AgroLife Scientific Journal - Volume 4, Number 1, 2015
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

# EFFECT OF CONSERVATION AGRICULTURE ON YIELD AND PROTECTING ENVIRONMENTAL RESOURCES

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***Abstract***

*Conservative soil tillage (minimum tillage and no-tillage) are considered among the most important components of conservation agriculture. Their research and extension was imposed especially in hilly areas with specific problems of desertification (erosion, drought) as bioremedial measures. Our research follows the effects of the three tillage systems: conventional systems, minimum tillage and no-tillage on soil properties (bulk density, penetration resistance, temperature and moisture, soil respiration) and on the production of wheat, maize and soybean, obtained on an Argic Faeoziom from the Somes Plateau. Average soil bulk density grows, compared to the conventional system (1.20-1.24 g/cm$^3$), in all variants with minimum tillage (1.22-1.32 g/cm$^3$); the highest growth is recorded at no-tillage, being 1.35-1.38 g/cm$^3$ with statistically significant positive differences. Soil moisture increases in all variants with minimum and no-tillage with different percentages, ranging from 1-15% v/v, compared to the conventional system. This is also reflected in the values of resistance to penetration. Tillage appeared to affect the timing rather than the total amount of $CO_2$ production: the daily average is lower at no-tillage (315-1914 mmoles m$^{-2}$s$^{-1}$), followed by minimum tillage (318-2395 mmoles m$^{-2}$s$^{-1}$) and is higher in the conventional system (321-2480 mmoles m$^{-2}$s$^{-1}$). Productions obtained at minimum tillage and no-tillage did not have significant differences for the wheat culture but were higher for soybean. The differences in crop yields were recorded at maize and can be a direct consequence of loosening, mineralization and intensive mobilization of soil fertility.*

***Key words****: minimum tillage, no-tillage, soil conservation, crop production.*

## INTRODUCTION

Conservation agriculture involves trying to make equal or close productivity to conventional agriculture, energy efficient and economical optimized, while reducing the environmental impact. In Romania, conservation agriculture is applied to approx. 10% of arable lands and includes a range of complementary agricultural practices (Rusu et al., 2009; Stanila et al., 2012; Sandoiu et al., 2012; Cociu et al., 2013): (i) minimum soil tillage (through a system of reduced tillage or no-tillage) to preserve the structure, fauna and soil organic matter; (ii) permanent soil cover (cover crops, residues and mulches) to protect the soil and help to remove and control weeds; (iii) various combinations and rotations of the crops which stimulate the micro-organisms in the soil and controls pests, weeds and plant diseases.

Motivations for practicing conservation agriculture are (Al-Darby and Lowery, 1987; Jitareanu et al., 2006; Moraru and Rusu, 2010; Marin et al., 2011): agrotechnical (combating drought and soil erosion control), economical (efficiency), environmental protection (soil greening) and of compatibility with the Common Agricultural Policy (GAEC 1, Measure 214 - Agri-environment payments, green crops). In the current system of agriculture, 50-60% of the water from rainfall is lost directly through evaporation during one year - therefore are imposed agrophytotechnical water conservation measures. These can be accomplished by conservative tillage based on soil protection works and its tillage so that crop residues remains on the surface, providing "the right of the soil for vegetation".

Scientific criteria for the extension of soil conservative tillage (minimum tillage and no-tillage) are considered the 10 benefits obtained through their application (Stefanic et al., 1997; Ulrich et al., 2006; Domuta et al., 2012; Dinca et al., 2013; Wozinak et al., 2014): time with soil tillage is reduced by 2-4 times; fuel consumption per unit area is reduced by 30-50%; number of agricultural machinery per unit area is lower; soil structure recovers and surface and depth compaction decreases; soil organic matter content increases; soil permeability for water grows and soil overall drainage improves; soil erosion decreases; crop residues left on the soil surface or incorporated at 10-15 cm depth (where biological activity is the greatest) contribute to increased soil fauna and flora; maintains groundwater and surface water quality (nutrients and pesticides applied are no longer washed by erosion, and increased biological activity - associated with soil organic matter - uses and decompose this nutrients and pesticides); maintains air quality by reducing emissions that result from burning fossil fuels (diesel) used by traffic on the land and reducing carbon released into the atmosphere by soil respiration (being fixed by increasing soil organic matter).

