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ORIGINAL ARTICLE

Preservation of acid Haplic Luvisols fertility and agrocenosis productivity increase under organic farming conditions

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The article presents the research results of the green manure and crop by-products effect on the fertility parameters in Haplic Luvisols of the northern part of the Right Bank Forest-Steppe and crop productivity for the 14th year aftereffects of re-liming. Liming of gray forest soil contributes to the preservation, and, in combination with organic fertilizers, to the reproduction of humus reserves, improving other indicators of physicochemical properties of soil fertility. Usage of by-products (5 t/ha), sideration (4.4-5.0 t/ha) as an organic fertilizer on the background of the aftereffect of repeated liming with a full dose of hydrolytic acidity in Haplic Luvisols allowed to obtain from 15% to 30% increase in yield, even without the application of additional nitrogen fertilizers.
Keywords: Haplic Luvisols, fertility, liming, organic fertilizer, productivity.

Introduction

Due to the trend of constant expansion of organic production in the world to 27% in the next decade, in Ukraine is also expected expansion of organic farming on an area of 1 mil ha. Soils with an acid reaction of the soil solution are classified as unproductive lands. However, their widespread distribution both in the world and in Ukraine attracts the attention of soil scientists and specialists in order to increase their fertility and prevent further degradation. Organic farming has significant prospects for development on acidic soils, and the basis of their effective use is their chemical melioration (liming). Its qualified execution directly affects the productivity and quality of organic products (Tkachenko, Hryhora, 2013; Shykula, 2000; Baliuk et al., 2015; Dehodiuk, 2001).

The agricultural lands of Ukraine include almost 10 million hectares of soils with high acidity, 4.6 million of which are medium- and strongly acidic. Soils with excessive acidity are common in the Polissya area, the Western Forest-Steppe, the northern part of the Forest-Steppe and the brown soil forest region of the Carpathians. Most of them are distributed in Polissya and are represented mainly by sod-podzolic soils (pH_{KCl} 4.4–5.5), they occupy about 1.4 million hectares of arable land. The smaller area in this zone among arable lands is occupied by gleyed varieties of podzolic and sod-podzolic soils-about 0.7 million hectares. In the Precarpathians, the Carpathians and Transcarpathia common are brown soils, brownish-podzolic surface-gleyed, brownish-podzolic, sod podzolic multi-gleyed and other types of acid soils. A characteristic feature of these soils is a more pronounced acidity, unsaturation of bases, high content of mobile forms of aluminum, gleying (Gusakov et al., 2012; Dehodiuk, 2001).

In the Forest-Steppe and partly in Polissya Haplic Luvisols and Luvic Chernozems on loess and loess-like loams are widespread, which also have an acidic reaction medium. Luvic Chernozems together with Luvic Greyzemic Phaeozems, as a rule, are characterized by a weakly acidic and close to neutral reaction of the soil solution (pH about 5.5-6.0). In Haplic Luvisols, the acidity is more pronounced-pH 4.5–5.8, they are marked by a deeper occurrence of carbonates on the soil profile. Soils with high acidity of the soil solution, which are distributed mainly in Polissya, Forest-Steppe, Precarpathian and Transcarpathian, require a set of reclamation measures with an annual demand of more than 4 million tons of limestone materials. (Biologizaczіya…, 2012; Vitanova et al., 2007; Hadzalo, Kaminskyi, 2016).

In order to prevent the development of degradation phenomena on acid soils for organic farming it is necessary to comply with the "laws of agriculture", that is, to carry out their liming, and calculate the application rate according to the indicators of acidity, taking into account the set of crops in crop rotation. At the same time, it is necessary to pay special attention not only to the initial level of acidity, but also to the ability of the soil to counteract secondary acidification. It should be noted that in organic farming liming should be carried out considering the quality of ameliorants, which is a promising direction in the cultivation of acid soils, which is aimed at creating a favorable soil environment for plant growth and development, increasing their yields and obtaining quality organic products.

