THE EFFICIENCY OF FERTILIZERS AND MINIMUM TIILAGE METHOD IN THE AGRICULTURAL PRODUCTION IN ROMANIA

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Abstract
Considering that vegetal production is related to the use of fertilizers or land works, this paper investigates the correlation between plant production in Romania and fertilizers in 1990-2015, but also checks on the efficiency of minimum tillage system. At macroeconomic level, there was a long and short bidirectional relationship between cereals' production in Romania and the quantity of natural fertilizers in the period 1990-2015. The statistical results on experimental data indicated that there are not significant differences between conventional systems and minimum tillage systems for the three plants in terms of production, power balance efficiency and energy utilization at 5% level of significance.

Key words: *agricultural production, minimum tillage, cereals, vector error correction model*

JEL Classification: *Q15, Q24, C53*

Introduction

Minimum tillage supposes shallow tillage based on a tine cultivator (Rasmussen, 1999), and it has the potential to preserve the organic matter, to promote aggregate stability, to stimulate a better infiltration and to diminish losses of sediment, but also to decrease the losses of sediment-bound pollutants (Quinton and Catt, 2004; Silgram and Shepherd, 1999).

The objective of this paper is to analyze the correlation between plant production and quantity of fertilizers in Romania during 1990-2015, taking into account that minimum tillage system uses fertilizers. Some vector error correction models were estimated to check the relationships on short and long-run between plants' production and quantity of fertilizers (natural and chemical fertilizers).

On the other hand, we use experimental data to check the efficiency of minimum tillage on a soil in Romania for 3 plants. The comparative analysis between minimum tillage and the other conventional methods are based on data that was obtained in a period of 3 years at the Didactical Department of the University of Agricultural Sciences and Veterinary Medicine. Wilcoxon signed-rank test was applied to test for the differences in the two groups of methods starting from three variables: production, power balance efficiency and energy utilization.

After this short introduction, some advantages and limits of minimum tillage system are presented. Most of the paper is dedicated to the statistical analysis on macroeconomic data and experimental ones. The last part concludes.

1. Advantages of minimum tillage

Water and wind erosion of agricultural soils are known as global environmental problems (Zuazo and Pleguezuelo, 2008; Chambers et al, 2000). Land in fall and winter cereal crops are not so much affected by soil erosion compared to other crops (e.g. potatoes and maize) (Evans, 2002) but, if they have low crop or bare ground during the winter and autumn they can still can be affected by large erosion losses (Chambers and Garwood, 2000).

Minimum tillage supposes shallow tillage based on a tine cultivator (Rasmussen, 1999), and it has the potential to preserve the organic matter, to promote aggregate stability, to stimulate a better infiltration and to diminish losses of sediment, but also to decrease the losses of sediment-bound pollutants (Quinton and Catt, 2004; Silgram and Shepherd, 1999).

The literature review noted the advantages and the disadvantages of minimum tillage and of the other methods, presenting the results of applying these methods in the United Kingdom and other (Stevens et al., 2009). Based on studies in literature, some economic advantages presented in a monetary form for minimum tillage on a loamy soil are described by Nix (2008).

In a review of studies assessing the minimum tillage, Strauss et al. (2003) proposed a median effectiveness of 74% for decreasing soil erosion. Even if the advantages for soil erosion are recognized, the potential for decreasing the nutrient pollution is not clear.

The economic agents with agricultural profile are interested in modern technologies for getting an efficient economic activity that supposes the non-conventional working system like minimum tillage. Some measures are necessary to have a viable minimum tillage:

- ➢ The agricultural exploatation should have the suitable machine system;

- The previous plants should not let vegetal rests;
- The soil should not have a high procent of argil;
- The fertilizers should be applied on seeded rows.

The climate and the soil conditions, the type of plant, the fertilization system and the system for weed determined more types of minimum tillage methods. Direct tillage system consists in the execution in a single pass, with an aggregate of minimum preparatory work for soil and sowing.

Tillage in two passes consists in the execution of two passes, the first of which provides for the mobilization of soil deep furrow and return without fertilizer application. On the second pass it attaches a cultivator or disc harrow and drill followed by a disposal for applying herbicides.

