Technology for obtaining soil ameliorant and evaluating the effectiveness of its application

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Abstract. The article is devoted to the results of research and development of technology for obtaining soil ameliorant based on organic and mineral waste from beet crop rotation and sugar production. The problem of soil degradation due to the intensification of sugar beet production is being solved by returning organic and mineral substances accumulated in sugar production waste and beet crop rotation back to the soil for its reclamation. The meliorant includes a defecate that is mixed with peat that has been pretreated by exposure in a hydrodynamic cavitation generator to pulsating jets and micro-explosions of gas bubbles dissolved in water or wastewater from sugar factories and organic residues of beet crop rotation plants. It is shown that the introduction of meliorant into the soil during the cultivation of sugar beet allowed to increase yields by 6.9%, and sugar yield by 11%. Keywords: sugar production, defecate, wastewater, peat, humates, straw, cavitation, soil, soil ameliorant, yield

1 Introduction

The increase in the density (share) of sugar beet crops to 30% or more in recent years in specialized grain-beet crop rotations used in beet-growing agricultural firms and agro-industrial unions poses a real threat not only to intensive degradation of soil fertility, but also to the loss of its optimal mycocenosis with the displacement of beneficial microflora by the most active pathogens of the genus Fusarium - pathogens of rot as in during the vegetation of plants, and during the storage of sugar beet root crops [1-4]. The humus content is a decisive factor for the soil [3]. However, this indicator unfortunately tends to decrease in all beet-growing regions of Russia [2]. If at the beginning of the XX century, before the rapid development of the food industry, for example in the Kuban chernozem, the humus content reached 10%, now it usually barely reaches 5-6%.

The emerging trend of intensive growth in the production capacity of sugar factories in the Russian Federation has significantly aggravated the problem of providing them with beetroot and served as the main reason for the transition to sugar beet cultivation in a specialized three-field grain-beet crop rotation, which is associated with the need for additional measures for microbiological improvement of the soil, maintaining its fertility

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and moisture content. The expansion of sugar production led not only to an increase in the acreage of sugar beet, but at the same time there was a sharp increase in the volume of defecation mud (defecate) at the production sites of sugar factories. Defecate is "spent" calcium carbonate with organic and inorganic impurities, which in the process of purification of sugar-containing solutions were "planted" on calcium carbonate and removed to the filtration fields [4-6].

For example, in the Kursk region alone, more than 400 million tons of defecate have accumulated on the territories of sugar factories. Naturally, the problem of using these reserves has arisen.

It is known that the defecate of sugar factories, in addition to calcium carbonate, contains phosphate acid (an analog of phosphoric fertilizers in the metabolic processes of plants), nitrogen (a potential substitute for saltpeter), potassium and trace elements necessary for plants [7-9]. Basically, the defecate, depending on the raw materials used and the technology for producing sugar, has the following composition: lime - 60-70%; organic substances – 10-15%; nitrogen – 0.2- 0.7%; phosphoric acid - 0.2-0.9%; potassium - 0.5-1.0%, a small amount of sulfur, magnesium and trace elements, at a humidity of 25-30% [6]. In conditions of a sharp increase in prices for mineral fertilizers, this source of phosphorus, potassium and nitrogen may turn out to be quite profitable. Moreover, the calcium contained in the defecate may be of particular importance for deoxidation of beet crop rotation soils and increasing the efficiency of nutrient use by plants [10-13].

Defecate is formed during the purification of diffusion juice, which includes the processes of preliminary and basic defecation, I and II denaturation, sulfation and filtration of juice. The amount of defecate is 1-9% by weight of processed sugar beet. The filtration precipitate (defecate) contains mainly calcium carbonate $CaCO_3$ (60-75% per dry substance), 10-15% of organic substances, including proteins and carbohydrates, calcium salts of oxalic, citric, malic acids, etc. The elemental composition of the sediment includes magnesium carbonate, nitrogen (0.2-0.7% N), phosphorus (0.2-0.9% P_2O_5), potassium (0.3-1.0% K_2O). Fresh defecate contains up to 60% moisture, but after drying at the factory, the humidity drops to 20-30% [7]. The content of heavy metals does not exceed MPC (mg/kg): lead – 12.96, cadmium – 0.83, copper – 14.32, zinc – 39.63, mercury > 0.01 [12.13]. Therefore, defecate can be attributed to the category of substances introduced into the soil that is permissible in terms of the degree of contamination. In terms of its effect on soil, plants and the quality of agricultural products, filtration sludge is equivalent to standard lime flour/. The introduction of defecate into the soil improves its structure, increases the activity of enzymes, increases the amount of potash, calcium and magnesium. Defecate contains sufficient amounts of zinc and copper, which are essential trace elements for the development of agricultural plants, but it is mainly used in agriculture to eliminate excessive soil acidity.