It is known that the most favorable conditions for the growth and development of most cultivated plants and their assimilation of nutrients are based on pH 5.5-7.0 soil environment. Therefore it is necessary to refrain from cultivation on acid soils (without preliminary carrying out of reclamation actions) especially sensitive to acid reaction crops - root crops, spring and winter wheat, barley, corn, soybeans, millet. Usage of acid soils in field crop rotations should be limited to growing those types and varieties of crops that can withstand slight acidification of the soil and do not require immediate liming. On these soils, preference should be given to growing oats, winter rye, lupine, cereals and other calcium-phobic crops. On Haplic Luvisols and Luvic Chernozems with close carbonates (loess and loess-like loams) it is especially important to include in the crop rotation such "phytomeliorants" as alfalfa, clover, sainfoin, etc., which can to some extent optimize alkaline soil environment in the root system.

Intensive technologies for growing crops, which are widely implemented by agricultural enterprises of the country, are aimed at further depletion of soil resources. Low doses of organic fertilizers and an unbalanced system of fertilizers with basic nutrients have led to a violation of the ecological balance of agroecosystems. Development of ecological resource-saving technologies for growing field crops and improving soil fertility is inextricably linked with the biologization of agriculture, an important part of which is the use of organic fertilizers, siderates, non-marketable crop products. Expanding the use of various organic fertilizers is one of the most important elements of organic farming, which improve soil fertility and ecological condition of agroecosystems. At the same time, the soil and climatic conditions of our country are favorable for the widespread use of various crops as siderate, depending on the amount of heat, precipitation, soil type, the availability of a range of seeds. In this regard, we see a fertility restoration problem of acid soils in terms of replenishment of humus reserves through siderate and non-marketable crop products, considering the optimization of physicochemical properties.

Academician E.K. Alekseev in his monograph "Theory and practice of green manure" noted, that Ukrainian Polissya and Forest-Steppe are the most favorable zones for sowing plants for green manure in Ukraine. The problem of using green manure in agriculture has been studied by a number of scientists who believe that green manure should be understood not only as the applying of aboveground mass, but also to should be taken into account the remnants of the plants root system in the arable soil. (Bovsunovskyi, 2009; Dehodiuk, 2001).

In Ukraine, scientists from L'viv National Agrarian University, Institute of Agricultural Microbiology and Agriculture of NAAS, Institute of Agriculture of the Carpathian Region NAAS, NSC "Institute of Agriculture NAAS", Podillya State Agrarian Technical University, Institute of Oilseeds of NAAS, Institute of Feed Research and of NAAS pays considerable attention to the study and implementation of green manure crops in agriculture. In recent years, Ukrainian scientific institutions have recommended a large selection of crops for green manure, which is determined by the biological characteristics of plants, in particular their reaction to the level of soil fertility, taking into account the content of humus in the soil, nutrients and acidity:

Legumes–perennial and annual lupine, sea bass, clover, winter and spring vetch, peas, alfalfa, clover, lentils, sainfoin, soybeans–grow best on more fertile soils (except annual lupines), do not require additional nitrogen application, but do not tolerate weed fields and cannot grow a significant biomass in a short growing season;

Cereals–winter rye and its varieties, oats, ryegrass annual and perennial – tolerate excessive soil acidity and low nutrient content, respond well to additional nitrogen application; *Brassicaceae*–white mustard, winter and spring rape, winter mustard, phacelia, oil radish–grow better on fertile soils, suppress weeds, react negatively to lack of moisture, require additional nitrogen application, very demanding on the level of agricultural crops, except for oilseed radish (relatively unpretentious). To increase nitrogen in the soil, leguminous greens are used, and to replenish the arable layer with organic matter, cereals are used. However, it should be noted that in recent years in Ukraine the area under green manure has decreased significantly. The above cultures are widely used not only in Ukraine but also in Belarus, the Baltics, Russia, in all countries of Eastern and Western Europe and in several other countries. (Ivanyshyna, Shuvara, 2016; Samorina, 2011; Shuvar, Roik, 2016).

Synthesis of scientific literature gives every reason for the wide and effective implementation of green manure in organic farming, because they: able to enrich the soil with organic components, nitrogen, phosphorus, potassium, formed due to the decomposition of the root system; reduce the level of soil acidity; contribute to loosening and improving soil structure, as well as air and water regimes; improve the water holding capacity of the soil due to its enrichment with organic matter; activate the activity of beneficial microorganisms; prevent the development of pests, protecting them from disease; inhibit the development of weeds; attract insects useful for plant development; protect the soil from weathering, overheating, erosion; increase the quality level of the decay process of compost components, improve its structure, enriching the composition; reduce anthropogenic and technogenic impacts on agrophytocenoses; contribute to the improvement of the ecological state of the environment (Slobodian, 1999; Tkachenko et al., 2019; Tracy & Baker, 2001; Heavy metals and …, 2004).

