

Prospects for the use of poultry and drilling waste in agriculture

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Abstract. The article presents the possibilities of obtaining useful products from poultry and oil industry wastes using Mephosphon biologically active agent. The use of an aqueous solution of the Mephosphone preparation in ultra-low concentrations (10^{-6} – 10^{-8} %) allowed obtaining the Compost UP-1 product from chicken manure and the Meliorant product from drilling waste. The Compost UP-1 belongs to the 4th hazard class in terms of physico-chemical and sanitary-biological characteristics, and the Meliorant product in terms of pollutant content belongs to the 5th hazard class. Studies on the influence of useful products derived from waste were carried out in the field in the experimental fields of the Laishevsky district of the Republic of Tatarstan. The Compost UP-1 and Meliorant products were introduced during pre-sowing cultivation in an amount of 26 t/ha and 1.3 t/ha, respectively. For comparison, during the research, reference plots were organized (Reference). The seeds were spring wheat of the Yoldyz variety (Compost UP-1) and Idelle (Meliorant). The analysis of growth and productivity indicators of plants grown in different areas showed that the use of the obtained products improved soil fertility: the introduction of the Meliorant product optimizes soil pH, activates mass transfer processes, and the introduction of the Compost UP-1 product increases the content of nutrients (N, P, K). So at the tillering stage in the section with Compost UP-1, the average phytomass per unit length of plants was 1.8 times higher than in the Reference. The use of Compost UP-1 leads to a significant improvement in grain quality: the mass fraction of protein increased by 32 %, vitreous content by 60 %, and the content of crude gluten by 34 %. Productivity increased and amounted to 42 kg/ha, which is 14 kg more than in the Reference. The use of the Meliorant also activated the growth of plants, and led to an improvement in the quality of grain.

1 Introduction

The search for new methods aimed at improving soil fertility, increasing productivity, obtaining high-quality grain products is an urgent problem of the modern agro-industrial complex of both the Russian Federation and the Republic of Tatarstan [1–3].

It is environmentally and economically feasible, when solving problems to improve the agrochemical parameters of soils, to consider the issue of recycling waste with useful properties.

Fresh chicken manure contains compounds of nitrogen, phosphorus, potassium, calcium, magnesium, other microelements available for plants, biologically active and organic substances, stimulating faster growth and development of plants. At the same time, its use requires preliminary treatment to remove pathogenic microflora, larvae and pupae of flies, cysts of pathogenic protozoa, eggs and helminth larvae.

One of the serious environmental problems of oil producing regions is production and technological drilling waste, which is accumulated and stored directly on the territory adjacent to the drilling site. Drill cuttings

include components of natural origin, such as quartz, albite, calcite, chlorite, kalionite, mica, as well as dolomite and gypsum, which are used as soil preparations. However, drill cuttings contain oil pollution, components of technological solutions.

In this paper, we studied the prospects of using poultry waste and drilling waste to increase soil fertility, increase productivity and improve grain quality [4–9]. During the research, reference plots (Reference) were organized to correctly compare the results.

2 Conditions, materials and methods

Liquid chicken manure from the Yaratel poultry farm of the branch of Ak Bars Poultry Complex was used in the work. The untreated chicken manure has 3rd hazard class (Federal Classification Catalog of Wastes, code 1 12 711 01 33 3). The semi-industrial processing of the manure was carried out as follows: an experimental pile of 10 tons was formed from fresh chicken manure. The pile had width of 3 meters, length of 4 meters and height of 2 meters. The experimental

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pile was treated with an aqueous solution of Mefosfon every ten days for two months from September to November (using the Karcher high-pressure sprayer), while mixing the manure. The mixing of the reference and experimental piles was carried out by the Amkodor 352C universal loader. The processing of the experimental collar was carried out in accordance with the Technological regulation “Reducing the hazard class (neutralization) of livestock waste using the biologically active drug Mephosphon” [5].

The processing of drilling waste was carried out in accordance with the technological regulation “Reducing the hazard class of crude oil using the biologically active Mephosphone product and envisaged the introduction of soil and fertilizers, 4-6-fold treatment by the drug with intense mixing. The number of treatments was determined by the residual oil content in the sludge.

