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THE EFFECT OF PROBIOTICS ON POULTRY DUNG APPLICATION, REDUCTION OF MINERAL FERTILIZATION AND YIELD OF SELECTED CROPS

Summary

Poultry dung may hardly be applied in fertilization of crops unless priobiotics are used and in many cases it may not be used as fertilizer, since it causes the so-called physiological drought. The use of adequate amounts of probiotics, i.e. the so-called live microorganisms, has an advantageous effect on fertilization properties of poultry dung. Application of poultry dung in combination with probiotics resulted in high, stable yields of cereals. This makes it possible to eliminate mineral fertilisation on farms, leading to tangible financial returns.
***Key words**: probiotics, poultry dung, manure, microorganisms*

WPŁYW PROBIOTYKÓW NA ZASTOSOWANIE OBORNIKA DROBIOWEGO, REDUKCJĘ NAWOŻENIA MINERALNEGO ORAZ PLON WYBRANYCH ROŚLIN UPRAWNYCH

Streszczenie

Obornik kurzy, bez zastosowania priobiotyków jest trudny w nawożeniu roślin uprawnych, a w wielu przypadkach nawożenie nim jest niemożliwe, gdyż powoduje tzw. suszę fizjologiczną. Zastosowanie w odpowiedniej ilości Probiotyków, czyli tzw. "żywych drobnoustrojów", wywiera korzystny wpływ na właściwości nawozowe obornika drobiowego. W wyniku zastosowania obornika drobiowego z dodatkiem probiotyków, stwierdzono utrzymanie się plonów zbóż na wysokim, wyrównanym poziomie. Stworzyło to możliwość wyeliminowanie nawożenia nawozami mineralnymi w gospodarstwie, w wyniku czego otrzymano wymierne efekty finansowe.
***Słowa kluczowe**: probiotyki, obornik drobiowy, nawóz naturalny, mikroorganizmy*

1. Introduction

Manure, also called dung or muck, is a natural and basic fertilizer composed of fermented faeces, urine and bedding. It is the most valuable natural fertilizer, since it contains all macro- and micronutrients required for plant growth [1].

Manure thanks to its properties is considered to be one of the best measures preventing or reducing soil degradation [3, 4, 6, 11]. While the use of mineral fertilizers only at high application rates over an extended period of time has a negative effect on soil structure, regular application of manure and calcium promotes good soil structure [13, 14]. In view of the chemical composition of manure, particularly the contained nitrogen, poultry dung may be considered the best source of this nutrient for plants. However, the adverse ratio of organic nitrogen to readily available mineral nitrogen limits applicability of such fertilizer in fertilization. Thus, inappropriate use of poultry dung may contribute to the development of the so-called physiological drought effect [8]. Moreover, a frequent problem in the wider application of poultry dung in field crop farming is connected with the high concentration of animal farms over a limited area [15].

In view of changes leading to the intensification of animal production, particularly poultry farms, manure is frequently perceived as noxious waste. However, using appropriate means and technologies the highly beneficial properties in plant nutrition and improvement of physico-chemical properties of soil may be restored to the discussed fertilizer at the simultaneous reduction of noxious gas emissions.

Chemical processes occurring in the poultry dung heap consist in the conversion of organic nitrogen to its mineral forms as a result of microbiological transformations included in the processes of ammonification, nitrification and denitrification [10]. These processes may be greatly accelerated and improved thanks to the application of an appropriate mixture of microorganisms. Direct supplementation of manure with microorganisms responsible for processes of organic matter transformation results in a reduction of time required for manure compositing and contributes to reduction of odour emissions. Our observations indicate that compositing time may be shortened, but also the course of the process may also be transformed into much safer for the environment [8].

2. Material and methods

The experiment was established in the years 2003-2005 on a farm belonging to Mr. and Mrs. Kosakowski in Raduszyna near Murowana Goślina over a total area of 60 ha. In the years 2008-2013 the investigations were continued, aiming at the verification of the potential to reduce rates of mineral fertilisation of selected crops as a result of poultry dung application. In the investigated farm in Łopuchowo its chemical composition differed primarily in the content of organic nitrogen (table 1).

Poultry dung produced on the farm was applied in the autumn under winter cereals, after it had been stored on a manure pad for 2-4 months. The farm comprises 7 poultry houses with the annual capacity of 700 thousand chickens. Assuming manure production at 2 kg/head per cycle we obtain 1 400 000 kg manure a year. Long-term composting of such tremendous amounts of dung is connected with numerous problems, of which the most significant is the emission of odours and pollutants as well as the necessity to allocate a vast area required for its storage. Regular observations were recorded in the course of the experiment in order to identify basic disease symptoms of cereals, i.e. winter rye, winter triticale, winter wheat, barley and spring oat, which account for 90% of all crops.

