Prospects for application of organic fertilizer from bird litter

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Abstract. Currently, the most effective way to dispose of bird droppings is to process it into organic fertilizer. The processed litter contains the basic micro and macro elements and amino acids in an easily accessible form for plants. Fertilizer from recycled litter is environmentally friendly and effective in neutralizing pathogenic microflora, larvae and helminth eggs, as well as weed seeds. In this work, we studied the modes of processing chicken manure at the Ark plant, the chemical composition of bird manure and organic fertilizer from it obtained in different ways. The effect of various doses of powder on seed germination, plant growth and development was assessed. It is shown that processing of bird droppings into powder increases the content of available macrocells for plants by two times, and also contributes to their longer preservation in organic fertilizer. The study indicates that pre-sowing soil treatment with powder in the optimal dose increases the germination rate of plants by 75 % compared with the control group.

1 Introduction

The production of a by-product exceeding the yield of meat and eggs by 2–4 times was, is and will be a characteristic feature of poultry farming. Annually in Russia, more than 20 million tons of litter is formed per year [1, 2]. When considering this product as a waste product, it should be disposed of, since it belongs to hazard class III.

Protecting the environment from bird droppings is relevant for all poultry farms in Russia. Ignoring this problem can lead to an environmental disaster with negative consequences not only for residents of settlements but also for biocenoses in general. Infectious and invasive diseases of people, animals, birds are also possible.

When bird droppings are decomposed, toxic substances such as methane, biogas, hydrogen sulfide, skatol and carbon dioxide polluting the environment are released into the atmosphere. Therefore, when developing technologies for the disposal of poultry waste, the following conditions are of particular importance: the fulfilment of veterinary and sanitary requirements; obtaining high-quality and environmentally friendly products; environmental protection.

Currently, there are many ways to convert poultry waste: processing poultry manure into biogas, electric energy, fuel briquettes, feed additives, growing California worms, fertilizer production [3, 4]. Given the extent to which humanity destroys the environment, including the soils of agricultural land, the most correct, in our opinion, is the processing of birds' waste products into organic and organomineral fertilizers to increase field fertility. This fact is especially true in the Non-Black Earth Zone, where soils are depleted in humus.

For preserving the initial composition of valuable fertilizer, it must be processed for long-term storage and use. The way out of this situation is the processing of bird droppings into granular powder and its use in the production of green mass for the further production of high-quality feed. Harvesting high-quality canned food can significantly increase the nutritional value of bulky feed and bring the actual content of nutrients in them to the physiological needs of animals [5–8].

Of all types of organic fertilizers, granular bird droppings are considered to be the most valuable, since the nutrients of bird droppings in their effect on crop yields are practically equal to those in mineral fertilizers. Moreover, their huge advantage is that they are in organic form, less washed out of the soil, entering it gradually and do not create a high concentration of salts [9, 10].

As a result, the quantity and quality of the crop increases (the content of vitamins, sugars, proteins, starch increases, and nitrates do not accumulate). Since phosphorus in the litter is represented mainly by organic compounds, it is practically not fixed in the soil in the form of phosphates of iron, aluminium or calcium. As a result, phosphorus litter is used better than phosphorus mineral fertilizers.

The amount of available nitrogen in granular chicken droppings reaches 100 %, phosphorus – 70 %, potassium – 90 %. The presence of calcium fertilizer in this form promotes deoxidation of soils [11, 12]. As a result, the composition and properties of the soil improve: the humus layer and optimal acidity are restored, the content of beneficial microflora increases and harmful growth is suppressed, and soil fertility increases [13].

Organic fertilizers on a marked basis can be produced in several ways:

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1. Passive composting – obtaining organic mixtures (bird droppings + bird droppings with litter, bird droppings + peat, bird droppings + sawdust, bird droppings + other local organic waste) ripening after 6-8 months of storage in the field.

2. Intensive composting – the organic mixture is loaded into special fermenters, in which the ripening process takes 6–7 days, the method is used in the case of the implementation of organic fertilizers through the retail trade.

3. Thermal drying of litter in special installations – the absence of a constant supply of organic components: peat, sawdust.

4. Vacuum drying of droppings – during the elimination of long-term accumulations of droppings, in the production of dry droppings from cell batteries. Of course, the cost of obtaining dry droppings will be the lower, the lower the humidity of the droppings.

