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The Effect of Pig Liquid Manure Fertilization on the Crop of Alternating Grassland and Some Groups of Soil Mesofauna

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The effect of different doses of pig liquid manure, with or without the VG agent, on the crop of green forage of alternating grassland and the density of soil mites, springtails and enchytraeids was investigated. Low and medium doses of fertilizer increased both the crop and density of mites, springtails and enchytraeids, while the highest dose decreased these values, compare to the control plot. The Oribatida were usually less abundant than the Gamasida, and the increase of their density under fertilization was lower than that of Gamasida. Springtails reacted to liquid manure positively, and their density increased with the doses of fertilizer, independently from the presence of the VG agent. The enchytraeids reacted positively to low and medium doses of fertilizer without and with 2%VG (bactericidal) agent, except at the highest doses, which reduced their density, similar as all doses of fertilizer with 1%VG agent (fungicidal).

Key words: Fertilization, pig liquid manure, alternating grassland, Acari, Collembola, Oribatida.

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Grasslands are very important parts of agricultural landscape. They provide farmers with green forage, which is relatively cheap and of high nutritional value, and moreover they bind nutrients in dense turf, protecting ground water against eutrofication. Grasslands easily soak in water, improving the water regime of the landscape, which is important in regions with small rainfall. They also protect the soil against erosion, activate the soil life and increase the biodiversity of the lanscape.

Farmers increase the production of grasslands by mineral or organic fertilization, also with liquid manure, which is produced in a great amount in farms where animals are kept without litter. Generally liquid manure creates environmental problems, and therefore it is stored for some time and then is used as a fertilizer. Polish law (DZ.U. 2004) obligates every farmer that breeds 2000 pigs in a farm, each above 30 kg, or 750 sows to use at least 70 % of the liquid manure in his own fields, with a yearly dose at most 170 N ha^{-1}.

Pig liquid manure is a good fertilizer because it contains all the nutrients for plants and increases the crop of green forage and its quality. However, it contains a rich microflora with many pathogenic species, which are dangerous for domestic animals and people (KLUCZEK & KURTYKA 1995). Therefore, some chemicals like chlorine and its derivative agents are added in order to stop the development of pathogenic species (TRACZYKOWSKI *et al*. 1993).

Applying pig liquid manure and chemicals to soil affects the soil properties and soil inhabitants, including mites, springtails and enchytraeids. These groups are common and very important for soil fertility, because they decompose the organic matter and release the nutrients for plant growth and mix the organic matter with mineral parts. Some species are also sensitive to different factors and may be good bioindicators of changes in soil habitat, which take place under human activity.

The aim of this study was to assess the influence of different doses of pig liquid manure, with or without the VG (bactericidal of fungicidal) agent, on the crop of green forage and the density of soil mites, springtails and enchytraeids.

Material and Methods

The investigation was performed in the Experimental Station of Faculty of Animal Production, University of Technology and Agriculture in Mo-

chełek, about 20 km from Bydgoszcz. The description of this area, climate, soil and vegetation has been given earlier (DOMEK-CHRUŚCICKA & SENICZAK 2005a; SOKOŁOWSKA & SENICZAK 2005).

9 alternating grassland plots (4×5 m each) were selected, with 3 m buffer zones (plots 1-8 were treated with pig liquid manure and plot 0 was a control). This grassland was established in 1998, as a mixture of alfalfa (*Medicago sativa* L.) – 50 %, fescue (*Festuca pratensis* HUDS.) – 15 %, timothy (*Phleum pratense* L.) – 15 %, white clover (*Trifolium repens* L.) – 10 % and meadow clover (*Trifolium pratense* L.) – 10 %. The plant composition has slightly changed since its establishment, and in plots 1, 2, 4, 5, 7 and 8 alfalfa predominated and in the other plots, treated with the highest dose of liquid manure, couch grass (*Agropyron repens* (L.) P.B.) was very dense. Among a total 21 vascular plant species, 15 species were in the control plot and 13-15 species in fertilized plots. In plots 2 and 5 the plants were about 1/3 higher, while in plots 3, 6 and 9 they were distinctly lower than in the control plot. Plant covering in the plots was high (90-100 %).

Pig liquid manure was used in the spring of 2002 and 2003 in doses 10, 20 and 30 thousand l ha^{-1}, without (plots 1-3) or with the VG agent. The composition of the VG agent was the following: dicoordinating dimethylamonium chloride (100 g l^{-1}), dioxy-12-ethane (32 g l^{-1}), glutin dialdehyde (40 g l^{-1}) and formaldehyde (31.5 g l^{-1}). The 2 % VG agent was bactericidal (plots 3-5), and 1 %VG was fungicidal (plots 6-9). Liquid manure was stored according to norms, had pH=7.2 and contained in 1 dm^3: 39943.1 mg dry matter, 28647.3 mg organic matter, 2904.1 mg N (with 824.5 mg NH_4), 174.2 mg K, 962.3 mg P (with 348.3 mg PO_4) and 84.7 mg Mg.

