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RESEARCH ON THE INFLUENCE OF THE SOIL TILLAGE SYSTEM ON SOYBEAN YIELD AT ARDS TURDA

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Abstract: *The purpose of this paper is to evaluate the soybean yield obtained from the application of the minimum tillage system compared to the classical tillage system. Conservative tillage systems have become an important part of agriculture, and the need to apply these systems is justified by the growing area of land degraded by the erosion process. Experimental factors: Factor A - the tillage system: classical tillage system and minimum tillage system (chisel variant); Factor B - soybean varieties: Onix, Felix, Mălina TD and Darina TD; Factor C - experimental years: 2015 and 2016. Following the application of the conservative tillage system, there is a slight decrease in yield compared to the classical tillage system, and between the two years studied, in 2016 there are yields with significantly higher differences compared to 2015. The application of conservative tillage systems brings important long-term benefits to both the soil and the environment by reducing soil compaction and fossil fuels used in crop technology.*

Keywords: *climatic condition, soybean, tillage systems, yield*

JEL Classification: Q01, Q15, Q16

INTRODUCTION

Soil is the thin layer of the ground in which biological processes are produced (Răuţă and Cârstea, 1983) and introducing conservative farming systems is trying to improve, conserve and more efficiently use natural, biological and water resources (Guş et al., 2003; Rusu et al., 2009).

The large number of works and repeated crossings on the ground with agricultural tractors and machines negatively influences soil properties resulting in soil structure degradation, surface and depth compaction, decreased humus content, reduced biological activity, resulting in decreased natural fertility of the soil.

Awareness of the problems arising from the use of intensive farming systems has led to the search for sustainable measures to assist farmers, among which the most important measures are the implementation of conservative soil cultivation systems, the cultivation of legumes for soil enrichment in rotation nutrients (Şimon et al., 2014) and the cultivation of plants used as raw material for biofuels.

The main aspects of these agricultural systems are the abandonment of the plow with a total or periodic plow, the rationalization of the number of works and the preservation at the soil surface of at least 30% of the total vegetal remains (Cheţan et al., 2015; Fabrizzi et al., 2005) in order to protect the soil from surface erosion, while eliminating the phenomenon of compacting it.

The technological works included in the conservative tillage system help to restore the soil structure, improve soil drainage, protect the soil against erosion of water and wind (Şimon et al., 2016). A major importance in the application of sustainable farming systems is the amount of vegetal remains left at the surface of the soil left by a crop after harvesting, these plant residues being sources for the formation of humus, which helps to soil structuring and soil leaching and to improve agrochemical indices it is important to rotate plants that

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leave plant rich plant residues that leave small amounts of plant debris and plants that leave large amounts of nutrients in the soil such as legumes with high nutrient-rich plants.

Soybean is currently one of the most important agricultural plants being used in human and animal nutrition but also as a raw material for industry, researchers being interested in the nutritional value, the potential of the soy in human health (Hermansen et al., 2000) the agro-phitotehnical importance as it contributes to the increase of soil fertility by the fixing of atmospheric nitrogen by the symbiosis between soybeans and *Rhizobium japonicum* bacteria, which form root radicals (Roman et al., 2006), constituting a good precursor for most agricultural crops.

Soybean has a high capacity to adapt to different climatic and soil conditions, with the best results being obtained on deep, fertile, neutral or slightly acidic soil, well-drained, rich in humus, phosphorus, potassium and calcium of humidity is a plant with relatively high requirements, the maximum intensity of water consumption taking place in June-August, when the soy consumes 5,8-4,6 mm/day.

MATERIAL AND METHOD

The experiment was conducted between 2015-2016 at Agricultural Research and Development Station Turda (ARDS Turda), on a faeozem vertical soil with neutral pH, loam-clay texture, humus medium content, good phosphorus and potassium supply.

The soybean was sown with a distance of 18 cm, with the Gaspardo Directa 400 seed drill at 65 g.s./m^2. The soybean has been grown in a crop rotation system for 3 years, the pre-plant being maize.