Requirements of transition to conservation agriculture system are as follows (Lazureant et al, 2011; Sin, 2013): farmers must make an initial investment in specialized equipment; farmers need thorough training and access to specialized counseling services; compared with the conventional agriculture it is necessary to apply a fundamental change in the approach (difficult separation of plow); normally, there is a need for a transitional period of 5-7 years in order that conservative farming system to equilibrate; productivity may be lower in the early years, and the attack of diseases, pests and weeds higher.

Our research follow the effects of the three tillage systems: conventional systems, minimum tillage and no-tillage on soil properties (bulk density, penetration resistance, temperature and moisture, soil respiration) and on the production of wheat, maize and soybean, obtained on an Argic Faeoziom from the Somesan Plateau.

## MATERIALS AND METHODS

The data presented in this paper were obtained on Argic-Stagnic Faeoziom (SRTS, 2003), at University of Agricultural Sciences and Veterinary Medicine in Cluj-Napoca, within the Research Center for Minimal Systems and Sustainable Agricultural Technologies. The field soil is a class II quality type, having 78 points for arable use. The soil profile is of type: Amp – Am – A/Btw – Btw – B/C – Cca. The clay content on 0-40 cm depth varies between 42.1 and 45.7%. On 0-20 cm depth, soil has a reaction at the limit neutral - weak acid, with a value of 6.02. The presence of carbonates in the next horizon, the 120-210 cm depth determines an increase of pH value to 7.88. The base saturation degree of 75% frames this soil type in the eumezobasic soils. As for the humus content, the soil is appreciated as good, namely 4.33% in the first 20 cm and 3.27% in the 20-40 cm depth. The field is with 8% slope, with the ground water level at 10 m depth.

These areas were was our research presents a medium multi annual temperature of $8.2^0$C medium of multi annual rain drowns: 613 mm.

The experimental variants chosen were: A. *Conventional system* (CS): $V_1$ – reversible plough (22-25 cm) + rotary grape (8-10 cm). B. *Minimum tillage system* (MT): $V_2$ – paraplow (18-22 cm) + rotary grape (8-10 cm); $V_3$ – chisel (18-22 cm) + rotary grape (8-10 cm); $V_4$ – rotary grape (10-12 cm). C. *No-Tillage systems* (NT): $V_5$ – direct sowing.

The experimental design was a split-plot design with three replications. In one variant the area of a plot was 300 $m^2$. The experimental variants were studied in the 3 years crop rotation: maize (*Zea mays* L.) - soybean (*Glycine hispida* L. Merr.) – autumn wheat (*Triticum aestivum* L.).

The analysis and determinations were done according to acting methodology and standards (MESP, 1987; SRTS, 2003).

The biological material was represented by the *LG32* – hybrid maize, *Felix* – of soya-bean and the *Ariesan* – species for the wheat. Except for the soil tillage, all the other technological sequences of sowing, fertilizing, are identical in all the variants. Weed control was supplemented each year for the NT version with herbicide before seeding, using Roundup (glifosat 360 g/l), 4 l/ha.

To quantify the change in soil properties under different tillage practices, determinations were made for each crop in four vegetative stages (spring, 5-6 leaves, bean forming, and harvest).

Soil parameters monitored included soil water content (Aquaterr MT300 – Capacitive Sensor), temperature (Aquaterr MT300 – Silicon Junction Sensor), soil bulk density (determined by volumetric ring method using the volume of a ring 100 $cm^3$), penetration resistance (FieldScout SC900 - digital penetrometer) and soil respiration using ACE Automated Soil $CO_2$ Exchange System. The average result values, obtained in the vegetal phases were statistically processed, taking into consideration the last three cultivation years within the crop rotation. The results were statistically analysed by ANOVA test. A significance level of $P \leq 0.05$ was established a priori.

## RESULTS AND DISCUSSIONS

Minimum Tillage (MT) and No-Tillage (NT) application reduce or completely eliminate the soil mobilization, due to this, soil is compacted in the first years of application. The degree of compaction is directly related to soil type and its state of degradation. Significant differences are recorded up to 18 cm depth. Determinations made on Faeoziom Argic (Table 1) shows a bulk density greater in case of the direct sowing at maize crop (1.35 $g/cm^3$) and soybean (1.38 $g/cm^3$), respectively at rotary harrow and direct sowing, in case of wheat (1.32-1.38 $g/cm^3$). The state of soil compaction diminishes over time, tending toward a specific type of soil density.

