AGROCHEMICAL AND BIOCHEMICAL PROPERTIES OF TIPICAL CHERNOZEM SOIL UNDER SUNFLOWER AND VETCH+OATS IN CROP ROTATION IN FUNCTION OF THE FERTILIZATION SYSTEM

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Abstract

The aim of research was to study the impact of two fertilization systems on the agrochemical and biochemical properties of soil fertility. And how do they change under the influence of fertilizers use in crop rotation in time and space for 2 years. As the object of study was typical chernozem soil from long-term experiment (of 19 years, Belti steppe, RM) cultivated with vetch+oats and sunflower. It was used two fertilization systems: i) Organic – 15 t manure/ ha of rotation surface, ii) mixed Mineral + Organic fertilizers (NPK 75, 130, 175 kg / ha, and 15 t manure / ha). Analyzed agrochemical parameters included: soil organic matter, ammoniacal and nitric nitrogen; those biochemical – soil basal respiration, nitrogen mineralization capacity of soil, dehydrogenase and urease activity. According to the results of the investigation both fertilization systems generate positive changes in the properties of chernozem soil compared with control–unfertilized soil. Manure application and the same amount of manure together with mineral fertilizers ensure expanded reproduction of the typical chernozem's organic matter. Agrochemical and biochemical properties of soil were lower in the Mineral+Organic than in the Organic fertilization system. The values of the majority of investigated biochemical parameters were reduced in the soil cultivated with vetch+oats, which follows sunflower in crop rotation. This can be explained by the necessary of changes which occurs in the functional structure of microbial communities when management type changes from the conventional to ecological agriculture or from one culture to another.

Key words: typical chernozem, crop rotation, fertilization systems, sunflower, vetch+oats

At the present stage of agricultural development one of the natural factors limiting the production of high and stable yields is effective soil fertility. To ensure the high harvest of superior quality, with low cost, regardless of the forms of agricultural practice, the deep knowledge for the correct soil management increasing its fertility is required (Toma, 2008). Unfortunately, in Republic of Moldova, the fertilizers application including organic ones as an effective factor in formation and development of plant resistance, productivity and the crop quality has substantially reduced. Although fertilizers application as method of nutrient co-relations equivalence of ensuring the level of biomass production is recognized as an obligatory technological element, however, so far the impact of organic fertilizers on the agrochemical and biochemical soil properties is poorly studied at the regional level for specific pedoclimatic conditions (Emnova, Toma, 2010).

The organic farming system enhances microbial activity and enzyme status of arable soils (Liu et al., 2007; Senikovskaya, 2007). However, relations between soil enzymatic activity and supply of plants with mobile nutrients are little-studied. Soil organic substances serve as the main source of energy for soil microflora and nutrients for plants determine level of productivity of grown crops and crop rotations entirely (Andrieş, 2000; Zagorcea, 1999; Zagorcea, 1990; Curcan, 1985). Growing crops without fertilizer for a long time leads to lower content of humus in soil and crop reduction (Nebolsin, Nebolsina, 2004).

The aim of research was to study the impact of two fertilization systems on the agrochemical and biochemical properties of soil fertility cultivated with sunflower and vetch+oats in dinamic of crop rotation in time and space for 2 years.

MATERIAL AND METHOD

Research was conducted on the basis of long-term experience at the Institute of Field Crops Research "Selectia" in Balti. The typical chernozem soil was the object of study. The territory has a block design of 6 field crop rotation. Two crops: sunflower and vetch+oats - were selected for research. Since 1991 two fertilization systems were used: i) Organic – 15 t manure/ ha of rotation surface, ii) mixed Mineral+Organic (Min+Org)

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fertilizers (NPK 75, 130, 175 kg/ ha, and 15 t manure/ ha). Soil samples were collected from the top layer of soil (0-20cm). Analyzed chemical parameters included: pH and soil moisture, which have been determined immediately after sampling and drying at the temperature of 105C for 8 hours. Soil organic matter (SOM) was measured by the method of Tiurin modified by Simacov (Arinuschina, 1970), the concentration of mobile forms of nitrogen in soil (N-NH4+) – by Mineev (1989). Biochemical parameters: net capacity of nitrogen mineralization (CNM) (Leiros et al., 2000), soil basal respiration (SBR) by the method proposed by Isermeyer (1952) and amended by Dilly and Nannipieri (2001), soil dehydrogenase activity (DH) by amended method of Galstean (Khasiev, 1990), urease activity (Ure) was determined by the method of Khasiev (1990).