It should be noted that one of the disadvantages of green manure is the drying of the soil during the growing season, in the dry season plowing of the green manure may be ineffective. To select crops for growing green manure, it is necessary to take into account the climatic, soil and economic conditions of the farm, special attention should be paid to seed production, as it is the main cost item in the technology of growing green manure. Of particular importance among all greens are legumes. The cost of legume seeds is higher, however, when they are grown on green manure, they are able to enrich the soil with nitrogen. Thus, the use of green manure not only increases the productivity of agricultural land, but also protects the soil from degradation, its physical, physicochemical and biological properties improve.

Scientists are attracted by the rational use of by-products, as the simultaneous applying of it during harvesting has a positive effect on the cost of the technology of growing crops, and at the same time contributes to a significant increase in yield, as well as improving soil fertility parameters. According to V.F. Saiko it is economically justified, because plowed straw and corn stalks are 2-3 times more efficient than manure application, at the same time about 30 kg / ha of diesel fuel are saved, across Ukraine - almost 1,2 million tons. One ton of straw with the addition of 8.0-10.0 kg of nitrogen in its action and aftereffect on the yield and accumulation of humus is equivalent to 4.0-5.0 tons of manure. When plowing 4 tons of straw per hectare soil gets: nitrogen - 16.0-20.0 kg, phosphorus-4.0-7.0, potassium-22.0-25.0, calcium-20.0-30.0, magnesium-2.0-7.0 kg, as well as trace elements: boron, copper, manganese and zinc (Kisel`, 2000; Baliuk et al., 2015). From the above it follows - one of the main ways of additional supply of organic matter is to application in the soil of crushed crop by-products, increasing the area under green manure crops and perennial grasses.

Purpose and Objectives

To establish the impact of the use of green manure, by-products, as well as the aftereffects of reclamation measures on the fertility indicators of Haplic Luvisols. Research on the reproduction of soil fertility, optimization of its properties and increase the productivity of agrocenosis through the use of green manure, by-products of the crop, increasing the share of legumes in the structure of sown areas, improving the physical and chemical parameters of the soil conducted in a long-term field stationary experiment of the Department of Soil Science and Soil Microbiology NSC "Institute of Agriculture NAAS" on Haplic Luvisols, registered as stationary field experiments of NAAS (Certificate No. 01), which is located at an altitude of 120 m above sea level 50°26′13″ north latitude, 30°30′20″ east longitude. The soil of the experimental site is characterized by the following initial indicators: pH-4.6; hydrolytic acidity-3.6 mg-eq/100 g of soil; metabolic bases: calcium-3.9; magnesium-0.58 mg-eq/100 g of soil; degree of saturation of bases-56%, low content of humus-1.44%, very low content of hydrolyzed nitrogen compounds-70-90 mg, which indicates its low natural fertility.

In arable soil, the aftereffect (14th year) of reclamation measures is studied among the factors (full dose re-liming conducted by hydrolytic acidity 1.0 Hg–5.0 t/ha $CaCO_3$) on the state of effective soil fertility depending on the manifestation of the processes of strengthening or weakening of the eluvial soil-forming process, aftereffect of green manure, which is applied into the soil in the form of green mass of oilseed radish up to 5.0 t/ha once per rotation of a 7-field crop rotation (in 2018), as well as used by-products of crops grown up to 5.0 t/ha per year.

Results

The most important humus characteristics are the total humus content and its reserves. According to the indicators, the influence of crop-root residues in crop rotation on the condition of soil humus is estimated. According to our research, the greatest influence was exerted by the crop-root residues of the precursor of winter wheat-white lupine. The main requirement for creating a deficit-free balance of humus for all soils is, first of all, a positive level of nitrogen return with organic fertilizers, because non-return causes intensification of mineralization processes of potential humus reserves (Table 1).

