CONSIDERATIONS REGARDING THE OPPORTUNITY OF CONSERVATIVE AGRICULTURE IN THE CONTEXT OF GLOBAL WARMING

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Abstract: *This paper focuses on conservative agriculture, determined as minimal soil tillage, no tillage and enduring soil cover (mulch) together with rational rotations, as to achieve a more sustainable cultivation system for the future, in the context of the global warming and the permanent increase of population. Both farming and tillage play important roles in the agricultural systems. The conservative tillage systems in agriculture appeared in the U.S. and have developed in different ways, adapted to climatic zones and are considered unconventional or for soil conservation systems.* Our research shows *an improvement on conservative tillage, where no tillage, mulch and rotations significantly improve soil properties and other biotic factors also reducing the* CO_2 *emissions. Advantages of conservative tillage systems are represented by improving soil physics and excellent control of soil erosion, accumulation and water retention in the soil, reduced labor and fuel costs and in some cases even increased productivity. In the conservative tillage systems, land must be covered with plant debris at a rate of 15-30%, and in minimal tillage system with crop residue mulch, coverage exceeds 30%. In the no tillage system, sowing is done directly in the stubble or on a ground covered with plant debris from the preceding plant, using precision machinery. The paper concludes that a conservative tillage system is a more environmentally friendly and sustainable management system for cultivating crops. Case studies from all over the world show that when using conservative agriculture for most of the crops we get a raise production sustainably and profitably. Advantages in terms of greenhouse gas emissions and their effect on global warming are also taken into consideration. These systems also have a big disadvantage, high consumption of herbicides for weed control. An increased attention for direct seeding requires preventive plant protection characters. Seeds must be treated with insecticide-fungicide and soil requires more herbicide than for the classic systems with plough. The paper concludes that farming and agriculture in the next decade will have to produce more food from less or the same land through more efficient management of natural resources and with less impact on the environment in order to sustain the permanent growing population demands. Promoting and adopting conservative agriculture management systems can help meet this goal.*

Key words: *conservation agriculture; no-tillage; minimum tillage, mulching, global warming*

INTRODUCTION

Climate change is a challenge for the whole world. Rising temperatures, melting glaciers, droughts and floods becoming more frequent are signs that climate change is really happening (JACKSON et al., 2011). The risks are great for the entire planet, but for future generations are enormous so as the need to act as quickly to find better solutions. Human activity has harmful effects on the environment, the most affected being the atmosphere, where concentrations of greenhouse gases increase, increasing the Earth's temperature (RUSU et al., 2014). Increasing temperature had a significant impact on natural systems, which are becoming more fragile or even disappear. Extreme weather conditions encountered more often led to large economic problems, caused losses increasing from year to year. Climate change has an impact also on food prices. The entire planet is experiencing global warming and the population is forced to adapt to climate change effects, but the most important element is the need for measures to reduce emissions of greenhouse gases. CO_2 emissions are caused mainly by the energy industry, transport and also by agriculture but to a lesser extent. Agriculture can contribute to tackling climate change by reducing its own emissions and producing renewable energy and bio-products. Crop production is biophysical affected by variable weather conditions, including temperatures, changing rainfall regime and increasing levels of atmospheric CO_2 (MORARU and RUSU, 2012). Effects of climate change on agricultural production may be positive in some agricultural systems and regions, but negative in others, so as these effects can vary over time (PARRY et al., 2004). Adapting to more diverse environmental conditions is not new to farmers as they regularly adapt to changing demand for cultures, new technological developments and the most important water variability.

Production varies from year to year, influenced by fluctuations in weather conditions, especially a significant decrease in precipitation during the growing season of plants. Sustainable management and water management combined with innovative agricultural technologies could mitigate the effects of climate change to help farmers adapt to effects of the changes. As agriculture is dependent on climatic conditions, it is the most exposed sector to these changes (RAMIREZ-VILLEGAS et al., 2012). To establish a sustainable management system in agriculture we can take certain measures adapted to local conditions: use of genotypes with high resistance to diseases and pests adapted to the climate conditions; adaptation of tillage systems compatible with the environmental structure and the efficient use of fertilizers by including legumes in the crop rotation. These are just a few ways to reduce emissions from agriculture. Agricultural technologies have an important role in solving the problems of sustainable development. In most technological links there is the opportunity to rationalize energy consumption, the amount of fertilizers and pesticides without significant effects on production (PICU, 1999).

