Scientific Papers. Series A. Agronomy, Vol. LXII, No. 1, 2019
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE CELLULOLYTIC ACTIVITY DEPENDING ON SOIL TILLAGE AND INFLUENCE OF FOREST STRIP UNDER WINTER WHEAT AGROCOENOSES

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Abstract

The aim of the study was to determine cellulolytic activity depending on soil tillage in a long-term crop rotation under winter wheat agrocoenoses. There also were determined the cellulolytic activity in dependence of experimental plots location toward forest strip. The study was carried out at the Didactic Experimental Station "Chetrosu" of the State Agrarian University of Moldova on carbonate chernozem with sandy loam texture. The cellulolytic activity was determined according to the Misustin E., 1978, method based on the principle of cellulose decomposition under aerobic conditions by incorporating linen tissue in the 0-30 cm soil layer. The research has shown that soil cellulolytic activity is characterized with very low index level under both Plowing and No-till variants during June of 2017-2018 crop year - that registered dry weather conditions. The presence of forest strip near the crop land has revealed its beneficial influence on soil moisture preserve that facilitated cellulolytic activity on the plots located besides the forest strip under both soil tillage variants. It has been confirmed that forest strip (shelterbelt) form a microclimate with benefits for crop land.

Key words: carbonate chernozem, cellulolytic activity, forest strip, soil moisture, soil tillage, weather conditions.

INTRODUCTION

Soils that are involved in agricultural production are influenced by powerful anthropogenic factors modifying the soil biological activity, physicochemical properties, and ultimately fertility. The study of the nature of the impact on soil microflora facilitates the selection process techniques, helping to improve soil fertility and its properties, makes it possible to predict changes in the level of cultivation. The most sensitive indicators, responsive to changing water and air, heat, soil nutrient regimes are soil microorganisms. However, despite the obvious need to study the soil microbocenosis, this issue is given little attention. Determination of the intensity of soil-biological processes under the influence of anthropogenic change will allow establishing the level of biological activity, in order to select human impacts that have a positive impact on soil fertility and crop yields (Churkina Galina et al., 2012).

Cellulose is the most abundant renewable natural product in the biosphere (Bakare et al., 2005). The degradation of cellulosic biomass represents an important part of the carbon cycle (Spence et al., 2010) at both local and global scales (Lynd et al., 2002). A large number of cellulolytic microorganisms are involved in the decomposition of plant material in soil (Spence et al., 2010) so bio-sequestered carbon return to soil environment (Lynd et al., 2002).

Cellulolytic microorganisms are fundamental for the transformation of cellulose into sugars that are essential nutrients for various organisms (Bhat & Bhat, 1997).

More than 90% of the global amount of cellulose is degraded in well aerated agricultural, grassland or forest soils (Bastian et al., 2009; Kurka, 2001).

Soil microbial community is very dynamic and promptly affected by different soil uses regarding management, frequency and amounts of applied fertilizers, or any other disturbance (Cardoso et al., 2013). The preservation of soil microbial diversity is crucial for a balanced agro-ecosystem, especially under increasing agricultural intensification. In the past, agricultural practices have failed to promote populations of microorganisms, limit production yields and threaten sustainability. Agricultural practices such as organic farming, reduced soil tillage, crop rotation, intercropping, and land use extensification may help soil microorganisms to become more abundant and active (García-Orenes et al., 2013).

Microbial abundance and activity are promoted by reduced tillage and fertilization, while incorporation of crop residues demonstrated a higher effect in comparison with other cropping technologies. Increase in microbial number and activity most likely occurred due to increases in organic matter and changes in organic matter quality. Development of sustainable agricultural strategies, based not only on crop productivity but also on ecological principles, is crucial to maintaining soil microbial communities as well as soil quality and fertility (Marinkovic, Jelena et al., 2018).

The objective of this study was to assess the cellulolytic activity in carbon chernozem under different soil tillage. Also the presence of forest strip near the experimental plots allowed to find out its influence on the agroecosystem soil moisture and respectively cellulolytic activity.

