Researches regarding the influence of the unconventional soil tillage systems upon weeding and soybean yield, in pedoclimate conditions in the transylvanian plain

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RESEARCHES REGARDING THE INFLUENCE OF THE UNCONVENTIONAL SOIL TILLAGE SYSTEMS UPON WEEDING AND SOYBEAN YIELD, IN PEDOCLIMATE CONDITIONS IN THE TRANSYLVANIAN PLAIN

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Abstract: *The importance of soybeans derives from the multiple uses in the human nutrition, animal feeding, industry, but also as a plant that improves the physical properties of the soil by improving the soil in nitrogen. Regardless of the use of practical cultures, for obtaining high yield in terms of quantity and quality, a particularly important role for all other technological links, can be to fight the weeds. Soybeans are sensitive to weeding the first stages of vegetation until the plants can reach the ground cover and at the maturation after the leaves start to fall. In this paper we present the weeding degree and the soybean yield realized, under the influence of unconventional tillage systems and climatic conditions from 2018-2019. In unconventional systems the number of annual monocotyledonous species decreases but the number of perennial weeds increases. As an alternative to the classical system, soybeans can be grown in a minimum tillage system (tillage with chisel), the difference in yield between the classical system is insignificant (only 16 kg/ha).*

Key words: *tillage system, clime, weeds, soybean, yield.*

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

INTRODUCTION

Soybeans are grown in several countries of the world, being one of the most valuable oil-protein plants due to seeds rich in protein, non-nitrogen extractive substances, fats, vitamins and mineral salts (Muntean et al., 1995; Scurtu, 2001). The judicious zonate of varieties, the efficient use of climate resources and the adaptation of all other technological elements specific to the cultivation area, is an important source in increasing soybean yield and does not require additional energy consumption.

Soybeans have high temperature requirements, the minimum germination temperature in the soil is 7-8°C and the air temperature 14-15°C. Immediately after rising and until the formation of simple leaves, soy temperatures of -2, -3°C, but for a short period of time. The optimum temperature for the flowering period is around 24°C, for seed formation a lower temperature of about 22°C and when ripening the beans are required 19°C (optimal). And compared to humidity has relatively high requirements, recording a specific consumption between 300-700 m^3 and the critical period for water is recorded in the phase of formation of reproductive organs, blooming and seeds formation (Muntean et al., 2008). The light requirements of the silk are like a short-day plant, by earlier sowing, the short days from the beginning of the vegetation play an important role in meeting the photoperiodic requirements of late and medium varieties (Muntean, 1995). Soybeans have high soil requirements, require medium-textured soils with neutral reaction (pH around 6.5), well drained, rich in humus phosphorus, potassium and calcium (Dencescu et al., 1982). The cultivation technology is differentiated according to the climatic characteristics, soil, the terrain of the area, the machine system and the impact of the technologies applied on the surrounding environment. The practice of the