Soil tillage system influences more significantly the penetration resistance. This is because the resistance to penetration is a more complex determination that depends on the condition of soil settlement and its humidity. The differences were mainly determined in the first 20 cm and there were no differences in the depth.

All determined values were higher in NT and MT compared with CS, the differences being significant distinct positive or significant positive at NT. Differences are also depending on the crop (Table 2): wheat - CS: 1524 kPa, CT: 1621-1735 kPa; maize - CS: 1421 kPa, CT: 1523-1624 kPa; soybean: CS: 1643 kPa, CT: 1755-1799 kPa.

Moisture determinations (Table 3) shows significant differences, statistically insured, at NT (wheat: 76%; soya-bean: 86%), although high values were recorded at MT, too. Soil moisture was higher in NT and MT at the time of sowing and in the early stages of vegetation, then the differences diminishes over time.

Soil temperature increases in all variants with MT and NT, with differences insured statistically, at wheat crop (Table 4). The differences are recorded especially in the first 15cm, where the NT recorded lower thermal amplitude compared with MT and CS.

Soil respiration (Table 5) varies throughout the year for all three crops of rotation, with a maximum in late spring (1383 to 2480 mmoli $m^{-2}s^{-1}$) and another in fall (2141 to 2350 mmoli $m^{-2}s^{-1}$). The determinations confirm the effect of soil tillage system on soil respiration; the daily average is lower at NT (315-1914 mmoli $m^{-2}s^{-1}$), followed by MT (318-2395 mmoli $m^{-2}s^{-1}$) and is higher in the CS (321-2480 mmol $m^{-2}s^{-1}$).

Wheat has ensured equal productions between 3745-3856 kg/ha (Table 6), with no significant differences between tillage systems. Maize responded better at the soil loosening, at the mobilization of soil fertility and nutrient mineralization, providing a production of 6310 kg/ha.

The production was between 5890-6145 kg/ha at MT, being significant negative at rotary harrow, respectively 5774 kg/ha at NT, being distinct significant negative. The soybean crop productions are between 2112-2341 kg/ha, being significant positive at MT and NT.

Table 1. Influence Soil Tillage Systems on Soil Bulk Density ($g/cm^3$), 0-50 cm Depth

| Variants | Wheat | Maize | Soya-bean |
|---|---|---|---|
| Plough | $1.24^{ws}$ | $1.20^{ws}$ | $1.22^{ws}$ |
| Paraplow | $1.28^{ns}$ | $1.22^{ns}$ | $1.26^{ns}$ |
| Chisel | $1.29^{ns}$ | $1.22^{ns}$ | $1.25^{ns}$ |
| Rotary grape | $1.32^{*}$ | $1.31^{ns}$ | $1.32^{ns}$ |
| Direct sowing | $1.38^{*}$ | $1.35^{*}$ | $1.38^{*}$ |

Note: wt – witness, ns – not significant, *positive significance, $^{0}$negative significance.

Table 2. Influence Soil Tillage Systems on Soil Penetration Resistance (kPa), 0-45 cm Depth

| Variants | Wheat | Maize | Soya-bean |
|---|---|---|---|
| Plough | $1524^{ws}$ | $1421^{ws}$ | $1643^{ws}$ |
| Paraplow | $1626^{*}$ | $1523^{*}$ | $1762^{*}$ |
| Chisel | $1627^{*}$ | $1523^{*}$ | $1755^{*}$ |
| Rotary grape | $1621^{*}$ | $1621^{**}$ | $1774^{*}$ |
| Direct sowing | $1735^{**}$ | $1624^{**}$ | $1799^{*}$ |

Table 3. Influence Soil Tillage Systems on Soil Moisture (% v/v), 0-50 cm Depth

| Variants | Wheat | Maize | Soya-bean |
|---|---|---|---|
| Plough | $61^{ws}$ | $83^{ws}$ | $75^{ws}$ |
| Paraplow | $65^{ns}$ | $88^{ns}$ | $77^{ns}$ |
| Chisel | $64^{ns}$ | $85^{ns}$ | $76^{ns}$ |
| Rotary grape | $64^{ns}$ | $86^{ns}$ | $86^{*}$ |
| Direct sowing | $76^{**}$ | $89^{ns}$ | $86^{*}$ |