The technical advantages are the following:

- better consumption and storage of the water in soil;
- lower subsidence of soil;
- destruction of the soil structure is avoided by reducing the number of works;
- higher quantity of organic material and a better conservation of humus;
- less erosion of the soil caused by wind or water;
- less losses of water by evaporation.

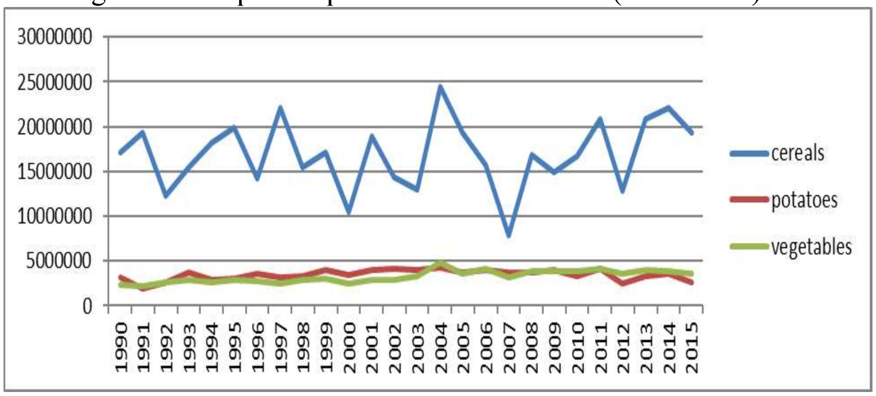
The economic benefits of minimum tillage are:

- Lower costs by eliminating plowing, disking, harrowing;
- Economies for fuel and lubricant;
- Less utilization of tractors and agricultural machines;
- Better labur productivity.

2. Statistical analysis

As specified, two tasks of the empirical analysis are considered: the correlation between plant production and fertilizers and the efficiency of minimum tillage method compared to conventional methods with respect to plant production, energy utilization and power balance efficiency. We will use data provided by the National Institute of Statistics from Romania for plant production (cereals, potatoes and vegetables) and fertilizers in the period 1990-2015.

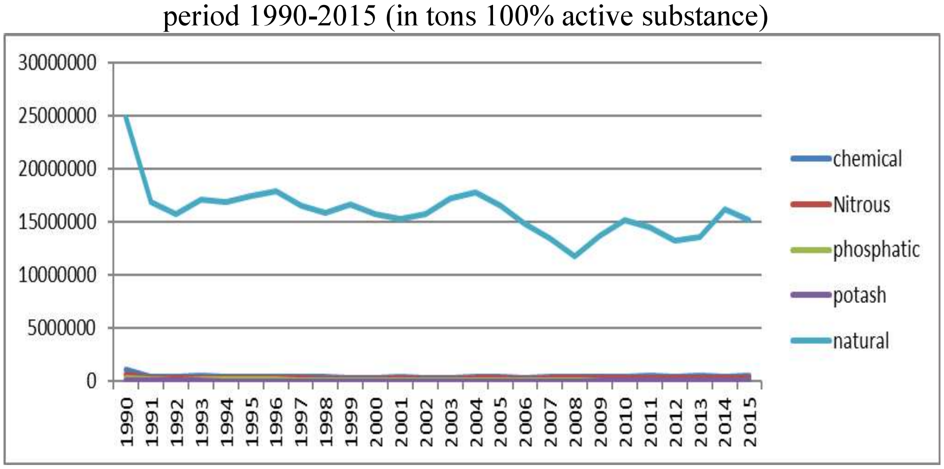
Figure 1. The plants' production in Romania (1990-2015)



Source: author's graph

As statistical data provided by the National institute of statistics shows, Romania produced mostly cereals with high fluctuations of plant production in the period 1990-2015. The maxim plant production in tons was registered in 2004. The quantity of cereals increased in Romania by 12.3% in 2015 compared to 1990. The fluctuations in the production of potatoes and vegetables were much lower than in the case of cereals.

Figure 2. Quantity of chemical and natural fertilizers used in Romania in the period 1990-2015 (in tons 100% active substance)



Source: author's graph

As Figure 2 shows, in Romania mostly natural fertilizers are used in agriculture, which is beneficial for the food quality, but the impact of these fertilizers on production should be checked.

