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# INFLUENCE OF FERTILIZATION AND SOIL TILLAGE SYSTEM ON WATER CONSERVATION IN SOIL, PRODUCTION AND ECONOMIC EFFICIENCY IN THE WINTER WHEAT CROP

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***Abstract***

*During the last years, in the Romanian agricultural practice, the alternatives of soil minimum tillage and no-tillage are very much applied in the winter wheat crop. During droughty autumns, when the soil is very dryand we can't have any plowing or the result of plowing would beclods very hard to chop, preparing the field by minimum tillage or direct sowing are prefered to plowing in order not to delay the wheat sowing, but also from an economic point of view. The paper presents the influence of thesoil tillage (conventional and no-tillage), of the fertilization systemand of the agricultural year (expressed by different climate conditions), on the soil humidity, production andeconomic efficiency in the winter wheat crop. The experience was polyfactorial, placed on a Faeoziom type of soil from the Transylvanian Plain (the average multiannual temperature of 9.1°C and average multiannual rainfall of 518.6 mm). The wheat crop responded favourably to the no-tillage technology, the production registered (6285 kg/ha) is very close to the one obtained in the conventional system (6320 kg/ha). The no-tillage system has the advantage of a better water preserve in the soil, which can be used in stages by the plants during drought seasons. Additional wheat fertilization (with $N_{40}$) brings a production increase of 111 kg/ha. The economic efficiency of the no-tillage system results mainly from the reduced fuel consumption (approximately by 50%) and the reduced number of tillage, which determines a reduction by 19.2% of the total technological expenses.*

**Key words**: *soil tillage, fertilization, water preserve, production, economic efficiency, wheat.*

## INTRODUCTION

Preparing the field for wheat sowing is often difficult due to the time left since the harvest of the preceding and up to the sowing, the difficult climate conditions during the tillage (drought from the end of the summer and the beginning of the autumn) and of the big surfaces which must be prepated and sowed during a relatively short period of time (Rusu et al., 2007). During the last years, in the Romanian agricultural practice, the alternatives of soil minimum tillage and no-tillage are very much applied in the winter wheat crop (Rusu et al., 2015). During droughty autumns, when the soil is very dry and we can't have any plowing or the result of plowing would be clods very hard to chop, preparing the field by minimum tillage or direct sowing are prefered to plowing in order not to delay the wheat sowing, but also from an economic point of view (Cociu and Cizmas, 2013; Dinca et al., 2013).

The conventional soil tillage system, having plowing as the basic tillage, preparing the germinative bed and maintenance works lead in time to soil compaction due to heavy machine traffic. The total loading on the axisof agricultural machines determines the compaction of the lower soil layer from beneath the working depth of the soil processing organs (Gheres, 2007). The effects of compaction are: increase of the apparent density, reduction of total porosity, of the hydraulic conductivity, water and air permeability. The negative effects of soil compaction are multiple, they influence even cultivated plants, the production capacity drops and therefore production is reduced (Rusu and Gus, 2007). As a consequence, a series of negative effects accelerates through a bigger loss of water, a weaker mineralization of vegetable scraps, formation of hard pan, end of continuity of capillarity, and if the plowing of slopy fiends is done according to the line of the highest slope, erosion is favoured (Calegari and Alexander, 1998; Gus et al., 2003; Domuta et al., 2012).

The alternative (conservative) soil minimum tillage and no-tillage systems require a reduced intervention on the soil, keeping the vegetable scraps at the soil surfaceat least 50-60% with a mulch role in protecting the soil. The soil is thus protected from the surface erosion, the soil aggregates are stabilized, the organic materials and the fertilization levelsh all grow, the soil compaction and the $CO_2$, emissions are reduced, the biodiversity rises (Lazureanu et al., 1997; Jitareanu et al., 2006; Marin et al., 2015). The vegetable scraps left on the soil surface protect it and under the action of micro- and macroorganisms in the transformation process contribute to the improvement of soil structure (Ulrich et al., 2006; Wozniak et al., 2014).

The application of conservative soil tillage alternatives is conditioned by the adoption of a new fertilization system, as well as by their optimization in relation with the local pedo-climate conditions. In order to choose the best technological variant one must take into account the soil technological characteristics: texture, humidity, field exposure, macro and microclimate, the humus content etc., but also the climate conditions of the agricultural year and the capacity of the technology applied to capitalize these resources (Stefanic et al., 1997; Moraru and Rusu, 2010; Szajdak and Rusu, 2016).

