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Soil fertility under winter wheat in conditions of ecologically safe fertilizers systems

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The purpose. To study influence of eco-logically safety fertilizer systems (ESFS) on physical-and-chemical and agrochemical properties of grey forest soil under winter wheat and on productivity of the crop. **Methods.** Field probes, physical and chemical, agrochemical and biochemical. **Results.** Results of probes proved that ecologically safety fertilizer systems, based on straw of pease, promoted alkalization of soil solution on 0,02 – 0,18 units concerning control. Most apparently this process was in conditions of importation of humus fertilizer (HF) on the background of straw of pease + $N_{30}P_{45}K_{45}$. With the same regularities the hydrolytic acidity of soil varied. It was fixed that in conditions of organic-mineral fertilizer systems there were the best conditions for phosphoric regime of soil, and use of HF on the basis of straw + $N_{30}P_{45}K_{45}$ was efficient for heightening content of alkaline-hydrolyzed and ammonium nitrogen. Application of humus or microbiological, or chelated fertilizer on the basis of straw of pease + $N_{30}P_{45}K_{45}$ increased potential nitrification ability of soil up to 0,162 – 0,183 mg + $N\text{-}NO_3$/kg of soil against 0,137 mg of $N\text{-}NO_3$/kg of soil in control. It is shown that ecologically safety fertilizer systems, such as the agrotechnical factor, enable to improve humus nature of soil. In conditions of indicated fertilizer systems the content of labile organic substance was on 35 – 42% above, than in control. Use of organic-mineral fertilizer systems on the basis of straw had stable and permanent effect, promoted increase of yield of winter wheat on 23,0 – 39,3% and augmentation of protein in grain on 1,1 – 2,7% concerning control. **Conclusions.** Application of fertilizer systems composed on the basis of straw of pease with mineral and organic fertilizers is effectual measures for martempering soil fertility, essential increase of yield and quality of grain of winter wheat in conditions of grey forest soils of Carpathian region.

Key words: *ecologically safety fertilizer systems, winter wheat, soil fertility, productivity.*

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Substantiation of ways to improve soil fertility, taking into account ecological safety, is practically impossible without studying the impact of the culture of modern agriculture on soil fertility. Prolificacy is one of the most important properties of the soil, emerging in the process of soil formation and is characterized by a set of its indicators.

In recent decades, the productivity of agroecosystems has considerably decreased, due to reduction of organic and mineral fertilizers, alienation from the biological rotation of far of organic substance [1-3]. The decline of soil fertility occurs in almost all regions of the country, including at regional levels, in particular in the Carpathian region. The soil-climatic conditions are characterized by washing water regime, and in the last decade the frequent fallout of storm rains and the presence of prolonged droughts from the t ° air of 1.8-2.6ºC above the average perennials in the summer. The soils of the Carpathian region are poor in the content of total nitrogen and humus, characterized by acidic or medium acid pH, a significant amount of fungal microflora.

Under these conditions, there is a growing need for scientific substantiation of measures to improve soil fertility, in particular, the concept of ecologization of agriculture, namely strengthening the role of fertilizer, becomes actuality [4-6]. The implementation of this approach requires the study of the effectiveness of environmentally safe fertilizer systems in agricultural crops in the Carpathian region, including a scarcity of traditional organic fertilizers. In this context, fertilizer systems formed on the basis of

the use of organic material in the form of plant residues, siderates, new organo-mineral fertilizers (OMF), intermediate sewing [7-9]. There are multivariate possibilities of improving fertilizer systems on the base of vegetable material, with the addition of humus, microbiological, chelated fertilizers, biostimulants. Such fertilizer systems can be able to improve soil fertility and increase the productivity of agricultural cultures with winning economic results.

The purpose of the research is to investigate the impact of environmentally safe fertilizer systems on the fertility of gray forest soil for the cultivation of winter wheat.

