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THE USE OF LOCAL FERTILIZERS SUPPLEMENTED WITH *Trichoderma koningii* Oudem. AT NO-TILL vs. CONVENTIONAL TILLAGE OF AGROCHERNOZEM IN SOUTHERN URAL

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Abstract

Local agrominerals and fertilizers, including marsh plants, which are the waste from cleaning lakes and reservoirs, have definite prospects in preventing soil erosion and restoring fertility alongside with the traditional anti-erosion technologies. Given this, we studied local fertilizers (manure, zeolite, sodium humate) and plant residues (marsh plants, straw) with the addition of $(NP)_{60}$ and suspensions of microscopic fungus *Trichoderma koningii* strain IB G-51 (*T. koningii*) when used at no-till (NT) and conventional tillage (CV) of the weakly eroded Chernozem (Mollisol). The effects were estimated based on the key agrochemical properties (humus content, mobile phosphorus, potassium, and alkaline hydrolyzed nitrogen), assay of activity of soil hydrolases and oxidoreductases and the yield of agricultural crops (spring wheat, barley and sugar beet). A three-year investigation was conducted in the Ural steppe zone. Single application of local fertilizers was shown to promote increasing in soil humus content, improvement of nutrient regime, and increment of enzymatic activity and crops yields. Thus, the increase of humus content in the 0-30 cm soil layer for 3 years is reliable for both types of tillage except the cases when zeolite and sodium humate were applied. These values increase by 3.5-5.6 % for NT, and by 1.8-4.1 % for CV as compared to the control. The soil phosphorus reserve increases from low to medium level due to manure and crop residues with mineral fertilizers added at no-till, whereas at CV a significant increase is observed due to the manure only. Potassium content elevated significantly, from 32 to 45 %, only at application of manure and marsh plants with the addition of $(NP)_{60}$ and *T. koningii*. The content of alkaline hydrolyzed nitrogen varies in a narrow range, and the significant increase is observed only at no-till with manure and marsh plants. Soil enzymatic activity is higher when manure and plant residues are introduced, in contrast to variants with sodium humate and zeolite. Among enzymes, protease and polyphenoloxidase show the closest correlation with agrochemical properties (r = 0.53-0.75, $p < 0.05$). The change of agrochemical properties and enzymatic activity of soil is more apparent in 0-10 cm layer under NT and in 0-30 cm layer under CT. The profitability of fertilizers under NT is higher, as compared to CV, only in arid conditions. Biologization of agricultural technology by introduction of the microscopic fungi *T. koningii* IB G-51 causes the faster humification of the marsh plants than the straw that must be especially accounted for at NT. The effect of marsh plants + *T. koningii* on soil properties is commensurate with that of manure.

Keywords: biologization of agriculture, agrochernozem, no-till, local natural fertilizers, marsh plants, *Trichoderma koningii*, soil enzymatic activity, humification, crop yields

Water and wind soil erosion remains one of the agronomic soil science problems in all natural and climatic zones of the planet. Along with traditional anti-erosion farming technologies [1-3], local agronomical ores [4, 5] and fertilizers are used to prevent soil erosion and restore fertility. It is possible to use floating mat [6, 7] as a basis for organic fertilizers, which is formed in large quantities when overgrowing of lakes and water reservoirs and requires disposal after their cleaning (RF patents No. 2524376 and No. 2531167). The methods of farming biologization are particularly effective in combination with soil-protective treatment, especially no-till [8-12]. In this case, not only the hydrophysical, agrochemical, but also the biological properties of the soil are improved, e.g. microbial biomass [13, 14], enzymatic activity [15, 16], as well as germination of seeds [17], are increased.

As is well known, long-term use of the no-till technology results in the accumulation of slowly decomposing plant residues [18], the destruction of which under anaerobic conditions can lead to an increase in soil phytotoxicity. It is advisable to use various species of microscopic fungi of the *Trichoderma* genus to speed up the humification of residues, which allows obtaining valuable organic fertilizer that has the ability to limit the development of diseases [19-21]. The use of *T. harzianum* and *T. viride* strains in the composting of post-harvest residues (rice, wheat straw) reduced the C:N ratio and formed the compost with nutrient content favorable for plants [22]. In these studies, composting was carried out under special conditions – in pits, composters, storage clamps, which required additional costs for transportation and specially designated areas. It would be much more profitable to carry out this process in the field, but only a few papers are related to the study of the possibility to use microorganisms of the *Trichoderma* genus in the field. It was shown that the introduction of *T. reesei* to accelerate the decomposition of straw in the field provided an increase in the activity of soil enzymes and an increase in the humus content in the soil [23]. The use of *T. viride* for the treatment of fields with sugar cane allowed increasing the content of nutrients in the soil, activating microbial respiration and increasing the crop yield [24]. These data indicate that various strains of the *Trichoderma* genus can survive under natural conditions for a sufficient time and accelerate the decomposition of plant residues, which are likely to accumulate excessively under the climatic conditions of the Southern Pre-Ural region; however, such studies have not been conducted in this region.