In sugar production, there is another type of waste, the amount of which is 150-200% by weight of processed beets - this is wastewater of the III category. These wastes are an aqueous solution of metal salts (potassium, calcium, sodium, as well as phosphorus, etc.) and organic impurities that were concentrated in molasses during the processing of sugar beet.

The scale of the problem increases due to the fact that the area of beet crop rotation exceeds 6 million hectares, on a significant part of which a huge amount (more than 18 million tons) of cellulose-containing non-commodity part of plants (straw and crop residues of cereals and other crops (sunflower, rapeseed, etc.) is formed, which has accumulated, as well as sugar beet root crops, a lot of macro and microelements. When decomposing this biomass, a significant amount of CO_2 is released into the atmosphere, which should be taken into account when calculating the carbon footprint.

Therefore, the problem of rational utilization of the non-commodity part of beet crop rotation plants is also relevant and the time has come for its reasonable solution. A radical way to suspend and stop these negative processes may be to return to the arable soil layer, after its use for the cultivation of sugar beet, the filtration sediment of sugar beet production, as a concentrate of useful mineral and organic substances (calcium, potassium, sodium, phosphates and nitrogenous compounds), involved not only in restoring fertility, but also being components a highly productive substrate for the intensive development of suppressor fungi that are antagonists against pathogenic fungi.

The purpose of the research is to develop the composition and technology of complex utilization of waste from the production of beet sugar and the non-marketable part of beet crop rotation plants and to test the effectiveness of the resulting meliorating mixture when applied to the soil.

2 Materials and methods

These problems can be solved by returning the organic and mineral substances accumulated in the waste of sugar production and beet crop rotation back to the soil for its reclamation.

3 Results and discussion

To solve the technical problem and achieve the claimed result, the defecate is mixed with an aqueous 15-20% peat solution or 15-20% peat solution in the wastewater of sugar factories, which has been pretreated by exposure to pulsating jets and micro-explosions of gas bubbles dissolved in water or wastewater at a modulation coefficient of 0.4-0.6, in a hydrodynamic cavitation generator. and when the suspension temperature reaches 50-80 degrees C, and then by ultrasonic action in the frequency range from 18 to 24 kHz, after which crushed straw biomass with a moisture content of 14-17% is introduced into the mixture at the rate of 0.5-0.7 tons per ton of defecate mixture with cavitation-treated peat solution [14,15]

A fertilizer-reclamation mixture is used at the rate of 10-15 tons per hectare, which becomes the key to increasing the content of environmentally safe organic matter in the soil. As a result, its agrochemical properties are improved and, as a result, crop yields are increased while reducing the environmental burden on the atmosphere and soil.

This is done using specially selected cavitation modes with a modulation coefficient of 0.4-0.6,. and when the suspension temperature reaches 50-80 degrees C, pulsating jets and microbursts of gas bubbles dissolved in water or wastewater and then ultrasonic exposure in the frequency range from 18 to 24 kHz, after which crushed straw biomass is introduced into the mixture with humidity 14-17% at the rate of 0.5-0.7 tons per ton of defecate mixture with cavitation-treated peat solution [15].

Cavitation, created by hydrodynamic generation of intense acoustic waves, is the main factor in the high-potential energy effect on the aqueous suspension of the components of the fertilizer-reclamation mixture. To create a difficult-to-fractionate suspension, ensure high productivity and reduce energy consumption, it is advisable to sequentially pass the aqueous suspension of the components of the fertilizer-reclamation mixture through a hydrodynamic cavitation generator at a modulation coefficient of 0.4-0.6,. for crushing conglomerates of humic molecules and increasing the temperature of the mixture to 50-80 degrees C, and then an ultrasonic generator for exposure in the frequency range from 18 to 24 kHz, which leads to redox reactions that take place between dissolved substances and products of ultrasonic splitting of water, to complete the formation of a difficult-to-fractionate suspension

Deviations from the specified parameters of the technological process in cavitators and the norms of introduction of the fertilizer-reclamation mixture obtained by the new method. reduces the effectiveness of the meoiorant and increases the energy intensity of the process.

The main advantage of the proposed method is that the replenishment of trace elements and biologically active substances that are scarce for the soils of this region is carried out by preparing a difficult-to-fractionate suspension from an aqueous suspension of defecate, humates of deep tpof, and other trace elements and organic substances necessary for soil and plants.

The composition of the fertilizer-reclamation mixture was established as a result of a series of production tests. With a decrease in humates in the composition of the product, the amount and digestibility of minerals decreases. An increase in the amount of defecate leads to a violation of the technological properties of the fertilizer-reclamation mixture.