In the Transylvanian Plain an interaction of a big number of limiting factors for agricultural technologies is recorded, of which two prevail. The first is the thermal background at its level of low temperature and with high time variations and the second is the hill orography of the land with a lot of soils degraded by erosion (Rusu et al., 2009; 2014; Chetan et al., 2015; 2016). They impose restrictions regarding the crop structure and systems of agricultural machines to ensure the application of a conservative technology.

The paper presents the results of the research made under the conditions from Agricultural Research and Development Station Turda (ARDS Turda), situated in the Transylvanian Plain, the influence of the soil tillage system, the fertilization system and the agricultural year, the soil humidity, the production and economic efficiency in winter wheat crop.

## MATERIALS AND METHODS

The research start from the idea of optimizing the existing possible relation among the soil tillage system, crop structure, water accumulation and preserve in the soil for a longer period of time, accesible to crop plants as well as the productions which can be madeat a lower price. These researches have been made during a trifactor experience, during 2014-2016, the experimental field is a 3 year rotation crop: soy-winter wheat - maize.

The experimental factors were:

A - the soil tillage system: $a_1$ - conventional systems with plowing (CS); $a_2$ - no-tillage systems (NT).

B - the fertilization system: $b_1$- $N_{60}P_{40}$ (in sowing); $b_2$ - $N_{60}P_{40}$ (in sowing) + $N_{40}$ (in spring at the wheat vegetation).

C - agricultural year: $c_1$ - 2014; $c_2$ - 2015; $c_3$ - 2016.

Sowing was made with Directa - 400 sower, at 18 cm among the lines, the incorporation depth of the seed is 5 cm; the sowing thickness was 550 germinable grains/m$^2$; the biological material used isthe type of winter wheat Andrada (created at ARDS Turda). The experience was placed on a verticphaeosiom type of soil (SRTS, 2012) with the following characteristics (MESP, 1987): pH 7.00; humus 3.40%; total nitrogen 0.226%; phosphorus 73 ppm; potassium 295 ppm, determined on the 0 - 30 cm depth.

In order to determine the soil humidity (U, %) the gravimetric method was used. The soil samples were taken 3 times, on the depth of 1 m, graduallyfrom 10 to 10 cm, with Theta drill probe. The access ible humidity reserve (Ra, m$^3$/ha) was determined on the depth 20; 50; 100 cm.

Taking the wheat samples was made by meeting the methodology rules of the experimental technique. This operation consisted of the following steps: taking the protective tapes from around the experiences;

taking the front and side margins of the experimental variants (the front deletions were 1 m and the side ones were 0.60 cm), taking into account the working width of the harvester of experimental parceling. The harvest surface of the experimental parceling was 28 $m^2$.

The economic efficiency of the variants researched was determined according to the number of technological works applied, the fuel consumption (based on the characteristics of the agricultural machines and equipment used) and material used reported per hectare.

The experimental data was processed by analyzing the variant (PoliFact, 2015) and setting up the limit differences (LSD, 5%, 1%, 0.1%).

## RESULTS AND DISCUSSIONS

The experience was set up on a fertile soil but also with susceptibility of quick subsidence at the passing of big agricultural aggregates or when it is worked mechanically under conditions of high humidity. The soil physical characteristics influence directly its fertility, which in its turn, has a powerful influence on the water, air and nutrition regime from the soil.

The analysis of the evolution of climate factors and their reporting in relation to the experimental results obtained aim to identify the best measures to adapt to the climate changes recorded, both worldwide and locally. An analysis of the evolution of the thermal and rainfall regimeat ARDS Turda (altitude of 427 m) during the last 60 years, respectively since 1957, when the station was set up and up to nowis presented next. The thermal and rainfall regime during 1957-2016, at ARDS Turda, is presented in Figure 1 and Figure 2. The research area is characterized by a multiannual average temperature of 9.1°C and multiannual average rain of 518.6 mm. But during the last 15 years one can notice a clear tendency of high temperatures and a drop of the rain recorded. The climate changes recorded, as well as the unpredictable ones in the future imposea rational choice of the biological material which is going to be cultivated and the application of adequate technologies to the new climate conditions.