Table 1. The composition of poultry manure produced on the analyzed farm
Tab. 1. Skład obornika drobiowego z badanej fermy

Sample code	Sample label	Level of component in % fresh matter				
		S.M.	Norg	P_2O_5	K_2O	MgO
NO/6/23	Hall 1*	52.55	2.37	1.83	1.91	0.442
NO/6/24	Biohouse 2**	53.78	3.53	1.86	2.73	0.494
Experimental procedure/standard		PB 26	PB 31	PB32	PB33	PB 41

* no probiotics applied ** at application of probiotics
Source: Own work / Źródło: opracowanie własne

On the farm probiotic preparations are used, which improve animal living conditions, resulting in the safe application of animal faeces, i.e. poultry dung, in soil fertilisation. The applied biological agents meet the guidelines of the Institute of Plant Protection.

3. Results

The composition of dung and properties of this manure are dependent on such factors as the weight and age of birds, used feed, amount of provided water as well as the adopted poultry keeping system [2]. This waste is mainly composed of bird droppings, small amounts of feathers and scattered feed. The chemical composition of bird droppings used in this study contained on average 1.6% N, 1.5% P_2O_5, 0.8% K_2O, 2.4% CaO and 0.7% MgO at a 56% water content. It is well known that chicken droppings have an advantageous effect on the amount of produced biomass, while its chemical composition is strongly modified not only as a result of applied fertilization, but also as a result of transformations, to which organic substances are subjected to in the soil and these in turn are dependent on the frequently changeable environmental factors [2, 15].

Table 2. Selected parameters of poultry dung depending on the moisture content
Tab. 2. Wybrane parametry obornika drobiowego w zależności od jego wilgotności

Years of study	Parameter		
	Moisture content in %	Nitrogen content in manure dry matter	$N \cdot t^{-1}$ manure
2003-2005	51.93	2.36	23.60 *
2010/2011	54.00	3.30	17.82 **
	47.00	4.63	21.76**
2011/2012	52.50	6.39	33.55***
Mean	51.36	4.17	24.18

* average result recorded on farms
** on the farm in Łopuchowo with no probiotics applied
*** on the farm in Łopuchowo at application of probiotics
Source: Own work / Źródło: opracowanie własne

Table 2 presents results of analyses on natural fertilizers conducted in the years 2003-2005 as well as 2010-2011 and 2011-2012. It results from the conducted analyses that at the chicken droppings moisture content of 51.93% the weighted mean of nitrogen content is 2.36% (23.6 kg $N \cdot t^{-1}$ manure) on a fresh mass basis. At a moisture content of 54 % and 47% the level of nitrogen in manure dry matter was 3.3% and 4.63% nitrogen, respectively. This practically means that at the application of a ton of manure 17.82 kg or 21.76 kg nitrogen are supplied, respectively. In turn, at a 52.5% moisture content of droppings the result was 6.39% N on a dry mass basis. This means that 1 ton manure contains 33.55 kg nitrogen. Due to the large amounts of nitrogen in chicken droppings and the contents of chemical substances as well as adverse bacterial flora potentially found in faeces and bedding [6], it should not be applied directly after the production cycle. Moreover, application rates should not exceed 10-15 $t \cdot ha^{-1}$.

The use of a mixture of microorganisms in rearing of broiler chickens resulted first in the marked reduction of ammonia emission and acceleration of manure fermentation processes, which is also confirmed by studies conducted by other authors [7, 15]. Apart from the reduced odour emissions, a markedly lower temperature of heaped manure was reported. The first such observation was recorded in the winter, when a 1-month old manure heap was covered by a layer of snow at a temperature of approx. 0ºC. It was found that poultry dung stored in heaps for 3 months has the consistency and composition of cattle manure stored in heaps for 6 months.

In 2010/2011 tillage and cultivation measures were applied in the culture of winter wheat cv. Gradan (tab. 3) on a field of 40 ha, divided into two parts: 15 ha – fertilized with poultry dung applied at 5 ton poultry dung per 1 ha, and 25 ha – fertilized with mineral fertilizers at 200 $kg \cdot ha^{-1}$. Belts of the width equivalent to two passages of a manure spreader, i.e. approx. 10 m, were applied experimentally. Manure application rate not only caused no physiological drought or lodging, but manure markedly improved health of plants and the yield produced was 46.6 $q \cdot ha^{-1}$.

The experiment showed the effect of poultry dung on health and yielding of fertilized cereals. High health status was observed in the four cereal species (tab. 4), along with no disease incidence and reduced weed infestation. As a result clean, high quality straw was produced, with no signs of infestation by disease or pests, at satisfactory, high yields (tab. 4). This system also resulted in lower costs of mineral fertilization.

In poultry dung biological transformations are very intensive, resulting in very high ammonia emissions to the atmosphere and unpleasant odour. In our experiment thanks to the use of microorganisms emissions of ammonia and noxious gasses were reduced, which was confirmed as early as in 1997 by Lee and Salminen [9]. Moreover, no physiological drought was observed in cereals even in the spring, which is found frequently when using poultry dung. The advantageous effect of fertilization with sewage sludge on the yield of durum wheat biomass was shown by Jamil et al. [7].

