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THE EFFECT OF POLYAMIDE PA-6 ON NITROGEN CHANGES IN SANDY SOIL FERTILIZED WITH SLURRY

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A b s t r a c t. The research was made in controlled laboratory conditions to determine the polyamide PA-6 effect on sandy soil pH, nitrogen changes and total microbiological activity.

It was noted that the polyamide alone causes the lowering of the soil pH which is especially unfavourable in case of sandy soils. When we apply it together with slurry, the soil reaction is similar to that in soil fertilized with slurry.

Polyamide PA-6 causes the stimulation of ammonification and nitrification processes and respiratory activity in the soil tested. Because of nitrogen balance and plant nutrition, the term of introducing this preparation into the soil should be controlled and applied together with components which would neutralize its acidifying effect.

K e y w o r d s: polyamide, sandy soil, pH, nitrogen transformation, microbial activity

INTRODUCTION

The applying of organic fertilizers belongs, since many years, to the traditional methods of improving physical, chemical and biological properties of soil and replenishing nutrients in light textured soil [2]. Slurry belongs to these fertilizers [4]. However, at improper slurry fertilization, especially in light textured soils, large loss of nitrogen occurs. Nitrogen which has not been uptaken by plants undergoes biological sorption to a little extent. Its majority oxidizes in the from of ammonia or free nitrogen and a part of it is leached from the soil in the nitrate forms [6]. Thus, there is a problem of too great loss and insufficient effectivity of slurry fertilization and of underground water pollution with nitrates [7]. The aim of the present work was to recognize the effect of polyamide PA-6, which has high sorptive capacity [15], on changes of nitrogen forms and the podzolic soil reaction after slurry application. Moreover, it aims at determining the influence of the polyamide sorbent tested on total microbiological activity of soil on the basis of the intensity of CO_2 emission.

MATERIALS AND METHODS

The study was carried out on pseudopodzolic soil formed from weakly loamy sand with 0.04 % organic C and 0.296 % total N content; pH(H_2O)-5.6. The soil taken from the layer of 0-20 cm after screening through a sieve (with mesh diameter of 2 mm) was placed in high glass containers of 330 cm^3 capacity. Into each jar a 100 g portion of soil was weighed. The laboratory experiment included the following combinations:

1 - not enriched soil - control,
2 - soil with slurry addition 6 cm^3,
3 - soil + 5 g of polyamide (5 %), and
4 - soil + 6 cm^3 of slurry + 5 g of polyamide.

Each combination was made in 3 repetitions. Soil samples were incubated in the temperature of 20 °C ±2 °C, keeping constant soil moisture on the level of 50 % of the total water capacity.

The biochemical analyses were made in the day of starting the experiment and after 3, 7, 14, 21, 42 and 110 days of incubation. The following determinations were performed: the pH(H_2O) of soil - potentiometrically, ammonification intensity with Greweling and Peech's method [12], nitrification intensity with brucine method by Greweling and Peech [12], N-NH_3 with absorption method according to Bremner [1], the content of N-NO_2 with modified Griess-Ilosvay method [3], and the respiration activity with Ruhling and Tyler's method [13].

RESULTS AND DISCUSSION

The analysis showed that fertilizing with polyamide alone caused the increase of soils reaction in the initial phase of the experiment (Fig. 1). A transitory pH increase of the soil enriched with polyamide was probably caused by releasing N-NH_4 from polyamide (1 ml of polyamide water extract contains about 25 µg of ammonium nitrogen), however after its change into nitrate nitrogen the decrease of soil reaction below the value achieved in the control proceeds.

The treatments with slurry and slurry with polyamide had quite stable soil reaction. In the soil with slurry and polyamide this stabilization is caused by two contradictory processes: the increase of N-NH_4 content (Fig. 2), which neutralizes the reaction of acid soil on one hand, and acidifying effect of polyamide on the other. The increase of the control soil reaction may have been caused by optimizing the temperature and moisture conditions in this soil which gave good conditions for microelemental plant residue decay (the soil samples were taken from the field cultivated shortly after farm-yard manure application).

