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The influence of biological preparations and their mixtures on soil properties in winter wheat

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Rationale: As the number of people around the world increases, so does the need for food. Agriculture is becoming more and more intensive to meet food needs. New, heavy machinery is emerging, using large amounts of fertilizers and pesticides, which help to grow a good harvest. However, all these measures also have a negative impact on the main means of agricultural production, the soil.

Methods: A two – factor field experiment in 2017/2019 was carried out at the Vytautas Magnus University Experimental Station on the winter wheat 'Sailor' crop test fields. Biological preparations and their mixtures was applied using different tillage technologies. Treatments of the experiment: Factor A: different tillage technologies; Factor B: bio-preparations and their mixtures .

Results: Soil organic carbon was not significantly influenced by the tillage technology, but the use of biological preparations and their mixtures increased the organic carbon content of the soil better than the use of nitrogen to stimulate straw mineralization. Organic carbon content was significantly better compared to compensatory nitrogen in the use of a mixture of biological preparations Ruinex + Penergetic k (15.6%), Ruinex + Azofix (13.6%), Penergetic k + Azofix (8.4%) and a mixture of all three preparations (25.0%). The use of Ruinex and Panergetic k single-component preparations also contributed significantly to the increase in organic carbon (Figure 1.).

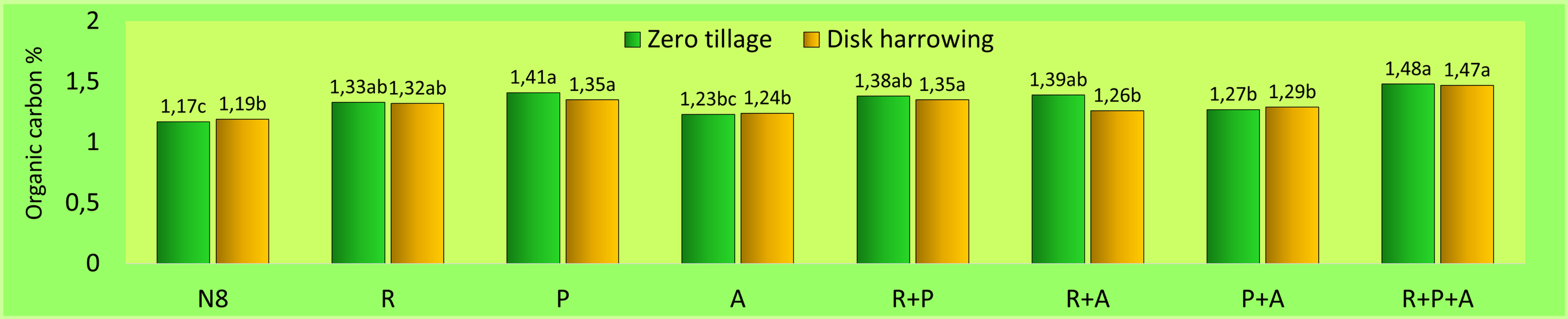
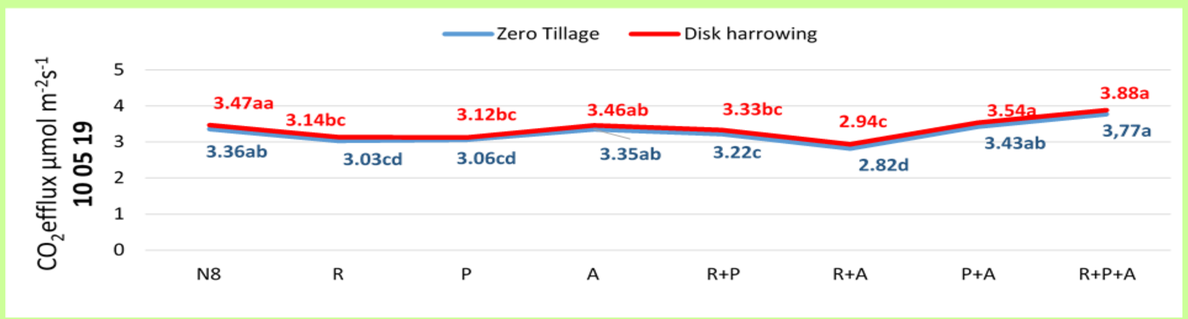


Figure 1. The influence of biological preparations on CO2 emisions in the middle of vegetation, 2019

Note1: Differences between averages(zero tillage and disk harrowing) marked with a star (*) are significant. Differences between averages(biological preparations) not marked with the same letter (a, b) are significant, P <0,05

Note 2: N8 – 8 kg of nitrogen to 1 t of straw without biological preparations; R – Ruinex 1l ha; P – Penergetic k 0,2l ha-1; A – Azofix 1 l ha-1; R+P – Ruinex 1l ha-1 + Penergetic k 0,2 l ha-1; R+A – Ruinex 1l ha-1 + Azofix 0,5 l ha-1; P+A – Penergetic k 0,2 l ha-1 +Azofix 1 l ha-1; R+P+A – Ruinex 1l ha-1 + Penergetic k 0,2 l ha-1 +Azofix 0,5 l ha-1

