MODIFICATION OF BIOLOGICAL ACTIVITY OF REDDISH PRELUVOSOIL AS A RESULT OF SOIL TILLAGE IMPACT

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ABSTRACT

The aim of the paper is to evaluate the impact of the soil tillage on the enzymatic and biotic activity of the reddish preluvosoil. For the results interpretation the authors have taken into consideration the modifications provoked by the soil tillage system on the soil bulk density and the weed infestation potential evaluated by weed seeds reserve. The chisel tillage system created most favorable conditions for biological processes in the soil, followed by mouldboard ploughing and disk. The enzymatic soil activity, evaluated by IEAP%, was modified as a result of different ways to till the soil. The highest enzymatic accumulation, increased up to 26.87%, was in variants tilled with disk 10 cm and chisel 40 cm; these increases are directly proportional with the evolution of the weed seed reserve, because a large weed seed reserve means a large weed infestation and the weeds, like any plant, have a major role on the soil micro-organisms by rhizosphere effect. Soil biological activity evaluated by BSI% increased as compared with mouldboard ploughing (average of depths) with 12.32% in tillage chisel system at 20 cm depth, and with 21,2% at 40 cm depth. In the disk tillage system BSI was lower with 3.11%, but this difference was not statistically significant.

Key words: chisel, disk, mouldboard ploughing, soil biological activity, soil fertility, soil tillage system.

INTRODUCTION

Tillage system is an integral part of crop production, affecting numerous factors important to crop growth. One of the very important affected factors is the soil fertility. Among the three components which define the soil fertility (physical, chemical and biological), the biological component is the most sensitive. The modifications of biological activity level reflect all the other changes determined by the soil tillage system on: bulk density, reserve of organic matter including humus, the level of accumulation of water in soil, evolution of the weed infestation etc.

The soil systems by which one minimizes the level of soil mobilization lead to an equilibrium between the processes of decomposition of organic matter and humus formation. This equilibrium is the base of soil fertility conservation and it is obtained by reducing the intensity of soil loosening, increasing the humus content by introducing organic matter under the form of compost, farmyard manure, crop residues, green fertilizers etc. in soil, and also by maintaining the soil structure stability.

In other words, the conservation of the soil fertility supposes the application of soil tillage which optimize the plant needs and the modifications induced in soil, providing the improvement of soil features and obtaining high and constant yields (Guş et al., 2007). Balesdent et al. (2000) showed that mouldboard ploughing reduces the content of soil organic matter and increases its recycling in different proportions.

This paper reports the effects of soil tillage impact on the biotical and enzymatic soil activities. For a better interpretation of results, the authors have taken into consideration the modifications provoked by the soil tillage system on the soil bulk density and on weed infestation potential evaluated by weed seed reserve.

MATERIAL AND METHODS

The experiment was initiated from 1992 in the experimental field of Soil Management Department, Faculty of Agriculture in the frame of University of Agronomical Sciences and Veterinary Medicine Bucharest.

The soil was a reddish preluvosoil with a humus content between 2.17-2.65%, a clay loam texture and pH - 6.2.

Experimental design was a randomized complete block in a split-split plot treatment arrangement with four replications. Factor A consisted of an annual cropping rotation (a_1 – soybean, a_2 – wheat, a_3 – maize) and factor B consisted of four tillage systems (b_1 – disk at 10 cm, b_2 – mouldboard plow at 20 cm, b_3 – chisel at 20 cm, b_4 – chisel at 40 cm).

The soil samples were collected on April 2, 2007 from wheat crop, from two different depths: 0-10 cm and 10-20 cm.

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After conditioning, the soil samples were analyzed using biotical (respiration and cellulolytic activities) and enzymatic (catalase, saccharase, urease and total phosphatases activities) tests according to methodology of Ştefanic (1999). On the basis of the results of these tests two modular indicators (Indicator of Vital Activity Potential and Indicator of Enzymatic Activity Potential) and the synthetic one (Biological Synthetic Indicator) were calculated.