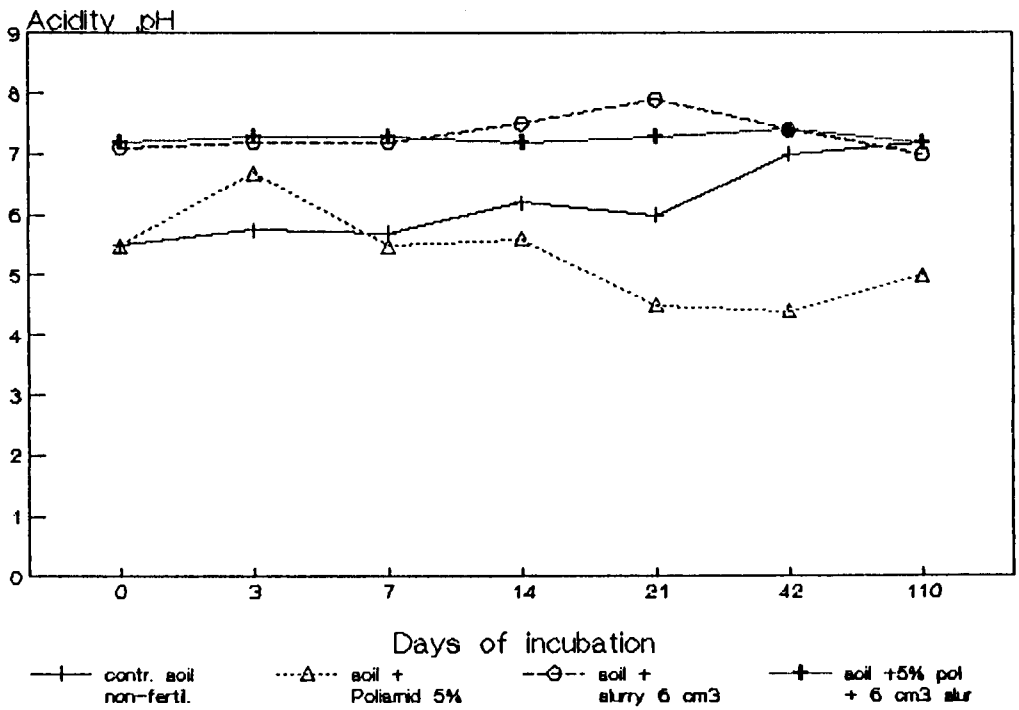

Fig. 1. pH changes of podzolic soil.

