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NEW VARIANTS OF SOYBEAN CULTIVATION UNDER THE CURRENT CLIMATE CHANGES

FELICIA CHEȚAN¹, CORNEL CHEȚAN²

Abstract: *The yield dates recorded in the period 2016-2018 indicate that soybean is less demanding at the soil cultivation system, so that in the three years of experimentation, the average yield achieved in the classical soil cultivation system had a close value of that obtained in the minimum system (chisel and disk), the differences being between 29-245 kg/ha. By marketing the production, it obtains the highest profit in the minimum soil cultivation system - the chisel variant of 1174 lei/ha followed by the classical system with 967 lei/ha and the disk variant 829 lei/ha. During these three experimental years there were very rapid changes in the weather, at hot to cold and vice versa, the torrential rains abundance of followed by long droughts. Higher values of available water reserve in the soil (R_a m³/ha) were determined in the classical system in the rainy years, but at the same time there is a faster loss than the minimum system where the accumulation of water in the soil is made more difficult but it's slower.*

Keywords: *tillage system, climate, water reserve, yield, soybean*

JEL Classification: *Q 01, Q 15, Q 16*

INTRODUCTION

By excessive work of the soil with mechanical machinery and primarily the basic work, the appearance, which has negative effects through a greater water loss, a weaker mineralization of the vegetal remains, the hardpan creation, breaking the continuity of the capillarity, and if the plowing is made after the highest slope line, favors erosion (Bogdan et al., 2007, Cociu, 2011, Ibanez et al., 2008, Moraru and Rusu, 2010, Pop et al., 2013; Berca, 2006). Obsolete, energy-efficient technologies are an initial factor for soil degradation, 35% of the degradation is due to human activity worldwide and 28% to other forms of improper land management (Brown, 2002). In the last few years the climate of the area has changed, due to the increase of the temperature and the unevenness of the precipitations distribution, and we have to look new variants of the soil cultivation (Rusu et al., 2014; Chețan et al., 2011, 2016, 2017).

The minimum work system involves the basic work without plow with the furrow return, using: disk harrow, chisel, rotary harrow, mills, complex aggregates and the keep vegetal debris 15-30% or superficial incorporation the mulch. The crop rotation also aims at keeping the water in the soil at cultivating the plants with low water consumption after the plants with high water consumption and including rotation of roots alternating the culture plants with the depth rooting with plants with the shallow rooting (Chețan, 2015). Soybean is currently one of the most important crops for human consume, animal feed, and is of agro-technics importance (soil fertility) by fixing the atmospheric nitrogen (symbiosis between the roots and *Bradyrhizobium japonicum*), Dencescu et al. , 1982; Guş et al., 2004; Vidican et al., 2013; Chețan and Chețan, 2013). Minimal work has been aimed at accumulating - storage the water in the soil in as large a quantity as possible in the soil horizons, accessible to crops.

MATERIALS AND METHODS

The researches was realized between 2016-2018, at the Agricultural Research Development Station Turda (ARDS), physically-geographically located in the Transylvanian Plain. The experience was placed on a haplic chernozem (SRTS, 2012): 56.07% clay; coarse sand 0.73%; porosity 58%; density 1.13 g/m³; SIC texture; with the following indices (MESP, 1987): pH 7.8; humus 3.49%; total nitrogen 0.207%; 65 ppm phosphorus; potassium 400 ppm; carbonate 0.7%, values determined at a

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depth of 0-28 cm (OSPA Cluj). The experimental field was included in a three-year crop rotation: soybean - winter wheat - maize. The biological material was represented by soybean Felix variety (maturity group 00, created at ARDS Turda).

