90	1.78	3.07%	3.25%
Greece	4.07	0.99	2.04	1.90	3.07%	3.25%
Hungary	1.74	0.42	0.87	0.81	3.07%	3.25%
Ireland	5.97	1.46	2.99	2.79	3.07%	3.25%
Italy	5.21	1.27	2.61	2.44	3.07%	3.25%
Latvia	1.18	0.29	0.59	1.18	3.07%	0.00%
Lithuania	1.03	0.25	0.52	1.03	3.07%	0.00%
Luxembourg	2.33	0.57	1.17	1.09	3.07%	3.25%
Holland	8.88	2.17	4.44	4.15	3.07%	3.25%
Poland	2.13	0.52	1.07	1.00	3.07%	3.25%
Portugal	4.81	1.17	2.41	2.25	3.07%	3.25%
<b>Romania</b>	<b>0.57</b>	<b>0.14</b>	<b>0.29</b>	<b>0.57</b>	<b>3.07%</b>	<b>0.00%</b>
Slovakia	1.36	0.33	0.68	1.36	3.07%	0.00%
Slovenia	4.15	1.01	2.08	1.94	3.07%	3.25%
Spain	3.66	0.89	1.83	1.71	3.07%	3.25%
Sweden	0.58	0.14	0.29	0.58	3.07%	0.00%

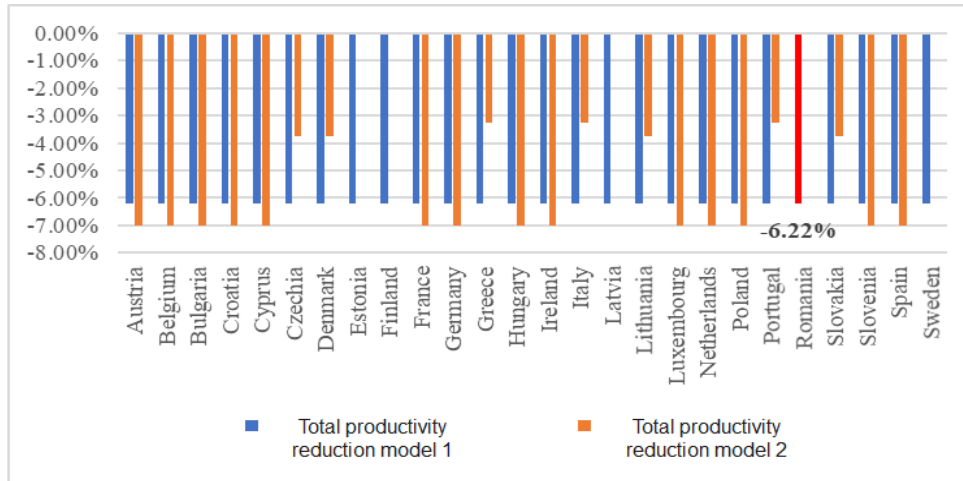
Source: Data processed by the authors based on information from FAOSTAT

After analysing the data in Tables 4 and 5, hypothesis H1 (that reducing the use of pesticides and fertilisers by 50% and 20%, respectively, will affect the level of agricultural productivity in Romania by a relatively small percentage, below 3.14% and below 3.07%, respectively) is confirmed.

Hypothesis H2 (that reducing pesticide and fertiliser use will affect productivity only in countries with higher consumption than the proposed strategy target) is also confirmed. It can be seen that a number of countries, which currently have low consumption, do not have to apply this reduction and thus are not affected at all. At the same time, it is also observed that the rest of the countries with higher intakes, above the F2F target, and which will have to use significantly less of both substances, have a relatively low impact on productivity (below 3.77% and below 3.25%, respectively).

Aggregating the information obtained in the two tables using a linear method yields the data in Figure 2.

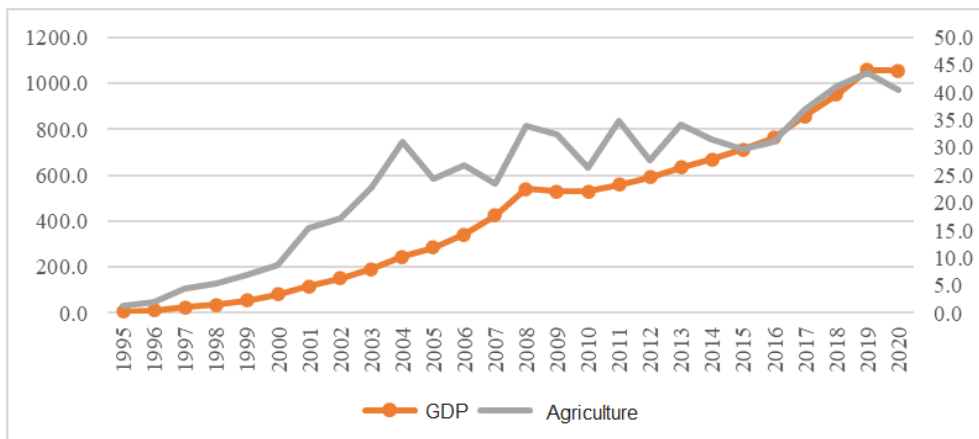
While in model 1, which is less plausible, all countries show a decrease in agricultural productivity, in model 2, which is more plausible, it is observed that some countries, including Romania, are not affected by the application of the F2F strategy.



