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The Effect of Cattle Liquid Manure Fertilization on Alternating Grassland and Some Groups of Soil Mesofauna

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The influence of different doses of cattle liquid manure, with or without the VG agent, on the crop of green forage of alternating grassland, and on the density of mites, springtails and enchytraeids was investigated. Fertilizer without VG increased both the crop and density of mites, springtails and enchytraeids. The mites reacted positively to higher dose of liquid manure, especially with 2%VG (bactericidal). Liquid manure increased the density of Oribatida, especially the lower dose with and without 1%VG (fungicidal). Springtails responded to liquid manure positively, and their density increased with the doses of fertilizer, especially with 1%VG. The enchytraeids reacted positively to liquid manure with and without 2%VG, while fertilizer with 1%VG reduced their density, compared to the control plot. Fertilizer also caused the migration of some enchytraeids from the soil to lower parts of plants, compared to the control plot.

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

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Large animal farms produce substantial amounts of liquid manure, which causes environmental problems. The amount of liquid manure depends on animal species, its age and kind of nutrition and also on the method of breeding (with or without litter). Cattle gives about 10-20 litters of liquid manure a day, and when it is stored properly, it contains 1-3% of dry matter, 0.3-0.6%N, 0.5-0.8%K and 0.04-0.08%P (WESOŁOWSKI 1999).

Liquid manure has been used as a fertilizer for a long time, but recently its value has increased, mainly because of ecological farming and growing interest in production of good food for people. Moreover, liquid manure is cheap and decreases the costs of production, compared to expensive mineral fertilizers, and also contributes to environmental protection. It is especially important after the accession of Poland to E.U. and all European regulations and developmental projects. These regulations pay great attention to protection of agricultural ecosystems, and accordingly liquid manure may be applied to fields only from the 1st March till the 30th November, with an annual dose not exceeding 170 kg N ha^{-1} for arable lands, with minimal time of storage 4 months.

Liquid manure increases the soil fertility, as it contains all nutrients for plants, some organic matter, which is transformed into humus, and also intensifies the soil life. Therefore it is readily used as a fertilizer in permanent grasslands, with recommended doses between 10-20 m^3 ha^{-1}; the period for application is spring. In alternating grasslands liquid manure is seldom applied, although it increases the crop and quality of green forage and improves the density of turf. Alternating grasslands are used only for 2-5 years and there is no danger of intensive growth of weeds, which are stimulated by nitrogen and potassium (KOSTUCH 1982).

However, liquid manure creates many sanitary problems, as a great reservoir of fecal bacteria, such as those of the genera *Escherichia* and *Salmonella* and many others (KLUCZEK & SKINDER 1993), which are dangerous for animals and people. Therefore, chemicals such as chlorine and its derivative agents (lime, iodine, phenol, aldehyde) are added to stop the development of pathogenic species (TRACZYKOWSKI *et al*. 1993).

Liquid manure and chemicals, after application to soil, affect soil invertebrates, such as mites,

springtails and enchytraeids, which decompose the organic matter and release nutrients for plants. Additionally, it can affect the symbiotic microflora, which live in the alimentary canals of mites (STEFANIAK & SENICZAK 1985) and springtails (BURGES & RAW 1971) and decompose even such decay-proof substances as cellulose, lignin and chitin.

In this study the influence of different doses of cattle liquid manure, with or without the VG agent, on the crop of green forage of alternating grassland and the density of mites, springtails and enchytraeids was investigated.

Material and Methods

The investigation was performed in the Experimental Station of Faculty of Animal Production, University of Technology and Agriculture in Mochełek, about 20 km from Bydgoszcz. This area is flat and situated in the south-east edge of Krajna Lake District (98.5 m above the sea level, 17°51' eastern longitude and 53°13' northern latitude). The climate of this area is moderately warm, with a mean annual air temperature of 7.6°C, 432 mm precipitation and 217 days of growing season (BORYS *et al*. 1997).

The investigated grassland was established in 1998, with a mixture of the following plants: 50% alfalfa (*Medicago sativa* L.), 15% fescue (*Festuca pratensis* HUDS.), 15% timothy (*Phleum pratense* L.), 10% white clover (*Trifolium repens* L.) and 10% meadow clover (*Trifolium pratense* L.). The soil represented a typical Orthic Luvisol, which developed on fluvioglacial sands or boulder clay (BORYS *et al*. 1997). A detailed description of site location, climate, vegetation and soil has been given earlier (SOKOŁOWSKA & SENICZAK 2005a).

In the investigated grassland 7 plots (4×5 m each) were selected, with 3 m wide buffer zones (plots 1-6 were treated with cattle liquid manure and plot 0 was a control). The plant composition has slightly changed since its establishment, and plots 0, 1, 2, 5 and 6 were predominated by alfalfa (*Medicago sativa* L.) and the others by couch grass (*Agropyron repens* (L.) P.B.). Among a total of 19 vascular plant species, more were in the control plot (17) than in fertilized plots (11-14).