Agricultural systems respond to changes in the production environment associated with climate change through the process of adapting. In the agricultural sector were taken a series of measures to reduce emissions of greenhouse gases. Among the most important measures are: work systems without disturbing the soil; cultivation of legumes in rotation for a nutrient enrichment of the soil; cultivation of plants used as raw materials for biofuels.

New technologies, specific to sustainable agriculture are based on the implementation of crop rotation, reduced energy consumption, implementation and development of the Integrated Management of Plant Protection and technologies based on recoverable resources (GUS et al., 2004; RUSU and BOGDAN, 2012). Technologies and practices exist or have been developed in different parts of the world in order to adapt to climate change in agriculture. Conservative tillage covers a number of strategies and technologies to establish crop residues from the preceding culture, purposely left on the soil surface. This slows the movement of water by reducing soil erosion (CLEMENTS et al., 2011). By reducing the tillage is desired to produce qualitative and quantitative production values as high as possible and improve the soil's fertility. Agriculture has to solve a key problem of social development, which refers to the food supply in line with population growth and prices.

Modern agriculture is not possible without specific technologies for each crop group and for each zone, continuously adapting to climate change and in accordance with the requirements of environmental protection. Integrated technologies contribute to the environment and the production of safe and quality food. Biological farming has as its primary purpose obtaining higher quality food products that are made with as little interference from man as possible and without using chemicals. Technical measures that are found in biological farming are: crop rotation with legumes, soil mobilization as superficial as possible, chemical reduction for combating diseases, weeds and pests (PÎRŞAN et al., 2008). Along with assessing the negative effects of conventional soil tillage (basic tillage-plowing), was taken into account the reduction of works or even eliminate them. The "minimum tillage" and "no tillage" systems appeared in the U.S., have been developed in different ways, adapted to climatic zones and are considered unconventional or soil conservation systems. Both negative effects accumulated in time and increasing fuel prices have led to major changes in the concept of soil tillage.

Advantages of minimum tillage are represented by excellent control of soil erosion, accumulation and water retention in the soil, reduced labor costs and fuel, etc. In the minimum tillage systems soil must be covered with plant debris at a rate of 15-30% and for minimum tillage systems with crop residue, mulch coverage exceeds 30%. For the no-tillage system, sowing is done directly in the stubble or on the soil covered with preceding plant's debris, using precision machinery (GASPARDO DIRECTA 400).

The most common conservative systems are no-tillage and minimum tillage systems using mulch. These systems have also a big disadvantage, high consumption of herbicides for weed control. A special attention in the case of no-tillage system requires phytosanitary protection of the plants, the preventive character being prevailing. Seed must be treated with insecticide and fungicide and the soil requires more passes with herbicide than in the classic plowing system (GUŞ, 2003). Administration of fertilizers is performed simultaneously with sowing to avoid soil compaction by repeated crossings. Cultivating annual legumes contribute to decreasing consumption of the mineral nitrogen, reducing pollution and helping to increase production (POPESCU, 1990).