MATERIALS AND METHODS

The present study was carried out on carbonate chernozem with sandy loam texture at the educational and experimental station of the State Agrarian University of Moldova DES Chetrosu in a long-term crop rotation (Photo 1).

Fhoto 1. Carbonate chernozem DES Chetrosu

The cellulolytic activity has been determined depending on: soil tillage - conventional (plowing) and conservative (No-till - 5 years old) and the spatial location of experimental plots against old forest strip - the plot no. 3 is located near forest strip and the plot no. 7 in the middle of the experimental field.

The cellulolytic activity was determined during June of 2017-2018 crop year according to the Misustin E., 1978, method based on the principle of cellulose decomposition under aerobic conditions by incorporating linen tissue in the 0-30 cm soil layer for 30 days, under winter wheat agrocoenoses (Photo 2).

Photo 2. Experimental field with winter wheat

The results of cellulolytic activity was evaluated according to Table 1.

Table 1. Values of cellulolytic activity on chernozems (Misustin E., 1978)

Index level	Cellulolytic activity
Very low	< 36
Low	36-52
Middle	52-68
Great	68-84
Very great	> 84

There were also determined soil moisture (May, June) and resistance to penetration (May).

Chemical and physical soil properties were determined according to methods recommended and used in the pedological monitoring of Republic of Moldova (V. Cerbari, 1997; 2010).

The soil of researched agroecosystem is carbonate chernozem characterized by the sub-moderate humus content (2.4% in 0-30 cm soil layer), the sum of Ca^{++} and Mg^{++} in arable layer is about 22.0 me/100 g soil. The carbonates are present throughout the profile

Ap-Ahk-Bhk-BCk-Ck, ranging from 1% in the upper layer to 8% at a depth of 110-120 cm. Soil reaction is slightly alkaline.

The weather conditions registered for 2017-2018 crop year (Figure 1) show that the months in which occurred research (May, June) was characterized with average temperatures over 3°C to multiannual average (1881-2003).

The amount of rainfall registered deficit to multiannual average: during May the precipitation deficit has been 28.7% and for June - 58.4%.

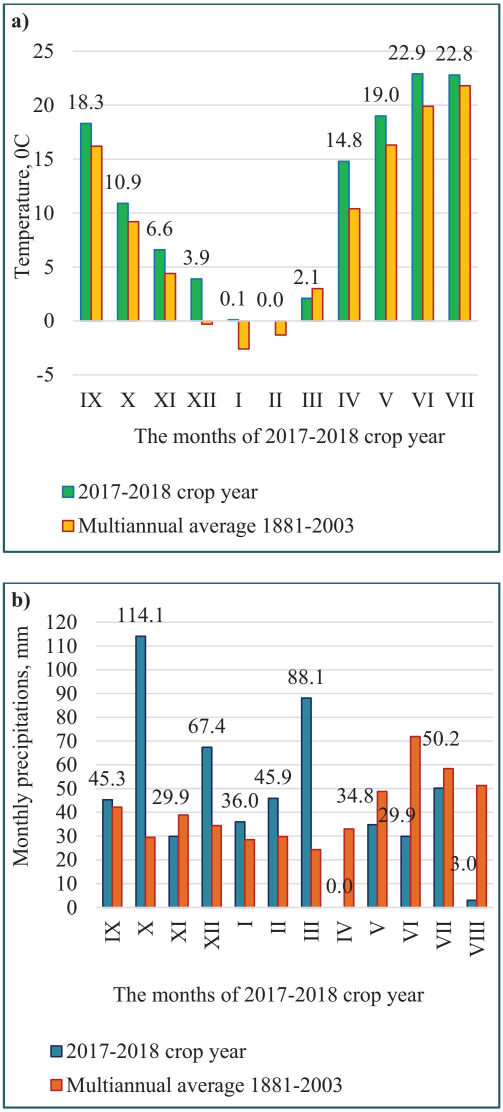

Figure 1. Meteorological conditions of 2017-2018 crop year, DES Chetrosu: a) temperature; b) precipitation

RESULTS AND DISCUSSIONS

The different cropping systems, inclusive soil tillage, can have a positive or negative effect on microbiological number and activity, which directly reflect the fertility of the soil (Falkowski et al., 2008).