The data for all variables were stationary only in first level of 5% level of significance, according to ADF test. Therefore, we will test the existence of cointegration relationships between variables.

Table 1. The selection of optimal lag

Variables	Optimal lag
Cereals-natural fertilizers	1
Cereals- chemical fertilizers	1
Potatoes- natural fertilizers	2
Potatoes- chemical fertilizers	2
Vegetables- natural fertilizers	2
Vegetables- chemical fertilizers	1

Source: own computations

According to lag length criteria, we have an optimal lag of 1 for cereals- natural fertilizers, cereal-chemical fertilizers and vegetables-chemical fertilizers and a lag equaling 2 for the rest of the paired variables.

The Johansen cointegration test will be applied in each case.

Table 2. The results of Johansen cointegration test

Variables	Rank or No. of CEs	No Intercept No Trend No data trend	Intercept No Trend No data trend	Intercept No Trend Linear data trend	Intercept Trend Linear data trend	Intercept Trend Quadratic data trend
Cereals-natural fertilizers	0	0	2	2	2	0
Cereals-chemical fertilizers	1	0	1	0	2	1
Potatoes-natural fertilizers	0	0	0	2	0	0
Potatoes-chemical fertilizers	0	0	1	1	0	0
Vegetables-natural fertilizers	0	0	0	0	0	0
Vegetables-chemical fertilizers	0	0	0	0	0	0

Source: own computations

The trace test and the maximum eigenvalue test indicated the same result. According to Johansen test, there is not any cointegration relationship between vegetable production and fertilizers (natural or chemical fertilizers). Indeed, fewer fertilizers are used in Romania in the case of vegetables.

D(CEREALS) = C(1)*(CEREALS(-1) - 0.1002772384*NATURAL_FETILIZERS(-1) - 15218815.63) + C(2)*D(CEREALS(-1)) + C(3)*D(NATURAL_FETILIZERS(-1)) + C(4)

D(NATURAL_FETILIZERS) = C(5)*(CEREALS(-1) - 0.1002772384*NATURAL_FETILIZERS(-1) - 15218815.63) + C(6)*D(CEREALS(-1)) + C(7)*D(NATURAL_FETILIZERS(-1)) + C(8)

D(CEREALS) = - 1.252988645*(CEREALS(-1) - 0.1002772384*NATURAL_FETILIZERS(-1) - 15218815.63) + 0.09533003081*D(CEREALS(-1)) + 0.8144998193*D(NATURAL_FETILIZERS(-1)) + 269157.1868

D(NATURAL_FETILIZERS) = - 0.1403258416*(CEREALS(-1) - 0.1002772384*NATURAL_FETILIZERS(-1) - 15218815.63) + 0.1021647974*D(CEREALS(-1)) + 0.1007857511*D(NATURAL_FETILIZERS(-1)) - 55774.59726

There is a long-run relationship from cereals production to natural fertilizers and from natural fertilizers to cereals production. If more natural fertilizers are used, we will get more cereals. On the other hand, if the production of cereals increases, the quantity of natural fertilizers also increases.

D(CEREALS) = - 1.239305612*(CEREALS(-1) - 23.80747212*CHEMICAL_FERTILIZERS(-1) - 6781680.282) + 0.03613411116*D(CEREALS(-1)) + 9.319426811*D(CHEMICAL_FERTILIZERS(-1)) + 244503.2336

D(CHEMICAL_FERTILIZERS) = 0.0002726300367*(CEREALS(-1) - 23.80747212*CHEMICAL_FERTILIZERS(-1) - 6781680.282) - 0.001345012706*D(CEREALS(-1)) + 0.01054001757*D(CHEMICAL_FERTILIZERS(-1)) + 3435.192294

There is only a long-run relationship from chemical fertilizers to cereals production. When the quantity of chemical fertilizers grew, the production of cereals also increased.