Soil samples of 16.7 cm^2 and 9 cm deep were taken from each plot in 10 replicates in spring, summer and autumn 2002-2003. Next they were divided into the lower part of plants (G, 3-0 cm), and the upper S1 (0-3 cm) and lower S2 (3-6 cm) soil layers. Mites and springtails were extracted in high gradient TULLGREN funnels and separated and determined. From a total of 1,800 samples, 96,399 mites and 9,370 springtails were extracted. The Oribatida were determined to species or genus, including the juvenile stages. The enchytraeids were sampled in a similar way only in autumn, and extracted with the BAERMANN method (GÓRNY 1975). From a total of 420 samples 4,783 enchytraeids were extracted. For the Oribatida the SHANNON index was calculated (ODUM 1982), while in statistical calculations we used the TUKEY HSD test (ANOVA/MANOVA of Statistica5). To assess the crop of green forage and its content of elements, two samples were taken from each plot in every growing season. The quantity and quality of crop and list of species of Oribatida have been given earlier (DOMEK-CHRUŚCICKA & SENICZAK 2005a; DOMEK-CHRUŚCICKA & SENICZAK 2005b).

Results

Fertilization of alternating grassland with low and medium doses of pig liquid manure without

Table 1

Crop of green forage (t ha^{-1}), density of mites, springtails and enchytraeids (*N* in thousands indiv. m^{-2}), and species number (*S*) and *H* index of Oribatida in the investigated plots. Results significantly different at P<0.05 between: * plots 1-9 and a control plot; ^{A} plots 1-3 with 4-9

Characteristics		Plot									
		0	1	2	3	4	5	6	7	8	9
Green forage	*t*	34.5	45.0	53.9	28.1	37.5	50.3	24.8	39.8	53.3	27.3
Acari	*N*	64.8	72.1	88.6	69.6*	83.8	110.6*	74.7*	85.0	95.9*	74.9*
Gamasida	*N*	6.6	6.5	9.0*	22.1*	6.4	8.4	23.0*	7.0	12.0*	19.2*
Oribatida	*N*	5.8	8.1	8.3	11.3*	8.1	5.9	17.5*	8.1	9.8	15.5*
	S	6	9	10	5	11	8	9	7	11	7
	H	0.46	0.35	0.47	0.41	0.57	0.67	0.29	0.31	0.46	0.27
T. velatus	*N*	5.1	7.5	7.3	10.1*	7.6*	4.8	16.5	7.5	8.8	14.5*
juveniles	*N*	2.6	3.6	3.2	3.3	2.9	2.2	4.8	2.9	4.0	4.8
Brachychthonius sp.	*N*	0.4	0.4	0.8	0.9	0.1	0.7	0.7	0.1	0.5	0.9
Collembola	*N*	5.8	5.2	9.6	16.3	4.9	7.7	15.2	5.5	9.8	13.9
Enchytraeidae	*N*	14.9	20.4	27.9*	6.0*	18.6	25.0*	5.8*	8.0*^{A}	10.5^A	6.9*

Table 2

Vertical distribution of mites, springtails and enchytraeids (density of individ. 50 cm^{-3}) in the investigated plots. G – lower part of plants, S1 and S2 – soil layers

		Plot									
Group	Horizon	0	1	2	3	4	5	6	7	8	9
Acari	G	80	91	113	72	104	141	74	108	107	75
	S1	29	27	34	42	35	41	48	33	50	47
	S2	2	3	3	3	1	4	3	1	3	3
Gamasida	G	6	4	8	20	3	6	23	5	8	14
	S1	5	6	7	16	7	8	15	7	11	17
	S2	1	1	1	1	1	<1	1	<1	1	1
Oribatida	G	2	6	3	7	2	3	10	3	3	13
	S1	8	7	11	12	12	7	19	11	13	13
	S2	<1	1	<1	<1	<1	<1	<1	<1	<1	<1
Collembola	G	1	2	4	8	1	4	11	2	3	7
	S1	8	7	12	19	7	10	14	8	13	16
	S2	<1	<1	<1	1	<1	<1	1	<1	1	1
Enchytraeidae	G	8	8	16	4	7	10	3	1	4	4
	S1	15	26	29	6	22	31	5	12	12	8
	S2	3	<1	3	1	2	2	1	2	2	1

the VG agent increased the crop of green forage, but the highest dose reduced it, compared to the control plot (Table 1). The mites reacted positively to all doses of fertilizer, but the increase of their density was the highest in the plot with its medium dose, and the lowest with its highest dose, compared to the control plot. The VG agent stimulated the density of mites, especially at its medium concentration.

In most investigated plots the Gamasida were more abundant than the Oribatida, and predominated in plots 0, 2, 3, 5, 6, 8 and 9, while in the other plots the Oribatida were more numerous. Generally the density of these groups increased with increasing doses of fertilizer, but the increase in the Gamasida was higher than in the Oribatida. Under the influence of liquid manure the species number of Oribatida increased, especially at medium dose, affecting the *H* index, which was the lowest in plot 9 and the highest in plot 5. Among the Oribatida *Tectocepheus velatus* (MICHAEL) highly predominated in all plots, making up 82,4-94,1% of this group, with percent of juvenile stages between 29 (plot 6) to 51 (plot 1). Less abundant was *Brachychthonius* sp., while the other species were not numerous.

