

REDUCING NITRATE LEACHING FROM SODDY-PODZOLIC SANDY LOAM SOIL WHEN APPLYING POULTRY MANURE IN COMBINATION WITH BARLEY STRAW

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Abstract

The results of the experimental research which established a decrease of nitrate nitrogen leaching from loamy sandy soddy-podzolic soil during application high doses of poultry manure (N200 and N400) in combination with barley straw are presented in this paper. The positive results are the basis for further research in the field and production experience to assess the impact of straw to reduce nitrogen losses when using high doses of poultry manure.

Key words: reducing nitrate leaching, poultry manure, straw

INTRODUCTION

Nowadays, in the large poultry farms of Russia annually accumulates about 20 million tons of poultry manure [9]. These organic wastes are potential and actual pollutants of the natural environment. In the ground waters at the sites of storage of poultry manure, where accumulated precipitation, the content of nitrate and ammonium nitrogen, mobile forms of phosphorus and potassium are often several times higher than the admissible limit values. Soil erosion, runoff organic waste leads to severe pollution of rivers and lakes.

Does not comply with environmental standards storage and use of manure not only causes significant harm to the environment, leading poultry farms adjacent to the territory in poor ecological condition, but is accompanied by a loss of a huge number of biophilic elements and organic matter.

Soil as an effective self-cleaning system, capable of providing microbiological and enzymatic transformation of biogenic waste, so one of the most reasonable methods for their disposal, from both an environmental and agronomic point of view, is the use as fertilizer.

It is known that the number of fertilizer

elements in poultry manure surpasses to other types of organic fertilizers and their availability - not inferior to mineral fertilizers. One of the main problems arising from the use of high doses of poultry manure as a fertilizer, is the increase the content of mobile phosphates and nitrates in the soil, often an order or more greater than background rates. High doses of poultry manure be able to influence phytotoxic effects, reducing crop yields. Against the background of possible deterioration of quality of plant products: the excessive accumulation of potassium and nitrates above acceptable norms.

For poultry manure is characterized by a fairly narrow ratio of carbon and nitrogen, so that the organic matter quickly mineralized soil microflora. The main part of the nitrogen in poultry manure is presented uric acid, which is converted to urea, then - in ammonium carbonate. As a result of the subsequent stages of transformation of nitrogen nitrification, denitrification is a significant part of the nitrogen may be lost as a result of emission of ammonia and oxides of nitrogen, migration of nitrates beyond the root layer.

The problem of preventing the loss of nitrogen, including due to leaching, has become global in the middle of the 90s, both

in production and in environmental aspects [2]. Recent research found that the leaching of nitrate from soils, which previously played a minor role in nitrogen decline, is much more important, while the emission of the gaseous products of denitrification compose only a few kg N ha^{-1} [5].

Migration of nitrogen in the soil profile occurs in the form of nitrates, nitrites, water-soluble ammonium and organic compounds. Numerous studies have established that in the rinse water dominated by 80-90 % nitrogen nitrate.

In the opinion of Kudeyarov V.N. [3], the regulation of nitrogen-carbon balance in the soil is possible with the help of methods aimed at reducing excessive amounts of mineral nitrogen by restocking available for microorganisms of carbon. Such a method is the application to the soil organic carbon in the form of straw and other materials of vegetable origin. As it is known that for fixing mineral soil nitrogen and fertilizer, it is necessary to appropriate amount of accessible for microorganisms of organic carbon. If the soil accumulation of mineral nitrogen, it indicates a deficiency of organic carbon in an available form.

After applying the soil available nitrogen from organic or mineral fertilizers occurs the activation of microbiological activity, mineral nitrogen fixed in the germ plasma, increasing the active phase of organic nitrogen. Fertilizer nitrogen within a certain time is passed on from generation to generation strenuously multiplying microflora and for a time as though is conserved in the bodies of microorganisms [12].

The temporary immobilization in the microbial biomass is protected by mineral nitrogen losses. Applying to easily mineralized plant matter and intensive development process of its transformation compensate for loss of soil nitrogen due to the formation of nitrous part of the molecule formed humic acids soil in the process of humification of plant residues [7].

