IMPACT OF ORGANIC FERTILIZERS ON BIOCHEMICAL AND AGROCHEMICAL PROPERTIES OF TYPICAL CHERNOZEM SOIL

IMPACTUL ÎNGRĂŞĂMINTELOR ORGANICE ASUPRA PROPRIETĂŢILOR BIOCHIMICE ŞI AGROCHIMICE ALE CERNOZIOMULUI TIPIC

TOMA S.[1], EMNOVA Ecaterina[1], NICA L.[2], DARABAN Oxana[1], DRUTA Iana[1]

[1]Institute of Genetics and Plant Physiology, Chisinau, Republic of Moldova

[2]Scientific and Practical Center "Selectia", Balti, Republic of Moldova

Abstract. *Organic and organic+mineral fertilization systems with manure amendment, at the rate 15 t ha^{-1}, promote the chernozem soil biochemical and agro-chemical parameters amelioration, and the restoration of correlations in plant development. Specific biochemical parameters: the chernozem urease and phosphatase activities increase, but the invertase activity reduces in soil fertilized by manure in comparison to NPK amendment, only. The organic fertilization of field crops provides the regeneration effect on soil biochemical properties, favors the soil fertility restoration and the crops productivity increase.*

Key words: soil, fertilization system, soil enzyme activity

Rezumat. *Sistemul organic şi organo-mineral de fertilizare cu aplicarea gunoiului de grajd în cantitate de 15 t/ha contribuie la ameliorarea parametrilor biochimici şi agrochimici ai fertilităţii cernoziomului tipic, şi restabilirii relaţiilor corelative în dezvoltarea plantelor. Parametrii biochimici specifici: activitatea ureazică şi fosfatazică a cernoziomului tipic sporeşte, iar invertazică se reduce în sol fertilizat cu gunoi de grajd în comparaţie cu administrarea numai NPK. Fertilizarea organică are un efect regenerabil asupra proprietăţilor biochimice ale solului şi contribuie la reproducerea fertilităţii solului şi sporirii productivităţii plantelor de cultură*

Cuvinte cheie: sol, sistem de fertilizare, activitate enzimatică a solului

INTRODUCTION

From the land of Moldova, perennial plantations occupy around 300,800 ha (8.9% of agricultural land), including in horticulture - 4.1%, viticulture - 4.5%, other plantations - 0.3% (Programul complex, 2004). Deep plowing necessary before the establishment of perennial plantations reduce soil anti-erosion resistance. Soils under orchards which are located on the slopes is in an unprotected state during spring-summer similar to the fallow land and can be eroded. To establish an orchard on fruit-growing land, the soil should be prepared specifically: aligned, cleared, fertilizers are used to ensure nutrient system and improve soil physical properties. Research conducted on different soil types showed that land use in

orchards leads to compaction of top layer just in the first years of existence (Nagacevschi Tatiana, 2004). As a result, soil biological properties responsible for the movement of nutrients in the soil are deteriorated. Organic fertilizers can contribute to maintaining soil fertility and structure, especially after stubbing the old plantations.

The aim of this research was the study of biological (biochemical) and agrochemical properties of typical chernozem, fertilized with cattle manure.

MATERIAL AND METHOD

The research has been conducted on long-term experiment established in 1991 in the north of Moldova (Balceana steppe, 140 km north of Chisinau). The soil is typical chernozem (alluvial clay), with a horizon rich in organic C up to 92 cm.

Soil organic matter content was 4.65% (0-20 cm layer). pH - 6.6-7.1 (water) and 6.2 (salt solution). Total N content is 0.24-0.26%, P - 0.12-0.13%, K - 1.2-1.4%. Three fertilizing systems are studied: mineral fertilizers (kg active ingredient / ha, N - 300; P_2O_5 - 255, K_2O - 255); organic fertilizers (cattle manure, 15 t/ha), and organic-mineral fertilizer. Soil samples were collected on June 11, 2009, with a trepan from the top layer of soil (0-20 cm). Total organic carbon content was determined in air-dried soil samples by wet oxidation with potassium dichromate in an acidified medium, and then the quantification of its excess by the method of Tiurin (Arinushkina, 1970). pH values were measured using a glass electrode, based on the ratio of soil to 1 M KCl solution 1:2.5 (weight: volume).

Ammoniacal nitrogen ($N\text{-}NH_4^+$) was extracted with 0.05 N NaCl solution (1:30 ratio of soil to solution) and subsequently measured with Nessler reagent (Mineev, 1989). Inorganic phosphorus was extracted with 0.5 N acetic acid (1:25 ratio of soil to solution) after Ciricov (Mineev, 1989) and was measured by the method of Murphy and Riley (1962). Water content of soil and dry soil mass were determined immediately after sampling by drying for 6-24 hours at a temperature of 105°C.

Soil dehydrogenase activity (DH) (EC 1.1.1.1) was determined by a modified method of Galstean (1978). Urease activity (Ure) (EC 3.5.1.5) was measured by the method of Khaziev (1990). Alkaline phosphatase activity (AlkP) (EC 3.1.3.1) – by the method of Tabatabai and Bremner (1969). Invertase activity (Inv) (3.2.1.26 EC) – by the modified method of Ciunderova (1971) and Galstean (1978).