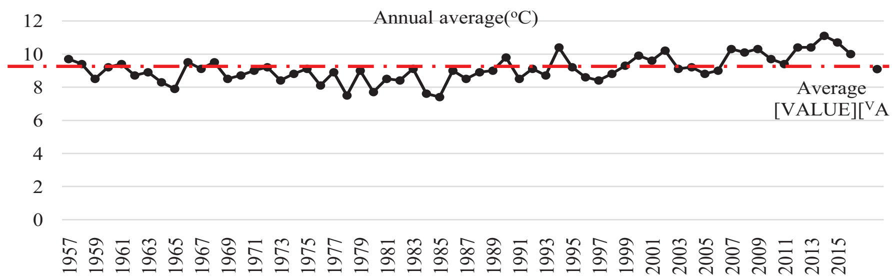



Figure 1. The thermal regime ARDS Turda, 1957-2016

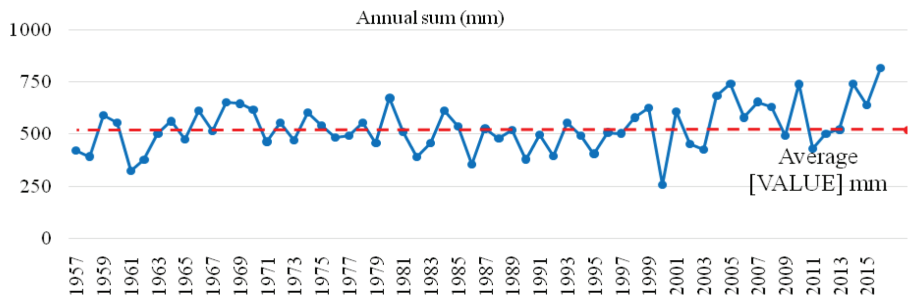



Figure 2. The rainfall regime ARDS Turda, 1957-2016

What was specific for the three years taken into account in the study (2014, 2015, 2016) was the unequal distribution of rain, there was a long period of pedological drought followed by heavy rain.

The 2014 was a good year for agricultural crops from the point of view of the climate, the alternation of months with normal temperatures from a thermal point of view and the warm ones was good for the vegetation steps. The rainfall in 2014 with the annual sum of 741.5 mm, was high in quantity, especially during the summer, even if the number of rainy days was smaller.

The 2015 was characterized as a hot and rainy year. The year average was 10.6$^o$C, that is 1.5$^o$C more than the multiannual average in 60 years. Rainfall in this year exceeded by 122.4 l/m$^2$ the value of 518.8 l/m$^2$, the multiannual average in 60 years. The amount registered was 641.2 l/m$^2$.

2016 is a hot year, with a deviation of + 0.9$^o$C compared to the multiannual average, with an annual average temperature of 10$^o$C. From the rainfall regime point of view, 2016 with 816.8 l/m$^2$ and a deviation of + 288 l/m$^2$ compared to the multiannual average is characterized as an excessively rainy year.

The choice of the best soil tillage system with the specific technology works applied for the winter wheat must ensure the accumulation and preserve in the soil of the entire quantity of water coming from the rainfall during summer and autumn. Following the results obtained during 2014-2016, regarding the humidity existing in the soil in winter wheat crop, one has noticed that there are certain differences among soil tillage systems.

In the NT system, the accessible water reserveis kept better in the soil even during drought, the depth water rises through capillaries to the radicular area paying off for the lack of water due to drought. Restoring the water reserve from the soil, as one can notice in Figure 3, is more difficult than in the case of CS, but the loss of water from the classical systemis as rapid. Restoring the water reserve during 2015, 2016 had to suffer due to short heavy rain when leaks from slopes were bigger than the infiltrations.

The results obtained show the insignificant influence of the factor tillage system in the forming of the wheat crop (figure 4), the difference between the two systems CS and NT is only 34 kg/ha. In exchange, one can notice the significantly positive influence of the technology with two fertilizations ($N_{60}P_{40}$ + $N_{40}$) in the achievement of wheat grain production (Figure 5).

Expressing the production potentialof Andrada winter wheat typeis mostly influenced by the year factor (Figura 6). We can notice the strongly significant negative influence of 2015 by the production achieved, that is 6175 kg/ha. 2016 had a strong positive influence upon wheat production, it was 6519 kg/ha with a difference of 307 kg/ha compared to 2014 taken as a mark, when 6212 kg/ha were produced.

The fuel consumption is different at each crop technology and the economic efficiency differs according to the soil tillage system. The aim of applying NT, which replaces the classical system is to reduce the fuel consumption and of course, the costs for the achievement of the agricultural production.

