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CROP YIELD AND CHEMICAL COMPOSITION OF THE SPRING TRITICALE AND OAT GRAINS FERTILISED WITH ORGANIC WASTE AND MANURE

PLONOWANIE ORAZ SKŁAD CHEMICZNY ZIARNA PSZENŻYTA JAREGO I OWSA NAWOŻONYCH ODPADAMI ORGANICZNYMI I OBORNIKIEM

Abstract: This research was conducted in the years 2004–2005 on Luvisols of the 6th class in a system of randomized blocks as one-factor experiment with three replications. The tested factor was a type of the applied organic matter (manure, fowl litter and conditioned waste from poultry abattoir), the doses of which were determined so that the amount of nitrogen introduced into soil would not exceed 170 N kg · ha^{-1}. The influence of the applied fertilisation on the crop yield and chemical composition of the cultivated plants was assessed.

The experiment carried out showed that the use of conditioned waste significantly increased the grain crop yields of spring triticale and oat with reference to the control. The grain of those plants reaped from the objects where a conditioned waste from poultry abattoir was applied contained the lower total nitrogen amount with reference with the control. However, the crop yield of total protein, which is dependent on the amount of grain crop yield and the grain total nitrogen content was clearly higher after using the conditioned waste, compared with the objects only with mineral fertilizers application.

Keywords: spring triticale, oat, manure, organic waste

Organic waste may become a valuable source of macro- and microelements for plants and play an important role in a balance of organic substance [1]. Fowl litter as a waste product from poultry farms and the conditioned waste from poultry hatcheries may be used as alternative fertilizers together with the manure [2, 3]. Their chemical composition indicates that they are abundant in mineral constituents required for the plant growth and development [4, 5]. Organic substances are mostly used to cultivate root crops, however, according to the Act on Fertilisers and Fertilisation [6], their appropriate use may be a problem in the vicinity of large livestock raising farms.

The aim of this study was to compare the effect of manure, fowl litter and conditioned waste from poultry abattoir on the crop yield of selected plants cultivated in light soil.

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Material and methods

The field experiment was carried out in 2004–2005 on Luvisols of the 6th class, a very poor rye soil complex, originated from glacial sands of Baltic Glaciations. Soil was characterized by acid reaction, low content of available forms of phosphorus and potassium and low abundance in available forms of magnesium. The investigation was realised as one-factor experiment in a system of randomised blocks with three replications, the tested plot area was 40 m^2. The tested factor was a type of organic matter and its doses were determined so that the amount of nitrogen introduced into soil would not exceed 170 kg N · ha^{-1}. A spring triticale was the test plant in the first year of the experiment and oat was in the second year.

A scheme of the field experiment included seven fertilised objects (plots):

K_0 – the control (mineral fertilisation),
K_1 – cattle stable manure applied every year,
K_2 – cattle stable manure applied once per every two years,
K_3 – fowl litter used every year,
K_4 – fowl litter applied once per every two years,
K_5 – conditioned waste from poultry abattoir, applied once per year,
K_6 – conditioned waste from poultry abattoir, applied once per every two years.

A grain crop yield of the test plants was determined at the harvest time. The content of total nitrogen in grain was determined by using Kjeldahl's method, phosphorus – colorimetrically, potassium and calcium by the method of flame photometry, and magnesium by using atomic absorption spectrometry (AAS). Additionally, a crop yield of total protein was calculated.

The climatic conditions were registered during the experiment (Table 1).

Table 1

Monthly total precipitation and mean air temperatures in plant vegetation period

Year	Month						Sum III–VIII
	III	IV	V	VI	VII	VII	
Precipitation [mm]							
2004	35.8	32.1	54.4	39.6	53.5	138.7	354.1
2005	22.5	34.8	82.6	30.5	33.6	43.4	247.4
Multi-year	31.8	27.5	58.7	48.3	83.7	60.8	310.8
Temperature [°C]							Mean
2004	2.9	7.5	11.3	14.7	16.4	17.9	8.8
2005	–0.4	7.4	12.2	14.9	19.4	16.3	8.7
Multi-year	2.2	7.8	13.2	16.1	18.0	18.2	9.4

The obtained test results were statistically worked out by using variance analysis at the level of significance $\alpha = 0.05$ and the differences were estimated by Tukey's test.

Results

The use of organic substances resulted in the increase in the grain crop yield of spring triticale and oat (Table 2) by 0.78 Mg · ha^{-1} and 0.48 Mg · ha^{-1} on average, respectively, with reference to the control.