The effectiveness of local fertilizers and plant residues with the addition of *Trichoderma koningii* Oudem. at soil-protective treatment of slightly eroded agrochernozem was studied for the first time and it was shown that introduction of microscopic fungi *Trichoderma koningii* strain IB G-51 enhances humification of the floating mat and, to a lesser extent, of the straw, which is especially important under the no-till technology conditions. Combination of the floating mat with *T. koningii* in terms of the effect on the soil properties is comparable to manure.

The objectives of this paper included a comparison of the effect of fertilizers on the agrochemical properties, the enzymatic activity of the soil and the crops yield at no-till and traditional soil treatments, as well as the effect of microscopic fungus *Trichoderma koningii* on the decomposition of plant residues.

Techniques. A 3-year study was carried out in the southern forest-steppe zone of the Republic of Bashkortostan on a clay-illuvial, slightly eroded agrochernozem. Against the background of no-till and traditional soil treatment, a small-plot experiment was established, which included a single introduction of 10 kg of fertilizers according to the following variants: 1 (control, without fertilizer); 2 — floating mat + $(NP)_{60}$; 3 — floating mat + *T. koningii* + $(NP)_{60}$; 4 — litter manure of cattle; 5 — straw + $(NP)_{60}$; 6 — straw + *T. koningii* + $(NP)_{60}$; 7 — zeolite (Tuzbek deposit); 8 — Na humate (brown coal powder, Bashinkom, Russia). The area of the plots was 4 m^2 (2×2 m), 3-fold replications. The floating mat was a plant mass (cattail, reed, sedge), extracted during the cleaning of a nearby pond. The floating mat was crushed together with the roots to 3-5 cm units and introduced into the soil in a wet state. Wheat straw was crushed to the same size. To accelerate the humification process, plant residues were treated with a suspension of microscopic fungus *T. koningii* strain IB G-51 grown in the Czapek medium (2% sucrose) for 14 days at 28 °C (the strain was previously isolated from the agrochernozem and is maintained in the collection of microorganisms (Ufa Institute of Biology, the Ufa Federal Research Center RAS).

In 2011, soft spring wheat (Omskaya 36 variety) was grown on experimental plots, in 2012 spring barley (Chelyabinsky 99 variety) was grown, in 2013 this was sugar beet (Masha hybrid, OOO KWS RUS; bred by KWS SAAT SE, Germany).

The moisture supply in 2011 and 2013 was close to the average perennial values, 2012 was extremely dry, the temperature for all three years corresponded to the average perennial values.

Soil samples were collected in the spring and autumn of each year from 0-10, 10-20 and 20-30 cm layers. Agrochemical studies were carried out using standard methods: humus content was determined according to Orlov and Grindel, alkaline hydrolyzable nitrogen content by Cornfield, mobile phosphorus and exchangeable potassium content by Chirikov [25], invertase activity by Shcherbakova with ending according to Samner, peroxidases and polyphenol oxidases content by Karyagina and Mikhailova, proteases and dehydrogenases content by Galstyan, cellulases content by Kong with ending according to Sumner, urease content by Shcherbakov [26].

The MS Excel software package was used for statistical processing of the obtained results. The tables show mean values (*M*) and their standard deviations (±SEM). The statistical significance of differences was evaluated using the smallest significant difference at 5% significance level (HCP_{05}). The effect of soil agrochemical indicators on its enzymatic activity was evaluated using correlation analysis (the r values at $p < 0.05$ are given).

