

COMPARATIVE STUDY OF THE DIFFERENT TYPES OF ORGANIC FERTILIZERS INFLUENCE ON THE CONTENT OF HUMUS IN TECHNOLOGICALLY DISTURBED LIGHT GRAY FOREST LIGHT LOAMY SOIL



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Mechanical mixing of the arable and subsurface layers of light gray forest light loamy soil in a 1:3 ratio leads to the fact that it significantly reduces fertility by the content of organic matter - by 64.7% compared to the corresponding characteristics of the arable layer of the background soil. To restore the fertility of the disturbed soil with its content under the cultural cenosis with a very high projective cover (about 80-95%) and with two years of green manure application, but without fertilizer and agricultural amelioration (control version) for 6 years of observations failed. The application of cattle manure at a dose of about 100 t/ha leads to an improvement in the basic agrochemical indicators of the soil to the “insignificant decrease in fertility” characteristic of the humus content after 5 years. By the effectiveness of the impact on the content of humus in the soil, the studied organic fertilizers can be arranged in the following order in descending order: cattle manure

half-subdued <straw-dung and peat-manure composts <straw of spring grains <peat transitional.

Key words: mechanical disturbance of soils, light gray forest light loamy soil, organic fertilizers, humus.

Land degradation is currently one of the most important socio-economic problems, which poses a threat to the ecological, economic and, in general, national security of Russia [1]. According to the State recording, the total area of only agricultural land degraded to varying degrees is 130 million hectares, of which 26% are medium and high degraded soils. The crop shortage on such soils reaches 36-47% [2]. According to academician A.L. Ivanova [3] of the Russian Academy of Science, the area of technologically disturbed lands has recently been expanding at a rate of about 100 thousand hectares per year. The area of such lands only in the Nizhny Novgorod region annually reaches 15-17 thousand hectares, which is about 2% of cultivated agricultural lands.

Considering that the application of organic fertilizers on disturbed lands is the most important method of their recultivation, which allows to improve the properties of the soil, at the vegetation site of the Department of Agrochemistry and Agroecology of the Nizhny Novgorod Region State Agricultural Academy at the end of the summer of 2011, a small-plot experience was established in order to compare comparatively the influence of different types of organic fertilizers on the restoration of soil fertility.

Model experience, with artificially created technologically disturbed soils, for creation of which the soil of the arable and subsurface horizons of light gray forest loamy soil were mixed. Agrochemical characteristics of the initial soil components:

- arable layer (0–30 cm): the sum of exchange bases is 14.3 mg eq/100 g of soil with a degree of saturation with bases of 87%, the content of humus is 2.18%, mobile compounds of phosphorus and potassium 158 and 127 mg/kg, respectively, the pH of the salt extract is 5.60;
- subsurface layers (30-80 cm): the sum of exchange bases is 27.4 mg-eq/100 g of soil with a degree of saturation with bases 92%, the content of humus is 0.67%, mobile compounds of phosphorus and potassium are 126 and 44 mg/kg, respectively, the pH of the salt extract is 4.9.

To create a model of technologically disturbed soil, the arable and subsoil layers of the soil were mixed in a ratio of 1: 3 respectively. The agrochemical characteristic of the technologically disturbed soil model immediately after mixing was as follows: the sum of exchange bases was 21.4 mg-eq/100 g of soil with a degree of saturation with bases of 88%, humus content of 0.77%, mobile phosphorus and potassium compounds 108 and 67 mg/kg accordingly, the pH of the salt extract is 5.02.

The experience was laid in 3 replicates; the plot area is 1.21 m². Trenches of 100 cm deep were excavated for the device and the laying of the experience, in which cubic shaped plots of 110x110 cm in size were arranged using polycarbonate vertical partitions. At first, the lower part of each plot was filled to the depth of 28 cm. Then the organic fertilizers were applied to soil designated to fill a layer of 0-28 cm (in depth similar to the arable layer in the natural conditions of growing plants, in accordance with the experimental scheme. After the application of organic fertilizers, the soil was thoroughly mixed, and then packed in the upper part of the plot area.

The following organic fertilizers were taken for the study:

- spring barley straw of 2011 harvesting, at a dose of 5.0 kg/plot (at the rate of \approx 40 t/ha).

In variants with the application of straw, a microbiological preparation was applied at the same time as the destructor of the organic substance Barkon at a dose of 10 ml/plot (based on the recommended dose of 2 l/t of straw by manufacturers). This preparation is developed by the All-Russian Scientific Research Institute of agricultural microbiology, intended to accelerate the mineralization of cellulose and lignin-containing plant waste;

- peat transitional with the initial humidity of 62%, pH 4.8, nitrogen content is 0.59%, phosphorus is 0.07% and potassium is 0.04% based on the natural humidity. The dose of application is 10 kg/plot (at the rate of \approx 80 t / ha);

- cattle manure (cattle manure) is semi-matured, with a nitrogen content of 0.44%, phosphorus of 0.17% and potassium of 0.52% in terms of natural humidity. The dose of application is 12 kg / plot (at the rate of \approx 100 t/ha).