Soils exposed to disturbance by tillage can be more susceptible to reductions in soil microorganisms due to desiccation, mechanical destruction, soil compaction, reduced pore volume, and disruption of access to nutrient resources (Huang et al., 2013). Ploughing and tillage operations facilitate aeration in soil and exposure of soil to light and thereby increase the biological activity of organisms, particularly of bacteria (Roger-Estrade et al., 2010).

Non-agricultural soils as no-tillage systems under native vegetation have a stimulatory effect on the microbial parameters (Marinkovic, Jelena et al., 2018).

With the purpose to know physical soil conditions on which largely depends cellulolytic activity there have been studied – soil moisture and resistance to penetration under Plowing and No-till variants (Table 2).

The research occurred in mid-May under winter wheat agrocoenoses has shown the same tendency regarding soil moisture and settlement of 0-50 cm layer for both investigated variants (Plowing and No-till). So the 0-20 cm soil layer has distinguished with 18% moisture and with close values of resistance to penetration - 13.2 kgf/cm^2 for Plowing and 16.4 kgf/cm^2 for No-till variant.

The underlying 20-50 cm soil layer has been very different from previous one: moisture has decreased to 13% and resistance to penetration has grown much to 30 kgf/cm^2 values under both variants.

The observed soil moisture difference could be caused by small amount of precipitation that has penetrated only surface soil layer, while more favourable soil resistance to penetration registered in 0-20 cm layer, beside good moisture conditions is due to roots abundance of winter wheat - concentrated mainly in the upper soil layers.

The research of cellulolytic activity (June) parallel spent with soil moisture determination (Tables 3, 4) shows the close dates under both soil tillage variants (Plowing and No-till). The index level of cellulolytic activity during June is very low - the tissue breaking (% to the initial mass) has registered the limits of 28.0-34.0% (Figure 2). This has been coused by dry weather conditions of June caracterized with unsuficient precipitations (deficit of 58.4% to multiannual average) and high temperatures that registered over 3°C to multiannual average (Figure 1). So the main limiting factor that has inhibited cellulolytic activity was soil moisture that registered limits of 12.3-15% in arable layer (0-30 cm) (Photo 3).

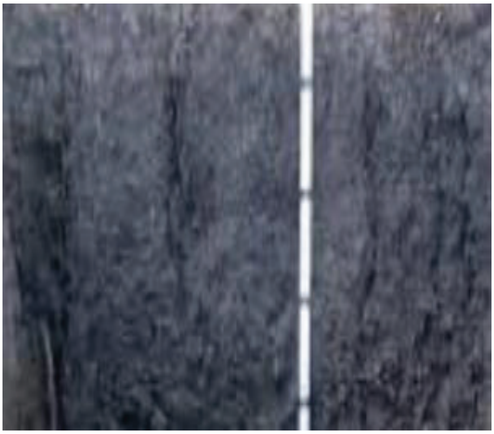

Photo 3. The arable layer (0-30 cm) of carbonate chernozem

The presence of forest strip near the crop land has revealed its beneficial influence on soil moisture preserve (Table 3) - on the plot no. 3, situated near the forest strip, has been registered higher soil moisture content (15%) in arable layer comparatively with the soil moisture (12.3%) of experimental plot no. 7 - situated in the middle of the field. The differences of 3% soil moisture recorded between these plots has facilitated cellulolytic activity near forest strip (Table 4) under both soil tillage variants.

It has been confirmed that around forest strip (shelterbelt) is formed a microclimate with many benefits for crop land: give a protection from wind, reduce evapotranspiration from crop lands, reducing transpiration from plants, controls blowing snow, habitat for wildlife, shelter for honeybees, energy saving, aesthetic value (Molla Mekonnen Alemu, 2016).