Results. The thickness of the humus-accumulative horizon of the experimental plot soil was on average 29 cm less than that of the nearby deposit, which was the basis for considering that the agrochernozem is clay-illuvial slightly eroded. The introduction of manure and plant residues (Table 1) led to a change in the agrochemical properties of the soil. The content of humus in the arable horizon has increased over 3 years, and not only at soil overturning but also under no-till conditions. Compared to control, it increased by 3.5-5.6% at the no-till and by 1.8-4.1 at the traditional soil treatment. At the same time, multidirectional tendencies were observed in the humus content dynamics: a slight decrease in this indicator was observed for the 3rd year of using manure and straw, a gradual increase was observed when using floating mat. This was most noticeable in the upper layer (0-10 cm) under the no-till. Similar results for the 0-5 cm layer were shown when using plant residues [27]. In the same layer, the introduction of *T. koningii* suspension to the floating mat contributed to a significant increase in the humus content compared with not only the control but also with the variant without its introduction. This effect was less pronounced at the introduction of straw.

In general, after 3 years, the increase in the humus content in the 0-30 cm layer was significant in all variants with fertilizer (except for the introduction of zeolite and sodium humate) regardless of the type of treatment, and the efficiency of the floating mat straw and manure was almost the same.

Along with the humus state, the content of nutrients has changed. Mobile phosphorus availability in the experiment soil was low. When introducing the manure and plant residues with the addition of mineral fertilizers against the background of no-till, the content of mobile phosphorus for 3 years increased to the average category, and in the case of traditional soil treatment, a significant increase was observed only on the variant with manure introduction.

1. Agrochemical properties of the soil in the 0-30 cm layer at different fertilizing depending on the treatment technology (*M*±SEM, Republic of Bashkortostan, 2011-2013)

Variant	Humus, %	R_{mobile}, Mg/100 g	$K_{exch.}$, mg/kg	$N_{alk.}$, mg/kg
N o - t i l l				
Control	7.53±0.03	4.7±0.1	95.7±0.3	197.4±1.2
Manure	7.95±0.03	6.8±0.3	127.6±5.0	213.2±2.5
Floating mat + *Trichoderma koningii* + $(NP)_{60}$	7.87±0.03	6.3±0.5	126.5±15.0	212.0±3.8
Floating mat + $(NP)_{60}$	7.77±0.05	5.6±0.3	109.1±4.6	212.6±3.1
Straw + *T. koningii* + $(NP)_{60}$	7.82±0.03	5.5±0.3	98.8±1.0	209.4±5.3
Straw + $(NP)_{60}$	7.79±0.03	5.3±0.2	97.8±2.1	200.1±5.8
Zeolite	7.59±0.02	4.8±4.6	103.5±0.9	197.2±3.8
Na humate	7.66±0.02	5.0±0.2	100.6±5.7	200.6±6.0
T i l l a g e				
Control	7.73±0.01	4.5±0.1	89.1±5.6	204.2±2.4
Manure	8.04±0.02	6.8±0.4	129.0±2.5	213.1±3.7
Floating mat + *T. koningii* + $(NP)_{60}$	8.05±0.03	5.4±0.7	123.1±2.9	206.9±1.6
Floating mat + $(NP)_{60}$	7.90±0.02	4.8±0.3	105.5±8.1	203.9±3.6
Straw + *T. koningii* + $(NP)_{60}$	8.00±0.02	4.6±0.2	99.1±2.4	206.2±4.1
Straw + $(NP)_{60}$	7.87±0.02	4.4±0.2	92.9±4.2	205.6±2.8
Zeolite	7.78±0.01	4.6±0.3	89.3±0.4	207.3±2.4
Na humate	7.76±0.02	5.6±0.7	98.8±4.4	203.8±5.0
LSD_{05}	0.11	1.1	8.2	10.9

Unlike mobile phosphorus, the content of exchangeable potassium was initially increased (see Table 1). Regardless of the treatment type, its significant (LSD_{05}) increase to a high degree of availability occurred only when manure and floating mat were introduced with the addition of $(NP)_{60}$ and *T. koningii*. In the first case, the amount of exchangeable potassium gradually decreased during the experiment, and in the second case, it increased with the decomposition of the floating mat. The content of alkaline hydrolyzable nitrogen varied in a narrow range, and an increase in its amount by 7-8% compared with the control was observed only with the introduction manure and floating mat under no-till. This is in good agreement with shown in the paper losses of nitrogen compounds exposed to leaching under no-till [28].