Table 4. Influence Soil Tillage Systems on Soil Temperature (°C), 0-50 cm Depth

| Variants | Wheat | Maize | Soya-bean |
|---|---|---|---|
| Plough | $17.3^{ws}$ | $23.2^{ws}$ | $22.2^{ws}$ |
| Paraplow | $19.3^{*}$ | $23.5^{ns}$ | $22.5^{ns}$ |
| Chisel | $18.9^{ns}$ | $23.4^{ns}$ | $22.5^{ns}$ |
| Rotary grape | $19.4^{*}$ | $23.9^{ns}$ | $22.3^{ns}$ |
| Direct sowing | $19.5^{*}$ | $23.9^{ns}$ | $22.6^{ns}$ |

Table 5. The Influence of Soil Tillage Systems upon Soil Respiration (mmmoli, $m^{-2}s^{-1}$)

| Culture | Soil tillage systems | Plough | Paraplow | Chisel | Rotary grape | Direct sowing |
|---|---|---|---|---|---|---|
| Wheat | Spring | 721 | 714 | 708 | 641 | 532 |
| | 5-6 leaves | 321 | 320 | 321 | 318 | 315 |
| | Bean forming | 1531 | 1460 | 1414 | 1408 | 1383 |
| | Harvest | 2114 | 2111 | 2070 | 1942 | 1914 |
| Maize | Spring | 1014 | 1010 | 1010 | 982 | 914 |
| | 5-6 leaves | 1580 | 1523 | 1541 | 1512 | 1510 |
| | Bean forming | 2340 | 2308 | 2312 | 2252 | 2218 |
| | Harvest | 2250 | 2242 | 2221 | 2208 | 2141 |
| Soybean | Spring | 1140 | 1140 | 1129 | 1092 | 1042 |
| | 5-6 leaves | 1620 | 1615 | 1612 | 1580 | 1550 |
| | Bean forming | 2480 | 2395 | 2382 | 2350 | 2320 |
| | Harvest | 2350 | 2314 | 2318 | 2270 | 2183 |

Table 6. Influence Soil Tillage Systems on Yield of Wheat, Maize and Soyabean (kg/ha)

| Variants | Wheat | Maize | Soya-bean |
|---|---|---|---|
| Plough | $3812^{ws}$ | $6310^{ws}$ | 2112 |
| Paraplow | $3856^{ns}$ | $6120^{ns}$ | $2251^{*}$ |
| Chisel | $3795^{ns}$ | $6145^{ns}$ | $2198^{ns}$ |
| Rotary grape | $3745^{ns}$ | $5890^{0}$ | $2241^{*}$ |
| Direct sowing | $3786^{ns}$ | $5774^{00}$ | $2341^{*}$ |

## CONCLUSIONS

The state of soil settlement is changed through the tillage, which increases bulk density and penetration resistance in MT and NT.

MT and NT systems reduce the thermal amplitude in the first 15 cm of soil and increase soil temperature by 0.5-2.2$^{0}$C.

Tillage appeared to affect the timing rather than the total amount of $CO_2$ production: the daily average is lower at NT (315-1914 mmoli $m^{-2}s^{-1}$), followed by MT (318-2395 mmoli $m^{-2}s^{-1}$) and is higher in the CS (321-2480 mmol $m^{-2}s^{-1}$). An exceeding amount of $CO_2$ produced in the soil and released into the atmosphere, resulting from aerobic processes of mineralization of organic matter (excessive loosening) is considered to be not only a way of increasing the $CO_2$ in the atmosphere, but also a loss of long-term soil fertility.

Water dynamics and soil temperature showed no differences that could affect crop yields. Productions obtained at MT and NT don't have significant differences at wheat and are higher at soybean. The differences in crop yields are recorded at maize and can be a direct consequence of loosening, mineralization and intensive mobilization of soil fertility.

Application of MT and NT systems can lead to soil conservation in the Somes Plateau, without affecting crop yields, especially on soils with high initial fertility.

## ACKNOWLEDGEMENTS

This paper was performed under the frame of the Partnership in priority domains - PNII, developed with the support of MEN-UEFISCDI, project no. PN-II-PT-PCCA-2013-4-0015: Expert System for Risk Monitoring in Agriculture and Adaptation of Conservative Agricultural Technologies to Climate Change.

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