Immobilization of mineral nitrogen by soil microorganisms is intensified when entering into soil organic matter with a wide aspect ratio C: N, for example, cereal straw.

Based on the analysis and generalization of these results we can draw a very important conclusion: applying straw into the soil helps to reduce unnecessary loss of mineral nitrogen fertilizers, transfer it into plasma microorganisms, later in humic substances, thereby contributing to the preservation and prolonged action.

It should be noted that the majority of studies on the use of poultry manure as organic fertilizer, were carried out in 80-90s of the last century. In recent years, the number of publications devoted to this problem, has declined slightly. The analysis of the state of knowledge of issues related to agro-ecological assessment of the effectiveness of the using of poultry litter in pure form and in combination with straw under crops specialized in grain crop rotations, showed a slight degree of study and reflection in the scientific literature. Nitrogen decline of fertilizer from the soil can be controlled by agricultural measures whose purpose is temporary fixation and transfer mobile nitrogen in the form of, inability to volatilization or leaching. One of these techniques may be the applying of litter in combination with plant biomass, characterized by a high ratio of C: N, for example it can be cereal straw. Adding straw, intensifying biological immobilization of mineral nitrogen produced in the process of transformation of nitrogen uric acid, promotes to its fixation in the biomass microorganisms, thereby reducing migration of nitrogen decline and groundwater contamination and increase in stocks of soil organic nitrogen.

To develop effective environmentally friendly ways of using poultry manure as a fertilizer and techniques to reduce nitrogen losses in Research Institute of Organic Fertilizers and Peat in field and laboratory experiments conducted research work to study the effect of poultry manure in conjunction with straw on nitrogen status and reproduction of fertility of soddy-podzolic sandy loam soil, yield and quality of grain crops in crop rotation.

In the present article discusses the results of a laboratory model experiment in which studied the effect of a combination of straw with bird droppings and mineral nitrogen fertilizers on nitrate nitrogen leaching from arable layer of

soddy-podzolic sandy loam soil.

MATERIALS AND METHODS

In vessels with a perforated bottom placed 650 g of soddy-podzolic sandy loam soil in an air-dry condition (with an experienced field), moistened to 60% of the field moisture capacity, fresh poultry manure was added in two doses of 200 and 400 kg of nitrogen per 1 ha of barley straw containing 41% organic carbon and 0.6% nitrogen (C: N = 68), shredded to a size of 0.5 - 1 cm, at a dose of 5 t ha⁻¹, the rate of ammonium nitrate N 200. Scheme of the experiment: 1. Soil (without fertilizer); 2. Bird droppings (BD) (N200); 3. BD (N200) + straw 5 t ha⁻¹; 4. BD (N400); 5. BD (N400) + straw 5 t ha⁻¹; 6. Straw 5 t ha⁻¹; 7. ammonium nitrate (N200); 8. ammonium nitrate (N200) + straw 5 t ha⁻¹.

The soil in the vessels was composting at room temperature and the optimum moisture content within 49 days. Periodically was adjusted soil moisture in the vessels to values exceeding the total moisture capacity and moisture-holding capacity of the soil, creating conditions for the washing of the water regime and the downward migration of nitrate down the profile. The washings were collected in special containers, taking into account their volume, and determined the content of nitrate nitrogen. Was calculated number of losses of nitrogen from the soil in each period of definitions and in total and for the whole period of composting.

RESULTS AND DISCUSSIONS

As a result of the research showed that adding straw when applying poultry litter and ammonium nitrate significantly reduced the leaching of soil nitrogen in nitrate form.

So, poultry manure applying at a dose of N200 adding straw at a dose of 5 t ha⁻¹ was accompanied by a decrease in leaching of nitrate nitrogen in the whole observation period from 21.4 to 13.2 mg / vessel, or 38% (in terms of - from 99 to 61 kg ha⁻¹); when using the poultry manure at a dose of N400 - from 28 to 16.9 mg or 66 % (from 129 to 78 kg ha⁻¹); in the variant with ammonium

saltpeter in a dose of N200 from 22.1 to 18.1 mg, or about 18 % (from 102 to 84 kg ha⁻¹).