As JOHN JOHNSTON (2013) writes, a new Intergovernmental Panel on Climate Change (IPCC) report was released on 29th of September, 2013, stating that the climate change is mainly being caused by human activity. Since the previous report in 2007, the IPCC has raised the probability that human activities, "largely the constant burning of fossil fuels, have been the chief cause of global warming since the middle of last century." The scientists are now very confident that humans are causing climate change. The IPCC said that humans have now emitted more than half the 1 trillion tone "carbon budget" scientists have estimated to be the maximum to keep global warming to the "safe" level of under 2 degrees Celsius. Regarding this, the IPPC says that a doubling of CO_2 concentrations in the air would lead to global warming of between 1.5 and 4.5 degrees. The lowest number is lower than the 2 degrees projected in 2007, but the new range is the same as the reports released before 2007. New, more advanced computer models have been used and do not directly compare with earlier models from more than a decade ago. The panel also says that sea levels are likely to rise by between 26 and 82 cm by late this century, which is higher than the 18 to 59cm projected back in 2001. Melting in Greenland and Antarctica was not fully accounted for in previous projections. The worst case projection is that sea levels could rise by 98cm by 2100. U.N. Secretary-General Ban Ki-moon has said that the study should be yet another call-to-action for governments around the world, especially in relation to reaching the planned and long-awaited U.N. climate accord in 2015. The last word should go to climate scientist Michael Mann, Director of the Earth Systems Science Center at Penn State, who has said when asked for a headline about the report, "Jury In: Climate Change Real, Caused by Us, and a Threat We Must Deal With".

MATERIAL AND METHODES

The results presented in this paper are obtained in the last 15 years through research at the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Research Center for Sustainable Agricultural Systems and Minimum Technologies. Used determinations and methods are: hydro macrostructural stability – Czeratzki method (H.S., %), bulk density –

Cylinders method using cylinders of 100 cm^3 (B.D., g/cm^3), soil permeability for water – field permeameter method (l/m^2/minut, cm/h), humus detemination – agrochemical specific methods done in agrotechnics and soil science labs. Soil analyzes and determinations of productivity that were made are consistent with the methodology and STAS into force (SRTS, 2003; MESP, vol. I-III, 1987, Howto of Agrotechnics and experimental techniques). Results of the determinations were processed using the analysis of variance (ANOVA, 2008) to ensure establishing statistical differences and in order to classify variants and multiple comparisons, the Duncan test was used.

The experimental variants were as follows: *A.* Conventional system*:* V_1 – classic plow + disk *–2x*, *B.* Minimun tillage: V_2 – paraplow + rotary harrow, V_3 – chisel + rotary harrow, V_4 – rotary harrow.

The experimental variants were applied in a 4-year rotation: maize - soybean - winter wheat - potato (sugar beet, oilseed rape, beans). Experiments were located according to the method of subdivided parcels with the minimum experimental plot size of 300 m^2. From climatic point of view the hilly area in which the experiments took place, is characterized by values between 500-613 mm average annual rainfall. The thermal regime of the area is characterized by average annual temperatures ranging from 8.2 to 8.8°C. The soils on which the researches have been conducted are shown in Table 1.

Table 1

Characteristics of soils (Ap horizon) on which experiments were conducted (RUSU et al., 2013)

Soil type	Clay content, %	Humus content, %	The degree of hydrostability of the structure, %	pH	A.a.r., mm	A.a.t, ^{0}C
Cambic Chernozem	43.1	3.52	78	6.73	500	8.8
Argic Faeoziom	43.2	3.92	76	6.71	500	8.8
Vertic Preluvosoil	42.0	2.49	65	6.06	613	8.2
Molic Aluviosoil	46.6	3.01	71	7.25	613	8.2

A.a.r. - Average annual rainfall; A.a.t. - Average annual temperatures.

RESULTS AND DISCUSSIONS

The tillage system through specific technological processes influences differentiated, primarily the physical attributes then the chemical and biological properties of soil. Thus, by replacing the plowing with paraplow, chisel and rotary harrow, the intensity of loosening of the arable layer of soil and it' s amplitude range of aeration during the agricultural year is reduced significantly, influencing the evolution characteristics of the soil. The soil tillage system influences the processes of transformation of organic matter through their positioning, amount and ratio between humification - mineralization. Tests carried out shows on all types of soil an increased content of humus with 0.8 to 22.1% by applying minimum tillage systems (Table 2). Statistical processing of the data shows significant positive values on the vertic preluvosoil for the variants made with paraplow and chisel and on the argic faeoziom - for the variants made using paraplow + rotary harrow. Comparing multiple variants highlights the advantages of using the paraplow (b) on the argic faeoziom, chisel on the vertic preluvosoil (b) and rotary harrow on the molic aluviosoil (b). From the data analysis is established an increasing significance as the minimum tillage is applied on soils with medium fertility.

