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Effect of fertilization with nitrogen and microelements on the content of total organic carbon and dissolved organic carbon in *Luvisols*

Magdalena Banach-Szott[1], Bożena Dębska[1], Michał Siennicki[1], Tomasz Knapowski[1], Piotr Wasilewski[2]*

[1]Department of Biogeochemistry and Soil Science, Bydgoszcz University of Science and Technology, 6/8 Bernardyńska St., 85-029 Bydgoszcz, POLAND
[2]Department of Agronomy; Bydgoszcz University of Science and Technology in Bydgoszcz, 7 Prof. S. Kaliskiego St., 85-796 Bydgoszcz, POLAND

*Corresponding author: e-mail: mbanach@pbs.edu.pl, phone +48 601484603

Abstract. The aim of the paper has been to investigate the effect of fertilization with nitrogen and microelements (Se and Cu, Mn, Zn) on the content of carbon (TOC) and nitrogen as well as dissolved organic carbon (DOC). The study was performed based on the soil sampled (*Albic Luvisol)* from a two-factor field experiment: the first factor was nitrogen fertilization (0, 40 and 80 kg ha^{-1}), the second one – variants of foliar and soil application of microelements and selenium. Soil was sampled from a depth of 0–30 cm at the beginning and the end of the growing season. Sampling 1 was after the start of spring vegetation, sampling 2 – after harvesting the crop from the field. Winter spelt (cv. Rokosz) was grown on the experimental plots, with winter rapeseed as the forecrop. In the soil samples the following were assayed: total organic carbon (TOC), total nitrogen (TN) with the Vario Max CNS analyser provided by Elementar and dissolved organic carbon (DOC). DOC was extracted with 0.004 M $CaCl_2$ and was assayed and using the Multi N/C 3100 Analityk Jena analyser. In the soil samples analysed TOC, irrespective of the sampling date and the microelements application method, ranged from 8.38 to 10.60 g kg^{-1}. In general, the application of microelements into soil in combination with selenium resulted in an increase in TOC in the soil sampled at the end of the vegetation period as compared with the soil sampled at the beginning of it. Irrespective of the application method, there has been identified no effect of fertilization with nitrogen and microelements on total nitrogen and dissolved organic carbon in soil, which is important in terms of the stability and equilibrium of the soil system investigated.

Keywords: soil, fertilization, organic carbon, dissolved organic carbon

INTRODUCTION

A progressing global soil degradation resulting from agriculture intensification (Hossain et al., 2020; Kopittke·et al., 2019) is getting more and more serious due to climate changes (Hari et al., 2020; Ray et al., 2019). And so, increasing and maintaining the quantity and quality of yields without a growing degradation of environmental systems of the Earth, soils especially, is a big challenge (Kopittke et al., 2019; Terzić et al., 2019; Viet, 2023).

Soil provides basic services which cover food production, nutrients cycling, water filtration and carbon sequestration (Lal et al., 2015). Soil functions, both physical and biological, are modified by, e.g., crop rotation, cover crops, the application of fertilizers and agricultural practices (Kalbitz, 2000; Chantigny, 2003; Dębska et al., 2016; Jaskulska, Jaskulski, 2021). Soil organic carbon (SOC) and nitrogen (N) are two of the most important indicators for agricultural productivity. The C and N dynamics are mostly affected by climate factors, soil environment and anthropogenic factors (Brevik, 2013). The aspect of the dynamics of those elements in soils is essential, e.g., due to crop productivity and enhancing the ecosystems management practices (Law et al., 2018). Adequate fertilization is of key importance to increase the crop production and, as a result, C and N return to soil in a form of plant residue

(Kirkby et al., 2014). Besides, over the last decade, more and more attention has been attracted to the importance of the so-called healthy soils (Safeguarding our soils, 2017).

One of the microelements indispensables for human and animal health is selenium (Se). Soil is an essential source of selenium used by plants and it serves an important function for selenium cycling in terrestrial ecosystems. Selenium content depends on the type of parent material, the processes of sorption by clay minerals in soil and iron oxides as well as on leaching processes. The form in which Se occurs in soil affects the availability of that element to plants (Borowska, Koper, 2004; Moreno et al., 2013). Selenium is an element which is indispensable for the adequate human and animal development (Piotrowska, 1985; Silva Lara et al., 2019). In big rates it is toxic, however its deficit increases the susceptibility to various diseases in people and in animals. As for animal needs, the selenium richness in some arable soils can be too low, especially in loose soils (formed from sands), and poor loam soils with Se content below 0.1 ppm. Currently around 15% of the world population show Se deficit (Stroud et al., 2010). According to Levander and Burk (2006), the main source of Se globally is wheat and so a decrease in Se consumption is connected with changes in Se content in cereals and soils.