5. Microwave processing of chicken manure is one of the modern processing methods. Drying bird droppings in the microwave – rays guarantee obtaining a powder with high sanitary and hygienic properties without weed seeds [14–16].

The purpose of this work is to study the effect of various doses of bird droppings powder on seed germination, plant growth and development.

2 Material and research methods

The studies were carried out in LLC Sanitary Ecology, in the laboratories of the Research Center for Feed Additives and the Department of Production and Processing of Agricultural Products, Kazan State Academy of Veterinary Medicine named after N.E. Bauman.

We studied the modes of processing chicken manure at the Ark installation, the chemical composition of bird manure and organic fertilizer from it obtained in different ways. Laboratory experiments on the effect of various doses of organic fertilizer from bird droppings to assess seed germination, growth and development of plants were carried out according to GOST 24933.2-81 [17].

Sampling was carried out according to GOST 13586.3-83 [18]; phenological observations were carried out according to the method of the State variety testing of crops. Seed germination was determined, according to GOST 12038-84 [19]. The analysis of quantitative and qualitative indicators of plant growth and development. Statistical processing of experimental data was carried out according to standard methods using the computer program "AGROS-2.09" for statistical analysis in crop production according to B.A. Dospehov.

3 Results

For microwave processing of chicken droppings, the Ark installation was used (LLC Sanitary Ecology).

The modes were selected based on the technical capabilities of the installation, subject to energy efficiency conditions, as well as the need to bring the initial raw materials to the required humidity level. Table 1 presents the investigated processing modes.

As a result, the microwave-treated chicken droppings are organoleptically a loose granular material of brown colour with inclusions (feed particles), with a faint smell of the initial raw material, with a moisture content of not more than 10 %. More rational is the use of a variant with a shorter processing time (1) because in this case, energy savings are achieved, and it becomes possible to process a more significant amount of raw materials per unit time. Analysis of the presence of pathogenic microflora in the final product showed their absence. Representatives of *Campylobacteriaceae*, *Klebsiella*, *Salmonella*, *Staphylococcus*, *Pseudotuberculosis* were not found in the studied samples.

Table 1. Modes of processing chicken manure

Processing option	Magnetron power, kW	Frequency, MHz	Processing exposure, min
Original chicken droppings	0	0	0
Microwave treated chicken droppings (1)	20	915	6
Microwave treated chicken droppings (2)	20	915	9
Microwave treated chicken manure (3)	20	915	12

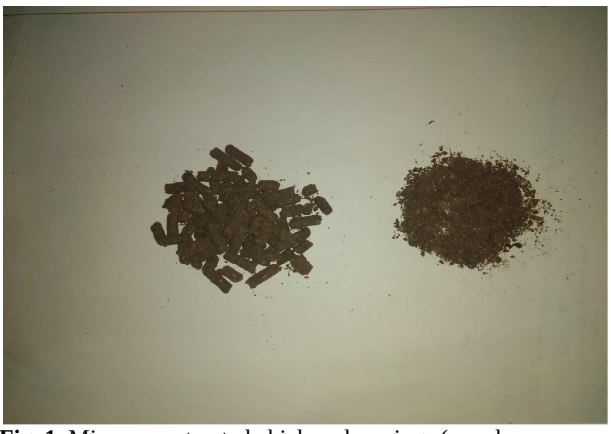

Fig. 1. Microwave-treated chicken droppings (powder, granulated)

The effectiveness of the fertilizer depends on its chemical composition and availability. It is known that the availability of nitrogen in granular chicken droppings reaches 100 %, phosphorus – 70 %, potassium – 90 % [13]. Table 2 presents the influence of the method of processing bird droppings on the chemical composition of the final product.

B In the litter, birds are calculated for the air-dry substance of amino acids (%): glycine 1.1–1.3; aspartic acid 1.01–1.02; glutamic acid 1.2–1.3; lysine 0.7–0.8; alanine 0.7–0.8; leucine 0.67-0.85; valine 0.6; serine 0.5–0.7; threonine 0.5–0.6; isoleucine 0.4–0.5; phenylalanine 0.36–0.45; arginine 0.35–0.42; proline 0.2–0.3; tyrosine 0.17-0.20; histidine 0.15–0.20 [15, 16].

In bird droppings, there are also many trace elements. 100 g of its dry matter contains (mg): iron 367–900; zinc 12–39; manganese 15–38; copper – 0.5; cobalt 1–1.2. Most of these elements are in water-soluble form.