2. Activity of soil enzymes in the 0-10 cm layer by years of study at different fertilizing and treatment technologies (*M*±SEM, Republic of Bashkortostan)

Variant	Treatment	2011	2012		2013	
		autumn	spring	autumn	spring	autumn
P e r o x i d a s e, mg benzoquinone/g of soil for 30 min at 30°C						
1	No-till	80.1±2.2	202.4±14.2	208.1±12.0	225.1±8.8	134.5±5.5
	Tillage	83.2±3.1	202.7±10.8	218.6±13.0	188.2±10.2	115.8±4.8
2	No-till	85.8±3.8	214.7±11.0	236.3±9.5	233.8±14.3	173.3±10.4
	Tillage	109.8±5.1	237.5±15.2	247.4±6.1	210.9±7.2	132.6±9.8
3	No-till	92.5±3.6	215.9±9.1	228.9±9.7	254.2±7.4	151.1±7.7
	Tillage	98.1±3.8	242.4±8.0	254.8±14.2	209.1±5.7	150.5±8.3
4	No-till	86.9±1.9	210.4±13.8	208.5±14.5	238.7±9.6	143.7±11.2
	Tillage	88.2±1.9	230.7±14.1	243.1±15.3	204.2±6.7	125.2±10.8
5	No-till	91.3±2.8	218.9±9.7	243.7±7.2	259.1±13.8	148.0±12.5
	Tillage	99.3±3.0	241.8±15.2	259.7±10.5	257.2±14.5	167.8±14.7
6	No-till	82.6±1.7	214.1±14.0	240.6±8.3	235.7±9.5	136.3±9.7
	Tillage	85.1±2.0	220.7±13.7	253.5±15.1	214.7±10.0	141.8±11.3
LSD_{05}		6.1	25.1	23.2	19.7	12.7
P o l y p h e n o l o x i d a s e, mg benzoquinone/g of soil for 30 min at 30°C						
1	No-till	80.0±3.1	101.2±7.8	93.2±4.4	107.6±7.9	90.8±4.2
	Tillage	88.6±2.8	87.1±5.7	94.7±3.9	93.9±6.5	95.0±5.7

Continued Table 2

2	No-till	95.9±4.5	116.0±8.1	116.1±6.7	134.4±12.5	125.2±9.7
	Tillage	100.7±5.2	93.5±7.8	109.0±7.9	134.1±11.6	99.7±8.4
3	No-till	103.8±6.7	117.4±6.6	105.1±4.7	128.9±8.8	114.8±7.6
	Tillage	112.4±11.0	94.1±4.2	119.4±10.6	104.4±6.2	117.9±9.2
4	No-till	92.5±9.8	106.5±8.8	104.2±9.9	114.8±10.6	109.9±8.6
	Tillage	91.0±9.8	89.8±10.3	112.7±12.1	95.3±9.7	98.0±6.7
5	No-till	91.3±7.4	107.5±7.6	104.4±10.1	109.9±12.4	100.2±3.8
	Tillage	115.4±12.2	89.1±9.9	105.5±5.7	144.1±15.3	123.9±5.7
6	No-till	82.6±5.6	102.4±5.9	96.5±8.2	110.2±8.9	89.8±10.4
	Tillage	108.3±7.6	86.7±6.2	97.7±8.7	131.9±13.4	101.4±8.8
LSD_{05}		7.3	6.8	6.6	9.7	8.1
		Invertase, mg glucose/g of soil for 24 h				
1	No-till	4.8±0.3	19.6±0.9	14.5±1.3	16.0±1.4	2.6±0.7
	Tillage	5.4±0.3	22.8±1.2	25.5±2.0	23.8±2.5	7.2±0.9
2	No-till	6.9±0.5	22.5±1.2	19.8±2.3	16.7±1.9	4.5±0.4
	Tillage	5.2±0.4	26.9±1.4	29.0±2.5	23.1±2.2	8.3±0.5
3	No-till	6.9±0.7	22.9±1.1	22.7±2.9	18.7±1.1	6.4±0.7
	Tillage	5.0±0.6	24.7±1.6	24.8±1.8	20.2±1.2	6.2±0.7
4	No-till	5.8±0.4	21.2±1.0	20.4±1.5	18.3±2.0	2.6±0.3
	Tillage	5.1±0.7	24.9±0.8	29.4±2.9	22.6±2.5	8.1±0.8
5	No-till	6.7±1.0	22.3±1.2	18.6±2.7	21.9±2.8	5.2±0.7
	Tillage	4.8±0.3	22.3±0.9	26.6±3.3	16.6±2.9	6.1±0.5
6	No-till	6.5±0.7	17.9±1.3	18.2±1.5	19.1±1.7	2.5±0.3
	Tillage	4.8±0.3	19.6±0.9	14.5±1.3	16.0±1.4	2.6±0.7
LSD_{05}		0.7	2.1	3.3	2.8	0.5
		Protease, mg histidine/g of soil for 24 h				
1	No-till	10.0±1.3	6.3±0.3	7.9±0.8	8.0±0.9	6.5±0.2
	Tillage	7.6±0.9	4.7±0.8	5.9±0.7	8.5±1.1	4.6±0.3
2	No-till	15.8±1.2	8.3±0.4	9.4±0.7	11.5±1.0	10.4±0.8
	Tillage	15.7±1.2	7.0±0.4	7.7±0.4	11.5±1.0	5.9±0.5
3	No-till	15.2±0.8	9.2±1.0	10.9±0.9	11.4±1.0	8.8±0.7
	Tillage	13.3±0.7	6.2±0.7	8.4±0.8	14.0±1.2	7.1±0.3
4	No-till	13.5±0.7	7.3±0.9	8.7±0.8	8.1±0.6	7.4±0.6
	Tillage	11.3±0.6	5.9±0.5	4.2±0.6	11.7±0.7	5.4±0.2
5	No-till	15.4±0.8	10.1±1.1	7.2±0.4	9.2±0.4	6.9±0.2
	Tillage	13.9±0.7	5.7±0.2	7.5±0.4	10.4±0.6	5.3±0.4
6	No-till	11.3±0.5	9.7±0.9	6.3±0.5	9.8±0.3	6.4±0.5
	Tillage	11.3±0.6	5.8±0.4	5.6±0.3	13.9±0.8	5.1±0.5
LSD_{05}		1.1	0.6	0.7	1.0	0.7

