THE APPLIED SOIL PROTECTIVE CULTIVATION SYSTEM – A METHOD TO REDUCE AND PREVENT THE SOIL DEGRADATION PROCESSES

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Abstract: The examination of new soil use methods started in 1997, at the University of Debrecen CAAES RISF Karcag Research Institute. Our goal was to prevent or reduce the soil degradation processes in Karcag. A lot of areas in this microregion are occupied by the "minute soils", which can be characterized by a very short period for optimal cultivation due to their unfavourable hydrological features and heavy texture. Any tillage operations applied out of this optimal period involve the risk of soil degrading effects. The cumulative effect of the past improper operations has resulted in formation of a physically degraded and dusty cultivated layer. The consequences of the structural degradation of the soil: unfavourable hydrological features, decreased nutrition supply capacity, moderated microbiological activity effects of soil protective cultivation technologies – involving direct seeding and residue management – on the soil, crop and economy of production are examined in a multiple long-term field experiment on a heavy textured soil. . The changes in quality and quantity of the organic material of the soil (humic matter) are monitored through laboratory examinations According to the research achievements of the first thirteen years of the experiment the applied treatments have not always significantly influenced the yield of the indicator crops (maize, winter wheat, peas, canary-grass), but considerably decreased the energy consumption and costs of cultivation. The soil structure and the soil organic substance improved.

Keywords: Soil Protective Cultivation System, humic matter fractions .

Introduction

Two of the major elements of sustainable development in Hungary are the rational utilization, protection and maintenance of the status and versatile functions of our soil stocks, as well as the preservation of our surface and subsurface waters. This is the common task of environmental protection and agriculture (Várallyay, 1996). Any soil cultivation or sawing methods can be considered as the element of conservation tillage that results in more than 30% of crop residues remain on the soil surface for soil protective reasons. In EU-countries methods without soil turning (non-ploughing) are classified as conservation tillage. The wide spread of these techniques was aided by the increase of soil erosion damages and the requirement to decrease the soil water losses. In order to reach these goals, several soil cultivation and sawing methods can be applied: no-tillage, slot planting, strip tillage, ridge tillage, non-turning systems like chisel system, disk system, rotary tillage system, stubble mulch system. The Hungarian situation slightly differs from the international one regarding the perception of conservation tillage, as mainly the energy- and cost saving requirements were the motors of the change in the soil cultivation systems. Two thirds of the carbon content of the organic materials getting into the soil by disturbing it is emitted as carbon-dioxide into the atmosphere thus increasing the global warming (Birkás, 2002). The organic material content of the soil has to be considered as one of the most important carbon stocks that influence the carbon-dioxide and methane contents of the atmosphere. Conservation tillage methods, especially direct seeding, increase the carbon storage capacity of the soil, enrich it with organic materials. Soil cultivation conduces to the better aeration, hence the faster microbiological decomposition of soil organic matters. As the result of decomposition, high amount of CO_2 is generated that contributes to the

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global climatic change (CTIC study). The research results and practical experiences of the last few years prove that conventional soil cultivation methods and their tools cannot meet the requirements of sustainable agricultural soil utilization in case of heavy textured soils of the Great Hungarian Plain. The main reason of this is the presence and speed-up of the soil degradation processes (structure degradation, dusting, compaction, wind erosion). During our research work we could just partly answer these questions, as the self-controlled mechanism of the decreased load and disturbance of the soil appearing in almost each element of the plant production technology reaches such a degree that can be detected in the increase of the soil fertility only after 10-15 years. That is why such research studies have to be based on long-term experiments.

Materials and methods

Location of the experiment: 16 ha plots with meadow chernozem soil on the territory of the Karcag Research Institute. The treatments were as follows: conventional tillage on 3.5 hectares and soil protective reduced tillage on 12.5 hectares. The main goal of the soil cultivation experiment set in 1997 was to determine the application possibilities and the efficiency of the applied reduced tillage system that can stop the physical degradation of the soil. The tractive power demand of these tools is measured with the permanent detection of the GPS co-ordinates of the pulling tractor. The data processing was done with software that can handle GPS data too. The organic carbon content of the samples was determined by the Tyurin method. Fractions of the humic substances and humus quality were examined according to Kononova and Hargitai (Kovács et al., 2010). The effect of the changes in the soil structure and the soil cultivation system on the carbon-dioxide emission of the soil has been studied since 2004. The plots of this experiment provide good opportunity to measure the CO_2-emission from the soil (Zsembeli et al., 2005). Soil moisture content (necessary for the evaluation of CO_2-emission results and soil compaction) was determined by gravimetric method.

Results and discussion

After processing the data bases of the measurement series it was proved that the tractive power demand of plough and disc representing conventional tillage is very high, it can be as high as 80 kN in the case of ploughing. Nevertheless, we measured higher tractive power values when Disk Ripper was used, if compared with disc application. These results can be cozening as the moving speed of the two tractor-tool connections was almost the same, contrary to the fact that the Disk Ripper is heavier with its ripper shanks behind the disc gangs. Furthermore, the high quality and even work of the Disk Ripper must be emphasized and also the fuel consumption was lower when this tool was used. While ploughing, the high horsepower tractor sometimes lost some speed, contrary to the fact that it has high performance reserves, some slip often occurred. In this case the even moving speed needed for the continuous, high quality soil work could be maintained only by changing to lower gears.