Methodology of research. The research was conducted during 2015-2017 on gray forest soil (pH of salt - 4.85, humus content - 2.1%, nitrogen alkaline hydrolyzed- 98, mobile forms of phosphorus 108 and potassium 87 mg / kg) in the field of winter wheat sort Poliska 90 in the conditions of stationary research of the Institute of Agriculture of the Carpathian region. The culture was sown on grain after peas. The fertilization of winter wheat envisaged ploughing of peas straw in the dose of 2.5 t / ha on the background of N30P45K45, as well as the compatible introduction of humus (HF) or microbiological (MF) or chelated (CHF) fertilizers and biostimulant (BS). Eco-Impulse humus fertilizer was carried out during the period of straw plowing in the dose of 3l / ha, microbiological fertilizer "Eco-grunt" was brought in spring at the terms of temperature of soil + 5º + 8ºC in the dose of 2l / ha and fertilizers on chelate basis "Rozasol- 18" in the phase - the beginning of exit in a tube, the dose is 3.0 kg / ha, as well as the processing of plants biostimulator "Terra sorb", twice during the vegetation: spring bruising, exit in a tube - 0,5 l / ha.

In dynamics, the pH was determined by the salt potentiometric method (NSU ISO 10390-2001, the hydrolytic acidity of the soil (Hr) by Kappen (NSU 2621291), the determination of alkali hydrolyzed by Confield and ammonium with the reagent of nitrogens by Nesler (NSU 26489-85), mobile phosphorus and exchangeable potassium according to Kirsanov (NSU -4115-2002), the nitrification capacity of the soil by Kravkov, the content of labile humus (NSU -4732-2007) and protein in wheat grain by Lowry. The experiments and crop accounting were conducted according to Dospehova [10].

The results of research. Determination of physical and chemical parameters of soil under winter wheat testifies to their dependence on ecologically safe fertilizer systems. It was established that the pH Kcl in the soil layer about 0-30 cm was within the range of 4.92-5.11 units, which characterizes the reaction of the soil solution as a medium acid (Table 1). For all fertilizer systems, the soil solution was observed for 0.02-0.18 units. More intensively, this process took place under the conditions of organo-mineral fertilization in the presence of peas straw in the system of organic matter containing Ca, Mg and K (1.82, 0.27 and 0.50%) and humus or microbiological fertilizers. Other fertilizer systems significantly lessened the level of exchange acidity. Hydrolysis acidity changed with certain regularity, the use of straw of peas without mineral fertilizers provided the value of hydrolytic acidity at the level of 2.48-2.46, and the combined application of mineral fertilizers against the background of straw provided a tendency for growth of Hr to 2.58-2.59 mg- eq / 100 g of soil. With the use of HF or MF on the background of straw + N30R45K45, the hydrolytic acidity remained at a lower level and fluctuated within the range of 2.38-2.48 mg-eq, which is not least due to the more extensive straw peas and the increase of alkaline elements in soil (Table 1).

1. Influence of ecologically safe fertilizer systems on physicochemical and agrochemical indicators of gray forest soil under winter wheat, average for (2016-2017).

№ var.	Fertilizer systems	pH $_{KCl}$	Hr mg - eq /100 g of soil	$N_{лг}$	NH_4	P_2O_5	K_2O
				mg /1 kg of soil			
1	Control (without fertilizer)	*4,93 4,92	2,61 2,63	101 81	19,6 13,6	109 84	94 79
2	Peas straw	5,02 5,03	2,48 2,46	97 88	19,3 13,6	122 91	106 84
3	Straw + $N_{30}P_{45}K_{45}$	4,95 4,95	2,58 2,59	116 93	21,8 15,1	128 94	114 88
4	Straw + $N_{30}P_{45}K_{45}$ + BS	4,96 4,94	2,56 2,58	115 90	21,6 14,8	128 93	112 90
5	Straw + $N_{30}P_{45}K_{45}$ + BS + HF	5,11 5,06	2,38 2,44	125 98	27,1 16,4	131 102	114 91
6	Straw + $N_{30}P_{45}K_{45}$ + BS+ MF	5,02 5,00	2,48 2,50	115 96	21,7 16,4	130 99	110 90
7	Straw + $N_{30}P_{45}K_{45}$ + CHF	4,95 4,97	2,58 2,56	113 90	21,8 14,7	132 108	117 94

Note. The value in the phase of spring bruising in the numerator; meaning in the phase of full ripeness of winter wheat in the denominator.