Data analysis was performed by use Microsoft Excel for Windows XP (Microsoft Office). Matrix with the same size was analyzed. Mean values were analyzed by Student t-test (bilateral test, type 3 with unequal variation). Correlational analysis was performed by calculating the Pearson coefficient (r) and the coefficient of determination (r^2). The values $r > 0.45$, $r^2 > 0.20$ and $P < 0.05$ give the limits of significance (Aon et al., 2001).

RESULTS AND DISCUSSIONS

Table 1 presents the soil chemical properties. Organic carbon content in typical chernozem fertilized with manure increased, although the difference was insignificant compared to that in soil fertilized with mineral fertilizers (MF). Mixed organic-mineral fertilization (OMF) provided the significantly ($P < 0.05$) highest level of organic matter in the investigated soil. Organic fertilizer (OF) increased the soil pH values and concentrations of mobile forms of nitrogen and phosphorus.

Analysis of dehydrogenase activity (DH) of soil samples showed lower values at mineral fertilization (MF) (2.33 mg TPF g soil^{-1} h^{-1} 30°C) and highest at mixed (OMF) and organic (OF) fertilization (2.83 and 4.08 mg TPF g soil^{-1} h^{-1} 30°C) (table 2).

Table 1

Agrochemical parameters of typical chernozem (0-20 cm upper layer)

Fertilization system	Total C (%)	pH (KCl)	N-NH_4^+ (µg N/ g soil)	Inorganic P (µg P/ g soil)	Water content (%)
Mineral (MF)	2.47 (0.14)	5.4 (0.2)	9.9 (0.4)	34.2 (5.1)	14.9 (0.9)
Organic (OF)	2.59 (0.20)	5.8 (0.6)	12.2* (0.8)	36.0 (11.5)	13.0* (0.4
Min+Org (OMF)	2.66* (0.19)	5.6 (0.5)	11.7* (0.9)	55.0* (2.3)	15.0 (1.0)

Note. Mean values of 4 replicates; in brackets is given standard deviation (SD)
* - significant difference against the mineral fertilization system, P <0.05

Urease activity (Ure) and phosphatase (AlkP) revealed the same trend. The lower values of Ure activity were observed at mineral fertilization (28.8 µg NH_3 g soil^{-1} h^{-1} 37°C) and significantly higher values were recorded at mixed and organic fertilization (respectively 39.9 and 47.4 µg NH_3 g soil^{-1} h^{-1} 37°C).

Mean alkaline phosphatase activity (AlkP) were equal at mineral and mixed fertilization (851-852 µg pNP g soil^{-1} h^{-1} 37°C), and insignificantly (P>0.05) higher at the organic fertilization (864 µg pNP g soil^{-1} h^{-1} 37°C). Activity of invertase (Inv) ranged from 630 µg Glu g soil^{-1} h^{-1} 37°C at mineral fertilization to significantly lower values at the mixed (592 µg Glu g soil^{-1} h^{-1} 37°C) and the organic (563 µg Glu g soil^{-1} 37°C). Thus, the chernozem urease and phosphatase activity typically increased and invertase activity reduced in soil fertilized with manure compared to the one fertilized with NPK, only.

Table 2

Biochemical parameters of soil at different fertilization systems

Fertilization system	DH[a] µg TPF g soil^{-1} h^{-1} 30°C	Ure[b] µg NH_3 g soil^{-1} h^{-1} 37°C	AlkP[c] µg pNP g soil^{-1} h^{-1} 37°C	Inv[d] µg Glu g soil^{-1} h^{-1} 37°C
Mineral (MF)	2.30 (0.38)	28.8 (9.6)	851 (17)	630 (14)
Organic (OF)	4.08 (3.05)	47.4* (22.6)	864 (18)	563* (21)
Min+Org (OMF)	2.83 (1.63)	39.9* (16.9)	852 (27)	592* (11)

Note. Mean values of 4 replicates; in brackets is given standard deviation (SD); DH[a] – dehidrogenase activity, Ure[b] –urease activity, AlkP[c] – alkaline phosphatase activity, pNP – para-nitrofenol, Inv[d] –invertase activity, Glu – glucose; * - significant difference against the mineral fertilization system, P <0.05

A positive correlation between levels of ammoniacal nitrogen and soil urease activity (Ure) was observed at all fertilization systems, the correlation coefficient (r) was for FM, OF and OMF systems, respectively 0.51, 0.68, 0.74. Also, a high positive correlation r = 0.76-0.79 between the values of ammoniacal

nitrogen and dehydrogenase activity (DH), that is the microbial activity, was revealed in soil amended with manure. Only for this last treatment of the studied soil a correlation between alkaline phosphatase activity and inorganic phosphorus content was found, and it was the negative correlation (r = -0.55). Urease and phosphatase activities were positively correlated with soil organic carbon content for the MF and OF fertilization systems. The summarized results lead to the conclusion that organic fertilization has a renewable effect on soil biochemical properties, contribute to reproduction of soil fertility. Organic fertilization system is recommended for implementation in sustainable agriculture.

CONCLUSIONS

1. Organic and organic + mineral fertilization systems in crop rotation with manure amendment, at the rate 15 t ha^{-1} surface, promote the biochemical and agro-chemical parameters amelioration, and the restoration of correlations in plant development.

2. Specific biochemical parameters: the chernozem urease and phosphatase activity increased, but the invertase activity reduced in soil fertilized by manure in comparison to NPK amendment, only.

3. The biotechnological, organic fertilization provides the regeneration effect on soil biochemical properties, favors the soil fertility restoration and it is recommended for the implementation in the sustainable agriculture.

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