The content of hydro-stable macro-aggregates increases in all versions where the minimum tillage system was used, from 1.3 to 13.6% on 0-30 cm depth compared to the classical system (Table 3). In the case of hydro stability of the structure of the soil, as for the content of humus, the statistical processing of the data show an increase in the positive significance of the use of minimum tillage system as originally the hydro stability of the macro aggregates was initially smaller, the effect being of conservation on the characteristics of the soil as well as restoring them. Through the analysis and classification of multiple variants compared to the version worked with plow (a), it shows that all variants with minimum tillage are superior (ab, b, c), with positive influence on the hydro-stability of soil's structure.

Minimum tillage systems and replacing the plowing with paraplow, chisel and rotary harrow, reduces the intensity of loosening of the arable layers of soil. Bulk density values (annual average), on the depth of 0-50 cm, increase from 0 to 4.7% for minimum tillage systems, the increase being not significant in any of the experimental variants and multiple comparison and classification of the experimental variants orders all values on the same level of significance (a).

Table 2

Influence of tillage systems on the content of humus (H., %; 0-30 cm) (RUSU et al., 2013)

Tillage system / Soil	Depth, cm	Classical plow + disk -2x	Paraplow + rotary harrow	Chisel + rotary harrow	Rotary harrow
Cambic Chernozem	Humus content, %	3.51 a	3.54 a	3.87 a	3.61 a
	Semnification (%)	C.(100)	ins(100.8)	ins(110.2)	ins(102.8)
Argic Faeoziom	Humus content, %	3.90 a	4.13 b	3.93 ab	3.98 ab
	Semnification (%)	C.(100)	*(106.0)	ins(100.9)	ins(102.2)
Vertic Preluvosoil	Humus content, %	2.48 a	2.94 ab	3.02 b	2.82 ab
	Semnification (%)	C.(100)	*(118.6)	*(122.1)	ins(113.9)
Molic Aluviosoil	Humus content, %	3.03 a	3.12 ab	3.09 ab	3.23 b
	Semnification (%)	C.(100)	ins(103.1)	ins(102.0)	ins(106.5)

C. – Control; ins – insignificant; * - significantly positive

Table 3

Influence of tillage systems on the content of hydro-stable macro-aggregates (H.S., %; 0-30 cm) (RUSU et al., 2013)

Tillage system / Soil	Specifications	Classical plow + disk -2x	Paraplow + rotary harrow	Chisel + rotary harrow	Rotary harrow
Cambic Chernozem	H.S., %	74.33 a	79.00 b	78.67 ab	80.33 b
	Semnification (%)	C. (100)	* (106.3)	ins(105.8)	* (108.1)
Argic Faeoziom	H.S., %	80.00 a	82.33 b	81.00 ab	81.67 ab
	Semnification (%)	C. (100)	* (102.9)	ins(101.3)	ins(102.1)
Vertic Preluvosoil	H.S., %	63.67 a	68.33 b	66.67 ab	72.33 c
	Semnification (%)	C. (100)	* (107.3)	*(104.7)	**(113.6)
Molic Aluviosoil	H.S., %	71.33 a	76.00 b	75.33 b	76.33 b
	Semnification (%)	C. (100)	* (106.5)	*(105.6)	*(107.0)

C. – Control; ins – insignificant; * - significantly positive; ** - distinct significantly positive

Water reserves accumulated in the soil is one of the most important indicators of soil quality and the influence of tillage on water conservation in soil. The water reserve accumulated on the whole crop rotation period is different depending on the practiced tillage system, but the differences are also based on the culture and especially the type of soil. Thus, on structured soils, such as cambic chernozem and molic aluviosoil, water supply is higher by applying minimal tillage systems, respectively 100-106% for the variants with paraplow and chisel. Recorded values are lower for the vertic preluvosoil in all the variants (differences being statistically ensured) and also in the variants where rotary harrow was used on the all soil types. We may conclude that increasing the supply of water accumulated in time can only be provided when the system is applied to help restore soil structure, improving overall soil drainage, including directly related to the presence and quantity of crop residues.