Macro- and microelements cycling in soil is closely connected with the content of organic matter and post-harvest residue management (Mythili et al., 2003; Orzechowski, Smólczyński, 2021). And, therefore, an inadequate soil management leads to organic matter and mineral nutrients loss in soil and, finally, to a decrease in their content in plants. The postharvest residue weight and chemical composition affect not only the content of organic matter but also its fraction composition (Ventorino et al., 2012; Dębska et al., 2022). Organic matter consists of fractions of various stability (resistance to decomposition): labile fractions which include the so-called dissolved organic matter (DOM) and fractions with a greater resistance to decomposition: fulvic acids, humic acids and humins (Guimaraes et al., 2013; Cao et al., 2016; Dębska et al., 2016; Rosa and Dębska, 2018; Guo et al., 2019; Dębska et al., 2020; Banach-Szott et al., 2021).

An important role is played by the most mobile and fast-decomposing humus fraction (DOM). Its content is determined based on the content of carbon in water extracts so called: dissolved organic carbon (DOC). DOC in arable soils, in general, accounts for less than 1% of TOC. Despite such a low share, DOM is essential, e.g., for biogeochemical cycling of carbon, nitrogen and phosphorus and it can be a source of nutrients for microorganisms (Gonet et al., 2002; Zsolnay, 2003; Bolan et al., 2011; Rosa, Dębska, 2018). Generally, it is assumed that changes in DOC can be an important indicator of changes which occur in soils, especially due to anthropogenic factors (Bolan et al., 2011). As results from literature reports (Kalbitz et al., 2000; Jokubauskaite et al., 2015; Rosa, Dębska, 2018), the dynamics of changes in DOM in soils is not clear-cut and it does not depend on the rate of the mineral fertilization applied.

Due to a growing soil degradation and total organic carbon (TOC) losses, as a result of changes in soil use and of agricultural production intensification, the local, regional and global soil protection has become one of the key goals of the Common Agriculture Policy (COM, 2006). Preserving the resources of soil humus is crucial not only for soil productivity but also for the role of soils in sequestration (fixing) carbon from the atmosphere. And so, the aim of the paper has been to investigate the effect of fertilization with nitrogen and microelements (Se, Cu, Mn, Zn) on the content of carbon and nitrogen as well as dissolved organic matter in soils.

MATERIALS AND METHODS

Materials

The research was carried out in a field experiment (Agricultural Experiment Station in Minikowo (53°10′2″ N, 17°44′22″ E, the kujawsko-pomorskie voivodeship) from which soil samples were collected.

The AES Meteorological Point in Minikowo provided data on weather conditions from 1949 to 2014 and in the 2013/2014 growing season (IX–VIII). The total rainfall during the study was 455.3 mm and was 8.7% lower than the multi-year average. On the other hand, the air temperature was 0.1 °C higher than the multi-year average (8.0 °C). It should be noted that during the spelt sowing period (IX.2013) and the start of spring vegetation (IV–V.2014), weather conditions were optimal. In turn, in VI and VII 2014, very dry periods were recorded.

The experiment was carried out in *Albic Luvisols* (according to the FAO-UNESCO international classification), IIIa soil quality class, of the very good rye soil complex (Systematyka Gleb Polski, 2019). The soil showed a neutral reaction and, in terms of richness – a high or average content of available forms of phosphorus, potassium, magnesium and manganese and a low content of copper and zinc. The granulometric composition was dominated by the sand fraction (2.0–0.05 mm) – 75%, the percentage of the silt fraction (0.05–0.002) was 19% and the percentage of the clay fraction (<0.002 mm) was 6%. The crop which was grown was spelt (winter cv. "Rokosz", Plant Breeding in Strzelce).