Fertilization	The beginning of the III rotation (1st year)		End of III rotation (7th year)		End of IV rotation (14th year aftereffect)	
	%	t/ha	%	t/ha	%	t/ha
Without fertilizers (control)	1.29	38.7	1.24	37.2	1.24	37.2
$CaCO_3$ (5.0 t/ha)	1.91	57.3	1.70	51.0	1.45	43.5
Green manure+$CaCO_3$ (5.0 t/ha)	1.91	57.3	1.76	52.8	1.65	46.2
By-products+Green manure	1.86	55.8	1.63	48.9	1.54	49.5

Note: initial humus content–1.44%.

Table 1. The content and reserves of total humus in the Haplic Luvisols depending on the organic fertilizer and the aftereffects of re-liming, soil layer 0-20 cm.

The results of research show that at the end of the IV rotation of crop the humus state of the soil as a whole stabilized and reached a state of equilibrium (the level of humus self-stabilization)–loss of humus compared to baseline–1.44% (43.2 t/ha) clearly observed in the version without fertilizers (control)–1.24% (37.2 t/ha)–this indicates that without sufficient fertilization and reclamation the sod process is weakened, forming a low content of humus, which is concentrated in the upper layer of the soil and has an unstable, easily mobile nature.

At the same time, long-term plowing of straw and use of green manure (by-products+green manure) allowed to keep and replenish humus stocks in a root-containing layer of soil, which affected the increase in crop yields. Precursor by-products and green manure are the basis for replenishing humus stocks in conditions of lack of organic fertilizers and are an effective measure to improve the humus condition of Haplic Luvisols. The use of green manure once per crop rotation and plowing of by-products annually contributed to the increase of humus content. Thus, at the end of the third crop rotation, the total humus content in the layer of 0–20 cm was 1.63% (initial humus content–1,24%), and the increase in humus content during the third rotation was 13% to the original content. The results obtained for the third rotation of crop rotation indicate that an important measure to preserve the decomposition products of organic compounds from their leaching and fixation in the soil profile is liming (1.0 Hg) in combination with organic fertilizer. Due to the introduction of green manure and re-liming (in the full dose of hydrolytic acidity)-the humus content was 1.70-1.76%, respectively, humus reserves of 51.0-52.8 t/ha.

The degree of the aftereffect influence of re-liming on the 14th year after application varied significantly depending on the level of organic fertilizer on its background, and the effectiveness of green manure and crop by-products for organic fertilizers depend on the application dose, as well as weather conditions due to instability and fluctuations in humus content. The greatest positive effect on the humus condition was revealed when green manure was applied on the background of liming (1.0 Hg)–the total humus content for the 14th year after re-liming was 1.65%, and its reserves are 49.5 t/ha. Relatively higher humus reserves here can be explained by higher crop yields, resulting in an increase in the number of root and crop residues, which are the source for the formation of humus.

In general, in the IV crop rotation the arable layer of soil lost some fertility compared to the previous rotation, there is a lack of sufficient organic fertilizer, which depends on crop yields. In addition, the effectiveness of greening was affected by weather conditions - worsened the expected results. But even in these conditions, the humus content when plowing only by-products and green manure on average per rotation increased by 24% compared to unfertilized soil. A similar accumulation was also observed in the 20–40 cm layer, which was 27% relative to the control. It is noted that the humus content of gray forest soil when using green manure with by-products was 1.54% (reserves of 46.2 t/ha) with an initial humus content of 1.44% (reserves of 43.2 t/ha). According to research of the Institute of Agriculture of the Carpathian region NAAS, in the process of accumulation of humus and stabilization of its content on light gray forest surface-gleyed soil, an organic fertilizer system is effective with the introduction of 10 t/ha of crop rotation area of manure, at which the humus content increased to 1.68%. With the application of only limestone fertilizers, the humus content was 1.51% in the arable layer of the soil. Co-application of organic fertilizers in crop rotation on the background of liming provides an increase in the level of total humus in the arable layer to 1.75%, and in the subsoil - up to 1.58%. At the same time, humus reserves increased to 47.60 and 32.71 t/ha, respectively. Thus, liming of Haplic Luvisols with a full dose of hydrolytic acidity is an effective measure to preserve the reserves of humus and its content not only in the arable layer but also in the subsoil.