Experimental factors:

A - Soil system: a₁ classic (SC), plow with Kuhn Huard Multi Master 125T at 28 cm depth + the seedbed preparation in spring with rotary harrow HRB 403 D + sowing + fertilized, with Gaspardo Directa 400 seed drill; a₂ conservative, minimal works (MC), scarified in autumn with the Gaspardo Pinocchio chisel at 28 cm depth; the seedbed preparation in spring with Kuhn HRB 403 D rotary harrow and sowing + fertilized, with the Gaspardo Directa 400 seed drill; a₃ conservative, minimal work, processed the soil in autumn with the Discovery hard disk at 12 cm depth (MD); the seedbed preparation in spring with Kuhn HRB 403 D rotary harrow and sowing + fertilized, with the Gaspardo Directa 400 seed drill; **B - year** (climatic conditions): b₁-2016, b₂-2017, b₃-2018.

The sowing was done at a density of 65 gg/m², 18 cm the distance between the rows and the seed incorporation on 5 cm depth. The basic (mineral) fertilization was carried with N₃₂P₃₂K₃₂ a.s./ha, at the same time with the sowing and the additional fertilization before the soybean flowering was made with 2.0 l/ha of foliar fertilizer NPK type + microelements (8:32:4 + Fe, Mn, Zn, humic acids). The weed control was realized in two phases: pre-emergence with 0.35 l/ha Sencor (*metribuzin* 600 g/l) + 1.5 l/ha Tender (960 g/l *S-metolachlor*) and post-emergence with 1.0 l/ha Pulsar 40 (40 g/l *imazamox*) + after 4 days with 1.5 l/ha of Agil 100 EC (100 g/l *propaquizafop*). For the control of *Tetranychus urticae* pests (red spider), used an acaricide Omite 570 EW (570 g/l *propargite*) at a dose of 0.8 l/ha and 0.2 l/ha Biscaya 240 OD (240 g/l *thiacloprid*) for *Cynthia cardui* (thistle caterpillar). The disease control, *Peronospora manshurica* and *Pseudomonas glycine*, was achieved by treatment with 2.5 kg/ha of Ridomil Gold MZ 68 WG (4% *mefenoxam* 64% *mancozeb*).

The reserve of accessible humidity (Ra m³/ha) was determined on the depth of 0-50 cm (for soybeans most of the root system is in the first 40 cm deep in the soil): Ra₅₀ = Ra₅₀ (mm) x 10 => Ra₅₀ (m³/ha). Soil harvesting was carried out in all three soil cultivation systems, with CASE combine harvester, the difference that in the minimum system the stalks were chopped and evenly dispersed on the soil surface as the mulch and in the classical system after harvest the land was released by plant debris (strains were bundled and transported off the field).

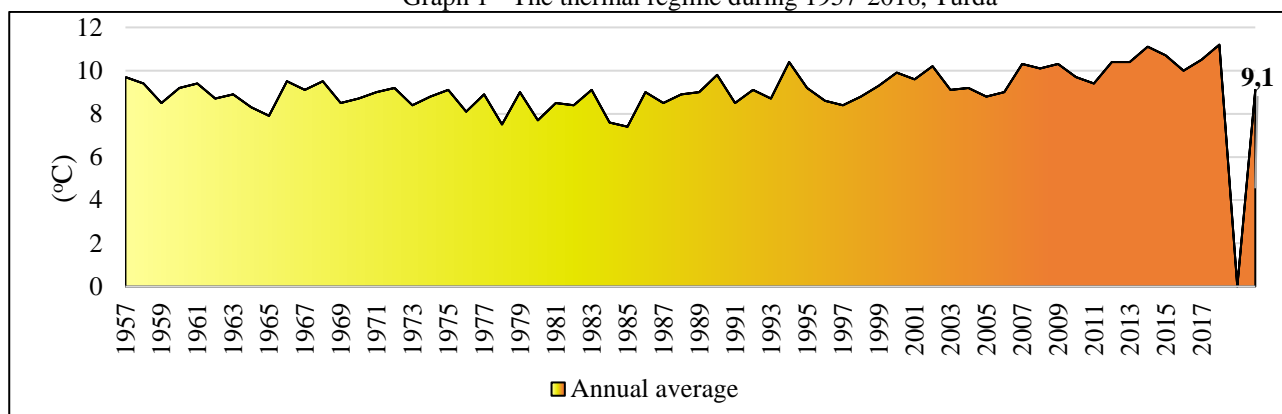
The economic efficiency of the investigated variants was determined by the number of technological works applied, fuel consumption (on the basis of the characteristics of agricultural machinery, equipment used, on land with 1.19% slope coefficient) and materials used, per hectare. The yield data obtained were statistically processed by variance analysis (PoliFact, 2015) and limiting differences (LSD, 5%, 1%, 0.1%). The climatic conditions during 1957-2018 (Turda Meteorological Station, longitude 23°47', latitude 46°35', altitude 427 meters) are presented in Graph 1 and 2.