Table 2. Impact of the method of processing bird droppings on the chemical composition of the final product, %

Indicators	Bird droppings, native	Heat treated bird droppings	Vacuum drying	Microwave treated (powder)
Dry matter	89.8	81.0	80.69	94.3
Organic matter	88.9	61.0	60.73	88.4
Nitrogen	2.15	3.25	4.30	4.59
Potassium	0.70	2.7	2.18	1.80
Phosphorus	1.48	1.75	1.09	3.70

The content of the necessary elements for the normal growth and development of plants is lost during long-term storage in semi-liquid form for five months: phosphorus – from 27 to 44 %, nitrogen – from 52 to 82 %, and potassium – 44 %. In the form of a powder, organic fertilizer does not lose its valuable qualities and does not pose an environmental hazard to the environment, unlike bird droppings. When pure bird droppings are introduced into the soil, its effectiveness in the first year is not pronounced. Moreover, it can have a depressing effect on plants. Moreover, when making powder in the mail, the organic substance is in an accessible form for plants.

For the study, the effect of powder on the growth and development of plants, the soil was compiled. Ordinary black soil with the following characteristics was chosen as the main soil: pHx – 6.92, humus – 4.61 %, C: N – 11.5, particle content <0.01 mm – 47.9 % [20].

Various doses of powder were added to the soil: in the first version, a pure grass mixture of cereals was sown (control). In the second variant, a grass mixture from cereal crops was sown with the addition of 1 g of powder in the soil (experiment 1). In the third version – 2 g of powder (experiment 2). In the fourth embodiment – 3 g of powder (experiment 3) (Table 3). The mass of soil in the vessels is 800 g, and the experiment is repeated three times. Watering the test samples was carried out three times, 80-100 ml per vessel. On the third and fourteenth day, the height of the aerial parts of the plants was determined.

Table 3. Scheme of experience

Options	Powder content per 1 kg of soil
Control	No
Experience 1	1 g
Experience 2	2 g
Experience 3	3 g

During the germination test, a temperature in the range of 20–25 ° C was chosen as the most favourable for germination. Simultaneously with germination, the germination energy was determined. The duration of the experiment was 14 days. Plant germination was checked every day. The results were recorded.

After 14 days, seedlings were counted in the experimental and control variants. The following indicators determined the growth and development of grass mixtures from cereals, grown in the soil with the addition of different doses of powder: total seedling mass, root length, tip length.

Fig. 2. Scheme of experience

As a result of laboratory studies, the following data were obtained: on the third day, the height in the first variant (experiment 1) was 0.5 cm, in the second variant (experiment 2) 0.8 cm, in the third variant (experiment 3) 0.6 cm, and in the control version – 0.4 cm (Table 4). On day 14, the second experimental variant in germination exceeded the control by 60 %.

Table 4. The height of the seedlings of grass mixtures from cereals in the control and experimental versions, cm

Options	The dose of powder, g	On the 3rd day, cm	On the 14th day, cm
Control	No	0.4	4.6
Experience 1	1	0.5	5.8
Experience 2	2	0.8	6.5
Experience 3	3	0.6	5.8

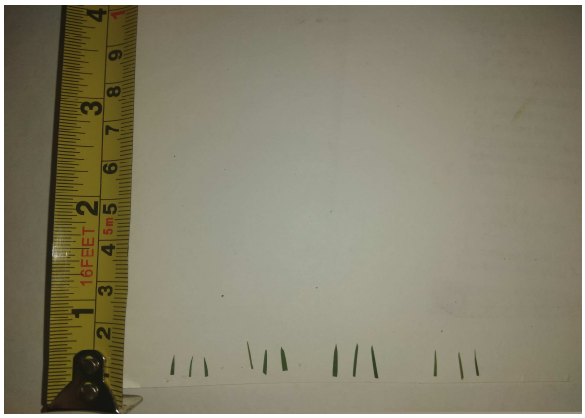

Fig. 3. Experimental plants on the 3rd day (arrangement of seedlings according to the scheme of experience)

On the third day, in the 1st experimental version, the sprout length increased by 25.0 % compared with the control, in the 2nd experimental version – an increase of 100 %, in the 3rd experimental version – an increase of 50 %.

On the fourteenth day, in the 1st and 3rd experiments, the sprout length increased in comparison with the control by 26.1 %, in the 2nd experiment – by 41.3 %.