A two-factor field experiment was established with the split-plot design. The experimental plots were 9 m^2 in size (1.5x6 m). The first factor included three rates of nitrogen fertilization (0, 40 and 80 kg ha^{-1}), the second one – variants of application of microelements (Table 1). On the experimental plots, pre-sowing, there was applied stable phosphorus fertilization in a form of 46% triple superphosphate (at the rate of 30 kg P ha^{-1}) and potassium fertilization in a form of 57% potassium chloride (at the amount of 103 kg K ha^{-1}). The nitrogen rates of 40 kg N ha^{-1} were

Table 1. Experiment design.

Nitrogen fertiliza-tion	Foliar fertilization				Soil fertilization			
	LSe10	LSe10+M	LSe20	LSe20+M	GSe10	GSe10+M	GSe20	GSe20+M
„0” control	LSe10-N0	LSe10-N0+M	LSe20-N0	LSe20-N0+M	GSe10-N0	GSe10-N0+M	GSe20-N0	GSe20-N0+M
40 kg ha^{-1}	LSe10-N40	LSe10-N40+M	LSe20-N40	LSe20-N40+M	GSe10-N40	GSe10-N40+M	GSe20-N40	GSe20-N40+M
80 kg ha^{-1}	LSe10-N80	LSe10-N80+M	LSe20-N80	LSe20-N80+M	GSe10-N80	GSe10-N80+M	GSe20-N80	GSe20-N80+M

Explanations: L – foliar fertilization, G – soil fertilization, Se – selenium fertilization, M – Cu, Mn and Zn fertilization
Factor I: N0, N40, N80, Factor II: microelements fertilization (Se10, Se20, Se10+M, Se20+M)
Form and dose: Cu – $CuSO_4 \cdot 5 H_2O$ (0.1 kg Cu ha^{-1}); Mn – $MnSO_4 \cdot H_2O$ (0.3 kg Mn ha^{-1}); Zn – $ZnSO_4 \cdot 7 H_2O$ (0.2 kg Zn ha^{-1}); Se10 – $Na_2SeO_4 \cdot 10 H_2O$ (0.01 kg Se ha^{-1}); Se20 – $Na_2SeO_4 \cdot 10 H_2O$ (0.02 kg Se ha^{-1})

applied in the form of 34% ammonium nitrate to start the spring vegetation, whereas the nitrogen rates of 80 kg N ha^{-1} were divided; 40 kg to start the spring vegetation and 40 kg (34-37 stages in the BBCH scale – of the stalk-shooting phase) (Matysiak, Strażyński, 2018).

Foliar and soil fertilization with microelements ($Na_2SeO_4 \cdot 10 H_2O$ – 0.01 kg Se ha^{-1}, $Na_2SeO_4 \cdot 10 H_2O$ – 0.02 kg Se ha^{-1} and a combined Se and Cu, Mn, Zn fertilization ($CuSO_4 \cdot 5 H_2O$ – 0.1 kg Cu ha^{-1}, $MnSO_4 \cdot H_2O$ – 0.3 kg Mn ha^{-1}, $ZnSO_4 \cdot 7 H_2O$ – 0.2 kg Zn ha^{-1}) was applied using sprayer Kwazar Zeus (capacity 15 L, battery-powered) in a form of technical salts (34-37 stage in the BBCH scale) together with the foliar and soil rate of 6% urea water solution. The treatments were performed on one day; adequately dissolving the rate of copper, manganese and zinc in the volume of water corresponding to 300 dm^3 ha^{-1}. Soil fertilization was performed in the inter-rows.

All the cultivation treatments, sowing and harvest (92-99 stage in the BBCH scale – at the full maturity of grain) were performed compliant with the agrotechnical guidelines optimal for a spelt (Kotecki et al., 2020).

During the vegetation of the cereal, plant protection agents were applied to combat loose silky-bent (*Apera spica-venti*) and dicotyledonous weeds (herbicides: Isoguard 500 SC at the rate of 2 l ha^{-1}, Aminopielik Tercet 500 SC at the rate of 1.8 l ha^{-1}, Aurora 40 WG at the rate of 20 g ha^{-1}) and basic fungal diseases (fungicide Yamato 303 SE at the rate of 1.5 ha^{-1} + surfactant Silwet Gold at the rate of 0.1 l ha^{-1}).