The products “Compost UP-1” and “Meliorant” – obtained as a result of routine works – were tested for toxicity: holotrichous ciliates *Paramecium caudatum* [10] and cladocerans *Ceriodaphnia affinis* [11] were used as test objects. The resulting product “Compost UP-1” had 4th hazard class in terms of physico-chemical and sanitary-biological characteristics meeting the requirements of GOST R53117-2008 “Organic fertilizers based on livestock waste”. Analysis of manure samples taken on the 65th day after the start of the experiment, carried out at the Test Center of Tatarstan Interregional Veterinary Laboratory, did not reveal any representatives of pathogenic microorganisms. The bacterial indices of the group of *Escherichia coli* and Enterococci allowed classifying the studied samples as clean. Their sanitary, parasitological and sanitary-entomological indicators were normal [12]. During the processing of chicken manure according to the technological regulations, a decrease in the level of unpleasant odors was recorded.

The content of pollutants in the product “Meliorant” obtained from drill cuttings did not exceed the established MPC in the soil (Table 1). According to the data received as per “Approval of the Criteria for Waste Classification ...”, it belongs to the 5th hazard class [7, 8].

Field tests with Compost UP-1 were carried out on the experimental fields of Volzhskaya agricultural farm in the Laishevsky district of the Republic of Tatarstan, on medium loamy sod-podzolic soil with exchange acidity of 5.2, humus content of 2.3 %, P₂O₅ content of 187.5 mg/kg, K₂O content of 92 mg/kg.

Table 1. The results of chemical analysis of drill cuttings

Indicator	MPC*(TPC)soil	Concentration [mg/kg]
Oil products	1500*	258–1382
Sulphates	156.7 (as H ₂ SO ₄)	3.0–6.3
Chlorides	293.5 (as KCl)	44.0–57.8
Copper	132 (at pH > 5.5)	33.0–38.0
Cadmium	2.0 (at pH > 5.5)	<1.0
Lead	32*	1.5–18.6
pH	–	7.8–8.2

The field experiments with drill cuttings were carried out at the experimental site of the Tatar Research Institute of Agricultural Research on gray forest loamy soil, the humus content of which was 2.9 %, the

availability of alkaline hydrolyzed nitrogen was 78.3 mg/kg (low), and labile phosphorus content was 260.0 mg/kg (very high), exchange potassium content was 130.0 mg/kg of soil (high), at pH of the soil solution of 5.8.

The drill cuttings used in the work contained inert components of natural origin (33 % of quartz (SiO₂), 31 % albite (Na[AlSi₃O₈]), 13 % of calcite (CaCO₃), 12 % of chlorite (aluminosilicate of variable composition), 8 % of kalionite (Al₄[Si₄O₁₀](OH)₈), less than 1 % of mica –used for deoxidizing (liming) soils, 3 % of dolomite (CaCO₃•MgCO₃) and gypsum as a fertilizer.

In the case of Compost UP-1, application to the soil was carried out at the rate of 26 t/ha. The dose of the Meliorant product introduced into the soil was based on previous studies [9] and amounted to 1.3 t/ha, which led to an increase in the pH of the soil solution to 6.5.

When conducting field trials in the experiment with the Compost UP-1, the object of the study was the Yoldyz spring soft wheat, a variety of lutescens. The average yield in the Middle Volga region is 27.3 quintals per ha. The variety is mid-season; the vegetation period lasts 78–95 days. It is moderately resistant to brown rust; the precursor is spring wheat [13]. The mass of 1000 seeds is 33–42 grams. In terms of resistance to lodging, the variety is inferior to the standard (Simbitsit variety) up to 1 point; the drought resistance is at the standard level. Bakery quality at the level of a good filler. The plant is medium-sized. The straw is weak. The wax coating on the head and sheath of the flag leaf is medium, while it is strong on the upper internodes of the straw. The head is white and fusiform having medium density with short awnlike offshoots at the end. The shoulder is straight and raised with medium width.

In field experiments with the Meliorant, Idedelle wheat, a variety of lutescens, was used. The mass of 1000 grains is 32–39 grams. The average yield in the Middle Volga region is 24.8 q/ha. The variety is mid-season; the vegetation period lasts 76–85 days. The baking qualities are good. The wheat is valuable. The variety is moderately resistant to brown rust. The predecessor is winter wheat.

During field trials, spring wheat cultivation technology generally accepted in the Republic of Tatarstan was used. The total accounting area of the experimental plot was 100 m², the allocation of plots is consistent, the repetition is three-fold.