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establishment of spring crops has shown that autumn ploughing is the work that ensures the best preparation of the germination bed, increasing the infiltration and conservation of water in the soil, combating weeds, diseases and pests, etc., especially for sugar beet, potato, maize, soybean crops, which are pretentious to the way soil is prepared (Gus et al., 2003). However, in dry autumns, when the soil is very dry and the ploughing is difficult or by ploughing would result in large lumps and difficult to shred but also for economic reasons, the preparation of the land through minimal works are preferred to the ploughing. Cultivation of soybeans in an unconventional system involves from the beginning the elimination of plowing and excessive tillage, aiming at preserving soil properties, reducing erosion, sequestration of carbon in the soil, accumulation and storage of water in the soil, reducing labor and fuel costs, reducing land traffic intended for culture, etc. In this system the basic work is carried out without the return of the furrow (chisel, disk, rotary harrow, cutters, etc.) with the preserve of plant residues in the proportion of 15-30% on the surface of the soil or superficially incorporated by the work performed, having the role of mulch (Chetan et al., 2019). It is accepted the ploughing a time every 3-5 years (Rusu et al., 2007). Regardless of the cultivation system practiced, in order to obtain superior yield in terms of quantity and quality, a particularly important role in all other technological links is the control of weeds, soybean being sensitive to weeding in the early stages of vegetation until the plants come to cover the land and towards maturity after the leaves begin to fall (Chetan et al., 2014). In its studies, Sarpe (1976) states that weeds cause significant damage to soybeans between 40-84% and significantly decrease yield. Kramer (quoted by Anghel et al.,1972) estimates that worldwide, weeds cause 95% damage (calculated by the difference between real and potential harvest) while Ciorlăus (1998) shows that in the countries with modern agricultural technologies losses can reach 27-42% of potential yield and in poorly developed countries losses can exceed 50-60%. The literature mentions 10% yield losses (Farmer's Digest, 1998) depending on the number of weed species present in the soybean crop: 0.3 pl/m.l. *Xanthium* sp; 1pl/m.l *Convolvulus arvensis*., 5 pl/m.l. *Agropyrum* sp. Slonovschi et al., 2001, specifies that weeds are much more resistant than crop plants to pedo-climate conditions due to a wide ecological plasticity, the large number of seeds they produce, germination in soil for several years. In reduce till and conservative systems, weed seeds usually remain at or near the surface of the soil, quickly germinating and infesting the next crop if not controlled by specific chemical treatments. Soil mulching is a means of keeping weeds under control due to the properties of weeds to remain inactive when light is absent. This practice uses: straw, vegetable scraps, leaves, sawdust, compost, to cover the soil. Without light weeds disappear, and at the same time water in the soil is better preserved and the activity of microorganisms (http://agroromania.manager.ro) is protected. In the relationship between the unconventional soil work system and weed control treatment, it is difficult to distinguish between cause and effect, since the degree of weeding can be influenced by the growth and defective development of soy plants which in turn can be influenced by other causes (strong infestation of the land in previous years with perennial weed species, quality of biological material used, unfavorable climatic conditions, etc.). In order to achieve successful results in agricultural yield and in the protection of the surrounding environment, it is necessary to choose the best combination of rotating crops, soil working method and chemical control of weeds (http://www.icpa.ro) in conservative agriculture. Treatments with herbicides applied pre-emerging and supplemented with treatments on vegetation can ensure a free crop of weeds (Berca, 2004), but the condition is the knowledge of the spectrum of weeds in order to take effective control measures as early as possible. When choosing herbicides, account should be taken of their selectivity, the spectrum of weeds specific to the respective soil, the recommended dose, the period of application as well as the correct and uniform administration (Rusu et al., 2014; Chetan et al., 2019). The ecological framework in Transylvania is given by the existence in interaction of a large number of factors, two of which seem to exhibit a dominant action for the agro-ecosystem: the first is the thermal background at its low temperature level and with large temporal variations, characteristics that impose significant restrictions on thermophile plants; the second is the hilly orography of the land with numerous soils degraded by erosion or temporary excess moisture, which impose restrictions on the structure of crops and the system of machines and tractors to ensure the mechanization of the work on the slope (ARDS Turda, 50th anniversary).

The purpose of the research carried out and presented in the paper is to establish the influence of the technology specific to the soil work system on the degree of weeding of the crop and yield obtained at soybeans.

MATERIAL AND METHODS

The research was carried out in 2018, 2019 at the Turda Agricultural Development Research Station, located in the Transylvanian Plain, on a vertical Phaeozem soil with a loamy-clay texture, with neutral pH, good and very good supply with mobile phosphorus and potassium, the soil content in humus being medium. The poly-factorial experience is organized according to the Method of the Latin Rectangle. The biological material used was the early variety Cristina TD, characterized by good resistance to fall and shaking, tolerance to drought, diseases and very good adaptability to mechanized harvesting (16-17 cm height of insertion of the first basal pods).