Note. 1 — control, 2 — manure, 3 — floating mat + *Trichoderma koningii* + $(NP)_{60}$, 4 — floating mat + $(NP)_{60}$, 5 — straw + *T. koningii* + $(NP)_{60}$, 6 — straw + $(NP)_{60}$.

On year 3 of the experiment, plant residues morphologically became indistinguishable due to their transformation. It is known that soil enzymes [29] and components of plant litter [30] play an important role in the humification of plant residues. When introducing manure and plant residues, in contrast to the variants with the use of sodium humate and zeolite, the enzymatic activity of the soil was higher than in the control (Table 2). The dynamics of the activity of the studied enzymes was multidirectional, which, on the one hand, may be due to the transformation of organic matter, and on the other, due to the change in the agrophysical properties of the soil. Thus, the maximum activity of peroxidase, cellulase and invertase was recorded in the 2nd year of the study, the activity of dehydrogenase consistently increased, and the activity of protease decreased. Dynamics of the polyphenol oxidase and urease activity was weakly expressed (data not shown). The closest correlation relationship ($p < 0.05$) was found for the protease with the content of mobile phosphorus ($r = 0.75 \pm 0.12$), potassium ($r = 0.69 \pm 0.12$) and nitrogen ($r = 0.53 \pm 0.14$), for polyphenol oxidase with the content of humus ($r = 0.62 \pm 0.13$), potassium ($r = 0.56 \pm 0.14$) and nitrogen ($r = 0.62 \pm 0.13$). For other enzymes, the correlation coefficients, as a rule, did not exceed 0.4. Addition of the microscopic fungus *T. koningii* suspension to the floating mat and straw promoted the growth of the soil enzymatic activity regardless of the treatment technology.

The yield of agricultural crops grown in the crop rotation system of the experimental farm depended not only on the use of fertilizers but also on the methods of tillage, which largely determine the moisture content. In contrast to manure and plant residues, zeolite and sodium humate were almost ineffective under the experimental conditions (Table 3). Probably, this was due to the lack of irrigation [31] and organic fertilizers, which increase the effect of zeolite [32], as well as due to the form of the introduced sodium humate (powder) [33]. In the 1st (wet) year, against the background of tillage, the yield of wheat was higher than in similar no-till variants. Obviously, this is due to the increased availability of nutrients with the addition of $(NP)_{60}$ and faster mineralization of the manure organic matter. The highest yield was ensured by use of manure and straw when tilling, and at no-till by the introduction of floating mats with the addition of microscopic fungi suspension. During the vegetative period of the extremely dry 2012, the moisture content at no-till was higher than during tillage [30], which predetermined a higher yield of barley. In 2013, the yield of sugar beet at moldboard tillage was higher than at no-till. This time, the limiting factor was the increase in soil density [34], to which sugar beet is very sensitive.