Soil was sampled from a depth of 0–30 cm at the beginning and the end of the growing season. Sampling 1 was after the start of spring vegetation, sampling 2 – after harvesting the crop from the field. The forecrop for spelt was winter rape.

Methods

In the soil samples, once they were dried at the room temperature and sieved through the screen (2 mm), the following were assayed: total organic carbon (TOC) and total nitrogen (TN) with the Vario Max CNS analyser provided by Elementar.

Dissolved organic matter (DOM) was extracted with 0.004 M $CaCl_2$ at the ratio soil to extractant 1:10 (w v^{-1}). The soil samples were shaken for 1 hour and then centrifuged. In the post-extraction solutions, DOC was assayed and using the Multi N/C 3100 Analityk Jena analyser it was expressed in mg kg^{-1} d.m. of the soil sample and as percentage share in TOC.

The obtained laboratory test results were subjected to analysis of variance in the model appropriate for the method of establishing the experiment in the field. Analysis of variance was performed for two-factor experiments in a split-plot, and Tukey's multiple range test with a probability of p=0.05 was used to assess differences between the object means, with ANALWAR software. The tables present the mean values for three replications. The evaluation of differences in the studied parameters between the sampling dates (sampling 2 – end of the growing season, sampling 1 – beginning of the growing season) for the studies was performed by calculating single-base indexes (Figs 1-6).

RESULTS AND DISCUSSION

One of the basic soil fertility indicators is organic matter content which determines the chemical, physical and biological properties of soil. In the soil samples analysed, TOC content, irrespective of the sampling date, nitrogen dose and the microelements application method, ranged from 8.38 (LSe20-N0 – sampling 2 and GSe10+M-N40 – sampling 1) to 10.6 g kg^{-1} (GSe20+M-N80, LSe10+M-N80 – sampling 1 and GSe10+M-N40 – sampling 2) (Tables 2 and 3). Analysis of variance did not show any influence of nitrogen dose and microelement fertilization (with or without selenium) on TOC content (Table 4). For the foliar fertilization with microelements TOC in variant LSe10+M was significantly higher than in LSe20 and LSe20+M (Table 5). In general, the application of microelements into soil in combination with selenium resulted in an increase

Table 2. TOC, TN and DOC content and TOC/TN ratio for the soil samples fertilized with nitrogen and microelements into soil.

Nitrogen fertilization	Sampling 1				Sampling 2			
	GSe10#	GSe10+M	GSe20	GSe20+M	GSe10	GSe10+M	GSe20	GSe20+M
	TOC [g kg^{-1}]							
„0" – control	8.98	8.52	9.35	9.28	9.39	8.72	9.39	10.4
40 kg ha^{-1}	9.89	8.38	8.46	9.15	9.03	10.6	8.96	9.73
80 kg ha^{-1}	9.02	8.70	9.34	10.6	9.36	9.71	8.77	9.54
	TN [g kg^{-1}]							
„0" – control	0.98	0.92	1.02	1,00	1.05	1,00	1.06	0.89
40 kg ha^{-1}	1.17	0.90	0.95	0.99	1.02	1.11	1.01	1.04
80 kg ha^{-1}	0.96	0.95	1.02	1.07	1.03	1.09	1.01	1.08
	TOC/TN							
„0" – control	9.16	9.26	9.17	9.28	8.94	8.72	8.86	11.7
40 kg ha^{-1}	8.45	9.31	8.91	9.24	8.85	9.55	8.87	9.36
80 kg ha^{-1}	9.4	9.16	9.16	9.91	9.09	8.91	8.68	8.83
	DOC [mg kg^{-1}]							
„0" – control	128	127	146	179	143	142	131	130
40 kg ha^{-1}	162	138	124	136	126	107	139	131
80 kg ha^{-1}	150	127	132	132	133	146	143	135

Abbreviations – see Table 1

in TOC in the soil sampled at the end of the vegetation period as compared with the soil sampled at the beginning of it, ranging from 0.43 to 26.8%. A decrease in TOC from 6.1 to 10.0% was observed in three variants (N80+Se20; N40+Se10 and N80+Se20+M) (Fig. 1).