The test products were introduced during pre-sowing cultivation. Sowing was carried out with the SZ-3.6 seeder, with a sowing rate of 6.5 million germinating seeds per hectare (650 seeds per m²).

Plant protection measures from weeds and diseases were identical in all variants of the field experiments. The crops were treated by the ballerina herbicide (400 ml/ha) and the Kolosal .Pro fungicide (300 ml/ha) in a tank mixture, in the phase of complete tillering of spring wheat plants with the OPSh-2000 aggregate.

During the field experiments using the Compost UP-1 product, the following activities were conducted:

1. Phenological observations according to the method of variety testing.

2. Accounting for the number of plants twice: after emergence and before harvesting on permanent sites of 0.25 m².

3. Crop harvesting by direct combining with the Sampo 2010 selection combine with a header width of 1.9 m.

4. Biometric and phytopathological observations according to the methodology of field research.

During the field tests the following were analyzed: field germination (%); stem length (cm); absolute dry mass of plants (g/m²); flag leaf area (cm²); head length (cm); the number of grains in a head (pcs); final yield (q/ha).

To assess the quality of the obtained wheat grain, the protein content was determined according to [14], the content of raw gluten and the quality of gluten (on an IDK device, according to ISO 5531-78), the natural mass of grain according to [15], its vitreousness according to [16]; the average weight of 1000 grains according to [17].

The field experiments with the Meliorant involved the following works:

1. Phenological observations according to the method of variety testing.

2. Accounting for the number of plants: after emergence and before harvesting on permanent sites of 0.25 m².

3. Agrochemical analysis of soil samples: before the the experiment establishment and during the growing season of spring wheat. The samples were analyzed for the content of alkaline hydrolyzable nitrogen (Nr) according to Kornfield (Practice book, Moscow State University, 2001); the content of phosphorus (P₂O₅) and potassium (K₂O) forms available to plants (GOST 26207-91), pH of salt extract (GOST 26483-85).

4. Harvesting crops by direct combine harvesting with the Sampo 2010 selection combine with a harvester width of 1.9 m;

5. Biometric and phytopathological observations according to the methodology of field research.

Structural analysis of plants determined the length of the stem, the length of the head, the number of grains in the head, the mass of grains from the main head, the mass of plants.

The reliability of the results was determined by univariate analysis of variance by the method of the least significant difference [12].

3 Results and discussion

Phenological observations carried out during field experiments showed that the substances introduced into the soil did not affect the duration of the growing season. The time of the phases of growth and development of spring wheat in the experimental variants did not differ from the reference.

Field observations of wheat growth in the control and experimental plots using Compost UP-1 and Meliorant showed that at the initial stages of growth, during the periods of formation, filling and ripening of the grain, a linear increase in phytomass was observed (Tables 1

and 2). An analysis of the state of plants at the beginning of the wax ripeness phase showed that the development of leaf diseases such as brown rust and powdery mildew did not exceed the economic threshold of harmfulness and varied between 0.08–0.20 and 1.58–2.95 %, respectively, which is lower than in the control variants (0.24–0.29 and 3.17–3.33 %, respectively).

It is fundamentally important to provide cereals with a sufficient amount of nutrients in the phase of the beginning of the plant shooting, because during this period the generative organs of grain crops begin to form, head nodus are formed which determine the number of spikelets in the head, the size of the head and its grain content. This period of plant development is considered critical and requires providing plants with soil moisture and nutrients.

The results of the analysis of samples taken in the phase of plant shooting showed that the use of Meliorant led to an increase in the content of alkaline hydrolyzable nitrogen in the soil, but, at the same time, the supply of soil with nitrogen remained at a low level (Table 2). Provision of plants with available forms of phosphorus and potassium in all cases was at an optimal level.

Table 2. Content of the main nutrients in the soil under spring wheat in the shooting phase (mg/kg)

Variants	N ₂	P ₂ O ₅	K ₂ O
Reference	74.0	320	156
Meliorant	84.0	300	163

The agrochemical analyzes of the soil carried out in the grain filling phase showed that the availability of plants practically did not change with respect to hydrolyzable nitrogen and available forms of phosphorus and potassium.