RESULTS AND DISCUSSIONS

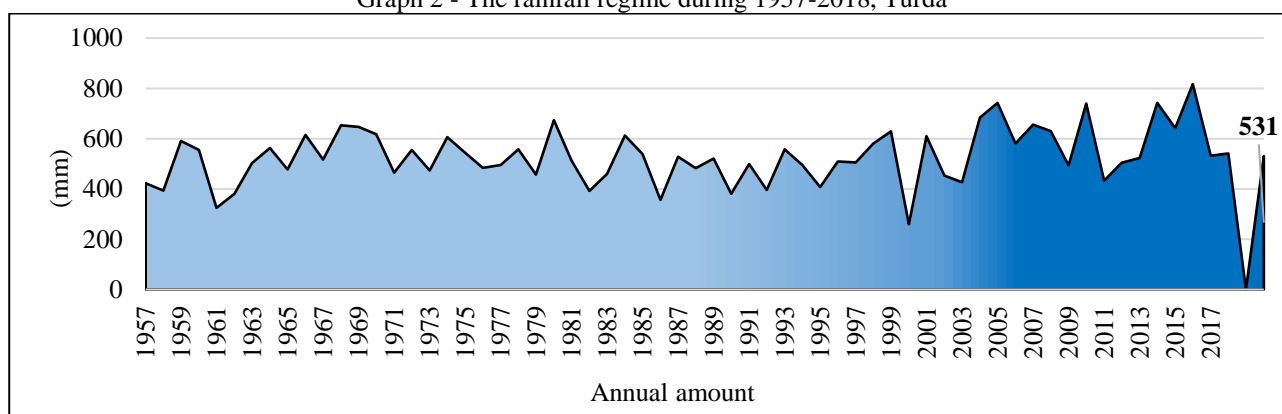
In the 62- years since the evolution of the climatic conditions in Turda was monitored, the data collected at the Turda Meteorological Station (1957-present) regarding their evolution in dynamics, it can be noticed that the weather in Turda is in a heating process and that felt more intense after 2007, which is part of the global warming phenomenon (Ignea, 2017). The 62-year multiannual average was 9.1°C, the number of years in which the annual mean temperature was below 9°C was 25- year, 25- year at 9°C and above 9°C, and 12- year with annual mean values temperatures above 10°C, especially in the last seven years (2012-2018). The highest average annual temperatures are attributed to 2014 (11.1°C) and 2018 (11.2°C).

The evolution of the rainfall regime was uneven and no dominant trend was observed, the 62-year multiannual amount was 531 mm, the number of years in which precipitation had values below 500 mm was 24- years-, over 500 mm in 21- years, over 600 mm were recorded in 13- year and in four years the precipitations had values over 700 mm. The highest rainfall over the period, 816.8 mm, was recorded in 2016.