For the foliar fertilization with microelements, there were found no significant differences between TOC in the soil sampled at the end and at the beginning of the vegetation period. An increase in TOC at the end of the vegetation period, as compared to the initial value, ranged from 0.22 to 5.6% and a decrease – from 0.23 to 12.6% (Fig. 2). As reported by Van Groenigen et al. (2017), Ouyang and Norton (2020), intensive nitrogen fertilization results in soil degradation (a decrease in the content of organic matter, pH), pollution of waters due to intensified leaching processes. As reported by Szczepanek et al. (2020), a decrease in the content of organic matter due to increased nitrogen fertilization rates can be a result of a decrease in plant root weight. Cai et al. (2019), drawing on a 25-year field experiment, demonstrate that fertilization with mineral fertilizers (NPK) only did not cause changes in TOC content. Mensik et al. (2018), based on a 62-year experiment, show that NPK fertilization lowers the OM content and quality (a lower TOC and a lower content of humus substances). In the present experiment (Tables 4 and 5, Figs. 1 and 2), irrespective of the microelements application method, no significant impact of nitrogen fertilization on TOC content was found, which is very important, in terms of soil system equilibrium.

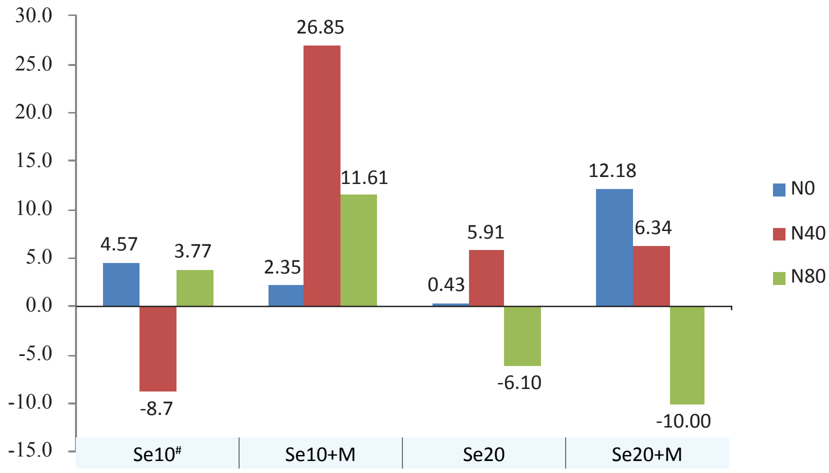
As seen from Tables 4 and 5, irrespective of the application method, there has been identified no effect of fertilization with nitrogen and microelements on TN in soil. The lack of significant changes in nitrogen content, especially for higher doses of this element, indicates an intensification of the mineralization processes of this element and/or an increased nitrogen uptake by plants (Lemanowicz et al., 2024; Bednarek, Reszka, 2008). The differences across the soil sampling time ranged from -12.8 to 23.3% for soil fertilization and from -8.11 to 9.4% – for foliar fertilization (Fig. 3 and 4).

TOC and TN result in the values of the ratio TOC/TN (Tables 2 and 3). TOC/TN values for soil fertilization ranged from 8.45 (GSe10-N40 – sampling 1) to 11.7 (GSe20 +M-N0 – sampling 2) and for foliar fertilization from 8.21 (LSe20+M-N40 – sampling 2) to 10.0 (LSe10+M-N80 – sampling 1). TOC/TN values coincide with the commonly known statement that the ratio TOC/TN in soils is the quality which is relatively constant and standard agrotechnical practices do not affect that value. Furthermore, the lack of significant differences in TOC/TN values indicates that the processes of carbon and nitrogen mineralization occurred with similar intensity. The experiments conducted by Simon (2008) show that the type of fertilization does not significantly differentiate the C:N ratio in the topsoil. Studies on the effect of fertilization and crop rotation were conducted by Pikuła (2018), who found that crop rotation does not significantly differentiate the C:N ratio in the topsoil. The application of manure and mineral fertilizers was the subject of research by Blecharczyk et al. (2018). Similarly to the research by Simon (2008), these authors found that the fertilization used did not significantly differentiate C:N in the soil. According to Kuś (2015), the C:N ratio in the

Table 3. TOC, TN and DOC content and TOC/TN ratio for the soil samples fertilized with nitrogen and microelements in a form of foliar fertilization.