Experimental factors are: Factor **A**- Soil work system: a_1- (CS) conventional soil work system with plough (in autumn) + spring prepared germination bed with rotary harrow + sowing + fertilized; a_2- (MC) minimum soil work system with chisel (in autumn) + spring prepared germination bed with rotary harrow + sowing + fertilized; a_3- (MD) minimum soil work system with hard disc (in autumn) + in spring prepared germination bed with rotary harrow + sowing + fertilized; a_4- (NT) sowing system directly in the stubble of the pre-emergent crop (in the case of corn) + fertilized; factor **B** - year (climate conditions) b_1- 2018 and b_2- 2019.

Due to the fact that in the conservative system the technological works are reduced (without the frying), weed control carried out chemically in two stages: pre-emerging 0.35 l/ha (*metribuzin* 600 g/l) + 1.5 l/ha (8-*metolaclor* 960 g/l) and postemergent with 1.0 l/ha (*imazamox* 40 g/l) +1.5 l/ha (*propaquizafop*) in the phenophase 3-4 trifoliated leaves, the dicotyledonous weeds in the 2-4 leaf stage and the monocotyledonous weeds were not twinning. Sowing was carried out with the Gaspardo Directa-400 machine, the distance between the rows 18 cm, seed incorporation at 5 cm depth, the sowing density 65 g. g./m^2. At the same time as sowing, chemical fertilizer of $N_{40}P_{40}$ kg a.c./ha was applied. The degree of weeding of the soybean crop was achieved visually and numerically with the metric frame with sides of 50 cm. Harvesting was carried out in step: harvesting of protective bands around the experience; the harvesting of the front and lateral edges of the experimental variants (the frontal eliminations were 1 m and the lateral eliminations 0.60 cm), taking into account by the Wintersteiger combine harvested work width for the experimental plots harvester (1.4 m), the harvestable area of the experimental plot was 28 m^2.The experimental data were processed by analysis of the variant (Poly Fact, 2015) and setting the limit differences (LSD 5%, 1%, 0.1%).The evolution of the thermal and rainfall regime at ARDS Turda (Turda Meteorological Station, longitude: 23°47'; latitude 46°35'; altitude 427 m), for the period March-September from the 2018, 2019 experiment years, is shown in Figure 1 and 2.

RESULTS AND DISCUSSION

Atypical climatic conditions marked the 2018 agricultural year having a negative impact on the evolution of soybean culture. After the first three months of the year in which there was an excess of moisture, the drought occurred during the sowing period and in the period immediately following the sowing caused a soybean staggered rise which favored the weeding but also with an effect on the size of the plants, the blooming and the pods formation phenophases. The month of June brought quite a lot of rainfall that led to a lush growth of soy plants and an increase in the attack of diseases, especially mana (*Peronospora manshurica*). Also due to the high summer temperatures, there was also a slight change coloration on the soy leaves, in the form of discolored spots (sunburn). The autumn months (September and October) were warm and dry. The year 2019 had January rich in precipitation (rain and snow), followed by dry months (February and March), during which the water supply was reduced. The rains in the second half of April favored to the emergence and uniform development of the culture. After April there followed periods of high temperatures, in June there was a more pronounced lack of water, a period that coincides with soy plants that are in important phenophases and have a high water consumption. The last few months have been characterized by a significant lack of water correlated with high temperatures, close to the hot temperatures, with the phenomenon of burning occurring since the second decade of June. The March-September period of the two experimental years showed large variations in temperatures and precipitation, with long periods of time recorded without precipitation, the drought present in several months of the year, short-term torrential rains but also periods when the maximum daily temperatures were above 32°C, setting up the burn.