Graph 1 - The thermal regime during 1957-2018, Turda



Graph 2 - The rainfall regime during 1957-2018, Turda

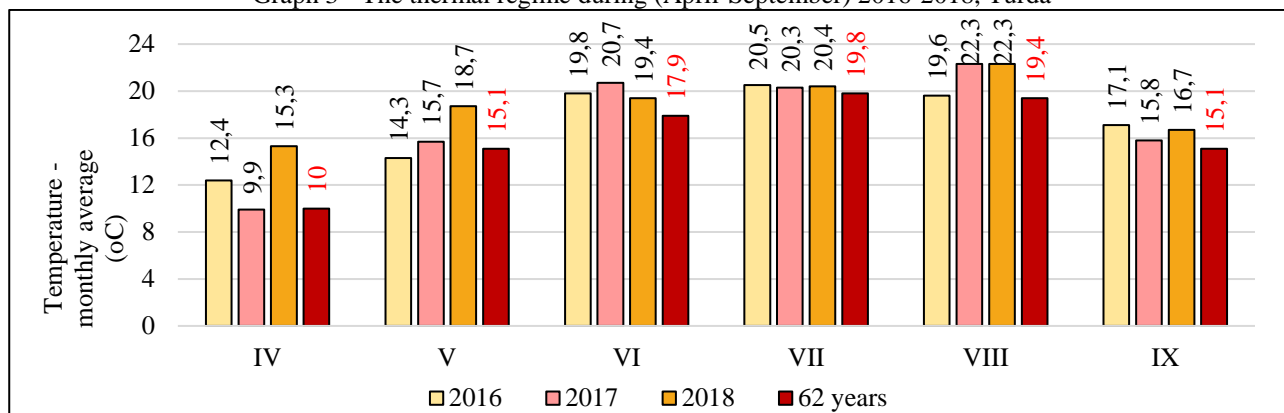


Soybean has high and different temperature requirements depending on the vegetation phases: for sowing-emergence requires at least 7-10°C (optimum 20-22°C); emergence-beginning bloom, minimum 16-18°C (optimum 21-25°C); pods formation, 13-14°C (optimum 21-23°C) and beginning maturity at minimum 8-9°C (optimum 19-20°C), (Bâlceanu, 1998; Ștefan, 2011). In the Turda area, these periods coincides with the second decade of April and the May; the second decade of June and the second decade of August and September. From the data presented in Chart 3, it can be noticed that during April - September the temperatures recorded during all three experimental years exceeded the average monthly multiannual temperatures for 62 years. In 2016 April with average temperature of 12°C was close to normal (10°C); with 14.3°C the May month was cooler than the monthly average multiannual (15.1°C) with deviation - 0.8°C, June had a hot character with deviation + 1.9°C; July with deviation + 0.8°C; August with + 0.3°C and September with + 2°C. In 2017 the April spring month with 9.9°C was close to the multiannual average monthly, deviation + 0.1°C; May 15.7°C with + 0.6°C deviation; the summer had two hot months, June with + 2.8°C deviation, August + 3°C and a normal July month with a + 0.6°C deviation; August with + 2.9°C deviation and in September recorded average temperature exceeded by + 0.7°C monthly average for 62- year. Atypical climatic conditions marked the agricultural year 2018, throughout the April - September period. Monthly average temperatures were above the multiannual monthly values, with deviations of + 5.3°C in April; + 3.6°C in May; + 1.5°C in June + 0.6°C in July; + 2.9°C in August and in September with + 1.6°C.