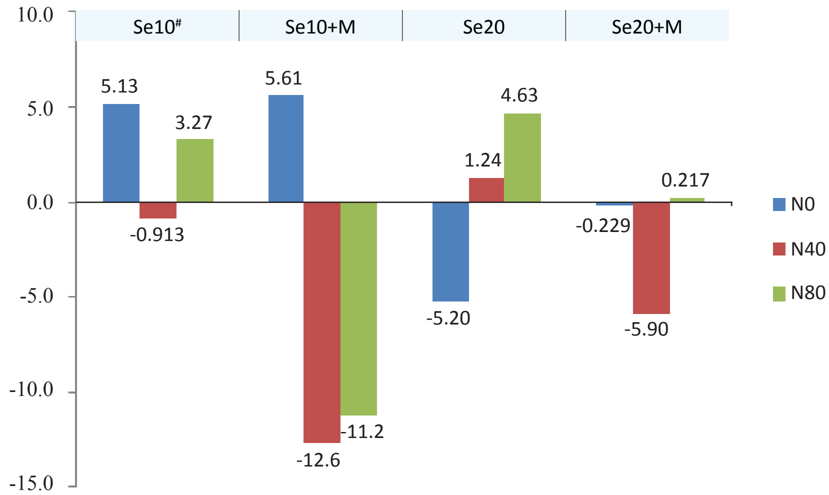
Nitrogen fertilization	Sampling 1				Sampling 2			
	LSe10#	LSe10+M	LSe20	LSe20+M	LSe10	LSe10+M	LSe20	LSe20+M
				TOC [g kg^{-1}]				
„0" – control	8.97	9.44	8.84	8.72	9.43	9.97	8.38	8.7
40 kg ha^{-1}	8.76	10.2	8.88	8.99	8.68	8.91	8.99	8.46
80 kg ha^{-1}	9.18	10.6	8.85	9.2	9.48	9.41	9.26	9.22
				TN [g kg^{-1}]				
„0" – control	1.07	1.05	0.94	1.04	1.06	1.10	0.98	1.00
40 kg ha^{-1}	0.95	1.11	1.07	0.98	1.02	1.02	1.01	1.03
80 kg ha^{-1}	0.96	1.06	0.96	1.03	1.05	1.04	1.04	1.05
				TOC/TN				
„0" – control	8.38	8.99	9.40	8.38	8.90	9.07	8.55	8.70
40 kg ha^{-1}	9.22	9.19	8.30	9.17	8.51	8.74	8.90	8.21
80 kg ha^{-1}	9.56	10.0	9.22	8.93	9.03	9.05	8.90	8.78
				DOC [mg kg^{-1}]				
„0" – control	129	157	134	128	119	143	122	132
40 kg ha^{-1}	134	157	130	139	123	134	131	132
80 kg ha^{-1}	140	149	132	135	125	129	126	128

Abbreviations – see Table 1



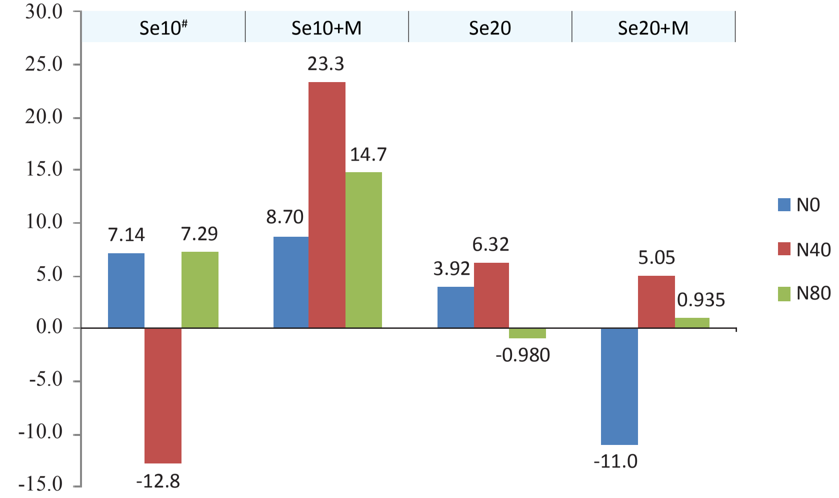
Abbreviations – see Table 1

Figure 1. Single-base indexes (expressed in %) of changes in TOC between sampling 2 (the end of the growing season) and sampling 1 (the beginning of the growing season) for soil samples fertilized with nitrogen and microelements into soil.