Cattle liquid manure was used in the spring of 2002 and 2003 in doses of 10 and 20 thousand l ha^{-1}, without (plots 1 and 2) or with the VG agent. The composition of the VG agent was as follows: 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 and 4), while 1%VG was fungicidal (plots 5 and 6). Liquid manure was stored according to norms, had pH=7.4 and contained in 1 dm^3: 16123.5 mg dry matter, 1296.1 mg N (with 327.4 mg NH_4), 505.4 mg K, 320.3 mg P and 49.3 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 of 2002-2003. Later 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 1,260 samples, 52,881 mites and 5,503 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, 2713 individuals were extracted. For the Oribatida the SHANNON *H* index was calculated (ODUM 1982), while in statistical calculations the TUKEY HSD test (ANOVA/MANOVA of Statistica5) was used. To assess the crop of green forage and the content of elements in it, two samples were taken from each plot in every growing season. The quantity and quality of crop and the list of species of Oribatida have been given earlier (SOKOŁOWSKA & SENICZAK 2005a; SOKOŁOWSKA & SENICZAK 2005b).

Results

Application of cattle liquid manure without VG to permanent grassland, especially the higher dose, increased the crop of green forage and the density of investigated groups of mesofauna (Table 1). Lower dose of fertilizer without VG slightly reduced the density of mites, but higher dose increased it, compared to the control plot. Both doses of fertilizer with 2%VG increased distinctly and significantly the density of mesofauna, but doses with 1%VG decreased it, compared to the control plot, except Collembola.

In the investigated plots the Oribatida were more abundant than the Gamasida and responded more distinctly to liquid manure than the Gamasida, especially to its lower dose. The density of Gamasida was significantly higher only in plots with liquid manure and 2% VG, compared to the control plot, while the density of Oribatida was significantly higher in all fertilized plots, except for the higher dose of fertilizer without VG. The fertilizer slightly increased the number of species of Oribatida, but generally decreased the *H* index, especially in plots treated with fertilizer and 1%VG. In plots 0, 1 and 4-6 *Tectocepheus velatus* (MICHAEL)

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 1-6 and 0; ^{A} plots 3, 5 and 1; ^{B} plots 4, 6 and 2

Characteristics		Plot						
		0	1	2	3	4	5	6
Green forage	*t*	36.0	46.2	56.3	33.8	32.3	38.3	27.0
Acari	*N*	67.8	65.0	84.6	95.9*^{A}	104.6*	50.5	66.6
Gamasida	*N*	5.9	6.1	7.1	8.6*	9.9*	4.1	7.9
Oribatida	*N*	1.9	13.9*	4.2	10.4*	10.0*^{B}	12.6*	9.5*^{B}
	S	4	5	5	7	9	9	7
	H	0.81	0.65	0.85	0.77	0.77	0.21	0.36
T. velatus	*N*	1.2	10.8*	1.61	2.0^{A}	7.7*^{B}	12.2*	8.6*^{B}
juvenile	*N*	0.7	6.1	1.0	1.0	5.9	4.6	3.0
Brachychthonius sp.	*N*	0.6	2.6*	2.4*	7.6*^{A}	1.5	0.2^{A}	0.7^{B}
Collembola	*N*	4.4	7.2*	7.7*	9.2*	9.3*	7.2*	9.6*
Enchytraeidae	*N*	6.0	15.1*	23.2*	13.0*	13.8*^{B}	2.7*^{A}	7.8^{B}

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

Groups		Plot						
		0	1	2	3	4	5	6
Acari	G	84	57	106	90	110	45	70
	S1	24	49	33	66	62	36	37
	S2	3	1	4	3	3	<1	3
Gamasida	G	3	3	5	2	4	2	5
	S1	6	7	6	11	12	4	7
	S2	1	<1	<1	1	1	1	<1
Oribatida	G	<1	2	1	1	1	1	3
	S1	3	22	6	16	16	19	12
	S2	<1	<1	<1	<1	<1	<1	<1
Collembola	G	2	1	2	1	1	1	3
	S1	6	11	10	15	13	11	13
	S2	<1	<1	1	<1	1	<1	<1
Enchytraeidae	G	2	15	22	11	15	2	7
	S1	8	9	14	10	7	3	6
	S2	<1	2	2	1	2	<1	1

highly predominated, and in plots 2 and 3 the genus *Brachychthonius* was the most numerous. Interestingly, in plots 3 and 4, treated with fertilizer and 2%VG, there were more juvenile stages (50-77%) in the population of *T. velatus* than in plots 5 and 6, treated with fertilizer and 1%VG (35-37%). The other species, such as *Achipteria coleoptrata* (L.), *Eupelops occultus* (C. L. KOCH), *Liebstadia similis* (MICHAEL), *Scheloribates latipes* (C. L. KOCH) and *Trichoribates novus* (SELLNICK) were distinctly less abundant. These species inhabited mostly the upper soil layer, but also migrated to the lower part of plants (Table 2).