The methodology to calculate the soil fertility indicators (Ştefanic et al., 2001) is based on the principle of numerical taxonomy (principle of the equal importance of all components of soil fertility), and mainly consists of:

1. The transformation of the result of each test in percentage from the maximum value obtained from numerous soil analyses (MEV) as follows:

$$X\% = X_a \times 100/MEV$$

where:

X_a = the absolute value obtained in the analytic test;

MEV = Maximum Empiric Value (Table 1);

Table 1. The Maximum Empiric Value for biotical and enzymatic tests

Tests	Maximum Empiric Value
Biotical	
Respiration (mg CO_2/100 g soil d.w./ 24 h	150
Cellulolyse (g decomposed cellulose/100 g cotton/18 days)	100
Enzymatic	
Catalase (cm^3 O_2/100 g soil d.w./ 1 minute)	2000
Saccharase (mg glucose/100 g soil d.w./ 24 h)	3500
Urease (mg NH^+_4/100 g soil d.w./24 h)	150
Total phosphatases (mg P/100 g soil d.w./24 h)	25

2. Computation of the Indicator of Vital Activity Potential (IVAP %), as:

$$\text{IVAP\%} = \sum_{k=1}^{2} \frac{(R, C)}{2}$$

where:

R = respiration potential;

C = cellulolyse potential.

3. Computation of the Indicator of Enzymatic Activity Potential (IEAP %), as:

$$\text{IEAP\%} = \sum_{k=1}^{4} \frac{(K, U, S, P)}{4}$$

where:

K = catalase;

S = saccharase;

U = urease;

P = total phosphatase.

4. Computation of the Biological Synthetic Indicator (BSI %):

$$\text{BSI\%} = \frac{IVAP\% + IEAP\%}{2}$$

Bulk density was determined using ICPA (1987) methodology. For determination of weed seed reserve, the soil samples were collected from top soil (0-10 cm) with Kalentiev sounder. In laboratory, the samples were washed for separation the weed seeds using Sieve shaker AS 200 basic, then the weed seeds were identified and counted. The calculation of weed seed reserve at unit of surface was realized in relation with the soil weight on layer 0-10 cm.

RESULTS AND DISCUSSION

1. Soil tillage influence on vital activity evaluated by the Indicator of Vital Activity Potential (IVAP %)

The best conditions for the activity of microorganisms were determined by chisel soil tillage, both at 20 cm and 40 cm. No statistical differences between these two depths were observed. The chisel tillage system was followed by mouldboard ploughing and disk (Table 2).

These modifications of the life level of the soil, evaluated by IVAP%, are due to both the direct influence of soil mobilization (degree of aeration, soil compaction, water reserve of the soil etc.) and the influence of soil tillage on evolution of weed infestation.

Table 2. The influence of tillage treatments on the vital soil activity of reddish preluvosoil from Moara Domnească (Ilfov District), evaluated by Indicator of Vital Activity Potential (%)

Variant	The depth of soil samples		Average A
	b_1 (0-10 cm)	b_2 (10-20 cm)	
a_1 – Disk 10 cm	b 40.48 a	b 38.90 a	c 39.69
a_2 – Mouldboard plough 20 cm	b 39.53 b	a 52.63 a	b 46.08
a_3 – Chisel 20 cm	a 52.96 a	a 52.18 a	a 52.57
a_4 – Chisel 40 cm	a 50.75 a	a 58.91 a	a 54.83
Average B	45.93 b	50.66 a	

LSD	A	B	AB	BA
5%	5.722*	3.276*	7.360*	6.553*
1%	8.665	4.766	10.965	9.532
0.1%	13.920	7.149	17.148	14.298

A high degree of weed infestation led to a qualitative and quantitative increase of the vegetal cover. In these conditions the microorganisms of soil are influenced positively, if the other factors necessary for microorganisms development, like the aeration degree, are favorable. Our results showed a direct relation between the soil life level and the weed infestation degree. For example, the disk tillage determined the highest reserve of weed seeds (49500/m^2), followed of chisel 40 cm, chisel 20 cm and mouldboard ploughing 20 cm (Figure 1).