The technical result of the proposed invention is to increase the content of environmentally safe organic matter in the soil and improve its agrochemical properties, and, as a result, increase crop yields while reducing the environmental burden on the atmosphere and soil.

Compared with the prototype, the proposed composition expands the range of fertilizer-reclamation mixtures for soil and plants, which has a positive effect on the composition of the soil and increases plant productivity due to a more complete composition and high nutritional value for soil microorganisms, the content of biologically active substances.

For the practical realization of the possibilities of a fertilizer-reclamation mixture, we have developed a technology and a project of the enterprise for their production in industrial volumes.

The technological scheme of the workshop for the production of a new type of fertilizer-reclamation mixture is shown in the figure 1.

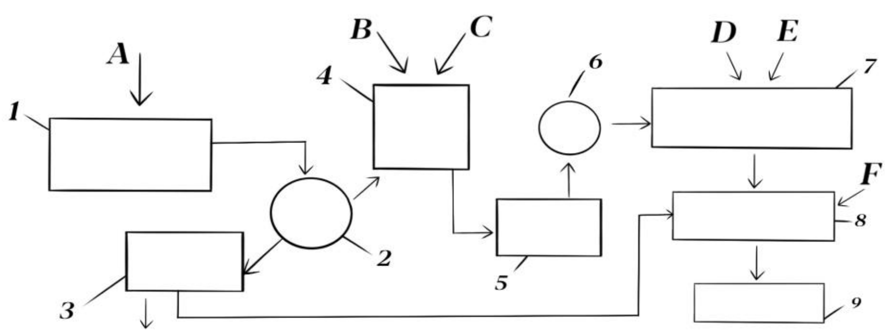

Fig. 1. Block diagram of the technological line for the production of a new type of fertilizer-reclamation mixture: 1 - Receiving hopper-peat dispenser; 2 - separator; 3 - accumulative screening hopper; 4 – peat aqueous solution preparation tank; 5 - ultrasonic cavitator; 6 - Hydrodynamic cavitator; 7 – hopper mixer; 8 – hopper mixer; 9 – accumulator-packer of the finished product.

Input of material flows: A peat; B – water; C – waste water; D – defecate; E – microbiological additives, trace elements; F – biomass of the non-commercial part of the harvest of beet crops.

Peat is received from vehicles into an open storage area (under a canopy), and from there in the summer it is loaded by a front loader into a receiving hopper (1) with a dispenser. In cold weather, peat is loaded onto a storage area heated by infrared radiators and, in a heated state, is overloaded by a pick-up loader into a receiving hopper (1). The dispenser delivers a dosed amount of peat (0.5 tons) to a peat separator (2), where mechanical impurities are separated, which are transferred by a conveyor (4) to a storage tank 3 and exported into the fields. The purified peat is fed into a mixing tank (4) filled with pre-prepared water from a container (filtered artesian or sugar factory drains. An aqueous solution of peat flows into an ultrasonic cavitator 5, and then into a hydrodynamic cavitator 6. in which the molecules of humic substances of peat are crushed by physical action on them with pulsating ultrahigh pressure [2,3].

At the last stage, a colloidal suspension of peat humates is mixed in a mixer 7 with a defect and bacterial components, as well as trace elements and natural biologically active substances or their synthetic analogues. After mixing and bringing the mixture to a humidity of 60-65%, the product enters the separator for packing into containers or big bags.

It is possible to introduce organic waste from livestock farms into the composition of the fertilizer-reclamation mixture. Hypothetically, the ratio of pulp-defecate components (cattle manure-defecate) in the meliorant is from 1:1 to 1:3 and is applied per hectare from 5 to 10 tons.

Fresh dry and semi-dry types of defecate can be of the greatest value for a fertilizer reclamation mixture. Defecate from dumps formed as a result of cleaning zero sedimentation tanks can also be used, but it is less valuable, since as a result of staying in dumps for several months, its organic components decompose and potassium salts are washed out.

The composition of the fertilizer-meoliorizing sisi is given in Table 1

Table 1. The results of the study of the composition of a fertilizer-reclamation mixture based on sugar production defecate

pH value	Units of measurement	
	-	7.35
W (Humidity)	%	90.95
Dry residue	% g/l	9.05 90.5
Ash	% from the dry residue	7.6
OV, including: Amino acids, mg/l (glycine-327, alanine-309, va lin-285, Leucine-195, isoleucine-164, proline-135, Phenylalanylic acid-140, glutamic acid-388, cystine-29, Tyrosine 35, meteonin-11, serine-103, aspartic acid-690, theonin-181, lysine=30, arginine-169, histitdine-72, etc.). Carbohydrates mg/l (pentoses 1896, methylpentoses-2627, hexoses-2377)	g/l	86.3 3.52 7.4
Humic acids	g/l	29.8
Fulvic acids	g/l	8.6
Gumin (n.o.)		47.4