Figure 1. The thermal regime at ARDS Turda during March-September from the 2018, 2019

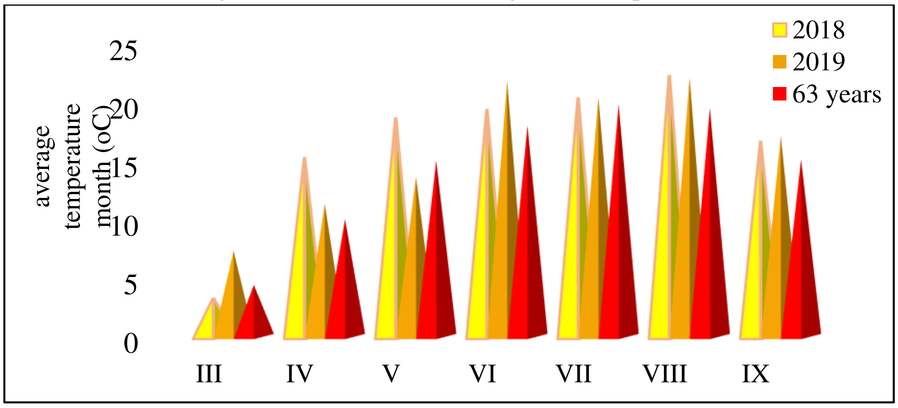
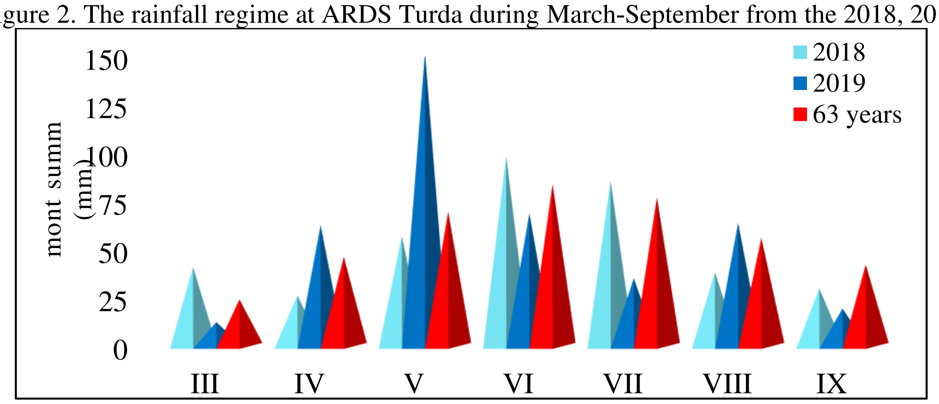


Figure 2. The rainfall regime at ARDS Turda during March-September from the 2018, 2019



The degree of improvement of the soybean crop according to the working variant of the soil, before the completion of the post-mergence herbicide is shown in Table 1. In 2018, with a dry spring, the degree of bottling of the soybean crop is higher with 130 weeds/m^2 compared to 2019 in which there were 104 weeds/m^2. This difference of 26 weeds/m^2 is due to a lack of water in the soil both before sowing and after sowing, soybean seeds have had poor germination and as a result of a defective emergence. The subsequent rains caused the soybean plants to rise in a staggered way, so that from sowing (24.04.2018) to sunrise the crop (17.05.2018) has passed almost a month, during which time the weeds have occupied the land. The effect of herbicides (*metribuzin* + *metolaclor*) applied in pre emergence has been diminished due to pedological drought and only by post-emergence treatment were weeds kept under control to some extent. The degree of weeding of soybean cultivation in 2018 was higher in the soil work system with disk (MD 41 weeds/m^2) and directly sown (NT 44 weeds/m^2). The beneficial effect of plowing and scarification with chisel was observed this year by the lower number of weeds (CS 21 weeds/m^2; MC 24 weeds/m^2). It was found that in all four variants of soil work predominates the annual dicotyledonous species followed by the perennial dicotyledonous species *Convolvulus arvensis, Rubus caesius* and *Lathyrus tuberosus.* The rains of April 2019 contributed to the solubility of the *metolaclor* in the surface layer of soil and the formation of the film of the *metribuzin* on the surface of the soil, with good effect in the control of weeds rise or rising (17.04.2019 weeding in pre-emergence), soil moisture has caused a uniform rises (17.04 sowing, rise on 30.04.2019) but also a good start in the development of soybean cultivation. The number of weeds recorded year was lower in all soil work systems, annual dicotyledonous weeds had the highest share and this year (CS 8 weeds/m^2; MC 11 weeds/m^2; MD 14 weeds/m^2; NT 17 weeds/m^2) and predominates species: *Xanthium strumarium, Chenopodium album, Hibiscus trionum* and *Polygonum convolvulus.*