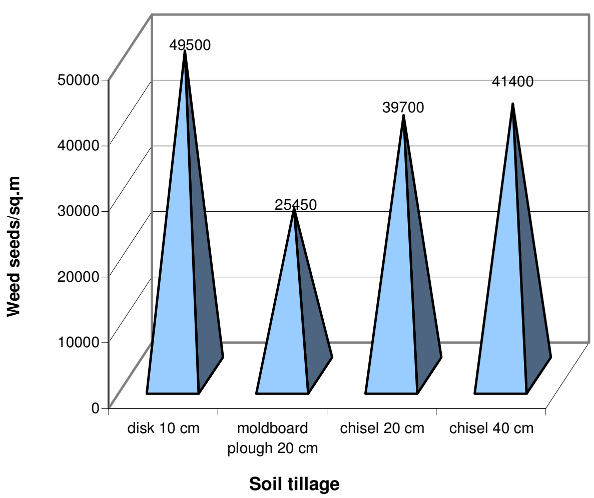

Figure 1. The influence of the tillage system on the weed seeds reserve

In comparison with the reserve of weed seeds after ploughing tillage, the chisel tillage at 20 cm shows an increase of 56%, the chisel tillage at 40 cm an increase of 63% and the disk tillage at 10 cm an increase of 85%. This suggest that a high reserve of weed seeds depends on a high weed infestation, which in turn contributes to stimulation of microorganism activity in soil both during the vegetation period (by rood exudates, root hairs) and after the end of vegetation (plant residues).

As shown by Traore et al. (2000), the exudates released by roots play a major role in the interactions between roots, microorganisms and soil. Carbon exudation from roots can range from 5 to 20% of the carbon fixed photosynthetically by plants (Whipps and Lynch, 1983). The nature and availability of this carbon influence the soil microflora (Jones and Darrah, 1996). Soil microorganisms feed largely on organic substances that originate from root exudates of which, released sugars represent the most important source for microbial growth. The physico-chemical and biological modifications caused by exudates in the rhizosphere affect the microbial activity and the structural stability of soil aggregates (Traore et al., 2000).

However, the fact that vital activity of soil is the highest in chisel tillage 40 cm and not in disk tillage (where was the greatest potential of weed infestation) was caused by the modification of one physical parameter very sensible to tillage treatments, more exactly bulk density (g/cm^3). Bulk density in disk treatment is 1.18 g/cm^3 in layer 0-10 cm and 1.34 g/cm^3 in layer 10-20 cm, while in chisel tillage system at 40 cm depth, bulk density is 1.22 g/cm^3 in layer 0-10 cm and 1.30 g/cm^3 in layer 10-20 cm. This means a better aeration, which is favorable to the vital processes and pedo-enzymes accumulation (Figure 2).

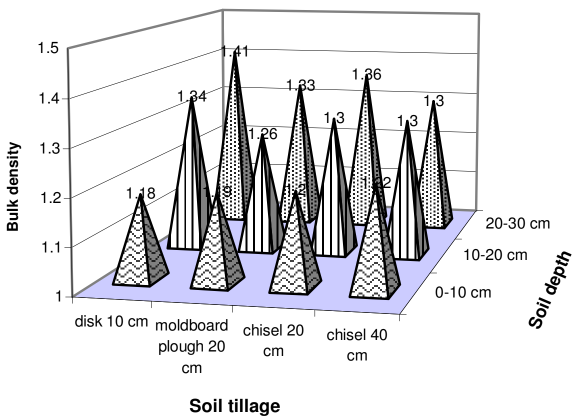

Figure 2. The influence of soil tillage system on soil bulk density

2. Soil tillage influence on enzymatic activity evaluated by the Indicator of Enzymatic Activity Potential (IEAP %)

The Indicator of Enzymatic Activity Potential offers information regarding the pedoenzymatic activity (enzymes accumulated in soil).

As it is well known, the main source of pedoenzymes is the soil microflora. In addition to this source there are the root hairs, roots, weeds controlled during the vegetation period, other plant residues, animals living in the soil, manure and green fertilizer etc., all these release the enzymes by autolysis and decomposition of tissues and cells. For these reasons, enzymatic activity does not automatically follow the same direction as the vital activity of the soil (Gheorghiță et al., 2007).