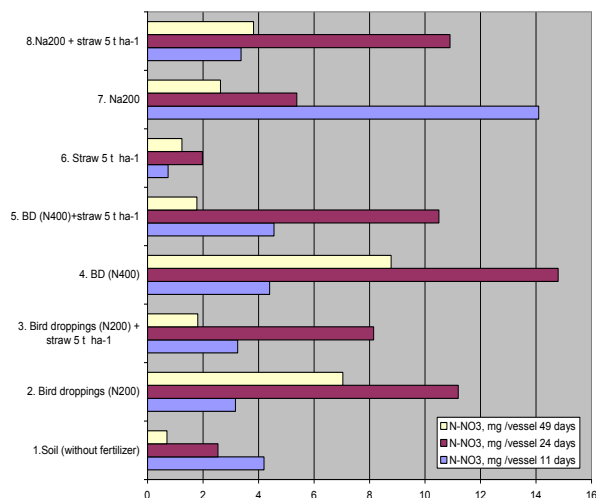


Fig. 1. The dynamics of nitrate nitrogen leaching in the model experiment

Moreover, there were noticed some differences in the dynamics of nitrogen leaching in variants with its inclusion in the composition of organic and mineral fertilizers. So, in the variant «ammonium nitrate N200» maximum amount of nitrate nitrogen is more than 64% of the amount which was detected in the washing water in the initial period of composting - 11 days. Adding straw reduced nitrogen leaching in this term more than 4 times (Fig.1).

In variants with bird droppings nature of the dynamics of nitrogen leaching was different. The maximum amount of nitrogen in the washing waters was not found at the beginning of the composting, and later at 24 and 49 hours of observation, when the mineralization of organic matter of manure, process of ammonification and then nitrification of ammonium nitrogen accumulation occurred in soil nitrate nitrogen, some of which migrated with the washing waters.

Straw has reduced of N-NO₃ losses in the variant «BD (N200) + straw 5 t ha⁻¹» 1.4 (24 days) and 3.9 (49 days) times; in the variant «BD (N400)+straw 5 t ha⁻¹» - 1.4 (24 days) and 4.9 (49 days) times (Fig.1).

A number of domestic and foreign researches have established that straw plowback into the soil compared to its disposal or incineration

reduces nitrate levels in the profile soil and reduces their movement beyond the root layer [1, 2, 6, 10, 11, 12].

So, in the opinion of Silgram M., Chambers B.J. was noted decreased nitrate leaching with straw on light soils in Norfolk and Nottinghamshire, England [10].

In their studies, Scherer H.W. and Mengel K., at two humidity levels (50 and 90% of the maximum water capacity) when applying straw were significantly reduced loss of ^{15}N in brown fallow soil [8].

According to the data of researches Ichir L.L., Ismaili M., nitrogen decline introduced with $(\text{NH}_4)_2\text{SO}_4$, labeled ^{15}N , reduced if the soil has been applied straw [1].

On the basis of studies conducted in China in cropping system with crop rotation both winter wheat and corn, it has been concluded that left straw residues increases the potential for the protection underground waters from pollution caused by nitrates by reducing the accumulation of nitrates in the soil and reduces the risk of deep migration [6].

As a result of research of the All-Russian Research Institute for Organic Fertilizers and Peat in a field experiment on sod-podzolic sandy loam soil it was noticed a significant increase in microbial biomass and organic nitrogen while adding straw to poultry manure [4].

CONCLUSIONS

Thus, as a result of studies found that the combination of cereal straw with a wide ratio of C: N and poultry manure reduced leaching of nitrate nitrogen from the soddy-podzolic soil through microbial immobilization.

The results obtained in this experiment, the positive results are the basis for further research in the field and production experience to assess the impact of straw to reduce nitrogen losses when using high doses of poultry manure.

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