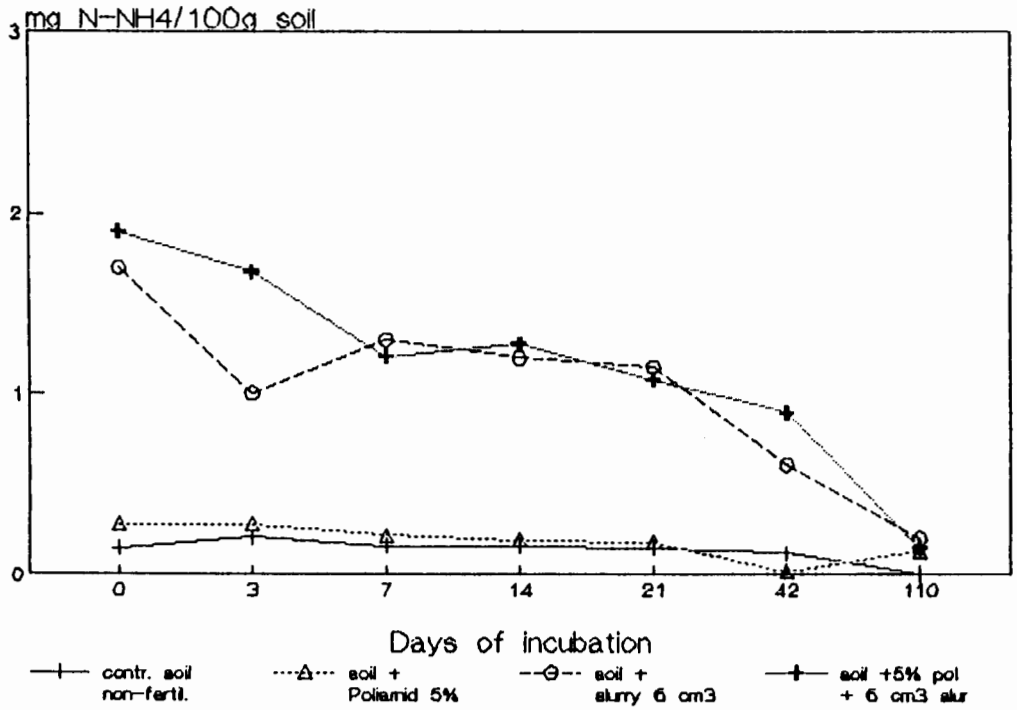

Fig. 2. Content of ammonium nitrate in podzolic soil.

The ammonium nitrogen content in podzolic soil changed periodically (Fig. 2). The lowest amount of this nitrogen form was noted in the soil enriched with polyamide, however, initially it was a little higher than in the control sample. This content lowered gradually during the incubation period achieving the minimal value after 42 days, amounting to 0.02 mg $N\text{-}NH_4$/100 g of soil. After the decrease period, a gradual increase of $N\text{-}NH_4$ amount proceeds, exceeding in the final phase of the experiment the values achieved in the control. A bit higher initial content of $N\text{-}NH_4$ is caused by the presence of soluble bonds in the polyamide water extract.

In the soil enriched with slurry and slurry with polyamide, a very high content of $N\text{-}NH_4$ was noted. As it results from the course of the curve, from the initial value of 1.7 mg in the slurry combination and 1.9 mg in that with slurry and polyamide, a decrease of ammonium nitrogen proceeded. From the 3rd to 7th day in the first case and from the 7th to 14th in the second, the increase of $N\text{-}NH_4$ content was noted. After the transitory increase, a renewed decrease of this form of nitrogen proceeded to the value of 0.2 mg at the end of the experiment. So high an initial $N\text{-}NH_4$ content is the result of high mineral nitrogen content (in ammonium form) in slurry [8] and quick mineralization of simple nitrogen linkages. The decrease of $N\text{-}NH_4$ content in the later period of the experiment may be explained by the transformation of this nitrogen form into nitrate N (Fig. 3) and the occurrence of loss (Fig. 4).

Probably also a quick depletion of simple nitrogen linkages contributed to the decrease of the amount of ammonium nitrogen, only after some time the selection of microorganisms and the proliferation of microorganisms capable of utilizing hardly accessible fractions of nitrogen substances proceeded. The ammonium nitrogen content in the combination