Analyzing the data content of mobile phosphorus compounds, we can conclude that the phosphate regime of gray forest soil is regulated by fertilizer systems. The lowest content of them in the spring planting season is characterized by the soil of a variant without fertilizers - 109 mg / kg. The use of straw of peas increased the content to 122 mg, and the use of ecologically friendly fertilizer systems (options 3-7) provided a level of 128-132 mg / kg of soil. The highest availability of mobile phosphorus forms in the phases of spring bruising and wax maturation was due to bringing the straw + N30P45K45 + CHF (var.7) 132 and 108 mg / kg of soil. The application of organo-mineral fertilizers changed the content of potassium mobile compounds, which was within the limits of 88-94 mg / kg of soil (Table 1).

One of the important indicators of soil fertility is the level of nitrogen content. The nitrogen mode of the soil is reflected by the dynamics of alkaline hydrolyzed and alkali hydrolyzed nitrogen for the ESFS. As a result of the researches, it was found that the lowest level of alkali hydrolyzed nitrogen was observed under the control variant-101 mg / kg. It was established that in the conditions of ecologically safe fertilizer systems, the reserves of alkaline increased hydrolyzed nitrogen forms in the soil, except for the option of introducing peas straw without mineral fertilizers (var.2).

The combined use of straw + N30R45K45 (var. 3) increased the content of given form of nitrogen by 12-15 mg / kg, and an additional injection of HF or MF provided an increase of 14-24 mg in the spring buckling phase and 9-15 mg in the period of waxy maturity relative to the control variant. The use of CHF on the background of straw allowed to maintain the content of Nah at the level - 113 in spring and 90 mg at the time of maturation of winter wheat.

Analogical dependence of the influence of ecologically safe fertilizer systems was observed on ammonium nitrogen reserves in soil under winter wheat, indicating their positive influence on the process of ammoniation.

The objective reflection of the availability of plants with nitrogen is the nitrification capacity of the soil, which is considered an agrochemical and microbiological criterion. If on the control it was at the level of 1.50 mg NO3 / 100 g during the spring bungalow period, then under the influence of the organo-mineral system (straw + N30R45K45 + BS + HF) the highest activity level was 1.92 mg NO3 / 100 g of soil (Table. 2).

Somewhat slower accumulation of NO3 in soil was observed in variants with the addition of straw + N30R45K45 of cheated fertilizer. The intensity of nitrification processes in soil under winter wheat was higher in spring period than during the period of wax ripeness due to the significant consumption of nitrate form during the growth and development of plants.

The nitrogen mode of the soil is closely related to the humus state, including its mobile labile part. This part of humus provides favorable conditions for the life of plants, as well as biochemical processes associated with photosynthesis, respiration, metabolism. Labile part of humus is characterized by low carbon content, low optical density, high hydrophilicity and content of functional groups of nitrogen [11].

2. The content of labile organic substances in gray forest soil and its nitrification capability under winter wheat for ESFS.

№ var.	Fertilizer systems	Nitration capability		C of labile humus	
		mg $N\text{-}NO_3$/100g of soil		мг/100г of soil	
		I	II	I	II
1	Control (without fertilizer)	1,50	0,56	411	382
2	Peas straw	1,42	0,49	486	423
3	Straw + $N_{30}P_{45}K_{45}$	1,57	0,61	652	586
4	Straw + $N_{30}P_{45}K_{45}$ + BS	1,56	0,62	636	590
5	Straw + $N_{30}P_{45}K_{45}$ + BS + HF	1,86	0,67	728	605
6	Straw + $N_{30}P_{45}K_{45}$ + BS + MF	1,62	0,64	690	642
7	Straw + $N_{30}P_{45}K_{45}$ + MF	1,62	0,62	671	649

Note. I - phase of spring bushing; II - the phase of full ripeness

The content of mobile organic matter has undergone significant fluctuations in the soil under winter wheat. The largest values of this indicator were in the phase of spring bruising: 411-728 mg / 1000 g of soil. In the phase of full ripeness, the content of the labile humus substance decreased by 10-17% relative to the phase of spring bruising. Such conformity can be explained by the decline in the nutrient content of the soil, in particular nitrogen, as mentioned above.