On the basis of the initial types of organic fertilizers, two types of compost were prepared: straw-dung and peat-manure composts, with a 1:1 ratio of composted elements. Composting dose is equal to 12 kg/plot (at the rate of 100 t/ha). All types of fertilizers (straw, peat, manure and composts) were applied into the upper (0-28 cm) layer of a previously prepared model of disturbed soil. The laying of the experience as a whole lasted three weeks, until August 15, 2011, after which the experience was left to naturally shrinkage until spring 2012. Placement of

plots in the experiment is systematic in three rows with an offset on two plots at the beginning of each row.

The full scheme of the experiment is shown in table 1.

Table 1

The scheme of experiment No.1

Nos.	Content of the variant	Reference designation
1	Model of technologically disturbed soil: a mixture of arable (0-30 cm) and subsurface (30-80 cm) soil layers in a ratio of 1:3	Control
2	Model of technologically disturbed soil + Straw at a dose of 5 kg/plot	Straw
3	Model of technologically disturbed soil + Peat at a dose of 10 kg / plot	Peat
4	Model of technologically disturbed soil + Cattle manure at a dose of 12 kg/plot	Manure
5	Model of technologically disturbed soil + peat-manure compost at a dose of 12 kg/plot	Peat-manure compost
6	Model of technologically disturbed soil + compost from straw and manure at a dose of 12 kg / plot	Compost from straw and manure

In the course of experiment, the following cultures were grown: from spring 2012 lupine-oat mixture in the ratio of 1:1, and by the end of summer white mustard; in 2013 also phacelia tanacetifolia and spring-planted brassica napus; in 2014, the wicker mix with the seeding of perennial legume-cereal grasses that grew until the end of the experiment (spring 2017). In 2012 and 2013 the above-ground phytomass of all crops after taking into account the yield, was ground and embedded in the soil as a green manure crop.

Soil samples were taken from each of the repetitions of the experience each year in early spring, before the start of field work, in 2012 and beyond in 2013, 2014, 2015 and 2016, on May 15 and September 30 of each year. In the spring of 2017, soil samples were last selected, after which the experience was closed.

Changes in the content and composition of soil organic matter - the main issue that is considered in any management system and for any soil. At the same time, soil humus is consid-

ered not only as a guarantee of preserving soil quality and productivity of agrobiocenosis, but also as a guarantee of soil resistance and the biota inhabiting to adverse environmental conditions [4, 5] and the possibility of restoring disturbed soil properties [6-11]. Moreover, this indicator, due to the Decree of the Government of the Russian Federation [12], is widely used to monitor soil condition in surveys and to assess the degree of soil degradation.

The results of the determination of the humus content are shown in table 2.

Changes in the characteristics of technologically disturbed soil only under the influence of weed cenoses, which are culturally and naturally compounded during the filling of soils, without using various kinds of agrochemical and agromelioration, can be judged by the changes in individual agrochemical indicators on the control variant. It is here all the recorded changes can be attributed to the self-restoration of the soil without the participation (or with minimal participation) of anthropogenesis.

Table 2

The effect of organic fertilizers on the dynamics of humus content in disturbed light gray forest light loamy soil

Experience variants	2012		2013		2012		2013		2016		2017 15.05.
	1	2	1	2	1	2	1	2	1	2	
Control	0,76	0,74	0,80	0,76	0,92	0,86	1,01	1,10	1,19	1,23	1,28
Straw	0,69	0,75	0,96	0,92	1,01	1,18	1,36	1,39	1,49	1,55	1,69
Peat	0,70	0,80	0,94	1,05	1,09	1,22	1,52	1,60	1,60	1,62	1,64
Manure	0,85	0,82	1,38	1,30	1,35	1,48	1,60	1,67	1,80	1,87	2,01
Peat-manure compost	0,78	0,82	1,30	1,36	1,28	1,44	1,64	1,80	1,83	1,83	1,98
Compost from straw and manure	0,73	0,79	1,27	1,30	1,46	1,46	1,61	1,80	1,83	1,90	2,02
<i>HCP₀₅</i>	0,04	0,04	0,05	0,06	0,07	0,06	0,05	0,07	0,06	0,06	0,05

Note: 1 – 15.05.; 2 – 30.09.

In the first year after sowing of cultivated plants, the content of organic matter (humus) in the soil remained almost unchanged. But already in the second year (2013), after planting the

phytomass of the planting in the plots croppers into the soil, there was a noticeable tendency of the positive influence of green manure on the soil supply with organic matter (from 0.76% in spring 2012 to 0.80% in spring 2013).