Interestingly, a low dose of liquid manure slightly decreased the density of springtails, while higher doses, with or without the VG agent, successively increased it. Low and medium doses of liquid manure with or without 2% VG increased the density of enchytraeids (significantly higher with a medium dose), while the highest dose of fertilizer significantly decreased it, compared to the control plot. Liquid manure with 1 % VG also decreased the density of enchytraeids, compared to the control plot.

The mites as a group preferred the lower part of plants, while the Gamasida and Oribatida lived mainly in the upper soil horizon (Table 2), like springtails and enchytraeids.

Discussion

The effect of pig liquid manure on production of alternating grassland depends mainly on its doses. A dose of 10 thousand l ha^{-1} increased the crop of green forage by 33.8 %, while 20 thousand l ha^{-1} by 56.2 %, compared to the control plot. Similar results obtained SOKOŁOWSKA and SENICZAK (2005) after application of cattle liquid manure without VG with doses 10 thousand and 20 thousand l ha^{-1}. Pig liquid manure contains distinctly more dry matter, total N, NH_4 and P, compared to cattle liquid manure (SOKOŁOWSKA & SENICZAK 2005). However, a dose of 30 thousand l ha^{-1} of pig liquid manure reduced the crop to 81.1 % of that from the control plot. The VG agent slightly decreased the crop of green forage. Green forage from fertilized plots was richer in crude ash, protein and fat, compared to the control plot (DOMEK-CHRUŚCICKA & SENICZAK 2005a).

The increase of crop of green forage under the influence of pig liquid manure in the investigated plots was partly caused by the positive reaction to this fertilizer of mites and enchytraeids, which decomposed the organic matter and released nutrients for plant growth. This was clear in the plots fertilized with only liquid manure, where all doses of fertilizer stimulated the density of mites, especially at medium dose. Similar results were obtained by SOKOŁOWSKA & SENICZAK (2005) with fertilization of alternating grassland with cattle liquid manure at doses 10 thousand and 20 thousand l ha^{-1}.

However, the highest dose of fertilizer increased the density less than the lowest dose which suggests perturbation in soil habitat. A negative influence of high doses of liquid manure on mites in grasslands was observed by BOLGER and CURRY (1980), while TROJANOWSKI and BALUK (1992) noted both the positive influence of a dose of 180 kg of mineral N ha^{-1}, and negative influence of higher doses of N on density of mites. MIKLASZEWSKI (1982) noted that the density of mites increased with higher doses of N. The mites reacted similarly to industrial pollution (SENICZAK *et al*. 1994, 1997), small doses of pollution stimulated the density of mites, while higher doses reduced it, compared to the control plot.

The enchytraeids reacted to liquid manure more distinctly than the mites. Small and medium doses of this fertilizer stimulated their density and increased the crop of green forage, while the highest dose decreased both the density of enchytraeids and the crop. This group reacted in a similar way to liquid manure in DEBRY and LEBRUN (1980) and to mineral fertilization (MAKULEC 1976).

A low dose of liquid manure slightly decreased the density of springtails, while higher doses successively increased it, independently of the presence of the VG agent. Similar results obtained MIKLASZEWSKI (1982) and DEBRY and LEBRUN (1980), but BOLGER and CURRY (1980) observed a negative influence of higher doses of liquid manure and ŻYROMSKA-RUDZKA (1976) of higher doses of mineral NPK on their density.

In the investigated plots the Oribatida were usually less abundant than the Gamasida, and under the influence of liquid manure the species number and their *H* index increased, especially with 2%VG, which is consistent with BIELSKA (1986) and BOLGER and CURRY (1980). BIELSKA and PASZEWSKA (1995) observed a positive reaction of mites to liquid manure in a meadow with boggy soil and a negative reaction in an intensely used meadow with mineral soil. Also BIELSKA (1986) noted a negative reaction to high doses of liquid manure, and ŻYROMSKA-RUDZKA (1976) to high doses of mineral NPK.

In the investigated plots the Oribatida were not abundant, which is typical for arable soils with neutral reaction (TISCHLER 1971). In these soils the bacteria predominate and decompose the organic matter quickly (BARDGETT & COOK 1998), decreasing the density of Oribatida, which prefer the litter (SENICZAK 1978). The density of mites in arable soils was also reduced by frequent soil cultivation (MIKLASZEWSKI 1982). Among the Oribatida *Tectocepheus velatus* highly predominated in all plots, this species tolerated different habitats (RAJSKI 1968) and liquid manure (BIELSKA & PASZEWSKA 1995).

The obtained results led to the following conclusions:

1. Fertilization of alternating grassland with low and medium doses of pig liquid manure increased the crop of green forage and density of mites and enchytraeids, while the highest dose decreased these values, compared to the control plot.

2. The Oribatida and Gamasida reacted to liquid manure positively, the latter group more distinctly than the former.

4. Springtails reacted to liquid manure positively, and their density increased with the doses of fertilizer, independently of the presence of VG.

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