Table 1. The weed species presented in culture before post-emergence herbicide applying, 2018, 2019

No.	**Classification**	**Weeds species presented**	**Tillage system (A) no. weeds/m^2 -2018**				**Tillage system no.weeds/m^2 -2019**			
			a_1-CS	a_2-MC	a_3-MD	a_4-NT	a_1-CS	a_2-MC	a_3-MD	a_4-NT
1	MA	*Bromus tectorum*	0	0	3	5	0	0	7	10
2		*Setaria glauca*	0	1	1	0	1	0	0	0
3		*Echinochloa crus- galli*	2	2	2	1	0	0	1	1
Total MA			**2**	**3**	**6**	**6**	**1**	**0**	**8**	**11**
1	MP	*Agropyron repens*	0	0	1	4	0	1	3	5
Total MP			**0**	**0**	**1**	**4**	**0**	**1**	**3**	**5**
1	DA	*Xanthium strumarium*	9	4	5	1	3	4	4	4
2		*Chenopodium album*	2	3	3	4	1	2	2	1
3		*Polygonum convolvulus*	2	3	4	3	0	0	1	1
4		*Tragopogon dubius*	0	0	2	4	0	0	1	2
5		*Sonchus asper*	0	0	2	2	0	0	1	1
6		*Hibiscus trionum*	1	3	2	4	1	1	2	3
7		*Anthemis cotula*	0	0	1	0	1	0	1	2
8		*Viola arvensis*	0	0	1	1	0	0	0	1
9		*Daucus carota*	0	0	1	0	0	0	0	1
10		*Silene noctiflora*	1	0	0	0	0	1	0	0
11		*Amaranthus hybridus*	0	1	0	0	1	1	0	0
12		*Datura stramonium*	0	1	0	0	0	0	1	0
13		*Galeopsis ladanum*	0	1	0	1	1	0	0	0
14		*Polygonum lapathifolium*	1	1	3	2	0	2	1	1
Total DA			**16**	**17**	**24**	**22**	**8**	**11**	**14**	**17**
1	DP	*Convolvulus arvensis*	1	2	3	4	1	1	2	3
2		*Rubus caesius*	2	2	2	3	1	1	2	2

3		*Cirsium arvense*	0	0	2	1	0	0	1	2
4		*Lathyrus tuberosus*	0	0	2	2	0	1	1	4
5		*Taraxacum officinale*	0	0	1	2	0	0	1	2
Total DP			**3**	**4**	**10**	**12**	**2**	**3**	**7**	**13**
Total weeds species			**130**				**104**			

To carry out post-mergence treatment, *imazamox* and *propaquizafop* herbicides had a good effect in combating weed species existing at the time, but the crop has re-infested with the annual dicotyledonous species mainly in the disk soil processing variant (MD 6 weeds/m^2 in 2018; 5 weeds/m^2 in 2019) and perennial dicotyledonous in the direct sowing variant (NT 7 weeds/m^2 in 2018; 5 weeds/m^2 in 2019). Variants CS and MC had the lowest number of weeds in both experimental years (1-2 weeds/m^2). Unconventional systems (MD and NT) have a different influence on the spectrum of weeds, so that in these systems the number of monocotyledonous species annually is reduced but the number of perennial weeds increases (Table 2). This may be influenced by the amounts of rainfall recorded in the spring but also by the staggered rise of weeds (the period of germination of weed seeds varies from species to species).