It was found that in the second year of the field experiment the oat grain crop yields on the objects K_2, K_4 and K_6 were lower by approx 13.7 % with reference to the control and those reductions were statistically proven. It is worth noticing that differences between the achieved grain crop yields of the cultivated plants are not statistically significant considering a type of the applied organic material.

Fertilisation with manure and organic waste reduced total nitrogen contents in the grain of cultivated plants (Table 2). Statistically proven levels of these reductions were indicated for the objects where organic material was used in the year of the experiment, and they amount to 2.8–4.3 g N · kg^{-1} for spring triticale grain and 1.2–1.9 g N · kg^{-1} for oat grain.

The calculated crop yields of total protein in the grain of spring triticale and oat fertilised with organic matter are statistically higher in comparison with the control (Table 2). The increases in the spring triticale total protein varied from 86.5 kg · ha^{-1} in object K_2 to 102.9 kg · ha^{-1} in object K_5 with reference to the control and those for oat ranged from 36.2 kg · ha^{-1} to 63.8 kg · ha^{-1}. The total protein crop yields of the tested plants fertilised with organic substances once per two years were distinctly lower by 21.3 kg · ha^{-1} with reference to the fertilised objects, however these values were not statistically proven.

Fertilisation applied in the experiment modified the content of total phosphorus in spring triticale and oat grain varying within the range from 3.77 to 4.00 g P · kg^{-1} and from 3.76 to 3.95 g P · kg^{-1}, respectively. However, the achieved differences were not statistically proven.

Fertilisation with manure or fowl litter resulted in statistically significant increase in potassium content in spring triticale grain by 0.84 g K · kg^{-1} on average with reference to the control. A statistically proven increase in the amount of this element by 0.85 g K · kg^{-1} on average was also achieved in oat grain fertilised annually with manure or fowl litter. Using conditioned waste from poultry abattoir decreased potassium content in both triticale and oat grain with reference to the control, however, these values were not statistically proven.

The research carried out showed that fertilisation with conditioned waste from poultry abattoir resulted in statistically proven decrease in calcium content in spring triticale grain by 14.1 % on average with reference to the object not fertilized with organic substances. The triticale grain from the object where manure or fowl litter was applied contained more calcium in grain, on average by 14.1 % higher with reference to the control. No statistically proven difference in calcium contents in oat grain was found under the effect of the applied fertilisation and its content ranged from 0.48 to 0.55 g Ca · kg^{-1}.

A mean content of magnesium in spring triticale grain amounted to 1.48 g Mg · kg^{-1} and was not significantly modified by the tested factors. At the same time the grain of oat fertilized with organic matter contained more magnesium with reference to the

Table 2

Yield and chemical composition of grain spring triticale and oat

Parameter		Plant	Fertilizations objects							Mean	LSD
			K_0	K_1	K_2	K_3	K_4	K_5	K_6		
Grain yield [Mg · ha^{-1}]		triticale	1.04	1.86	1.83	1.78	1.81	1.84	1.82	1.71	0.147
		oat	1.15	1.79	1.53	1.71	1.49	1.75	1.50	1.56	0.138
N-total [g · kg^{-1}]		triticale	27.0	22.7	22.9	23.6	23.3	24.2	24.1	24.0	2.45
		oat	20.5	18.6	19.6	18.9	19.7	19.3	19.9	19.5	1.18
Protein yield [kg · ha^{-1}]		triticale	175.4	263.9	261.9	262.6	263.6	278.3	274.1	254.3	32.01
		oat	147.3	208.1	187.4	202.0	183.5	211.1	186.6	189.4	27.61
P	[g · kg^{-1}]	triticale	4.00	3.77	3.81	3.78	3.80	3.95	3.89	3.86	n. s.
		oat	3.95	3.80	3.76	3.77	3.81	3.89	3.88	3.83	n. s.
K		triticale	4.55	5.31	5.33	5.47	5.44	4.12	4.09	4.90	0.637
		oat	5.11	5.95	5.44	5.96	5.59	4.97	4.61	5.38	0.531
Ca		triticale	0.32	0.38	0.36	0.35	0.37	0.27	0.28	0.33	0.029
		oat	0.51	0.55	0.54	0.53	0.52	0.49	0.48	0.52	n. s.
Mg		triticale	1.49	1.48	1.47	1.48	1.47	1.47	1.49	1.48	n. s.
		oat	1.28	1.43	1.35	1.44	1.34	1.36	1.33	1.36	0.125

control. However, the achieved differences were statistically proven only for the grain obtained from the object annually fertilized with manure or fowl litter and were: 0.15 and 0.16 g Mg · kg^{-1}, respectively, with reference to the control.

