Impact of different organic fertilizers based on peat, sapropel and brown coal on organic nitrogen compounds in soil

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Summary

Amino acids represent a form of organic nitrogen which is easily hydrolysable by chemical compounds and enzymes and is readily available for plants and soil microorganisms. The impact of organic fertilizers based on peat, sapropel and brown coal on soil organic nitrogen in the form of amino acids was investigated.

The highest increase in bound amino acids in the soil was observed for fertilizer based on brown coal. Soil treated with this fertilizer supplied 93.7 % more amino acid nitrogen than the reference soil. Soil receiving two other fertilizes based on peat and sapropel supplied 64.1 % and 56.3 % more amino acid nitrogen, respectively, than the reference soil. Neutral amino acid predominated in all plots receiving different organic fertilizers, while acidic amino acids were present in the lowest concentrations.

Key index words: organic fertilizers, peat, sapropel, brown coal, amino acids

Introduction

Management of soil organic matter has emerged as a major strategy to help achieve the central role which soil organic matter plays in storing and cycling nutrients. Knowledge of the ratio between humified and non-humified materials in natural substrates, such as soils, and fertilizers, can be considered as very important from agronomical and environmental points of view. Addition of humified materials to the soil is equivalent to the addition of stabilized organic carbon. In contrast, due to biological activities, non-humified materials yield humified compounds and metabolic energy. The actual humification degree in soil is depended on the organic materials applied, soil type, and climatic condition (Hassink 1995; Nieder *et al.*, 2003; Seiter and Horwath 2004).

Balanced organic fertilizers (BOMF) were developed by the Institute for Problems of Natural Resources Use and Ecology of the National Academy of Sciences of Belarus and widely investigated in that country (Skoropanov *et al.,* 1987; Bambalov and Sokolov 1998).

The goal of this study was to investigate the content of bound amino acids in soils treated with different organic fertilizers prepared on the basis of peat, sapropel and brown coal.

Materials and Methods

The study were carried out in long-term field experiments located at the Ducora Experimental Station, 50 km South-East of Minsk, Belarus. The station belongs to the Institute for Problem of Natural Resources Use and Ecology, National Academy of Sciences of Belarus. The investigation was established on a sandy loam podsolic soil.

The following organic fertilizers called “Balance Organic-Mineral Fertilizers” (BOMF) were used: $BOMF_P$ - peat, cow manure, NPK; $BOMF_S$ - sapropel, cow manure, NPK; $BOMF_{BC}$ - brown coal, cow manure, NPK. The initial materials were taken from fen sedge peat deposit with a 30 % degree of organic matter decomposition, siliceous sapropel from Chervonoe Lake, brown coal from Khandinskoe deposit, and semi-liquid cattle manure.

Different kinds of BOMF were applied for the cultivation of potatoes at equal rates of 60 ton ha^{-1} to soils ploughed in April. The potato crop was planted in May. Soil samples were collected in July from the upper 20 cm layer of the soil from 10 locations in every plot. Samples were air dried and crushed to pass a 1 mm-mesh sieve. These 10 samples were mixed to prepare a representative sample for each plot, which was used for potentiometric determination of pH (in 1 N KCl), total nitrogen, P_2O_5, V-sorptive

Table 1. Physicochemical properties of the experimental soil

pH 0.1 N KCl	N_{total}, %	P_2O_5 extraction with 0.2 N HCl, mg 100 kg^{-1}	V sorptive capacity %	K_2O extraction with 0.2 N HCl, mg 100 kg^{-1}	Humus content, %
6.05	0.15	496.0	77.07	203.2	3.0

capacity, K_2O, and humus content as well as amino acids (Kuprevich 1951; Rowell 1994), (Table 1).

The quality and quantity of bound amino acids was determined in soils treated using different kind of organic fertilizers and in reference soils. Within investigated soils from 19 to 21 bound amino acids were identified and determined. For the analysis of bound amino acids, soil samples were hydrolyzed with 6 M HCl for 24 h at 105° C. Separation and determination of the bound amino acids were carried out on a T 339 amino acid analyzer (Mikrotechna-Prague) using an Ostion LGFA (0.37 x 20 cm) column (Szajdak and Österberg 1996).