The experimental factors are: Factor A - experimental years: A1 - 2015, A2 - 2016; Factor B - Tillage system: B1 - The classical tillage system, which includes a 30 cm deep hole after harvesting the previous crop and soil processing to prepare the germinating bed with the disc and combiner before sowing; B2 - Minimum tillage system with the chisel at 30 cm deep after harvesting the previous crop and soil processing to prepare the germinating bed with the rotary before sowing; Factor C - soybean varieties: C1 - Onix, C2 - Felix, C3 - Mălina TD, C4 - Darina TD.

After sowing, treatment with Gliphosate (4 l/ha) was performed in the two systems. Control of monocotyledonous and dicotyledonous weeds was performed with Pulsar herbicides (1,0 l/ha) and Agil (1,0 l/ha) in weed rosette phenophase.

To protect the soybean culture against the red spider (*Tetranicus urticae*), the Omit 570 EW (0,8 l/ha) insecticide treatment was performed and with the Ridomil Gold MZ 68 WG fungicide was treated the *Peronospora manshurica* (2,5 kg/ha).

The obtained results were statistically processed by the variance analysis method and the lowest significant difference was determined - DL - (5%, 1% and 0,1%) (ANOVA, 2015).

Climate conditions are a determinant of agricultural yield, and the analysis of the evolution of climatic factors is justified in the current context of climate change, which is increasingly visible both globally and in our country.

The climatic conditions of the years 2015-2016 are presented according to the Turda Meteor Station. Over the past 59 years, the annual average temperature recorded was 9,1^{0}C (Table 1) and the annual precipitation amount was 520,6 mm (Table 2). The average temperatures recorded during the soybean crop growing months varied in the two years but were higher than the average for 59 years with 1,5^{0}C in 2015 being considered a warm year and 0,9^{0}C in 2016 , a year considered warmly.

In 2016, the temperature values recorded in the soybean crop growing months ranged from multi-year averages with a deviation of -0,7^{0}C in May, with a cool spring up to +2^{0}C in

June, characterized as a warm moon, in the other months the recorded temperatures were close to normal.

Table 1. Average air temperatures (^{0}C), Turda 2015-2016

2015													
Monthly average	Ian.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual average
	-0,7	0,0	5,5	9,6	15,8	19,4	22,3	21,9	17,3	9,7	6,1	0,7	10,6
Average 59 years	-3,4	-0,8	4,5	9,9	15,0	17,8	19,7	19,3	15,0	9,5	3,9	-1,4	9,1
Deviation	+2,7	+0,8	+1,1	-0,3	+0,8	+1,6	+2,6	+2,6	+2,3	+0,2	+2,2	+2,3	+1,5
2016													
Monthly average	Ian.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual average
	-2,8	4,6	5,9	12,4	14,3	19,8	20,5	19,6	17,1	8,3	2,9	-2,7	10,0
Average 59 years	-3,4	-0,8	4,5	9,9	15,0	17,8	19,7	19,3	15,0	9,5	3,9	-1,4	9,1
Deviation	+0,6	+5,4	+1,4	+2,5	-0,7	+2,0	+0,8	+0,3	+2,1	-1,2	-1,0	-1,3	+0,9

Source: Turda Meteor Station, longitude: 23^{0}47 '; latitude 46^{0}35 '; altitude 427 m

The amount of precipitation recorded in the first half of 2015 was below the monthly average of the 59 years, the spring months of 2015 were drought, and in June although it was a very rainy month in the first decade, only 0.6 l / m2, following very dry July and rainy August, soybean suffered during this period due to the drought recorded during periods of vegetation when it needed acute water, which was specific to the summers of 2015 was the persistence of high temperatures up to on the heel threshold, over a long period of time.