The use of Ruinex and Panergetic k single-component preparations also contributed significantly to the increase in organic carbon. In the early spring vegetation, in zero-tillage crop fields, CO_2 emissions ranged from 2.82 to 3.77 CO_2 efflux µmol $m^{-2}s^{-1}$. Disk harrowing, after application of preparations, had a slight 3.4% effect on bigger CO_2 emissions. A bigger CO_2 emission was determined by spraying crops with a combination of Ruinex + Penergetic k + Azofix. CO_2 emission release became more active in the middle of vegetation, more intensive processes were noticed in zero-tillage background when Penergetic k and Azofix were used alone. However, in many cases, CO2 emissions were intensified by biological preparations (especially mixtures) where they were worked in with a disk harrow (Figure 2.).



•**Figure 2.** The influence of biological preparations on CO_2 emisions in the middle of vegetation, 2019

•Note1: Differences between averages(zero tillage and disk harrowing) marked with a star (*) are significant. Differences between averages(biological preparations) not marked with the same letter (a, b) are significant, P <0,05

•Note 2: **N_8 –** 8 kg of nitrogen to 1 t of straw without biological preparations; **R –** Ruinex 1l ha; **P –** Penergetic k 0,2l ha^{-1}; **A –** Azofix 1 l ha^{-1}; **R+P –** Ruinex 1l ha^{-1} + Penergetic k 0,2 l ha^{-1}; **R+A** – Ruinex 1l ha^{-1} + Azofix 0,5 l ha^{-1}; **P+A** – Penergetic k 0,2 l ha^{-1} +Azofix 1 l ha^{-1}; **R+P+A –** Ruinex 1l ha^{-1} + Penergetic k 0,2 l ha^{-1} +Azofix 0,5 l ha^{-1}

The application of all biological preparations and their mixtures to the stubble (zero technology) increased the humus reserves in the soil more compared to the use of compensatory nitrogen.

Compared to the use of nitrogen fertilizers, Penergetic k (24%), Ruinex + Azofix (22.5%) and a mixture of all three preparations (23%) significantly increased the humus content in the zero tillage system. The latter mixture most (24.0%) promoted the formation of humus and the incorporation of biological preparations by a disc cultivator (no-till technology). Ruinex (19%), Penergetic k (21%) and a mixture of both (21%) were also important in using this technology (Table 1.).

Table 1. Influence of biological preparations and their mixtures on humus content and its change in 2017–2018.

Bio-preparations and their mixtures	Humus %		Change 2017/2018
	2017	2018	
	Zero tillage		
1. Nitrogen 8 kg t of straw, without biological preparations (control)	1.79c	1.96d	+0,17
2. Ruinex 1l ha	2.09a	2.29bc	+0,20
3. Penergetic k 200 ml ha	2.10a	2.43a	+0,33
4. Azofix 1 l ha	1.90bc	2.12d	+0,22
5. Ruinex 1l ha+ Penergetic k 200 ml ha	2.02ab	2.38ab	+0,36
6. Ruinex 1l ha + Azofix 0,5 l ha	1.96bc	2.40a*	+0,44
7. Penergetic k 200 ml ha Azofix 1 l ha	1.84c	2.19c	+0,35
8. Ruinex 1l ha+ Penergetic k 200 ml ha Azofix 0,5 ha	2.15a	2.41a	+0,26
	Disk harrowing		
1. Nitrogen 8 kg t of straw, without biological preparations (control)	1.79c	1.92c	+0,13
2. Ruinex 1l ha	2.09a	2.28a	+0,18
3. Penergetic k 200 ml ha	2.10a	2.33a	+0,23
4. Azofix 1 l ha	1.90bc	2.14b	+0,24
5. Ruinex 1l ha+ Penergetic k 200 ml ha	2.02ab	2.33a	+0,31
6. Ruinex 1l ha + Azofix 0,5 l ha	1.96bc	2.22ab*	+0,26
7. Penergetic k 200 ml ha Azofix 1 l ha	1.84c	2.22ab	+0,38
8. Ruinex 1l ha+ Penergetic k 200 ml ha Azofix 0,5 ha	2.16a	2.38a	+0,22

Note 1: Differences between averages(zero tillage and disk harrowing) marked with a star (*) are significant. Differences between averages(biological preparations) not marked with the same letter (a, b) are significant, P <0,05

•**Conclusions:** Organic carbon in the soil increased more with the use of biological agents than with the release of compensatory nitrogen. No significant differences were found between tillage methods. At the start of vegetation, CO2 emissions were increased by the use of the mixtures of biological preparations. In the middle of the vegetation, the release of CO2 emissions was activated by using not only Panergetic k and Azofix alone but also a mixture of them. The use of all biological preparations and their mixtures in zero tillage increased humus stocks in the soil, better compared to the use of compensatory nitrogen.