Table 2. The crop re-infested with weeds species after the soybean harvestig, 2018, 2019

No.	Classification	Weeds species presented	Tillage system(A) no. weeds/m^2-2018				Tillage system (A) no. weeds/m^2 -2019			
			a_1-CS	a_2-MC	a_3-MD	a_4-NT	a_1-CS	a_2-MC	a_3-MD	a_4-NT
1	MA	*Bromus tectorum*	0	0	1	3	0	0	1	1
2		*Setaria glauca*	0	0	0	0	0	1	1	0
3		*Echinochloa crus- galli*	1	1	1	0	1	0	0	0
Total MA			**1**	**1**	**2**	**3**	**1**	**1**	**2**	**1**
1	MP	*Agropyron repens*	0	1	1	1	0	1	2	2
Total MP			**0**	**1**	**1**	**1**	**0**	**1**	**2**	**2**
1	DA	*Xanthium strumarium*	2	1	2	1	1	2	1	1
2		*Polygonum convolvulus*	1	0	1	0	0	0	1	0
3		*Tragopogon dubius*	0	0	1	2	0	0	1	1
4		*Hibiscus trionum*	0	1	0	0	0	0	1	0
5		*Galeopsis ladanum*	0	0	1	0	0	1	0	0
6		*Polygonum lapathifolium*	0	0	1	0	1	0	1	1
Total DA			**3**	**2**	**6**	**3**	**2**	**3**	**5**	**3**
1	DP	*Convolvulus arvensis*	0	1	2	3	0	0	1	1
2		*Rubus caesius*	1	1	1	1	0	1	1	2
3		*Cirsium arvense*	0	0	1	2	1	2	1	1
4		*Taraxacum officinale*	0	0	0	1	0	0	0	1
Total DP			**1**	**2**	**4**	**7**	**1**	**3**	**3**	**5**
Total weeds species			**38**				**35**			

As can be seen in Table 3, in the classical soil work system considered as a control, the yields achieved were superior (2741 kg/ha) to the conservative systems (MD 2506 kg/ha and NT 2381 kg/ha), which had a significant and distinctly significantly negative influence in crop formation, the differences being 235 kg/ha (MD) 361 kg/ha (NT). The yield difference between the chisel work system (MC) and the control system (SC) is only 16 kg/ha which suggests that soy is a crop without high demands compared to the MC system applied in our area.

Table 3.The influence of the tillage system factor on the soybean yield, 2018-2019

Factor A-Tillage system	Yield kg/ha	%	Differences	Signification
a_1 CS	2741	100	0	Mt.
a_2 MC	2726	99	-16	-

a_3 MD	2506	91	-235	0
a_4 NT	2381	87	-361	00
LSD (p 5%) 181; LSD (p 1%) 333; LSD (p 0.1%) 738.				

The reaction of soybeans in the crop year is reflected in Table 4. In 2018 (considered a control) the drought during the sowing period (April with 26.2 mm precipitation) and especially in the summer months in which high temperatures persisted over a long period of time contributed to a yield of 2428 kg/ha. Although 2019, difficult in terms of temperatures and precipitation distribution, the rains in the period immediately after sowing (April 62.6 mm and May 152.4 mm) contributed to a good start in soybean cultivation, significantly influencing yield (2749 kg/ha), with the difference of 321 kg/ha compared to the previous year.

Table 4. The influence of year factors on the soybean yield, 2018-2019

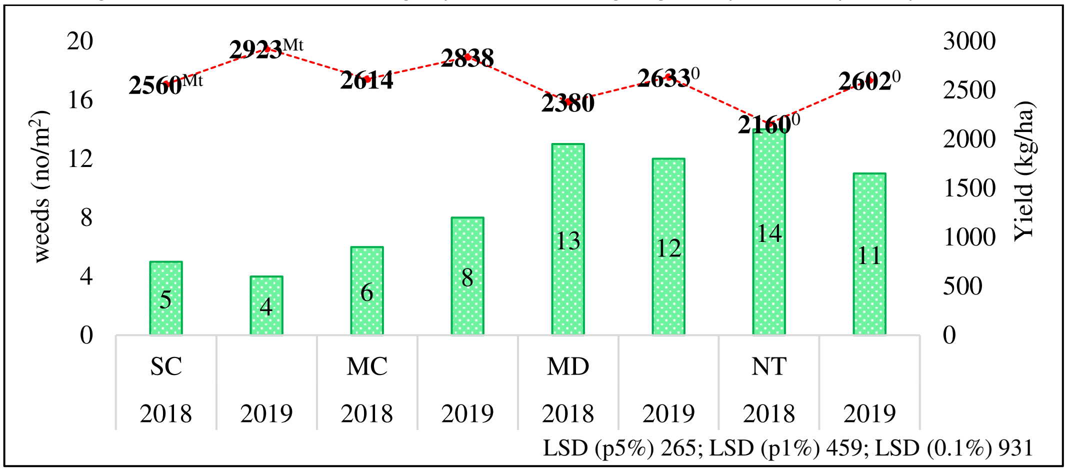
Factor B-year	**Yield kg/ha**	**%**	**Differences**	**Signification**
b_1 2018	2428	100	0	Mt.
b_2 2019	2749	113	321	**
LSD (p 5%) 137; LSD (p 1%) 226; LSD (p 0.1%) 424.				