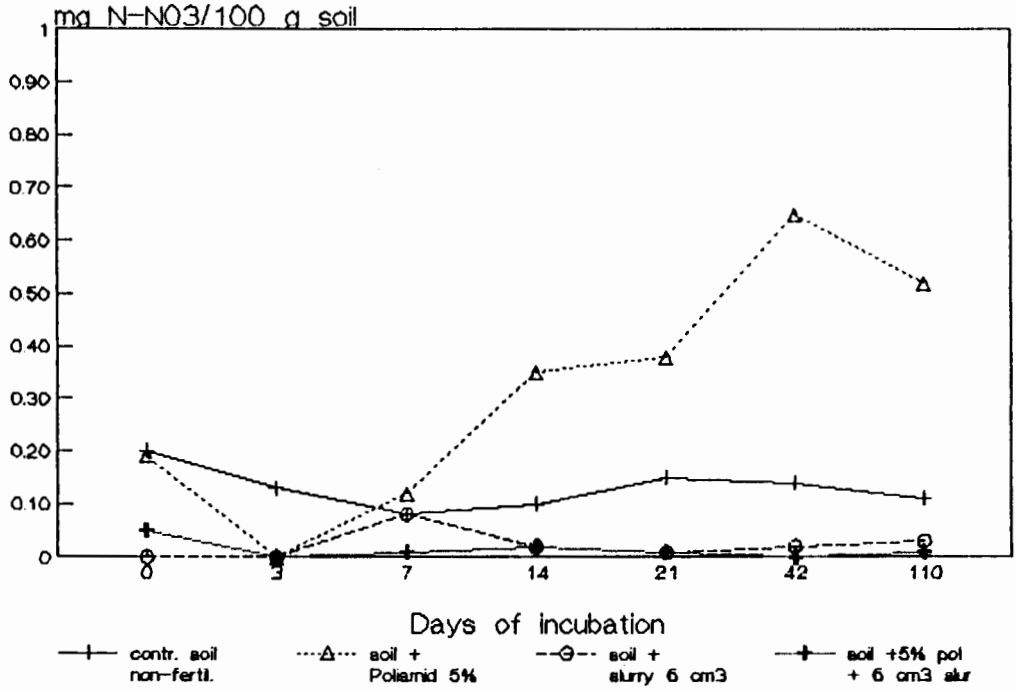

Fig. 3. Content of nitrate nitrogen in podzolic soil.

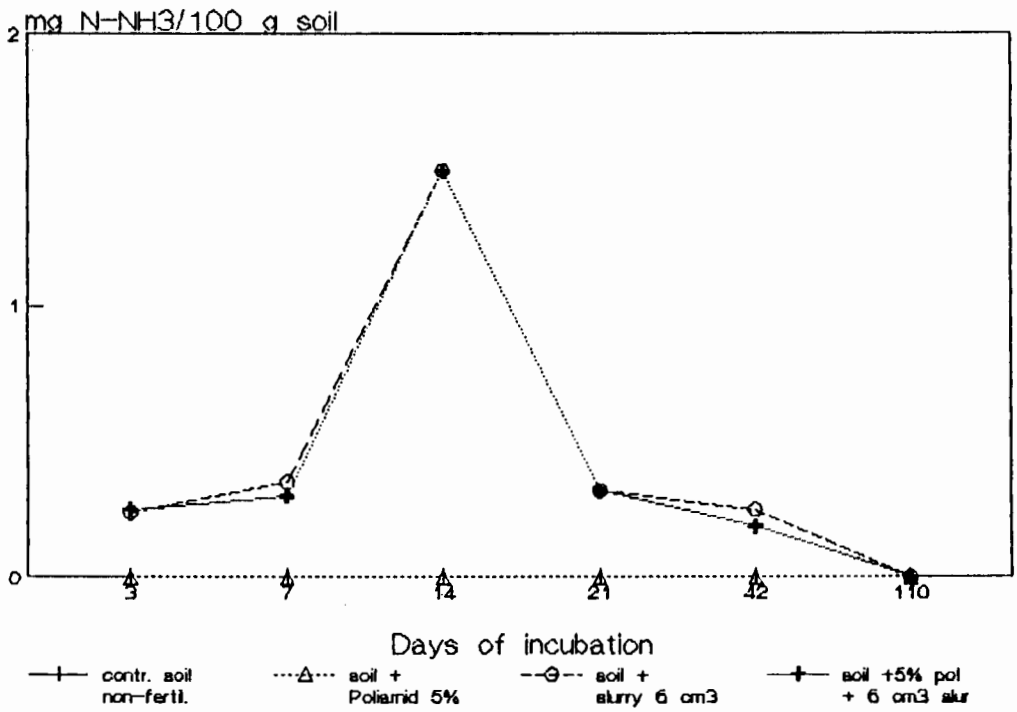

Fig. 4. Content of ammonium nitrate in podzolic soil.

with polyamide and slurry was slightly higher than in the combination with slurry alone. This difference should be probably explained by sorptive properties of polyamide. As we know, slurry contains phenols to which microorganisms are sensitive [10]. Probably polyamide is capable of these compounds sorption.

It should be stressed that so quick a mineralization process of nitrogen compounds is an unfavourable phenomenon, especially in light textured soils. In the field conditions, high loss of $N\text{-}NH_4$ as a result of elution and nitrogen oxidizing would occur.

The results pertaining to nitrate nitrogen content in podzolic soil indicate various intensity of nitrification course, depending on the factor enriching the soil (Fig. 3). In the soil enriched only with polyamide the discussed nitrogen form showed distinct increase tendency between the 3rd and 42nd day of the incubation; in that period the content of $N\text{-}NO_3$ increased four times. In the final phase of the experiment the decrease in the nitrate nitrogen content proceeded in this treatment. In the soil enriched with slurry as well as in that with polyamide and slurry the nitrification was the slowest oscillating around the value of 0.02 mg $N\text{-}NO_3$/100 g of soil. Such a low nitrification force was probably caused by large ammonium nitrogen loss in these combinations (Fig. 4).