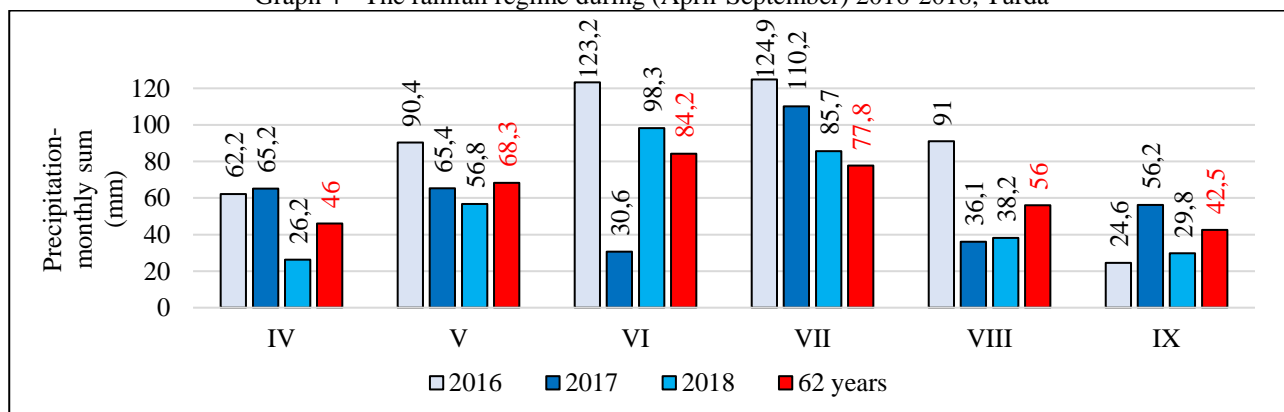
From the rainfall point of view (Graph 4), compared with the monthly multiannual sum (April 46 mm, May 68.3 mm, June 84.2 mm, July 77.8 mm, August 56.0 mm, September 42.5 mm), the year 2016 have the month April and May very rainy (April 62.2 mm with deviation + 16.2 mm, May 90.4 mm with deviation + 21.8 mm), very rainy June (123.2 mm, deviation + 38.4 mm), excessive rainy July (124.9 mm, deviation + 48.7 mm) and excessive rainy August (91 mm with deviation + 34.5 mm). Year 2016 with an annual sum of 816.8 mm, was the rainiest of the past 62- year (531 mm multi-annual amount). In April and May 2017 the precipitations had very close values (65.2 mm with deviation + 16.2 in April and 65.4 mm in May with deviation of -2.9 mm) compared to the monthly

multiannual sum, followed by a very dry June (30.6 mm with deviation - 53.6 mm versus multi-annual value of 84.2 mm); July very rainy with 110.2 mm (deviation + 32.4 mm); followed by two months very dry: August, which recorded a deficit of - 19.9 mm versus 56 mm, representing the multiannual average for this month and in the September it was 56.2 mm with a deviation + 13.7 mm.

Graph 3 - The thermal regime during (April-September) 2016-2018, Turda



Graph 4 - The rainfall regime during (April-September) 2016-2018, Turda



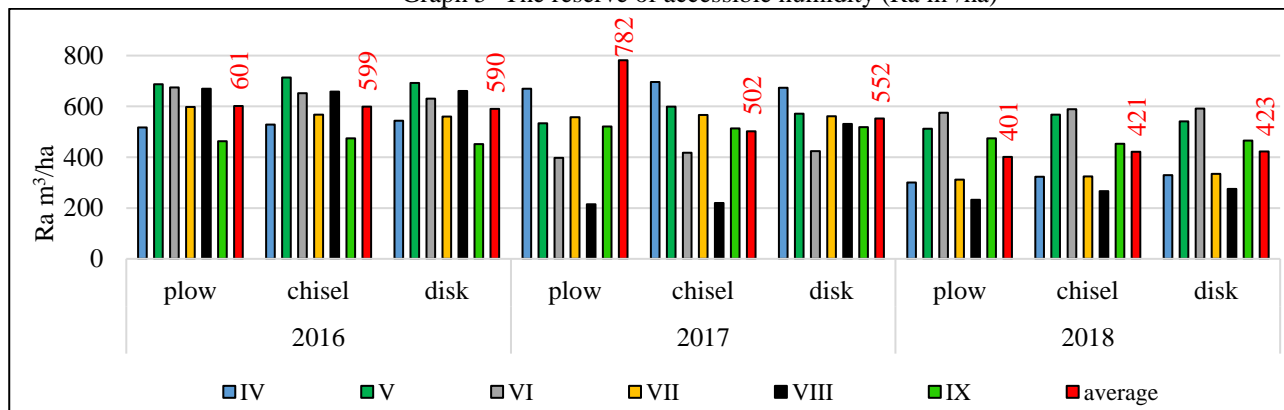
During these three years there were very rapid changes in the weather, warmth to cold and vice versa, as well as the abundance of torrential rains followed by long droughts. Graph 5, shows the average values of the accessible humidity reserve (R_a m^3/ha) recorded in the period 2016-2018, starting from April to September, compared to the three soil cultivation variants (classic-plow, minimum-chisel; minimum-disk). The classic system with recorded R_a values proved to be superior in the six months (average 601 m^3/ha) at which the R_a determinations were made on the 0-50 cm depth in the rainy year 2016, the infiltration of water being made easier compared to the minimum system in which only part of the precipitation (short-torrential rains) infiltrated into the soil but the leakage on the slopes was higher than the infiltrations (chisel 599 m^3/ha , 590 m^3/ha of disk), the difference being between 2- 11 m^3/ha in favor of the plowing system. Even though the total value of the average 782 m^3/ha is attributed to the classic plug- in the whole period of April-September in 2017, this variant also recorded the lowest value of the whole research period in August, only 215 m^3/ha , close to the minimum-chisel system (220 m^3/ha).