All the determinations were performed on 5 replicates, and the results averaged. All the chemicals used in this study were of analytical grade

Results and Discussion

Soil organic matter affects biochemical, chemical, biological and physical soil properties that control soil microbial activity (Flaig 1971; Stevenson 1986). Crop production practices such as tillage, rotation, residue management, and fertilization influence organic matter content and quality in soil. Long-term studies have shown a decline in organic matter with tillage intensity. Also, decreasing tillage intensity and increasing surface residue cover have been shown to reduce loss of organic matter from soils (Tiessen *et al.,* 1982; Dick 1983; Odell *et al.,* 1984; Dolal and Mayer 1986; Ryszkowski *et at.,* 1998).

Degradation of organic matter and autolysis of microorganisms in soils releases amino acids, which typically account from 40 to 60 % of the total organic N present in soil (Stevenson 1985; Szajdak *et al.* 1998). These amino acids are commonly bound to the central core of humic and fulvic acids (Bremner 1967; Hartworth 1971), which protects them from rapid degradation by microorganisms. Amino acids in soil can undergo mineralization, migration down the soil profile, plant uptake, soil adsorption, and humification (Kuzyakov 1997). Peptides and amino acids represent different aspects of chemical, physical and biological properties of soil. Hydrophilic and hydrophobic properties of peptides and amino acids in soil are responsible for water movement, capillary rise, viscosity and absorptivity of organic matter (Szajdak *et al.,* 2000; Maryganova *et al.,* 2004; Maryganova *et al.,* 2007).

The total amount of bound amino acids in reference soil was equal to 519 mg kg^{-1} (Table 2) and the amount was increased by all the fertilizers tested.

The highest increase (97.7 %) was brought about by the $BOMF_{BC}$ fertilizer. $BOMF_S$ had the lowest impact, increasing the total amount of amino acids by 57.5%. The effect of $BOMF_P$ was intermediate between $BOMF_{BC}$ and $BOMF_S$. This fertilizer increased the total amount of amino acids in soil by 69.5%.

On grouping the amino acids into acidic, neutral and basic, it was revealed that in all soil samples, those with the neutral net charge showed the highest concentrations (Życzyńska-Bałoniak and Szajdak 1993). Acidic amino acids were present in the lowest concentrations. The highest influence of organic fertilizers in increasing the amount of amino acids was observed for basic amino acids which were increased by 105.1 % to 182.4 % compared with the reference soil (Table 2).

In addition, the results showed a significant supply of organic nitrogen in amino acid structures. Amino acids represent a form of organic nitrogen which is easily hydrolysable by chemicals and enzymes, and is available for plants and soil microorganisms (Maciak *et al.,* 1977). The highest supply was observed for $BOMF_{BC}$ which increased total amino acid nitrogen by 93.7% compared with the reference soil. Two other fertilizes, $BOMF_P$ and $BOMF_S$ supplied an additional 64.1% and 56.3%, respectively, compared with the reference soil.

Conclusions

All the organic fertilizers tested significantly increased the total amount of amino acids and total amino acid nitrogen

Table 2. Total amount of bound amino acids and total nitrogen amount in soils treated with different kind of fertilizers in mg kg^{-1} of soil

Amino acids	Reference soil	Soil treated		
		$BOMF_{BC}$	$BOMF_P$	$BOMF_S$
Total amount of amino acids	519.39±22.8	1027.90±45.02	880.51±38.30	818.23±36.2
Acidic amino acids	79.02±5.5	98.22±6.4	117.99±7.7	114.37±7.4
Neutral amino acids	308.22±22.0	500.02±32.5	457.45±29.8	393.65±25.8
Basic amino acids	132.15±8.7	429.66±28.2	305.07±19.8	310.21±20.5
Total amount of nitrogen in amino acids	64.40±2.80	124.75±5.42	105.66±4.60	100.64±5.64

in the soil. The highest amount of bound amino acids was found in soil treated with organic fertilizer based on brown coal while a fertilizer containing sapropel had the least effect on bound amino acid content. Neutral amino acids predominated in soils treated with all organic fertilizers, while acidic amino acids were present in the lowest concentrations.

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