D(POTATOES) = - 0.01572670705*(POTATOES(-1) - 8.375386713*NATURAL_FETILIZERS(-1) + 127328519) - 1.081943855*D(POTATOES(-1)) - 0.5161027406*D(POTATOES(-2)) + 0.0257777157*D(NATURAL_FETILIZERS(-1)) - 0.1670509629*D(NATURAL_FETILIZERS(-2)) + 111.1596918

D(NATURAL_FETILIZERS) = 0.02842099925*(POTATOES(-1) - 8.375386713*NATURAL_FETILIZERS(-1) + 127328519) - 0.5325107101*D(POTATOES(-1)) - 0.6729932388*D(POTATOES(-2)) + 0.4056573641*D(NATURAL_FETILIZERS(-1)) - 0.2299796175*D(NATURAL_FETILIZERS(-2)) - 84672.44507

There is only a long-run relationship from natural fertilizers to potatoes production. When the quantity of natural fertilizers grew, the production of potatoes also increased.

D(POTATOES) = - 1.236959618*(POTATOES(-1) + 6.080000128*CHEMICAL_FERTILIZERS(-1) - 6102537.855) - 0.3015417932*D(POTATOES(-1)) - 0.2983932619*D(POTATOES(-2)) + 6.260799314*D(CHEMICAL_FERTILIZERS(-1)) + 0.1574480294*D(CHEMICAL_FERTILIZERS(-2)) + 31259.02728

D(CHEMICAL_FERTILIZERS) = 0.04082634757*(POTATOES(-1) + 6.080000128*CHEMICAL_FERTILIZERS(-1) - 6102537.855) - 0.02213506992*D(POTATOES(-1)) + 0.01435849105*D(POTATOES(-2)) - 0.5822614296*D(CHEMICAL_FERTILIZERS(-1)) - 0.2463135534*D(CHEMICAL_FERTILIZERS(-2)) - 479.6188759

There is only a long-run relationship from chemical fertilizers to potatoes production. When the quantity of chemical fertilizers grew, the production of potatoes also increased.

Table 3. Results of Wald test

Variables	Chi-square statistics	p-value
Cereals-natural fertilizers	6.401296	0.040736
Cereals- chemical fertilizers	2.859060	0.239421
Potatoes- natural fertilizers	9.963901	0.006861
Potatoes- chemical fertilizers	7.514319	0.023350

Source: author's calculations

On short-run, there was a significant association between cereals production and natural fertilizers, potatoes production and natural fertilizers, and potatoes production and chemical fertilizers in the period 1990-2015.

The data for plants' production, power balance efficiency and energy utilization are experimental and are taken from the study of Rusu (2016). We considered two types of methods:

- conventional methods (reversible plough + rotary harrow and classic plough + disc –2x);
- minimum tillage techniques (chisel + rotary harrow and paraplow + rotary harrow).

The production was measured for three plants: winter-wheat, soya-bean and maize.

Wilcoxon signed-rank test was applied to test for the differences in the two groups of methods starting from three variables: production, power balance efficiency and energy utilization.

Table 4. Wilcoxon signed-rank test for checking the differences between methods regarding the production of plants (kg/ha), power balance efficiency (%) and energy utilization (MJ)

Variable	Computed statistics	p-value
Production of plants (kg/ha)	1.572	0.1159
Power balance efficiency	0.632	0.5271
Energy utilization	0.946	0.3441

Source: author's calculations

The statistical results indicated that there are not significant differences between conventional systems and minimum tillage systems for the three plants in terms of production, power balance efficiency and energy utilization at 5% level of significance. If the theoretical approaches show the superiority of minimum tillage techniques, the experimental data in the laboratory for Romanian soil did not indicate significant increases in the production.

Conclusions

The personal contribution of this paper is given by the empirical findings based on statistical analysis on macroeconomic data and experimental data. At macroeconomic level, there was a long and short bidirectional relationship between cereals' production in Romania and the quantity of natural fertilizers in the period 1990-2015. The production of potatoes was influenced on short-term also by the quantity of chemical fertilizers. The production of vegetables was not affected by the fertilizers quantity in Romania.

The statistical results on experimental data indicated that there are not significant differences between conventional systems and minimum tillage systems for the three plants in terms of production, power balance efficiency and energy utilization at 5% level of significance. So, minimum tillage did not provided the expected results in Romania. The research is limited by the fact that a small sample of values is used and n a certain type of soil. On other type of soil from Romania, the results might be better.

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