The storage and preservation of a larger quantity of water in the soil active horizons was achieved in the minimum-disk system, which had a R_a value of 531 m^3/ha . In the dry year 2018, the accumulation and preservation of water in the soil for a longer period of time we believe it is easier to achieve in the minimum system due to the fact that, in the absence of plowing, the capillary water circuit in the ground is not interrupted, the rains have not had a torrential character in this so that they infiltrated more easily into the soil, plus the intake of vegetal mulch from the soil surface that provides a somewhat constant moisture, fades in the cultivation of the soybean the growth and competition of weeds for water. The loss of moisture in the 0-50 cm layer in the summer months, of June to August

when recorded prolonged drought periods correlated with temperatures higher than the multiannual average for this period, determined the lowest values of Ra in the classic- plow 575 m³/ha in June, 312 m³/ha in July and 232 m³/ha in August, and in the minimum-chisel the values were 589 m³/ha in June, 325 m³/ha in July and 267 m³/ha in August. The minimum-disk version had Ra values of 592 in June, 334 in July, 275 in August.

Conservation of water in the soil through the application of minimum systems (chisel and disk) is noticeably higher in drought years, when in these systems the Ra values recorded during the critical periods for soybean culture exceeded the Ra values in the classical soil working system with the plow with the return of the furrow). It seems that in the rainy years the water builds up faster in this system, but it is easier to lose from the horizon of 0-50 cm.

Graph 5- The reserve of accessible humidity (Ra m³/ha)



Applied technologies should be better suited to the pedo-climatic conditions of the area of interest and cultivar requirements so as to improve their stability to some extent. The increase in yields on the surface unit is based on the use of modern technologies, varietal performance and the application of scientific research results and the use of innovations in agricultural production activity (Ion, 2010).

From the data presented in Table 1, one can notice the significant negative influence of a minimal-disk soil working system in soybean crop production. The difference between the three classic, minimal-chicken and minim-disc systems suggests that soybeans are not preference to the soil operating factor and are suitable for the minimal works variant where the difference from the control was only 29 kg/ha. It appears that in the Turda area, soybean produces the lowest yields in the soil-processing variant with the disc with a difference of 245 kg ha compared to the control and shows distinct significantly negative assurance statistics. These production differences are believed to be due primarily to the soil type with a high content of clay (over 50%).

Soybean crop is influenced more by the year factor (climatic conditions), it can be noticed the negative influence of the years 2017 and 2018 (significantly negative) in expressing the soybean production potential. In 2017, although rain was rainy in April, very low precipitation occurred during May-June, which led to a lower production of 2882 kg/ha (insignificant influence) and a minimum disc of 2731 kg/ha (distinct significant positive influence), with differences from the control between 34-185 kg / ha. Compared with 2016, which was favorable in terms of temperatures and precipitation for soybean culture with a positive impact on production (3296 kg/ha in the classic-plow variant, 3390 kg/ha in minim-chisel and 3240 kg/ha in minim-disk), in 2018 the lack of water in the spring led to the achievement of small productions in all three variants of soil work: classic-plow 2394 kg/ha; minim- chisel 2362 kg/ha; minim-disk 2220 kg/ha. Referring to the classic version - plow taken as a control, the lowest production was made in the minim-disk version with a difference of 173 kg/ha (Table 1).