The introduction of tested ameliorants contributed to an increase in the content of divalent cations Ca²⁺ and Mg²⁺ in the soil (the sum of the bases of the soil-absorption complex in the experimental soils was 34.8–35.3 mg-equiv./100 g against 24.3 mg-equiv./100 g in the reference), which contributes to the structuring of the soil, maintaining neutral acidity.

The ultimate goal of sowing cereal crops in the field experiments was to determine the effect of the used products on the yield of spring wheat and the quality of the obtained grain.

Comparison of the threshing results showed that the introduction of the tested products contributed to an increase in the yield of spring wheat.

The structural analysis of Idelle spring wheat showed that by the time of harvesting, the largest number of plants and productive stems were noted in the experimental plots with the Compost UP-1 product.

The analysis of grain quality carried out at the Tatar Scientific Research Institute of Agriculture of the Kazan Scientific Center of the Russian Academy of Sciences showed that products obtained using the Compost UP-1 product provide higher quality grain: the vitreousness was 83 % (55 % for reference), crude gluten content was 20.8 % (15.5 % for reference), dry gluten content was 7.71 % (5.79 % for reference), protein mass fraction was 12.30 % (9.25 % for reference), including dry matter

content of 12.94 % (10.57 % for Reference), falling-number of 358 seconds (305 seconds for Reference).

Table 3. Biometric indicators of spring wheat plants of the Yoldyz variety in field experiments using the Compost UP-1 product.

Indicator name	Experiment variant	
	With Compost UP-1	Reference
Average stem length (cm) during periods of:		
1) tillering	34	30
2) shooting	50	40
3) earing	55	43
4) milk ripeness	59	55
5) wax ripeness	68	59
6) full ripeness	72	62
Area of flag leaf (cm ²) during periods of:		
1) tillering	7	6
2) shooting	6	5
3) earing	8	7
Tillering coefficient	1.06	1.02
Average head length (cm) during periods of:		
1) earing	7.6	5.7
2) full ripeness	9	7.8
Number of plants to harvest (pcs)	533	529
Number of productive stems (pcs)	564	541
Number of grains in ear (pcs)	45	27
Mass of 1000 grains (g)	29.8	27.6

Table 4. Biometric indicators of spring wheat plants of the Idelle variety in field experiments using the Meliorant product

Indicator name (early wax ripening)	Experiment variant	
	With Meliorant	Reference
Average length (cm) of:		
1) stem	72	68
2) head	6.7	6.3
3) flag leaf	15.2	12.8
Flag leaf width (mm)	1.18	1.04
Flag leaf area (cm ²)	12	8.9
Biological mass of plants, g/m ²	1960	1160
Number of productive stems (pcs)	531	512
Number of grains in ear (pcs)	26	19
Mass of 1000 grains (g)	26.4	25.2

The obtained experimental data show that the use of Compost UP-1 in the cultivation of Yoldyz spring wheat provides a high yield of 42 q/ha (27 q/ha for Reference).

Comparison of the mass of the root system of plants on plots with the Meliorant product and reference plot showed that in the experimental version it was more developed and was 135–191 % by weight versus the reference. The number of productive stems when using the Meliorant product was also higher than in the reference (Table. 4).

The results of grain threshing obtained on the site with Meliorant showed that it has higher technological

parameters: the protein content in it was 12.2 % (12.0 % for Reference); the content of raw gluten was 21.6 % (21.1 % for Reference), the Fiber Deformation Measurement was 76 units (76 for Reference), the total vitreousness was 36 % (33 % for Reference) (LSD⁰⁵ = 0.22).

4 Conclusion

The tests obtained during the field experiments showed:

1. The introduction of the Compost UP-1 product into sod-podzolic medium loamy soil accelerates the process of plant development and grain ripening and contributes to an increase in head length: by 33 % in the earing phase, by 15 % in the full ripeness phase, and an increase in the number of grains in wheat heads at the stage of full ripeness by 67 % compared with Reference.
2. Grain obtained from the site using Compost UP-1 has higher characteristics of vitreousness, gluten and protein content, the falling number has higher rates.
3. The obtained experimental data show that the introduction of the Meliorant product into the gray forest loamy soil when growing spring wheat provides an increase in soil pH and a higher quality crop.
4. The use of Compost UP-1 and Meliorant products obtained from poultry waste and drill cuttings increases the resistance of spring wheat plants to leaf diseases such as brown rust and powdery mildew.

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