The technology specific to the minimum system (MC), with the processing of the soil with chisel at 30 cm depth, seems to have a positive influence both in weed control and in the yield of near-control soybean yield (CS variant) during the two experimental years. Thus, in 2018 in the MC system there was a yield of 2614 kg/ha with 6 weeds/m^2 and in the control variant (CS) the yield was reduced by 54 kg/ha although there were only 5 weeds/m^2 (2560 kg/ha). In the second year of experimentation CS (2923 kg/ha) exceeded the MC system (2838 kg/ha) in terms of yield by 85 kg/ha and we believe that this difference is also due to the number of weeds higher in the MC system (8 weeds/m^2) compared to CS (4 weeds/m^2).

The specific technological variants MD and NT related to the degree of weeding of the crop negatively influenced the yield in the two experimental years, so that in 2018 MD with 13 weeds/m^2 there was a yield of 2380 kg/ha, 180 kg/ha lower than CS (witness) and 234 kg/ha compared to MC. In 2019 MD yield was 2633 kg/ha and 1230 kg/ha was recorded, the difference of 290 kg from the control has statistical assurance and has significantly negative influence. The NT system in 2018 significantly negatively influenced soybean yield, with the lowest yield and the highest number of weeds recorded in this variant (2160 kg/ha and 14 weeds/m^2), the difference from CS being 400 kg/ha and 9 weeds/m^2. Even though soybean yields in 2019 were higher in all soil tillage variants (compared to the previous year), the NT system has significantly negative influence (2602 kg/ha and 11 weeds/m^2) and resulted in yield with 321 kg/ha lower and 7 weeds/m^2 more than compared to the control variant.

The yield results obtained in the two experimental years are influenced by the climatic conditions, the technology applied, the weeding degree of the crop, but also by the type of soil in the experimental area (high clay content above 40%). As an alternative to the classical system, soybeans can be grown in the minimum tillage system (processing of the soil with chisel), the yield difference between the classical system (CS) is insignificant (only 16 kg/ha).

Figure 3. The influence of tillage system x weeding degree x year on soybean yield, 2018-2019



CONCLUSIONS

The soil work system, climate conditions and technology specific to each system influence the productive potential of the Cristina soybean variety created at SCDA Turda.

Soybeans respond less favorable to cultivation in the system minimum tillage-disk (MD) and no tillage-direct sowing (NT), recorded yields were lower by 235 and 361 kg/ha respectively compared to the classical system (CS) and 220-345 kg/ha compared to chisel variant (MC), and influenced yield of higher weeding in these systems.

In the system minimum tillage-disk (MD) and no tillage- direct sowing (NT), the number of monocotyledonous species is reduced annually but the number of perennial weeds is increased.

In addition to the genetic and technological factors, in the formation of yield a major role it is represented by climatic conditions, the low rainfall between May and August in conjunction with the high temperatures that persisted over a long period of time had a negative impact on the soybean crop in 2018 with an average yield of 2428 kg/ha.

Rains in the period immediately after sowing in 2019 contributed to a uniform emergence and good development of soybean culture, which led to a lower degree of weeding and thus a higher average yield (2749 kg/ha).

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