Changes in the content of humus on the control, which can be considered significant (by 0.15% compared with the original characteristic of disturbed soil), occurred on the third year, i.e. after two years of maintaining the disturbed soil under a continuous grass stand without alienating the bio-mass (i.e., using the above-ground plant mass as a green fertilizer). The results of this year, however, show that the organic matter of the soil, the source for the formation of which was the seasonal mass of plants, is unstable in time. As a result, in the year of active mineralization of green manure crop between the spring and autumn content of humus in the soil, a noticeable decrease from spring to autumn can be observed.

During the two-year period of maintenance of disturbed soil under the cover of legume-cereal grasses (2015 and 2016), there is a significant increase in the content of organic matter in the soil, and by the time of the organic mat is plowed up – stabilization of its content.

In the end, the content of technologically disturbed soil without the use of fertilizers, but with practically continuous soil flooding and using green manure from cultivated plants grown on soil, it was possible to raise the humus content by 0.51% compared to the initial humus content in technologically disturbed soil for 2011 (or 66%).

However, this value (1.28%) is much lower than the humus content in the soil arable layer (background), taken to create a model of disturbed soil (2.18%). Taking into account the recommendations on the assessment of soil fertility and its changes under the influence of various technologically factors, fixed in the Decree of the Government of the Russian Federation No. 612, it is impossible in this case to fully establish the restoration of fertility due to humus provision. Thus, in the Resolution it is noted that the decrease in soil fertility in terms of the content of humus in it should be considered a decrease in the indicator by more than 15% higher than the initial value. In the specific case, the humus content in the control variant of the experiment is 0.90% lower than in the original undisturbed soil, which is 41.3% and characterizes the soil of the control variant as significantly reducing fertility in terms of "organic matter content".

The use of straw in the process of biological recultivation (a substance with a predominant content of nitrogen-free organic compounds), as a potential source of humic substances in the soil, in the first year led to a significant decrease in the content of humus. The fact is quite understandable, since it is known that straw has a very wide carbon-to-nitrogen ratio (it contains

predominantly non-toxic organic compounds), and to ensure the mineralization of the soil microflora, nitrogen is needed, which it can only get from readily available organic matter in the soil. This is inevitable, so this led to a decrease in the initial content of humus in disturbed soil (0.77% in summer 2011) to 0.69% in the spring time for the analysis of soil samples on the variant with straw introduced into the soil in 2012. However, the incorporation of fresh organic matter of green mass of cultivated plants (and twice during 2012) allowed by the fall (five months of the spring-summer season) to restore almost the same level of humus content in the soil, which it had at the time of starting the experience (0.75% versus 0.77% at the beginning of the experience).

In the following years, the humus content on the straw introduction variant gradually increased, having reached the level of 1.69% after 5 years, which is more than twice the initial humus content in disturbed soil. Here, however, it should be recalled that in all variants of the experiment, including the one being discussed, it was intended to grow crops of continuous sowing, with maximum surface coverage with minimal mechanical effect on it (pre-sowing tillage only), which minimizes the natural loss of soil organic matter because of the active life of its biotic component.

On the variant with the application of peat, there were processes that were generally similar to the variant with the introduction of straw. The only difference is that during the years when the soil was found under the cover of perennial legume-cereal grasses, probably due to the established optimal soil conditions for decomposition of the organic matter of peat, there was a more noticeable increase in the humus content in the soil. However, at the moment of plowing the grasses, these two variants for the content of humus in the soil were identical.

The variant with the application of cattle manure was the best immediately after the start of the experiment, only in certain periods of soil sampling giving way to peat or straw-dung compost. At the same time, in the years immediately after the planting of green manure into the soil (2012 and 2013), by the fall on this variant (Manure) there was a slight decrease in the content of humus in the soil compared to the spring value of this indicator, which clearly indicates an increase in the intensity of mineralization processes occurring in the totality of the microflora of manure and the fresh organic matter of the green phytomass of plants.

In terms of the effectiveness of the increase in the content of humus in technologically transformed soil, the best variants were the introduction of clean manure (half-dug cattle manure), torus background and straw-manure composts. Their use in a dose of about 100 t/ha for 5

years of keeping the light gray forest light loamy soil under crops with a continuous projective cover made it possible to raise the humus content from 0.77% to 1.98-2.02%, i.e. 2-2.5 times. Moreover, this content is only 0.16-0.18% lower than the humus content in the arable layer of the background soil (2.18%), which corresponds to 7-9 relative percentages.

Thus, taking into account the recommendations of the Resolution of the Government of the Russian Federation, No. 612, on the content of humus, technologically transformed soil when used as organic fertilizer of half-converted cattle manure, as well as peat-manure or straw-manure composts on its basis, reached values that allow us to consider that the soil has restored its fertility. The term of the restoration of fertility in terms of "organic matter content" was five years.

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