The technological differences of the minimum tillage system reduce the soil degradation process caused by the compacting phenomenon at repeated crossings with heavy machinery on the soil surface.

The cost of mechanical, manual and material works (seed, fertilizers, pesticides, etc.) in the minim- chisel variant is 2592 lei/ha and 2581 lei/ha in the disk version and 2761 lei/ha in the classic system. By selling the production at an average price of 1.3 lei kg, there is a profit of 967 lei/ha in the classic system, 1174 lei/ha in the minim- chisel variant and 829 in the disk variant (Table 2).

Table 1- The influence of experimental factors on the soybeans yield, 2016-2018

Variants system/year	Yield (kg)	%	Difference	Significance
a ₁ classic- plow	2868	100	0	Mt.
a ₂ minim - chisel	2897	101	29	-
a ₃ minim - disk	2623	91	-245	00
LSD 5% = 60 kg/ha; LSD 1% = 248 kg/ha; LSD 0.1% = 440 kg/ha.				
b ₁ 2016	3309	100	0	Mt.
b ₂ 2017	2843	86	-466	000
b ₃ 2018	2325	70	-984	000
LSD 5% = 59 kg/ha; LSD 1% = 90 kg/ha; LSD 0.1% = 144 kg/ha.				
a ₁ x b ₁	3296	100	0	Mt.
a ₂ x b ₁	3390	103	95	-
a ₃ x b ₁	3240	98	-56	-
a ₁ x b ₂	2916	100	0	Mt
a ₂ x b ₂	2882	99	-34	-
a ₃ x b ₂	2731	94	-185	00
a ₁ x b ₃	2394	100	0	Mt
a ₂ x b ₃	2362	99	-32	-
a ₃ x b ₃	2220	93	-173	00
LSD5% = 100 kg/ha; LSD 1% = 170 kg/ha; LSD 0.1% = 354 kg/ha.				

Table 2- The technological expenses for 1 ha of soybean, 2016-2018

No.	Elements of expenditure	Tillage system		
		classic-plow	minim-chisel	minim-disk
1.	Mechanical works, lei/ha	546	512	501
2.	Materials, lei/ha	2099	1964	1964
3.	Hand works, lei/ha	116	116	116
Total expenses, lei/ha		2761	2592	2581
Average yield kg/ha (2016-2018)		2868	2897	2623
Yield sale price (1.3 lei/kg)		3728	3766	3410
Profit (lei/ha)		+ 967	+ 1174	+ 829

CONCLUSIONS

The soil cultivation system, climate conditions and technology specific to each system influence the productivity potential of the soybean.

Soybean is less demanding than the soil cultivation system, so that in the three years of experimentation, the average production achieved in the classical soil working system had a value close to that obtained in the minimum system (chisel and disc), the differences being between 29-245 kg / ha.

In the yield formation the major role is played by climate conditions, the reduced precipitation from May to August, combined with high temperatures that have persisted for a long time, had a negative impact on the soybean crop in the years 2017 and 2018.

Higher water reserves ($Ra\ m^3/ha$) were determined in the classical system during the rainy years, but at the same time a faster loss is recorded than in the minimum system where the water accumulation in the soil it is harder to do but it is slower.

By selling the average yield obtained in the three experimental years, the highest profit is achieved in the minimum system - the chisel variant of 1174 lei/ha followed by the classic system with 967 lei/ha and the disk variant with 829 lei/ha.

The application of conservative technology is aimed not only at ensuring harvests close to or equal to those obtained in classical technology, but also in reducing soil degradation by erosion, organic matter growth, soil structure rebuilding, the accumulation and storage the water in the soil (increase of plant availability), the economy of the fuel and labor.

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