One of the main tasks of agricultural and microbiological science is to solve the problem of soil fertility and plant productivity. Research has so far proved that microorganisms present one of the main factors of soil fertility and growth plants. Soil microflora and, in particular, that part of it that develops around the roots, acts directly on plant growth and development. These microorganisms perform differently functions depending on their own particularities and host plants. Some are able to optimize soil fertility dissolving its mineral and releasing some of the nutrients into forms accessible to plants (Кожемяков, Тихонович, 1998; Onofraş et al., 2003).

Table 2. Physical soil conditions under winter wheat, May 2018

Soil tillage	Depth, cm	Moisture, %	Penetration resistance, kgf/cm^2
Plowing	0-10	19.07	9.0
	10-20	17.14	17.3
	20-30	12.52	29.9
	30-40	13.45	30.0
	40-50	13.64	30.0
No-till	0-10	20.11	11.9
	10-20	15.46	20.8
	20-30	11.67	28.9
	30-40	12.87	29.6
	40-50	13.16	30.0

Table 3. Soil moisture under winter wheat agrocoenoses depending on soil tillage and experimental plot, June 2018

Depth, cm	Plowing				No-till			
	Plot no. 3 (near forest strip)		Plot no. 7 (in the middle of the experimental field)		Plot no. 3 (near forest strip)		Plot no. 7 (in the middle of the experimental field)	
0-10	17.51	14.9	12.21	12.3	15.52	15.0	11.37	12.4
10-20	15.46		12.38		15.99		12.93	
20-30	11.67		12.36		13.36		12.78	
30-40	12.87	12.8	12.90	13.0	12.98	13.4	12.33	13.6
40-50	13.16		13.11		12.31		12.86	
50-60	13.41		13.34		12.07		12.98	
60-70	12.10		12.63		13.43		13.89	
70-80	12.97		12.97		13.48		14.18	
80-90	12.64		13.67		14.16		14.36	
90-100	12.37		12.94		14.25		14.78	
100-110	12.89		12.17		14.28		13.68	

Table 4. Cellulolytic activity (%) depending on soil tillage and experimental plot, June 2018

Soil tillage	Plot nomber	Depth, cm	Tissue breaking, % to the initial mass		Index level
Plowing	3	0-10	32.1	31.9	Very low
		10-20	32.8		
		20-30	30.9		
	7	0-10	28.0	29.3	
		10-20	29.5		
		20-30	30.3		
No-till	3	0-10	33.0	32.9	
		10-20	34.0		
		20-30	31.8		
	7	0-10	28.6	29.7	
		10-20	29.8		
		20-30	30.8		

Figure 2. Tissue breaking, June 2018

CONCLUSIONS

Determination of physical soil conditions - soil moisture and resistance to penetration (mid-May) under winter wheat agrocoenoses has shown the same tendency for both soil tillage variants (Plowing and No-till). The resistance to penetration is high (about 30 kgf/cm^2) in the 20-50 cm soil layer and favourable in 0-20 cm layer, that beside good moisture conditions, may be caused by roots abundance of winter wheat - concentrated mainly in the upper soil layers.

The weather conditions registered for May, June of 2017-2018 crop year are characterized with average temperatures over 3°C to multiannual average (1881-2003) and with precipitation deficit of 28.7% for May and of 58.4% for June.

The research of cellulolytic activity, parallel spent with soil moisture determination, showed the close dates under both soil tillage variants (Plowing and No-till).

The index level of cellulolytic activity during June is very low - the tissue breaking (% to the initial mass) has registered the limits of 28.0-

34.0%. The cellulolytic activity was inhibited by drought.

The presence of forest strip near the crop land has revealed its beneficial influence on soil moisture preserve. The plot situated near the forest strip, has been registered higher soil moisture content (15%) in arable layer comparatively with the soil moisture (12.3%) of experimental plot situated in the middle of the field. The differences of 3% soil moisture content recorded between these plots has facilitated cellulolytic activity near the forest strip under both soil tillage variants. It has been confirmed that around forest strip (shelterbelt) is formed a microclimate with benefits for crop land.

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