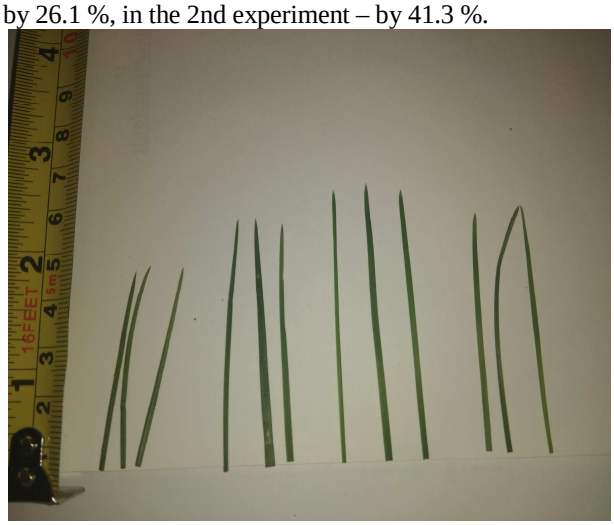

Fig. 4. Experimental plants on day 14 (arrangement of seedlings according to the scheme of experience)

The accelerated germination and increase in the size of the primary leaf grown on a powder contributes to the rapid transition of the plant to an autotrophic type of nutrition, and the conversion of sunlight to organic matter allows the plant gaining a sufficient amount of vegetative mass and rapid tillering.

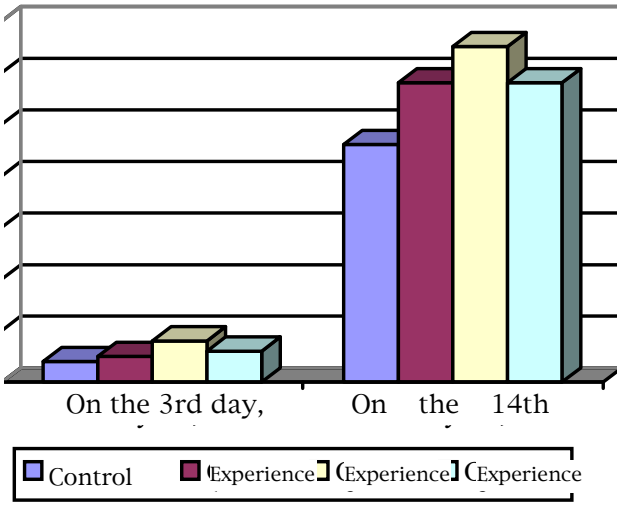

Fig. 5. The results of the experiment

The results of laboratory experience in studying the effect of powder on the growth and development of a mixture of cereal grasses showed that adding 1 and 3 g of powder to the soil increases the height of plants above ground by 1.2 cm compared to the control group and 2 g per – 1.9 cm. The optimal dose for the growth and development of plants is the introduction of 2 g of powder into the soil during sowing of seeds of cereal crops.

4 Conclusion

Thus, the processing of bird droppings into powder helps to reduce the stored droppings at livestock enterprises, which leads to a reduction in toxic volatile compounds released into the atmosphere.

Using microwave irradiation to process litter into powder, the Ark plant is environmentally safe and effective in neutralizing pathogenic microflora, larvae and helminth eggs, as well as weed seeds. As a result of this treatment, a high level of microbiological safety of chicken manure is achieved, which allows it being used as organic fertilizer.

Processing of bird droppings into powder allows preserving the content of organic matter in the final product at the level of the feedstock, increases the content of available macrocells for plants by two times, and also contributes to their longer preservation in organic fertilizer.

The plant's assimilation of potassium and nitrogen fertilizers readily soluble in water under the influence of powder increases several times. This data allows reducing the dose of nitrogen and potassium fertilizers by 30 %.

Given the high cost of mineral fertilizers, the use of powder is more efficient and cost-effective. This type of organic fertilizer is not only rich in nutrients, but also high utilization rates by plants.

The shelf life of the powder in granules is not limited; it does not have toxicity.

Under the influence of powder in plants, nitrogen, phosphorus, potassium and carbohydrate metabolism are enhanced. Given the significant increase in permeability of the root system of plants, the central problem of plant growing is successfully solved: the effective absorption of mineral fertilizers.

The results of laboratory studies on the germination of grass mixtures from cereals showed that pre-sowing cultivation of the soil and the introduction of 2 g of powder in it is optimal for the growth and development of plants.

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