Abbreviations – see Table 1

Figure 2. Single-base indexes (expressed in %) of changes in TOC between sampling 2 (the end of the growing season) and sampling 1 (the beginning of the growing season) for soil samples fertilized with nitrogen and microelements of foliar fertilization.

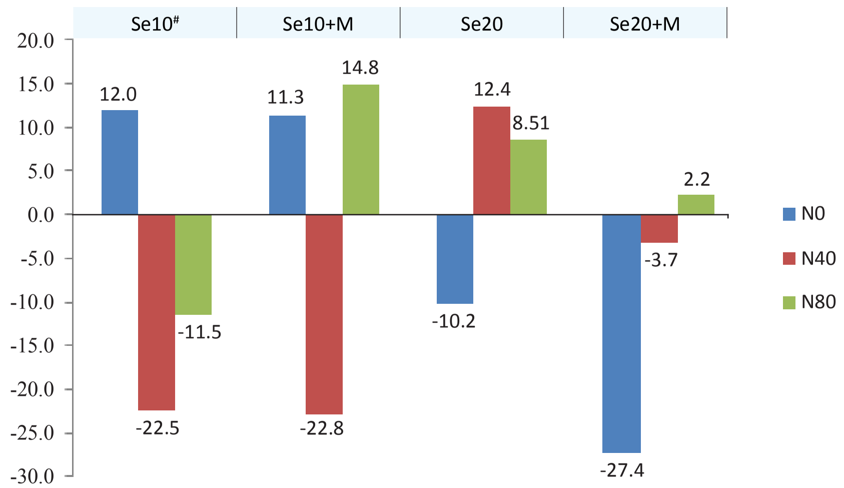


Abbreviations – see Table 1

Figure 3. Single-base indexes (expressed in %) of changes in TN between sampling 2 (the end of the growing season) and sampling 1 (the beginning of the growing season) for soil samples fertilized with nitrogen and microelements into soil.

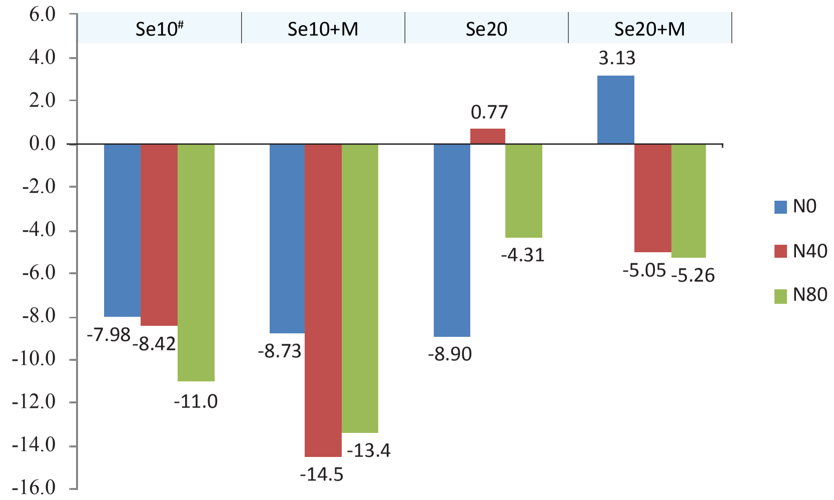
Abbreviations – see Table 1

Figure 4. Single-base indexes (expressed in %) of changes in TN between sampling 2 (the end of the growing season) and sampling 1 (the beginning of the growing season) for soil samples fertilized with nitrogen and microelements of foliar fertilization.



Abbreviations – see Table 1

Figure 5. Single-base indexes (expressed in %) of changes in DOC between sampling 2 (the end of the growing season) and sampling 1 (the beginning of the growing season) for soil samples fertilized with nitrogen and microelements into soil.



Abbreviations – see Table 1

Figure 6. Single-base indexes (expressed in %) of changes in DOC between sampling 2 (the end of the growing season) and sampling 1 (the beginning of the growing season) for soil samples fertilized with nitrogen and microelements of foliar fertilization.

Table 4. Results of the statistical analysis for TOC, TN and DOC content for the soil samples fertilized with nitrogen and microelements into soil.