Macronutrients, mg/l		
N		634.9
P		98.0
K		37045
Trace elements, mg/kg from the dry residue		
Cr		-
Ni		0.07
Co		0.02
Pb		-
Sr		0.01
Cd		-
As		-
Ba		7.20
Zn		67.96
Cu		43.04
Hg		-
Mn		67.20
Sn		0.01
Mo		0.83

The study of the effectiveness of the application of a fertilizer-reclamation mixture prepared according to the claimed method based on sugar production defecate was carried out in the technology of sugar beet cultivation. The experiments were carried out on crops of the sugar beet hybrid LMS-94.

Date of sowing crops, seeding rate, agricultural machinery:

The sugar beet hybrid was sown with a norm of 140 thousand seeds per hectare on April 29.

Agrotechnics of experimental plots:

The soil of the experimental site is a typical medium-sized leached chernozem, heavily loamy on loess-like loam. The humus content is 5.0%, P_2O_5 is 25 mg, K_2O is 18 mg per 100 grams of dry soil, pH=5.8, hydrolytic acidity is 3.01 mg-eq per 100 grams of soil, the amount of absorbed bases is 42.4 mg-eq. per 100 grams of soil.

The predecessor of sugar beet was the sowing of winter wheat.

After harvesting the previous crop, a fertilizer-reclamation mixture was applied to the experimental field with an organic fertilizer spreader at the rate of 5 t / ha, after which the control and experimental fields of the field were loosened twice with an aeration cultivator KPE-3.8 to a depth of 14-16 cm. In mid-October, plowing with a plow PN-5-35 to a depth of 27-30 cm was carried out under sugar beet, followed by leveling the soil with a cultivator KPS-4. In the spring, after the soil maturation, harrowing of the control and experimental fields was carried out with simultaneous alignment with a coupling of VNIS-R harrows and plume harrows.

Sugar beet in the control and experimental fields was grown against the background of mineral nutrition $N_{120}P_{120}K_{120}$ kg of d. v. per 1 hectare. Sowing of sugar beet was carried out with row spacing of 45 cm with CST-12B seeders.

Additional measures for the care of experimental plots – snow retention, fertilization with mineral fertilizers, disease control and insect control – were not carried out. With the mass appearance of weed seedlings on sugar beet crops, herbicidal treatment was carried out with a tank mixture of Biceps Garant preparations - 1.1 l/ha with Miura - 0.6 l/ha (May 23). For the second wave of weeds, a tank mixture was used in the composition: Betanes 1.5 l/ha + Caribou 30 g/ha + Lontrel-300 0.5 l/ha + Zellek-super 0.5 l/ha (June 6).

Sugar beet plots were placed in fourfold repetition.

Records, observations and assessment of biological and economic efficiency were carried out according to generally accepted methods and in accordance with the methodological recommendations of the VISR. Mathematical processing of crop data was carried out according to B.A. Dospekhov.

Cleaning date:

Harvesting of sugar beet on September 19th. Accounting for sugar beet yields was done manually. Sugar beet plants were dug up on the entire area of the accounting plot with an area of 25 m2, followed by pruning of the tops and weighing of root crops.

One of the most important indicators of crop productivity is the collection of sugar. In our experience, the highest sugar yield was obtained in the fourth variant of 8.41 t/ha, while in the control variant it was the lowest 7.56 t/ha. In other variants, the sugar harvest ranged from 8.11 to 8.16 t/ha (Table.2)

Table 2. Sugar beet productivity

Experience option	Yield, t/ha +/	To control Sugar content, % Sugar harvest, t/ha	Yield, t/ha +/	To control Sugar content, % Sugar harvest, t/ha
Control	50.2	-	15.05	7.56
Application of fertilizer-reclamation mixture, 5 t/ha	53.7	+3.5	15.66	8.41
HCP_{05}		2.5		

Thus, the claimed technical solution meets the criteria of "novelty" and usefulness.

4 Conclusion

The developed technology makes it possible to dispose of beet crop rotation waste, defecate and wastewater generated during the processing of sugar beet to significantly increase soil fertility, increase the content of environmentally safe organic matter in the soil. The technology of production and application of a fertilizer-reclamation mixture can significantly reduce losses and eliminate fractionation of components during transportation, storage and application to the soil, followed by sealing to a depth of 20-25 cm. .

As a result, the agrochemical properties of the soil are improved, and, as a result, crop yields are increased while reducing the environmental burden on the atmosphere and soil. The s

urvey showed that the introduction of a fertilizer-reclamation mixture into the soil during the cultivation of sugar beet allowed to increase yields by 6.9%, and sugar yield by 11%.

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