Moreover, the cause of the nitrification process disturbance might be phenols occurring in slurry to which microorganisms are sensitive. It is difficult to explain in details why in soil enriched only with polyamide the nitrification was most intense. It is probably caused by the availability of nitrogen in ammonium form from the water polyamide extract for the nitrificators. Also the research carried out in the Department of Agricultural Microbiology showed that the amount of microorganisms performing the nitrification in this combination was the greatest. In the literature there are no data pertaining to the adsorption of microorganisms cells on polyamide surface, however, it is known that these formula contain proton-accepter sorptive centres co-operating with function groups of the surface structures of microorganisms cells [5,14]. If it proved that polyamide possesses the ability of microorganisms adsorption, it would be significant, especially in the field conditions where microorganisms are most exposed to unfavourable conditions of the environment. Taking into account a weak sorptive complex of sandy soil it was considered useful to control the loss of $N\text{-}NH_3$. The results of these are presented in Fig. 4.

In soil enriched with polyamide only, trace loss of $N\text{-}NH_3$ after 14 days of incubation was noted. A considerable nitrogen oxidation was noted in soil enriched with slurry and slurry with polyamide. This loss was greatest after 14 days of incubation and achieved the value of 1.5 mg $N\text{-}NH_3$/100 g of soil. Further incubation of soil caused gradual decrease of nitrogen loss up to complete decline at the end of the experiment. This loss was caused by quick mineralization rate of nitrogen substance in sandy soil with a very weak sorptive complex. During the experiment also periodical content of $N\text{-}NO_2$ was observed in the incubated soil.

The presence of nitrites in the amount of 0.05 mg/100 g of soil was noted only in the combinations with slurry and slurry with polyamide in the final phase of the experiment. These results prove undisturbed course of nitrification. It is generally known that in soils with small sorptive capacity a quick mineralization rate of urea which is contained by slurry gives conditions for $N\text{-}NO_2$ formation which, in turn, disturbs the activity of bacteria of the second nitrification phase [9].

The results pertaining to periodical measurement of CO_2 emission in sandy soil are presented in Fig. 5. In soil enriched with polyamide, the amount of the effused CO_2 was higher than in the control and showed constant upward tendency (with the exception of slight decrease in the 42nd day of incubation). In the combination with slurry and slurry with polyamide after the initial increase to 68-70 mg CO_2, a rapid decrease to 20-20.5 mg CO_2/100 g of soil after 21 days of incubation occurred.