Table 2. Recorded precipitation (mm), Turda 2015-2016

2015													
Monthly amount	Ian.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual amount
	12,3	20,9	12,8	32,2	66,0	115,7	52,2	72,2	172,6	45,4	32,0	6,9	641,2
Average 59 years	21,3	18,7	23,1	44,7	67,7	84,5	76,7	55,9	40,3	32,0	28,7	26,9	520,6
Deviation	-9,0	+2,2	-10,3	-12,5	-1,7	+31,2	-24,5	+16,3	+132,3	+13,4	+3,3	-20,0	+120,6
2016													
Monthly amount	Ian.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual amount
	25,0	23,8	47,0	62,2	90,4	123,2	124,9	91,0	24,6	152,2	45,3	7,2	816,8
Average 59 years	20,8	18,4	19,3	44,4	67,1	83,4	72,9	54,6	42,0	32,5	32,3	26,0	513,6
Deviation	+4,2	+5,4	+27,7	+17,8	+23,3	+39,8	+52,0	+36,4	-17,4	+119,7	+13	-18,8	+303,2

Source: Turda Meteor Station, longitude: 23^{0}47 '; latitude 46^{0}35 '; altitude 427 m

In 2016, the sum of precipitations was higher than the average for 59 years, being considered an excessively rainy year, temperatures and precipitation were beneficial for soybean culture, and yields are the result of the interaction of optimum climatic conditions.

RESULTS AND DISCUSSIONS

The climatic conditions of the crop growing period play a decisive role in the formation and expression of soybean yield, as can be seen in Table 3 of the production resulting in 2016, when the precipitation and temperatures recorded optimal conditions for the development of the plants was higher than that determined in 2015, with a very significant difference of over 1625 kg/ha, the water deficit correlated with the thermal surplus during the flowering-grain period made the average production of the four varieties in 2015 to be only 2043 kg/ha.

Table 3. Influence of the annual factor on soybean production, Turda 2015-2016

Experimental year	Yield (kg)	Diferences (kg)	Significance
2015 (control variant)	2043	-	mt.
2016	3668	1625	***
LDS (p 5%) 19 LDS (p 1%) 95 LDS (p 0,1%) 555			

The tillage system influences the productivity elements of the agricultural crops and finally the obtained yields, in the case of the minimum tillage system (the chisel variant) the obtained yields were very close to the variant worked according to the classic system (the variant plows with the return of the furrow) the difference of -9 kg/ha being statistically unsecured, the average yiled recorded for the application of the conservative tillage system was 2851 kg/ha, as can be seen in Table 4.

The research carried out by Cheţan and collaborators (2016) over the period 2012-2014 on the same soil type, at the Onix soybean genotype, showed that soybean is a culture that lends itself to the application of conservative tillage systems, the yield obtained being close to that recorded in the classical tillage system.

In addition to these results supporting the implementation of conservative tillage systems, it is important to take into account their long-term benefits (reducing soil compaction, erosion and fossil fuel consumption, improving soil fertility and economic efficiency).

Table 4. Influence of soil soil system factor on soybean production, Turda 2015-2016

Tillage system	Yield (kg)	Diference (kg)	Significance
Classical (control variant)	2860	-	mt.
Minimum	2851	-9	0
LDS (p 5%) 6 LDS (p 1%) 13 LDS (p 0,1%) 142			

Regarding the average yield recorded by the four soybean varieties studied during the period 2015-2016, the control variant, Onix variety, recorded the lowest yield of only 2807 kg/ha, the Felix and Darina TD varieties there were recorded more yields with significant distinct differences of 18-20 kg/ha compared to the control variant, but Mălina TD is distinguished by an average yield of 2963 kg/ha, with a very significant difference of +156 kg/ha compared to the control variant.

Good results of yield for soybeans Felix, Mălina TD and Darina TD obtained Mureşanu and collaborators (2012), during 2007-2010, the yield increases made by these varieties cultivated at ARDS Turda compared to the control variant Onix were 0,7% for Felix, 0,1% for Mălina TD and 11,7% for Darina TD.

Table 5. Influence of the variety factor on soybean production, Turda 2015-2016

Varieties	Yield (kg)	Diferences (kg)	Significance
Onix (control variant)	2807	-	mt.
Felix	2827	20	**
Mălina TD	2963	156	***
Darina TD	2824	18	**
LDS (p 5%) 12 LDS (p 1%) 17 LDS (p 0,1%) 124			

Consumption of fuel needed for a ha of soybean cultivation differs according to the adopted tillage system, classical technology involves a larger number of mechanized agricultural works to prepare the germinating bed, which makes the total fuel required for a ha of 99,9 l (Table 6), at a total cost of 599,4 lei/ha compared to the minimum tillage system where the number of works is reduced and the fuel consumption reaches 82,8 l/ha (Table 7) at a cost total of 496,8 lei/ha, with 17,1 l/ha less fuel and a cost of 102,6 lei/ha lower, besides this economic aspect it is also important to reduce soil compaction as a result of the reduction of the number of crossings with agricultural machinery on the soil surface.