The statistical analysis of experimental data was determined with Microsoft Excel program for Windows XP (Microsoft Office). The arithmetic mean, standard deviation, coefficient of reliability (p) according to Student t-test, the correlation coefficient Pearson (r) has been calculated.

RESULTS AND DISCUSSIONS

Agrochemical parameters. Values of typical chernozem pH in crop rotation in 2009 shows a higher value in soil cultivated with sunflower 6.15 - 6.19 indifferent of fertilization system (tab.1*)*. In 2010 the mean value of pH ranged between 6.07-6.22 in organic fertilizers variant (Org), and from 6.14 to 6.24 at the application of mixed fertilizers (Min+Org), compared with pH 5.6 in unfertilized soil. Differences in pH of soil samples were practically insignificant. Thus the application of organic fertilizers stabilizes soil reaction. *Soil moisture* at sampling in 2009 was 20% in soil under sunflower regardless of fertilization system *(tab. 1)* and 15-13% in soil under vetch+oats, in top layer of soil. In 2010 soil moisture was lower compared to 2009, yet as in the previous year soil moisture under sunflower was higher than in samples selected under vetch+oats. This fact can be explained by differences in root system structure and morphology of studied plants (the roots of vetch+oats are located usually in top layer of soil and thus water and nutrient absorption takes place more quickly).

Content of soil organic matter (SOM), which is considered as an integral parameter of the soil potential fertility, varied slightly in function of fertilization systems and cultivated plants species. However, the amount of SOM in soil under crop rotation differed between field plants, and increased in soil samples fertilized with mixed fertilizers Min+Org,. It coincides with multi-research data (Boincean and others, 2007; Stadnic, 2006). The SOM average values ranged between 4.23-4.40% at the application of Org fertilizers, and from 4.35 to 4.49% on application of mixed fertilizers Min+Org, compared to 3.71% in unfertilized soil cultivated with sunflower. It is obvious that the productivity of this crop on unfertilized soil is provided only from the reserve of SOM.

Table 1

Agrochemical parameters of typical chernoziom in crop rotation

Treatment	SOM %	2009			2010		
		pH (KCl)	Soil moisture %	$N–NH_4^+$ mg 100 g^{-1} d.w.s	pH (KCl)	Soil moisture %	$N–NH_4^+$ mg 100 g^{-1} d.w.s
vetch+oats Min+Org	4,35	5,65	13,60	1,50	6,14	12,50	0,66
vetch+oats Org	4,40	5,78	14,00	1,56	6,07	12,80	0,67
sunflower Min+Org	4,49	6,19	15,10	1,87	6,24	14,90	0,54
sunflower Org	4,23	6,15	16,00	2,01	6,22	16,20	0,51
Sunflower unfertilized	3,71	--	--	--	5,60	14,70	0,61

Note. SOM - soil organic matter; d.w.s. –dry weight soil

Ammoniacal nitrogen content (tab. 1) in soil samples collected in 2009 was lower in the top layer of soil under vetch+oats (1.50 to 1.56 mg $100g^{-1}$ d.w.s), compared to the soil cultivated with sunflower (1.87 to 2.01 mg 100 g^{-1} d.w.s). In 2010 the soil ammoniacal nitrogen content ranged from 0.51 to 0.61 mg 100 g^{-1} d.w.s regardless of fertilization system and plants.