All these are well demonstrated in the data base of the measurement series, the tractive power demand values moving hectically up and down indicate the performance lost of

the tractor very well. In case of Disk Ripper application, the curve is more even, slip seldom occurred during the measurements. Taking all these into account and analysing the fuel consumption data, the advantages of the application of Disk Ripper are obvious. We have established that the Disk Ripper can be considered as the basic tool of primary tillage of the new, conservation tillage methods and can fully substitute plough and heavy discs applied in conventional tillage. Based on our measured data it can be concluded that the tractive power demand of Disk Ripper is only 35% of the tractive power demand of the plough, while 38-40% of the disc (*Table 1.*).

Table 1. The tractive power demand of the investigated tools

	Volume of cultivated soil along 1 m length (m^3)	Average tractive power demand (kN)	Specific tractive power demand (kN)
Plough RW Kondor 6/5	0.5625	80	142.22
Disc IH-6.6	1.296	70	54.01
JD-510 Disk Ripper	0.95+0.57=1.52	30	19.73

The organic carbon content of the soil samples and of the isolated fractions of humic matter. In the *Table 2.* can be seen there was no significant difference between the total amount of organic carbon of the soils cultivated with different tillage systems.

Table 2. Organic carbon content of the different fractions

	Conventional tillage – CT (m/m) %	Reduced tillage - RT (m/m) %
Total Organic Carbon	2.18	2.11

Figure 1. shows that the ratio of extinction of the NaF and NaOH extracts (humus stability number) at different wave-length was significantly higher in the case of the reduced cultivation.

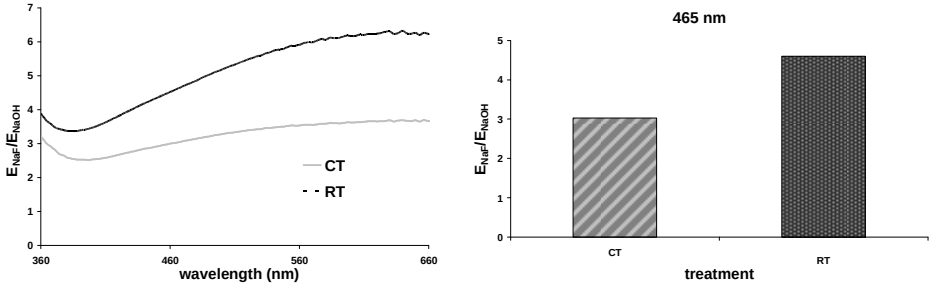

Figure 1. Effect of cultivation on the Ext. NaF/Ext. NaOH ratio of humic acids

Figure 2. shows the CO_2-emission values determined for the treatments of the soil tillage experiment in 2009. Three measurement dates are indicated, the first measurement was done after the harvest and before the relevant tillage application. In July, a higher emission was detected in the reduce tillage system. In August, the measurements were done after the tillage application. This period was very dry (*Figure 3.*) and that could explain the very low CO_2-emission values. The meteorological conditions and also the emission levels were similar in September. Of course, the

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shortness of the investigated period does not allow us to conclude general conclusions, but there is no doubt that we have gained remarkable results about the correlation between the soil status and the CO_2-emission from the soil. Experimental data provided information about the length of the time period when CO_2 emission increasing effects of soil cultivation are observable.

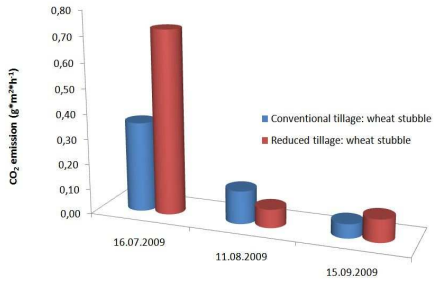

Figure 2. CO_2-emission values in the soil tillage experiment in 2009

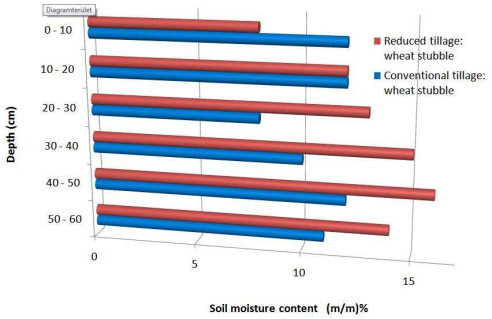

Figure 3. Soil moisture content values in august 2009

Conclusions

After processing the measured data it can be established that there was a big difference in the pulling resistance of the machinery applied in conventional and conservation tillage. As the number of tillage operations is much lower in case of conservation tillage, the soil compaction caused by the machinery as well as fuel consumption are lower resulting in decreased environmental load, lower costs and labour use (higher profitability). Analysing the amount and fractional composition of the soil organic matters we found that reduced tillage produced an increased ratio of the stabile humic materials that bound to the soil minerals taking part in the formation of a more favourable soil structure. Based on our results it can be concluded that the application of reduced cultivation supported the soil in approaching its natural equilibrium state that manifested in the investigated factors of the soil carbon cycle. Under favourable soil moisture conditions, microbiological activity (indicated by the level of CO_2-emission) was increased where conservation tillage system was applied, that can be the results of the decomposition of crop residue that remained on the experimental site.

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