**Figure no. 2. Total reduction of agricultural productivity in the case of the two models**  
 Source: Data processed by the authors based on information from FAOSTAT

Agricultural productivity can also influence the level of macroeconomic indicators. For example, the impact of agricultural productivity is reflected in the value of the gross domestic product (GDP).

Figure 3 shows that between 1995 and 2019 (the period for which we have data from the NSI), both total GDP and the value of GDP from agriculture increased. In the case of agriculture, there are also negative variations caused by weather conditions and drought in some years.



**Figure no. 3. GDP evolution (billion lei) compared to the level of agriculture for the period 1995-2020**

Source: NIS, authors

However, in Figure 4 we see that the share of agriculture in GDP has decreased, stabilizing around 4% since 2015. This is because the industry and trade have seen considerable annual increases.

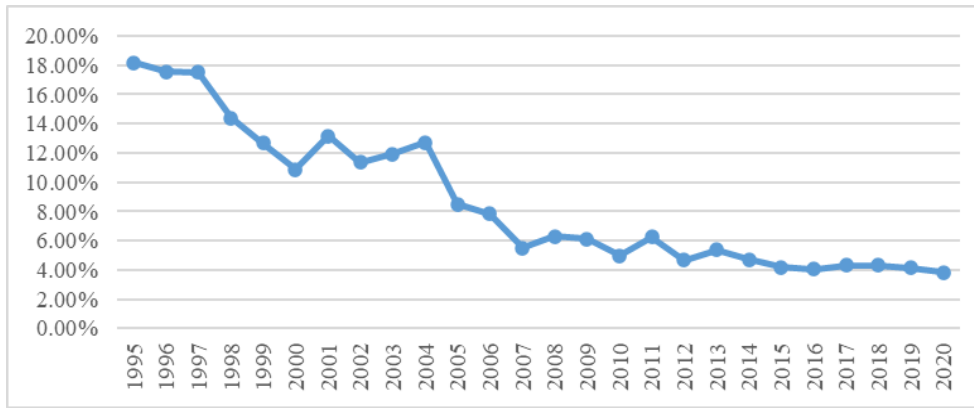


Figure no. 4. The share of agriculture in GDP for the period 1995-2020

Source: NIS, authors

This will transform Romania from a predominantly agrarian country into a country similar to the developed economies of Western Europe, where agriculture has a smaller share in GDP. This will be an advantage, encouraging investment in agriculture in order to fill the production gap in the countries affected by the strategy.

**Conclusions**

The research results highlight two categories of states. The states in the first category use pesticides or fertilisers above the EU target level and will be obliged to reduce their consumption of these substances. Countries in the second category use smaller amounts of the two types of substances and already comply with the recommendations but have the possibility to reduce them further.

The analysis showed that even if the use of the two types of substances is reduced, there is a tolerance margin so that agricultural productivity is not affected.

The study shows that in addition to the clear advantages of sustainable agriculture and increased food quality, the F2F strategy also has minor disadvantages for several EU countries that will experience a drop in agricultural productivity. This may lead to higher food prices, with negative effects on disadvantaged groups. This could also be offset by the fact that healthier diets help governments to save significant amounts of money in their budgets to treat conditions caused by the excessive use of chemicals in agriculture.

Considering the situation in Romania regarding the possibility of reducing the level of pesticide use by up to 50% and fertiliser use by up to 20% in the context of the F2F strategy, two research conclusions were formulated.

C1: Reducing the use of pesticides and fertilisers according to model 1 will also affect the level of agricultural productivity in Romania similarly to the rest of the countries, although the impact is limited. If we consider that in the period of F2F implementation, whose applicability is until 2030, we will most likely have both the technological progress expected to come from the IoT (Internet of Things) area and the emergence of more resistant varieties, this decrease will be able to be compensated for.

C2: Romania will not be affected by the reduction in pesticide and fertiliser levels, as it uses significantly reduced amounts below the F2F target. In this case, agricultural productivity will not be negatively affected; moreover, interest in the country's agricultural sector will increase, leading to increased investment, and thus increased agricultural productivity and production.

Furthermore, the importance of the research is shown by the analysis of the impact of the F2F strategy on agricultural productivity in Romania. In this respect, it has been observed that the reduction of pesticides and fertilisers will have little or no impact on agricultural productivity in Romania.

Our contributions to present such a conclusion were supported by the application of two mathematical models, which demonstrated that a reduction in the use of pesticides and fertilisers by 50% and 20%, respectively, at EU level will not have a negative impact on agricultural productivity in Romania.

A limitation of this study is presented by the fact that, now, the current research only presents a forecast of the impact that the F2F strategy would have on the production levels of EU countries because of reducing the level of pesticides and fertilisers in agriculture. Because the strategy has not yet been applied in all EU countries, there is no data to show the impact that pesticide and fertiliser reduction has on the agricultural productivity of European countries, including Romania.

Future research will focus on statistical analysis, developed over a longer period, looking at the impact of reducing pesticide and fertiliser use on farmers' prices and the impact of these prices on consumers.

We conclude that the ability of the strategy to promote real change in the governance of the EU food system will depend to a large extent on addressing these challenges and the ability of the EU leadership to maintain political momentum.

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