By applying CS a higher number of passing with equipment on the soil surface is made especially for the preparation of the germinative bed, three technological works are necessary, after which there is still the straw baling after the harvest and their transport from the field. To these works are added others specific for the crop: sowing, crop maintenance and harvesting, which leads to a fuel consumtion of 110 liters/ha at a cost of 630 lei/ha.

The technology differences of the NT system reduce the soil degradation process caused by the compaction phenomen on at repeated passings with heavy machines on the soil surface, a fuel savings is made for the set up of a hectare of wheat crop of approximately 50%, being necessary a consumption of only 55 liters/ha at a cost of 315 lei/ha.

Due to the high costs of materials necessary for the crop set up (especially pesticides) and up to the harvest (including freeing the land by straw baling with the classical system) the economic efficiency results more from the fuel savings (Table 1) the total result on NT technology is a saving of 19.2%.

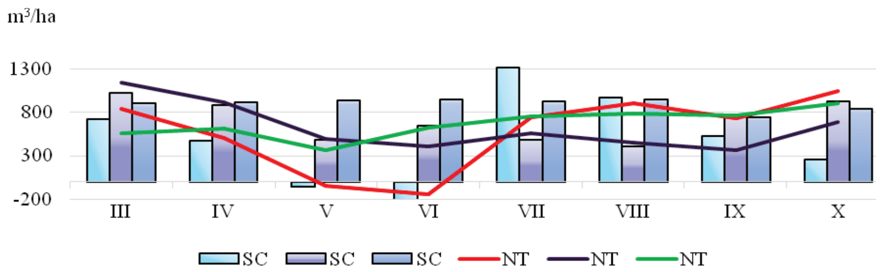
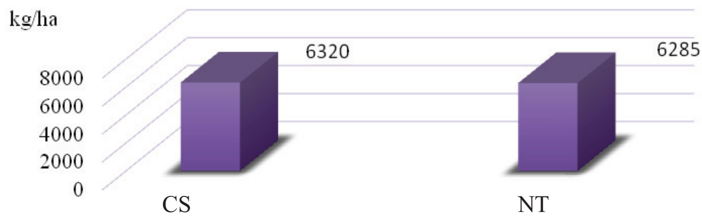



Figure 3. The influence of the tillage system in wheat cropon the soil water preserve ($m^3$/ha), 2014-2016

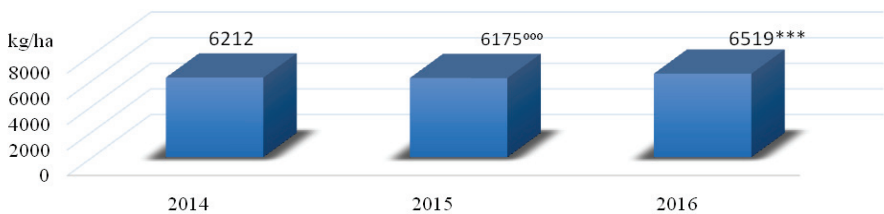



DL (5%) = 74; DL (1%) = 171; DL (0.1%) = 313

Figure 4. The influence of the soil tillage system on wheat production 2014-2016


DL (5%) = 30; DL (1%) = 69; DL (0.1%) = 220

Figure 5. The influence of the fertilization levelon wheat production 2014-2016




DL (5%) =16; DL (1%) = 23; DL (0.1%) = 34

Figure 6. The influence of the year on wheat production, 2014-2015

Table 1. Efficiency of crop technologies for the set up of 1 ha wheat

| Consumption | CS | NT | Difference to NT ± |
|---|---|---|---|
| Fuel, l/ha | 110 | 55 | - 55 |
| Price, lei/ha | 630 | 315 | - 315 |
| Materials (wheat seed, pesticides, chemical fertilizers etc.) | 1537 | 1437 | - 100 |
| Total, lei/ha | 2167 | 1752 | - 415 |

## CONCLUSIONS

The higher values of the water preserve accessible in the soil were determined in the CS system, but at the same time here there is a faster loss compared to the NT system, where the water accumulation in the soil is made more difficult, but it is lost slower.

The soil tillage system doesn't have a significant influence on the wheat production, the difference between the two systems is only 34 kg/ha.

The additional wheat fertilization (with $N_{40}$) brings a production increase of 111 kg grains/ha.

The agricultural year through the climate conditions (temperature and rainfall) influences significantly the wheat production, the production increase made reaches up to 307 kg/ha during the rainy year 2016, compared to 2014, taken as a mark.

By applying the conservative no-tillage system a saving per hectare of 19.2% is made.

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