Factor		TOC [g kg^{-1}]	TN [g kg^{-1}]	TOC/TN	DOC [mg kg^{-1}]
Nitrogen fertilization	0	9.26	0.99	9.35	140.8
	40	9.28	1.02	9.03	130.3
	80	9.38	1.03	9.14	137.1
LSD		n.s.	n.s.	n.s.	n.s.
Microelements fertilization#	GSe10	9.28	1.04	8.98	140.3
	GSe10+M	9.11	0.99	9.16	127.8
	GSe20	9.05	1.01	8.94	135.8
	GSe20+M	9.79	1.01	9.67	140.4
LSD		n.s.	n.s.	n.s.	n.s.

Abbreviations – see Table 1; n.s. – nonsignificant differences

Table 5. Results of the statistical analysis for TOC, TN and DOC content for the soil samples fertilized with nitrogen and microelements in a form of foliar fertilization.

Factor		TOC [g kg^{-1}]	TN [g kg^{-1}]	TOC/TN	DOC [mg kg^{-1}]
Nitrogen fertilization	0	9.05	1.07	8.57	132.9
	40	8.98	1.02	8.80	134.9
	80	9.40	1.02	9.18	134.1
LSD		n.s.	n.s.	n.s.	n.s.
Microelements fertilization#	LSe10	9.08	1.07	8.63	129.9
	LSe10+M	9.76	1.06	9.17	144.8
	LSe20	8.87	1.00	8.88	129.2
	LSe20+M	8.92	1.02	8.75	132.1
LSD		0.784	n.s.	n.s.	n.s.

Abbreviations – see Table 1; n.s. – nonsignificant differences

soil is constant and is usually 10:1, regardless of crop rotation and fertilization.

As reported by Bolan et al. (2011), a very sensitive indicator of changes which occur in soils due to anthropogenic factors are changes in dissolved organic matter. Contrary to the results reported by Jokubauskaite et al. (2015) and Embacher et al. (2008), mineral nitrogen fertilization was not found to change the content of extractable organic carbon considerably. DOC in the soils sampled from variants with the application of microelements into soil, irrespective of the soil sampling date, ranged from 107 (GSe10+M-N40 – sampling 2) to 179 mg kg^{-1} (GSe20+M-N0 – sampling 1, Table 2) and, as for foliar fertilization – from 119 (LSe10-N0 – sampling 2) to 157 mg kg^{-1} (LSe10+M-N0 and LSe10+M-N40 – sampling 1) (Table 3). The statistical analysis, however, did not identify a significant effect of nitrogen fertilization and adding microelements on DOC (Tables 4 and 5). The DOC content differences across the soil sampling time with the application of microelements into soil accounted for -27.4 to 14.8% and for foliar fertilization from -14.5 to 3.13% (Fig. 5 and 6). No significant impact of nitrogen fertilization on DOC content were also reported by Zsolnay and Gorlitz (1994) as well as by McDowell et al. (1998). As seen from literature (Zsolnay, Gorlitz, 1994; Chantigny et al., 1999; Kalbitz et al., 2000; Jokubauskaite et al., 2015; Rosa, Dębska, 2018), the dynamics of DOM did not depend on the rate of the mineral fertilization applied. Mineral fertilization, with nitrogen mostly, can lower the contents of dissolved organic carbon (DOC) by increasing the microbiological activity, which is related to an increased consumption of soluble organic carbon compounds (Chantigny, 2003). An increase in the microbiological activity can also trigger an increase in DOC due to intensified processes of decomposition of stable fractions of organic matter (humic and fulvic acids and humins) (Kalbitz et al., 2000). One can therefore assume that in the experiment presented, DOM mineralization and decomposition of stable forms of organic matter leading to the formation of DOM reached the state of equilibrium.

CONCLUSIONS

Fertilization with different doses of nitrogen as well as soil and foliar fertilization with Cu, Mn, Zn with or without Se covered by this study did not affect TOC, TN content and consequently the values of TOC/TN and DOC content significantly, which is important in terms of the stability and equilibrium of the soil system investigated.

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Author	ORCID
Magdalena Banach-Szott	0000-0002-9981-0841
Bożena Dębska	0000-0003-2004-007X
Tomasz Knapowski	0000-0003-1466-8477

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