The soil tillage system affects productivity elements of the cultivated species and ultimately the obtained yields. The crops from the rotation responded differently to the application of minimal tillage systems (Table 4). For the cultures of wheat and maize, the conventional system has ensured productions of 3451-5680 kg / ha, respectively 4860-6327 kg / ha, the minimum tillage systems ensuring 92-100% relative production and for the barley production the results were equal to the conventional system. For the soybean crop, production in the conventional tillage system was between 1970-3227 kg / ha, the minimum systems providing 94-111%, differentiation depending on soil type. The lowest productions by applying minimum tillage systems were determined for oilseed rape (95-98%), sugar beet (98-99%), beans (88-95%) and potato (82-93%).

Table 4

Influence of the soil tillage systems on the obtained yields (kg/ha and %) (RUSU et al., 2011)

Soil	Crop	Classical plow + disk -2x	Paraplow + rotary harrow	Chisel + rotary harrow	Rotary harrow / no-tillage*
Cambic Chernozem	Wheat	4608 / 100	4588 / 100	4479 / 97	4488 / 97
	Maize	6327 / 100	6322 / 100	6196 / 98	6121 / 97
	Soybean	3227 / 100	3247 / 101	3198 / 99	3024 / 94
	Beans	1237 / 100	1120 / 91	1090 / 88	1170 / 95
	Sugar beet	38250 / 100	37540 / 98	37200 / 98	37820 / 99
Argic Faeoziom	Wheat	5680 / 100	5410 / 95	5240 / 92	5568 / 98
	Barley	3780 / 100	3780 / 100	3770 / 100	3767 / 99
	Maize	5240 / 100	5000 / 95	4870 / 93	4950 / 94
	Soybean	1970 / 100	2100 / 107	1870 / 95	2190 / 111
Vertic Preluvosoil	Wheat	3730 / 100	3615 / 97	3486 / 93	3612 / 97*
	Maize	4860 / 100	4730 / 97	4710 / 97	4583 / 94
	Soybean	3025 / 100	3385 / 112	3113 / 103	3313 / 109
Molic Aluviosoil	Wheat	3451 / 100	3387 / 98	3391 / 98	3282 / 95
	Maize	5857 / 100	5737 / 98	5704 / 97	5395 / 92
	Soybean	2848 / 100	2867 / 101	2860 / 100	2747 / 96
	Potato	39428 / 100	36853 / 93	36317 / 92	32521 / 82
	Oilseed rape	1588 / 100	1532 / 96	1552 / 98	1505 / 95

CONCLUSIONS

The tillage system through specific technological processes of soil work influences the content of humus, the physical attributes, the chemical and biological properties of soil. The use of minumum tillage systems determine an increase in the content of humus with 0.8 to 22.1% with significant positive values on the vertic preluvosoil for the variants made with paraplow and chisel and also on the argic faeoziom - for the variants made using paraplow + rotary harrow. The content of hydro-stable macro-aggregates increases in all versions where the minimum tillage system was used, from 1.3 to 13.6% on 0-30 cm depth compared to the classical system. Both in the case of humus content and soil's hydro-stability structure, statistical data processing show increasing positive significance by application of minimum tillage systems as soil fertility and hydro-stability of macro aggregates was initially lower, the effect being both for conservation of soil characteristics as well as for restoring them with positive influence on soil's permeability and the water stored in the ground as water reserve.

Yields obtained by applying minimum tillage systems show that results can be achieved differentiated, the choosing of the best tillage variant in relation to the crop being decisive. Thus, compared with the conventional tillage system, the yields obtained for minimum tillage were: 92-100% for maize, 94-111% for soybean, 92-100% for wheat, 88-93% for potato and 95-98% for oilseed rape.

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