The lowest level of labile humus of 411-486 mg / 100 g of soil was noted in variants with no fertilization or plowing of straw peas (var.1 and 2).

The lowest level of labile humus 411-486 mg / 100 g of soil was observed in variants with lack of fertilizer or plowing of straw peas (var.1 and 2). The results of the research showed that the advantage of

fertilizer based on peas straw + N30R45K45 with the addition of MF or CHF appeared more intense accumulation of the labile humus substance than in the control variant, however in the variant with the addition of HF (var.5) the proportion of mobile humus diminished in relation to the higher mentioned systems of fertilizer and can specify the fixation of labile humus forms in the soil, which is a positive phenomenon for this type of soil (Table 2).

The improvement of the nutritional mode under the influence of ecologically safe fertilizer systems has a positive effect on the yield of winter wheat. The results presented in Table 3 show that straw plowing provided a slight increase in the winter wheat yield in relation to control- 0.17 t / ha, which presents 5%, and adding N30R45K45 and straw - 0.73 t / ha or 18.3% respectively. The use of biostimulant a background of straw+ N30R45K45 improved biological processes in plants, which contributed to an increase in yield to 0.94 t / ha. The highest yield of winter wheat was obtained in variants using HF or MF or CHF on the background of straw + N30R45K45 + BS; grain growth was 1.25, 1.03, 1.08 t / ha compared to the control.

The obtained results show that the content of protein in winter wheat of Poliska 90 in conditions of ecologically safe fertilizer systems during the years of research was 10.2-12.0%, and under control - 9.3%. The highest grain protein content was found in variants 6 and 7-11.8-12.0%. Less protein content under the condition of consistent straw + N30R45K45 + BS + HF can be conditioned by the higher productivity, which partially alleviates the protein content of the grain.

3. Influence of ecologically safe fertilizer systems on yield of winter wheat and protein content in grain (2016-2017g.).

№ var.	Fertilizer systems	Crop capacity, t/ha	Growth from fertilizers		Protein content	
			t/ha	%	%	t/ha
1	Control (without fertilizer)	3,18	-	-	9,3	0,29
2	Peas straw	3,35	0,17	5,0	10,2	0,34
3	Straw + $N_{30}P_{45}K_{45}$	3,91	0,73	18,3	10,8	0,42
4	Straw + $N_{30}P_{45}K_{45}$ + BS	4,12	0,94	22,9	11,4	0,46
5	Straw + $N_{30}P_{45}K_{45}$ + BS + HF	4,43	1,25	28,2	11,1	0,49
6	Straw + $N_{30}P_{45}K_{45}$ + BS + MF	4,21	1,03	24,5	11,8	0,49
7	Straw + $N_{30}P_{45}K_{45}$ + CHF	4,26	1,08	25,4	12,0	0,61
$HIP_{0,05}$		0,142 – 0,148 0,137 – 0,152				

Conclusions:

- Growing of winter wheat in the Carpathian region on gray forest soils in conditions of fertilizer systems composed on peas straw in combination with mineral and organic fertilizers certifies a tendency to soiling the soil grout and is an effective measure of increasing the stocks of nitrogen and phosphorus readily available for plants.

- The use of ecologically safe fertilizer systems in the field of winter wheat, provided the optimal mode of nitrification processes in the soil and contributed to the increase in the content of labile forms of humus.

- Combined use of fertilizers (MF or MF or HF) in systems of ESFS with straw peas + N30R45K45 positively influenced the yield of winter wheat, which improved on the control near 1.08-1.28 t / ha, and the protein content increased by 1.5 -2.7%, respectively.

- The use of ecologically safe fertilizer systems is one of the ways to broaden the fertility of the soil.

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