Table 2

Biochemical parameters of typical chernoziom soil in crop rotation

Treatment	2009				2010			
	SBR, CO_2 mg kg^{-1} d.w.s. d^{-1}	NMC, N–NH_4 µg g^{-1} d.w.s. $hour^{-1}$	Dh, TPF µg g^{-1} d.w.s $hour^{-1}$	Ure, NH_4^+ µg g^{-1} d.w.s. $hour^{-1}$	SBR, CO_2 mg kg^{-1} d.w.s. d^{-1}	NMC, N–NH_4^+ µg g^{-1} d.w.s $hour^{-}$	Dh, TPF µg g^{-1} d.w.s. $hour^{-1}$	Ure, NH_4^+ µg g^{-1} d.w.s. $hour^{-1}$
vetch+oats Min+Org	50,11	0,82	2,83	39,93	61,11	0,03	3,03	46,33
vetch+oats Org	29,33	1,61	4,07	47,39	49,14	0,05	3,10	44,45
sunflower Min+Org	48,82	2,83	2,67	67,39	59,74	0,13	2,98	50,40
sunflower Min+Org	25,95	1,62	2,69	38,37	52,48	0,05	3,05	43,45
sunflower unfertilized	--	--	--	--	194,10	0,02	0,91	28,52

Note. SBR – soil basal respiration; NMC - nitrogen mineralization capacity; Dh – dehydrogenase activity; Ure – urease activity; d.w.s. –dry weight soil; TPF – triphenilformazan; d - day.

Biochemical parameters. Soil basal respiration (SBR), which indicated the rate of organic matter degradation in 2009 had a higher value in soil fertilized with mixed fertilizers Min+Org compared to soil fertilized with Org manure (tab.2) regardless of cultivated plants. This confirms the smaller loss of organic matter in soil fertilized with Org manure. In 2010 the fertilization system did not affect significantly the process of soil microbial respiration. The extensive elimination of CO2 in the long time unfertilized soil and cultivated with sunflower in 2010 was revealed, which probably testifies about the huge decomposition processes of humus to provide the microbial communities and plants with energy and nutrients.

Nitrogen mineralization capacity (NMC) (ammonification) of typical chernozem in crop rotation varied strongly, the significant differences between the fertilization systems were not revealed. However, nitrogen mineralization processes differed in depending on soil fertilization systems. Ammoniacal nitrogen content formed at the incubation of soil fertilized with Org fertilizers and cultivated with sunflower and vetch+oats showed the same level. The amount of ammoniacal nitrogen in soil fertilized with Min+Org fertilizers was higher on plots with sunflower and unexpectedly low at vetch+oats. In 2010 the nitrogen ammonification capacity in soil was comparatively lower. That is why the soil ammoniacal nitrogen content in 2010 was significantly lower compared with 2009 (tab. 1). But still it requires a deeper research.

Dehydrogenase activity (DH). Analysis of soil samples under both cultures studied showed no significant difference in depending of the cultivated plants and fertilization systems. Dehydrogenase activity was higher in soil fertilized with Org manure. Org fertilization contributes to activation of soil microbial communities due to the addition of nutrients *(tab. 2).* Unfertilized soil cultivated with sunflower revealed a very low dehydrogenase activity. These data are to some extent in contradiction to those for soil respiration under the indicated culture, what can be explained by the fact that in unfertilized soil under sunflower is faced to acute deficiency in mobile forms of nitrogen, causing decomposition of organic substances, what contain C and N, and therefore the elimination of CO2 is enhanced.

Urease activity (Ure). Soil fertilized with Min+Org fertilizers cultivated with sunflower in 2009 contributed to increased urease activity in comparison with Org fertilization system. Thus, manure amendments under sunflower activated Significant changes are probably caused by changes in soil miscrobial community structure (Schloter, 1998). In 2010 a significant difference between plants and between fertilization systems was not shown, except for unfertilized soil, cultivated with sunflower, where urease activity was lower against other treatments.

CONCLUSIONS

Both fertilization systems generate positive changes in properties of cernoziom soil compared with unfertilized control. Application of manure and manure together mineral fertilizers provides enlarged reproduction of organic matter of typical chernozem. The agrochemical and biochemical

property values were lower at Min+Org fertilization system than at the Org one. The values of most biochemical parameters investigated were reduced in soil cultivated with vetch+oats following suflower in rotation. It may be due to changes in the functional structure of microbial communities, which are necessary when the type of management changes from conventional agriculture to the ecological one, or from one crop to another.

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