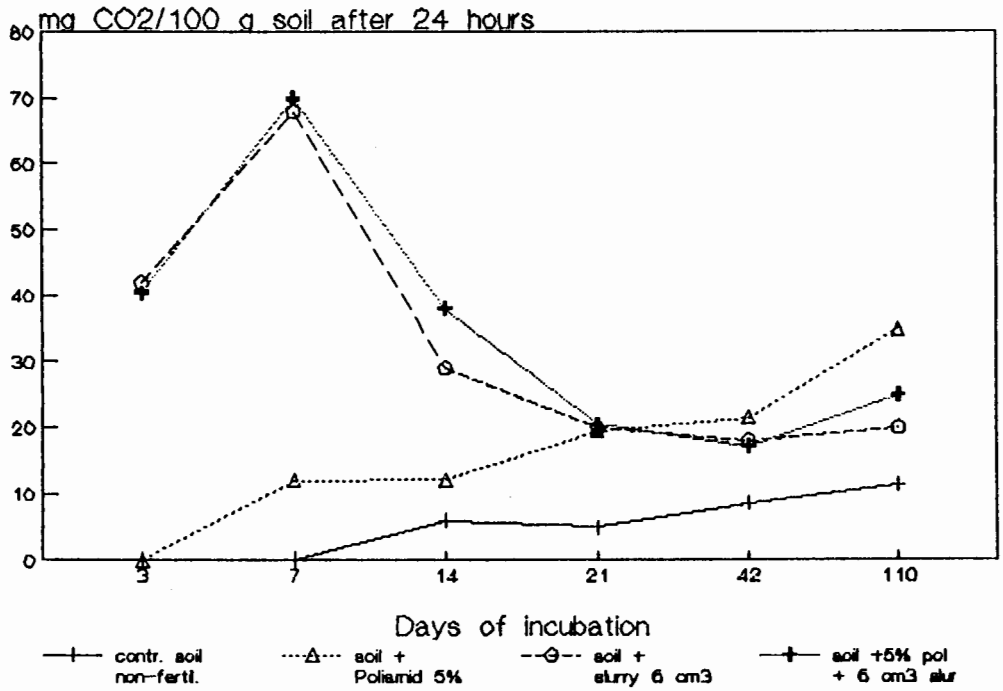

Fig. 5. CO_2 evolution in podzolic soil after 24 h incubation.

In the final phase of the experiment a renewed increase of the emitted CO_2 amount in the tested combinations was noted.

The initial increase of respiratory soil activity can be explained by a quick mineralization of organic substance introduced into the soil and, in case of polyamide by the content of water soluble linkages which stimulate total microbiological soil activity. The quick utilization of available carbon and nitrogen bonds was the main cause of the decrease of respiratory activity of microorganisms living in a given soil. The renewed stimulation of CO_2 emission and the stabilization with slight upward tendency in all the combinations should be explained by the selection of microorganisms adopted to utilizing hardly available carbon linkages. It is significant that the strongest stimulation of the respiratory activity in the medium and final phase of the experiment was noted in the soil enriched with polyamide PA-6.

The research made in the Microbiology Department indicate that the polyamide formula stimulated the increase of number of fungi and, therefore the increase of CO_2 emission is probably the reflection of their metabolic activity. It seems also possible that, because of low organic carbon content in the soil tested, the intensive CO_2 emission may testify to a partial polyamide mineralization. As Wolski [14] states, it contains small urea amounts and low-molecular organic compounds, especially aminocaproic acid. According to Naumowa [11] some soil microorganisms, especially fungi and actinomycetes may decompose aminocaproic acid.

CONCLUSIONS

The results of the research carried out in controlled laboratory conditions allow us to draw the following conclusions:

1. Applying polyamide PA-6 as the only formulae improving physical and chemical

properties of light-textured soils is not advisable because of its decreasing effect on the pH of soil. However, if it is applied together with slurry it does not have the unfavourable effect on the pH of soil.

2. Polyamide PA-6 caused the stimulation of ammonification, nitrification and respiratory soil activity processes.

3. Because of nitrogen balance and plant nutrition, the term of introducing this material into the soil should be controlled.

4. The fertilization of sandy soil with slurry caused periodical significant nitrogen loss. Polyamide, introduced additionally to soil, did not cause the decrease of ammonium nitrogen loss.

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WPŁYW POLIAMIDU PA-6 NA PRZEMIANY AZOTU W GLEBIE PIASZCZYSTEJ NAWOŻONEJ GNOJOWICĄ

Przeprowadzono doświadczenie w kontrolowanych warunkach laboratoryjnych nad wpływem poliamidu PA-6 na pH gleby piaszczystej, przemiany azotu i ogólną aktywność mikrobiologiczną.

Stwierdzono, że sam poliamid powoduje obniżenie pH gleby, co jest szczególnie niekorzystne w przypadku gleb piaszczystych. Stosując poliamid łącznie z gnojowicą, odczyn gleby jest podobny jak w glebie nawożonej wyłącznie gnojowicą.

Poliamid PA-6 powoduje stymulację procesów amonifikacji, nitryfikacji i aktywności oddechowej w badanej glebie. Ze względu na gospodarkę azotową oraz odżywianie roślin, należałoby kontrolować termin wprowadzania tego preparatu do gleby oraz stosować poliamid łącznie z komponentami, które by neutralizowały jego zakwaszające działanie.

S ł o w a k l u c z o w e: poliamid, gleba piaszczysta, pH, przemiany azotu, aktywność mikrobiologiczna.