Table 3. Applied tillage and cultivation measures in culture of winter wheat cv. Gradan fertilized using poultry dung and mineral fertilizers in 2010/2011
Tab. 3. Stosowane zabiegi uprawowe i pielęgnacyjne w uprawie pszenicy ozimej Gradan nawożonej obornikiem drobiowym i nawozami mineralnymi w 2010/2011 roku

No.	Cultivation and tending measures *Zabiegi uprawowe i pielęgnacyjne*	Dose, unit *Dawka, jednostka*	List *Wyszczególnienie*
1.	Probiotic spraying Oprysk probiotykiem	20.0 $l \cdot ha^{-1}$	EmFarma
2.	Presowing cultivation + manure – 15 ha	5 $t \cdot ha^{-1}$	Disc harrow
3.	Presowing cultivation + Lubofoska – 25 ha	200 $kg \cdot ha^{-1}$	
3.	Wheat sowing	322.0 $kg \cdot ha^{-1}$	Sowing and cultivation unit „Poznaniak"
4.	Fertilisation: ammonium nitrate	92.0 $kg \cdot ha^{-1}$	34% ammonium nitrate
5.	Blind cultivation - harrowing	-	Weeding harrow
6.	Spring fertilisation: ammonium nitrate – 25 ha	150.0 $kg \cdot ha^{-1}$	Ammonium nitrate
7.	Spraying with probiotic with added fertiliser	10.0 $l \cdot ha^{-1}$ 3.0 $l \cdot ha^{-1}$	EmFarma Florovit
8.	Spraying with chemical herbicide	13.3 g 48.0 g 0.08 l	Apyros 75 WG Picaro SX 50 SG Trend 90 EC
9.	Fertilisation Florovit	3.0 $l \cdot ha^{-1}$	Florovit
10.	Spraying with probiotic EmFarma Ema 5	20.0 $l \cdot ha^{-1}$ 3.0 $l \cdot ha^{-1}$	EmFarma Ema 5
11.	Harvesting with a combine harvester	46.6 $q \cdot ha^{-1}$	Grain yield

Source: Own work / Źródło: opracowanie własne

Table 4. Health status and yielding of cereals fertilized with poultry dung
Tab. 4. Zdrowotność i plonowanie zbóż nawożonych obornikiem drobiowym

List	Cereal species			
	Winter wheat cv. Gradan	Winter rye cv. Bosmo	Spring barley	Spring oat cv. Flemings Profi
Diseases and pests	High health status			
	No disease: powdery mildew of cereals, take-all disease, septoria leaf spot, septoria ear spot disease, ear blight, yellow rust, leaf-strip disease, loose smut of wheat, snow mould, root rot of seedlings			
	Counts of agrophages below infestation threshold			
Yield quality	grain: no infestation by pests,			
	straw: clean, high quality, no symptoms of infestation by disease or pests			
Grain yield in q/ha	**46.6**	**40.3**	**41.6**	**18.8**
Weed infestation	observed, herbicides applied			
	Apyros 75 WG, Picaro SX 50 SG	Glean 70 WG	Dragon 450 WG	Lintur 70 WG
Others	Shorter snowmelt deposition in depressions and water-logged sites			
	Lower costs of mineral fertilisation and fuel purchase			
	Limited emissions of ammonia and noxious gases			
	Accelerated droppings composting			
	No physiological drought			
	Lower demand for energy			

Source: Own work / Źródło: opracowanie własne

4. Concluding remarks

Long-term studies showed a positive effect of fertilization with poultry dung on productivity, yield quality and plant health.

Limitations concerning the type of manure admissible in organic farming result from the fact that manure produced in commercial scale intensive animal rearing may contain such contaminants as residue of hormones, antibiotics, pesticides, pathogens or other adverse substances. The composition of droppings and their properties are dependent on many factors such as the weight and age of birds, used feed, the amount of provided water as well as the adopted poultry breeding system has a considerable effect on the composition and properties of produced manure. The application of probiotic substances in composting of manure collected from commercial intensive farms causes a considerable improvement of manure properties. Additional studies need to be conducted, which would provide the basis for certification for the application of such processed manure also in organic farming.

The high content of nutrients in poultry droppings and the specific action of nitrogen results in a situation, when it needs to be used at application rates of 10-15 $t \cdot ha^{-1}$under the same crops and at identical dates as cattle manure.

Due to the high amounts of nitrogen in poultry dung it should not be used directly after the production cycle, among other things due to the contained chemicals and adverse bacterial flora potentially found in faeces and bedding. It was shown that the application of probiotics reduced the time required for manure composting two-fold. Thus it may be stated that in their presence the course of this process was safer for the environment and contributed to an increased contents of available nutrients.

In this study the application of manure improved soil structure in contrast to the control tillage and only mineral fertilization. This seems to be connected with the continuous release of organic substance to soil, which provides advantageous conditions for the formation of aggregates more resistant to the disintegrating action of water. Recorded observations need to be confirmed by further regular and detailed investigations of the effect of probiotics used during chicken rearing on poultry dung, reduction of odours and emission of noxious gases to the atmosphere during its composting.

5. References

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