The soil enzymatic activity is modified by different tillage treatments. Taking the mouldboard ploughing like control, it is observed that the accumulation of pedoenzymes in soil increased in all other treatments (Table 3). The highest increases were measured in disk tillage at 10 cm, and chisel at 40 cm. These increases are directly proportional to the evolution of weed infestation degree, like in the case of vital activity (IVAP %).

This high reserve of weed seed will contribute to make a richer vegetal cover. In these conditions, the accumulation of the enzymes will be higher, because of all factors which influence the soil life, the plants occupies a unique place.

Table 3. The influence of tillage treatments on the vital soil activity of reddish preluvosoil from Moara Domnească (Ilfov District), evaluated by the Indicator of Enzymatic Activity Potential (%)

Variant	The depth of soil samples		Average A
	b_1 (0-10 cm)	b_2 (10-20 cm)	
a_1 – Disk 10 cm	a 24.46 a	b 20.64 b	a 22.55
a_2 – Mouldboard plough 20 cm	b 18.68 a	c 17.65 b	c 18.16
a_3 – Chisel 20 cm	b 19.06 a	b 20.11 a	b 19.59
a_4 – Chisel 40 cm	a 23.25 a	a 22.83 a	a 23.04
Average B	21.36 a	20.30 b	

LSD:	A	B	AB	BA
5%	0.883*	0.693*	1.320*	1.387*
1%	1.338	1.009	1.954	2.018
0.1%	2.150	1.513	3.023	3.027

3. Soil tillage influence on biological activity evaluated by the Biological Synthetic Indicator (BSI%)

Biological activity of soil, evaluated by BSI%, is directly influenced by the tillage treatments. Taking the mouldboard ploughing as control, where the BSI% is 32.12% (average of depths), the biological activity in chisel tillage system increased with 12.32% at 20 cm depth and with 21.20% at 40 cm depth (Table 4).

The disk tillage determined a light reduction of biological activity with 3.11%, but this difference was not statistically significant.

Of course, a correct interpretation of the observed the measures of biological soil activity should take into consideration all other soil properties.

The improvement of the soil life is strongly linked with the evolution of soil structure, as well as of other soil physical and chemical parameters.

Table 4. The influence of tillage treatments on the biological soil activity of reddish preluvosol from Moara Domnească (Ilfov District), evaluated by Biological Synthetic Indicator (BSI %)

Variant	The depth of soil samples		Average A
	b_1 (0-10 cm)	b_2 (10-20 cm)	
a_1 – Disk 10 cm	b 32.47 a	a 29.77 a	c 31.12
a_2 – Mouldboard plough 20 cm	b 29.11 b	b 35.14 a	c 32.12
a_3 – Chisel 20 cm	a 36.01 a	b 36.15 a	b 36.08
a_4 – Chisel 40 cm	a 37.00 b	a 40.87 a	a 38.93
Average B	33.64 a	35.48 a	

LSD:	A	B	AB	BA
5%	2.754*	1.831*	3.778*	3.662*
1%	4.170	2.663	5.612	5.327
0.1%	6.699	3.995	8.733	7.990

Marin et al. (2007) reported that annual application of mouldboard ploughing decreased the proportion of stable soil aggregates. The chisel tillage system is favorable for building water-stable aggregates, and this is very important for fertility and soil conservation.

The increase of stable aggregates proportion leads to an improvement of soil physical and chemical properties and therefore could contribute to an improvement of the soil life conditions. This improvement is confirmed of our results.

CONCLUSIONS

In order of favorability for biological processes of conditions created in the soil, the chisel tillage system is the best, followed by mouldboard ploughing and disk.

The enzymatic soil activity, evaluated by IEAP %, was modified as a result of different ways to till the soil, the highest enzymatic accumulation being found in variants tilled with disk at 10 cm and with chisel at 40 cm.

Soil biological activity evaluated by BSI% increased with 12.32% in chisel tillage system at 20 cm depth, and with 21.2% at 40 cm depth, as compared with mouldboard ploughing (average of depths). In the disk tillage system BSI was lower with 3.11%, but this difference was not statistically significant.

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