Table 6. Fuel consumption and expenditures/ha at the application of the classical tillage system

Tillage	Diesel consumption (l/ha)	Price (lei)	Cost (lei/ha)
Plowing (30 cm)	28	6	168
Disking (2)	5,7x2	6	68,4
Processing with the combiner	5,7	6	34,2
Sprayer (2)	1,6x2	6	19,2
Sown + Fertilized	8	6	48
Treatment	1,6	6	9,6
Harvesting	30	6	180
Harvest transport	6 hours	6	36
Strains transport	6 hours	6	36
Total	99,9		599,4

Table 7. Fuel consumption and expenditures/ha at the application of conservative tillage system

Tillage	Diesel consumption (l/ha)	Price (lei)	Cost (lei/ha)
Processing with chisel (30 cm)	28	6	168
Rotary harrow processing	6	6	36
Sprayer (2)	1,6x2	6	19,2
Sown + Fertilized	8	6	48
Treatment	1,6	6	9,6
Harvested by chopping and spreading vegetal remains	30	6	180
Harvest transport	6 hours	6	36
Total	82,8		496,8

As regards the cost of the materials needed in the soybean culture process, this is the same for the two tillage systems (classical and conservative) and is 1424,1 lei/ha, as shown in Table 8, the most the high price of products for the protection of soybean culture.

Table 8. Expenditure on materials

Materiale	Cantitity (kg/l/ha)	Price (lei/kg/l)	Price/ha (lei/ha)
Seeds of soybean (Onix, Felix, Mălina TD, Darina TD)	100	4	400
Chemichal fertilizers $N_{40}P_{40}$ (NPK 20:20:0)	200	1,7	340
Fungicide Ridomil Gold MZ 68 WG	2,5	106,82	256,15
Insecticide Omite 570 EW	0,8	20	16
Herbicide Clean Up (glyphosat)	3	36,33	108,99
Herbicide Pulsar	1	145	145
Herbicide Agil 100 EC	1	158,05	158,05
Total			1424,1

Analyzing the total expenditure by cultural technology, Table 9 shows that the total cost of the classical technology is 2023,5 lei/ha with 102,6 lei/ha higher than the conservative tillage technology, the economic efficiency of minimum tillage systems being one of the advantages of implementing conservative tillage systems.

Table 9. Total spend per technology

Tillage system	Diesel consumption (l/ha)	Price (lei/ha)	Material costs (lei/ha)	Total (lei/ha)
Classical	99,9	599,4	1424,1	2023,5
Minimum	82,8	496,8	1424,1	1920,9

The economic efficiency achieved as a result of applying the minimum tillage system results only from the fuel economy used/ha, due to the fact that the outputs achieved for the two tillage systems are close, following the application of the conservative tillage system, a profit per hectare higher by 89,1 lei compared to the one obtained after applying the classical tillage system where the profit is 2266,5 lei/ha, as can be seen from Table 10.

Table 10. Economic efficiency of systems according to outputs

Tillage system	Cost (lei/ha)	Average yield (kg/ha)	Soybean price (lei/ha)	Yield price (lei/ha)	Profit (lei/ha)
Classical	2023,5	2860	1,5	4290	2266,5
Minimum	1920,9	2851	1,5	4276,5	2355,6

CONCLUSIONS

Soybean yield is greatly influenced by climatic conditions, the yield difference achieved in a year where conditions are optimal for soybean cultivation compared to a year in which environmental conditions are less favorable may also be 100%.

By applying the minimum tillage systems, the average yield does not decrease very much compared to the yield recorded in the classical tillage system, the difference being insignificant, but with the implementation of the conservative tillage systems an important fuel and money economy is achieved.

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