3. Yields of agricultural crops at different fertilizing and treatment technologies (*M*±SEM, Republic of Bashkortostan)

Variant	Wheat, g/m^2 (2011)		Barley, g/m^2 (2012)		Sugar beet, kg/m^2 (2013)	
	tillage	no-tillage	tillage	no-tillage	tillage	no-tillage
1	406.8±33.8 / 2000.0±51.7	283.5±30.5 / 1950.0±70.6	95.1±6.0 / 385.3±12.8	146,8±10,7 / 393,3±13,7	2,9±0,3	2,3±0,2
2	723±42.1 / 3500.0±52.8	582.8±49.4 / 2316.7±120.3	231.3±10.4 / 510.0±13.5	254,1±12,3 / 783,3±15,1	3,6±0,3	2,6±0,3
3	651±43.2 / 3066.7±93.7	621.4±39.0 / 2433.3±115.7	165.3±15.4 / 471.7±19.3	192,6±13,6 / 570,0±22,3	3,9±0,5	2,7±0,2
4	425.0±28.6 / 2900.0±88.3	546±35.7 / 2733.3±87.4	120.9±9.4 / 463.3±12.9	150,3±12,4 / 466,7±17,5	3,7±0,3	3,0±0,3
5	705.0±48.3 / 3666.7±114.7	566.4±60.3 / 2000.0±103.0	115.8±11.6 / 483.3±16.4	166,7±13,4 / 568,3±23,5	3,6±0,3	2,8±0,3
6	686.6±65.0 / 3566.7±106.8	432±53.6 / 2483.3±98.3	128.6±11.0 / 413.3±14.5	167,2±12,8 / 470,0±16,7	3,5±0,2	2,7±0,1
7	368±38.9 / 2466.7±87.5	330±37.1 / 2250.0±90.3	122.6±16.7 / 343.3±20.4	104,9±11,4 / 380,2±23,1	2,8±0,4	2,0±0,3
8	424.1±39.7 / 3300.0±106.5	369.8±36.8 / 2283.3±123.5	125.4±14.6 / 383.3±22.7	129,6±14,7 / 386,7±19,7	3,0±0,3	2,3±0,2
LSD_{05}	43.1 / 450.8		9.2 / 57.8		0.2	

N o t e. 1 — control, 2 — manure, 3 — floating mat + *Trichoderma koningii* + $(NP)_{60}$, 4 — floating mat + $(NP)_{60}$, 5 — straw + *T. koningii* + $(NP)_{60}$, 6 — straw + $(NP)_{60}$, 7 — zeolite, 8 — Na humate. The grain weight is above the line, g/m^2, the mass of the sheaf is below the line.

Thus, on average over 3 years of the study, the yield of crops under the traditional soil treatment was higher, but in the dry 2012, it was greater under no-till, when profitability was 257% versus 116% under tillage. The yield increase was on average 40-72% (for manure 67%, for floating mat + *T. koningii* 47%, for floating mat 40%, for straw + *T. koningii* 72%, for straw 66%) under tillage and 21-38% (for manure 32%, for floating mat + *T. koningii* 28%, for floating mat 36%, for straw + *T. koningii* 10%, for straw − 26%) under no-till.

So, in the conditions of the Southern Pre-Ural region on the clay-illuvial, slightly eroded agrochernozem, introduction of manure and plant residues under tillage and no-till promotes the increase in the humus content, improvement in the supply of nutrients, increase in the enzymatic activity of the soil and crop yields. Under no-till, the changes in agrochemical indicators are more pronounced in the 0-10 cm layer, under the traditional treatment − in the 0-30 cm layer. The profitability of fertilizers with no-till technology is higher than with traditional tillage only in dry conditions. The use of microscopic fungi *Trichoderma koningii* in biologized technologies leads to an increase in the processes of plant residues humification, especially floating mats. In terms of affecting the soil properties, this fertilizer is close to the variant with the introduction of manure.

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