The springtails responded to all doses of liquid manure and VG by significantly increasing their density. A higher dose of fertilizer increased the density of springtails, with the highest density in the plot with 1%VG. The density of enchytraeids was significantly higher in plots treated with fertilizer with and without 2% VG, but 1% VG had a small effect or reduced their density, compared to the control plot.

The springtails preferred the upper part of the soil, and fertilizer increased their number on plants from 75% of the population in the control plot to 81-93% in the fertilized plots. Liquid manure also increased the number of enchytraeis on the lower part of plants from 20% of the population in the control plot to 20% to 40-63% in fertilized plots.

Discussion

The application of cattle liquid manure with or without VG to alternating grassland, especially the higher dose, increased the crop of green forage and the content of crude protein and fat, compared to the control plot (SOKOŁOWSKA & SENICZAK 2005a). A dose of 10 thousand l/ha increased the crop by 28%, and the dose 20 thousand l ha^{-1} more than 56%, compared to the control plot. Similar results were obtained by DOMEK-CHRUŚCICKA & SENICZAK (2005) after application of pig liquid manure without VG with the same doses of fertilizer per ha, but the dose 30 thousand l ha^{-1} reduced the crop of green forage, compared to 10 thousand l ha^{-1}. Cattle liquid manure contained less dry matter, total N, NH_4 and P, compared to pig liquid manure (DOMEK-CHRUŚCICKA & SENICZAK 2005). The addition of VG to cattle liquid manure slightly decreased the crop, except a lower dose of fertilizer with 1%VG.

A positive effect of cattle liquid manure on the crop of green forage may be partly explained by the increase of abundance of all investigated groups of mesofauna, especially enchytraeids and springtails, which decompose the organic matter and release the elements for plant growth. A higher dose of fertilizer without VG highly increased the density enchytraeids and springtails, and distinctly increased the density of mites. A positive influence of small and medium doses of N fertilization on density of enchytraeids was reported by MAKULEC (1976) and NOWAK (1976) and on springtails by ŻYROMSKA-RUDZKA (1976), CURRY (1979), BOLGER & CURRY (1980), MIKLASZEWSKI (1982) and BIELSKA & PASZEWSKA (1995). In the study of DOMEK-CHRUŚCICKA & SENICZAK (2005), a dose of pig liquid manure of 30 thousand l ha^{-1} reduced the density of mites, springtails and enchytraeids, compared to the control plot.

On the basis of the obtained results it is difficult to explain a decrease of crop of green forage under the influence of liquid manure with 2%VG, which increased the density of mites and springtails, but decreased the density of enchetraeids, compared to fertilizer without VG. In arable soils bacterial-feeding fauna (BARDGETT & COOK 1998) predominate, so 2%VG probably decreased the activity of bacteria and the crop.

The Oribatida tolerated liquid manure, especially its lower concentration, and were generally more abundant than the Gamasida. Also CURRY (1979), BOLGER & CURRY (1980) and BIELSKA (1986) observed a reduced density of mites under a high dose of this fertilizer. The reaction of Oribatida to different doses of fertilizer and VG is well explained at the species level, e.g. in predominating *Tectocepheus velatus* and *Brachychthonius* sp. In plots 1, 4, 5 and 6 *T. velatus* was about 5-6-times more numerous than in the control plot, while in the other plots the genus *Brachychthonius* was more abundant, achieving in plot 3 over 12 times higher density than in the control plot. It is known that *Tectocepheus velatus* tolerates liquid manure (BIELSKA & PASZEWSKA 1995).

Liquid manure caused the migration of some enchytraeids from the soil to the lower parts of plants, but did not affect distinctly the vertical distribution of mites and springtails. The enchytraeids were sensitive to pig liquid manure with a dose of 30 thousand l ha^{-1} (DOMEK-CHRUŚCICKA & SENICZAK 2005), so their migration to the lower parts of plants may be caused by a higher N concentration in soil. In the lower parts of plants many oribatid species occurred, such as *Achipteria coleoptrata*, *Eupelops occultus*, *Liebstadia similis*, *Scheloribates latipes* and *Trichoribates novus*, which are potential hosts of cestoids from the group of Anoplocephalata (RAJSKI 1959), which parasitize on cattle and sheep and therefore have an epidemiological meaning.

The following conclusions can be made from the investigation:

1. Fertilization of alternating grassland with cattle liquid manure without VG increased both the crop of green forage and density of mites, springtails and enchytraeids.

2. Cattle liquid manure increased the density of Oribatida, especially the lower dose with and without 1% VG.

3. Springtails responded to liquid manure positively, and their density increased with the doses of fertilizer, especially with 1%VG.

4. The enchytraeids reacted positively to liquid manure with and without 2%VG, while 1%VG reduced their density, compared to the control plot. Compared to the control plot, the fertilizer also increased the migration of enchytraeids from the soil to the lower parts of plants.

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