Discussion

In the subject literature, the opinion prevails that fertilisation with organic substances affects the increase in the grain crop yield of cereal plants [7–9]. The results of Authors research confirm this opinion and the achieved growths in grain crop yield range from 29.6 % to 78.8 %. Similar increases in grain crop yields (by 60 %) were obtained by Stepien and Mercik [4] who applied feather meal cultivating spring triticale. Low crop yields of spring triticale 1.71 Mg · ha^{-1} and oat 1.56 Mg · ha^{-1} in our own research resulted from extremely low precipitation during plant vegetation period and a type of soil where the field experiment was carried out (Table 1).

Fertilisation with manure or other organic matter resulted in increase in the total nitrogen contents in the grain of cereal plants [5, 10, 11]. In our research it was found that the use of organic matter for cereal cultivation is to the detriment of the total nitrogen accumulation in grain. It probably resulted from a low amount of precipitation in the years of conducting the field experiment, which is crucial for the effectiveness of the applied fertilisation.

The increase in both grain crop yield and total nitrogen contents is brought about a considerable increase in total protein under the effect of applying organic matter [5, 10]. Using mineral and natural fertilization, Cwojdziński and Nowak [12] achieved the increase in the total protein crop yield by 181 % for spring barley and by 157 % for spring wheat; in our own research the growths in this crop yield ranged from 24.6 % to 58.7 %. Such a low increase in total protein of spring triticale and oat is a consequence of significant reduction of its content in the grain of these cereals.

The research by Stepien and Mercik [4] proves that applying feather meal induces the growth in contents of potassium, calcium and magnesium in spring triticale grain and does not modify the content of total phosphorus. The results of our own research showed that the use of conditioned waste from poultry abattoir significantly reduced only the amount of calcium in spring triticale grain. Differences in the results obtained may account for different granulation rate of the applied waste, which is important for the rate of its decay in soil. Rabikowska [10] demonstrated that fertilisation with manure increased the content of phosphorus in the grain of maize, but had no effect on calcium content. The research by Szulc [13] argues that mineral-natural fertilisation does not increase magnesium content in cereal grain. Our own research indicated that fertilization with manure or fowl litter increased the amount of: potassium in the grain of spring triticale and oat, calcium in spring triticale grain, and magnesium in oat grain. The growths of potassium contents in the achieved crop yield do not confirm the research made by Sadej and Mazur [7]. The diversity observed in the results of the research is probably a consequence of very unfavourable weather conditions so characteristic of the years 2004–2005, when the experiments were performed.

Conclusions

1. After applying manure, fowl litter or conditioned waste from poultry abattoir, a significant growth in the grain crop yields of spring triticale and oat as well as total protein content in their grains was observed. It indicates the possibility of usage these products in cereal fertilization.

2. Using organic substances in the fertilisation of triticale and oat reduced the total nitrogen content in the grain of these plants.

3. The research showed that natural fertilisation increased: potassium content in the spring triticale and oat grains, calcium in triticale grain, and magnesium in oat grain.

4. Fertilisation with conditioned waste from poultry abattoir lowered calcium content in spring triticale grain.

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PLONOWANIE ORAZ SKŁAD CHEMICZNY ZIARNA PSZENŻYTA JAREGO I OWSA NAWOŻONYCH ODPADAMI ORGANICZNYMI I OBORNIKIEM

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Abstrakt: Badania przeprowadzono w latach 2004–2005 na glebie płowej, zaliczanej do VI klasy. Eksperyment realizowano jako doświadczenie jednoczynnikowe w trzech powtórzeniach metodą losowanych bloków. Czynnikiem badawczym był rodzaj zastosowanej masy organicznej (obornik, pomiot ptasi i kondycjonowany odpad z ubojni drobiu), a jej dawki określono tak, aby ilość wprowadzonego azotu do gleby nie przekroczyła 170 kg $N \cdot ha^{-1}$. Oceniano wpływ zastosowanego nawożenia na plon i skład chemiczny uprawianych roślin.

Przeprowadzone badania wykazały, że stosowanie kondycjonowanego odpadu powodowało znaczący wzrost plonów ziarna pszenżyta jarego i owsa w stosunku do obiektu kontrolnego. Ziarno roślin pozyskanych z obiektów, na których stosowano kondycjonowany odpad z ubojni drobiu, zawierało mniej azotu ogólnego w odniesieniu do kontroli. Jednakże plon białka ogólnego, który zależy od ilości plonu ziarna i zawartości w nim azotu ogólnego, był wyraźnie większy po zastosowaniu kondycjonowanego odpadu w porównaniu z uzyskanym z obiektów nawożonych tylko nawozami mineralnymi.

Słowa kluczowe: pszenżyto jare, owies, obornik, odpady organiczne