Similar results were obtained on light gray soils of Polissya region (Ivanyshyna, Shuvara, 2016; Kisel`, 2000). According to the literature (Biologizacziya…, 2012; Kisel`, 2000) for 2.5-4 months in the soil decomposes to 46%, for 1.5-2 years - up to 80% of the total mass, this is also confirmed in our studies. It is known that the loss of humus during plowing and the level of self-stabilization of humus depend on the genetic characteristics of the soil, as well as on the characteristics of agriculture (Fig. 1).

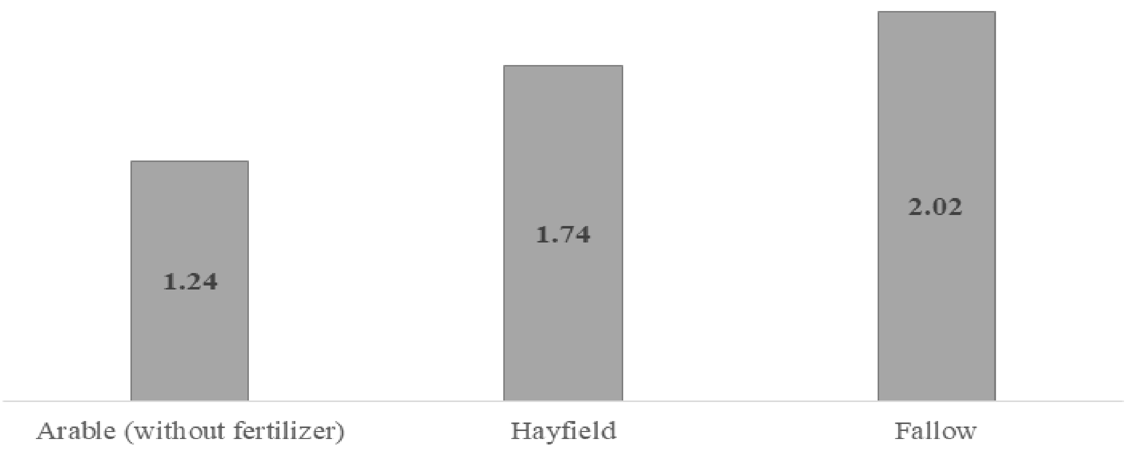

Fig. 1. The structure of agriculture soils**.**

The analysis of indicators of the content and stocks of humus of Haplic Luvisols under its various management shows that preservation and reproduction of its fertility is clearly observed in natural ecosystems: under haymaking field humus content-1.74%, under fallow-2.02%, respectively stocks of 52.2 t/ha and 60.6 t/ha. The results of research have shown that arable soil without fertilizer is gradually depleted and loses its fertility.

Equally important is the control of soil for physicochemical fertility indicators, which should be monitored for organic production during crop rotation. Acid reaction of the soil inhibits the growth and development of plants, there is an increase in their damage by disease. Constant downward currents of water, high acidity in soils can affect and change the direction of chemical reactions and soil processes during organic farming on them, as a result the basic physical and chemical property worsen, solubility of clay minerals amplifies, activity of microorganisms changes. In the range of pH 6.0–6.2 there is a moderate production of CO_2 by the soil, processes of synthesis of humic substances prevail, in an acid interval pH (<6.0) the biochemical situation causes the intensification of oxidative processes and the intensive decomposition of humus, which is one of the problems of the acidic influence on the soil, changes the speed of the processes.

At the beginning of the third crop rotation liming was carried out by defecate with a content of 50% $CaCO_3$. Defecate in the composition along with lime contained 6-10% of organic matter; 0.4–0.5% nitrogen; 0.6–0.7% phosphorus; 0.1–0.4% potassium. With an average dose of ameliorant (5.0 t/ha) the soil receives additional 25 kg of nitrogen, 30-35 kg of phosphorus, 10-15 kg of potassium, which has a positive effect on the first crop. Ameliorant is not contaminated with heavy metals and is environmentally friendly for organic farming. After the application of ameliorant, the acidity is practically eliminated, neutralizing the harmful effects of mobile aluminum, which allows you to grow more demanding to the reaction of the soil environment crops. Re-liming (beginning of the third rotation) with a full dose Hg (5.5-6.0 t/ha $CaCO_3$) once per crop rotation has a positive effect in the next IV rotation. Soil acidification is weakened, the structure of soil absorbing complex improves, namely, the loss of metabolic calcium and magnesium is reduced, which contributes to the optimization of physicochemical parameters of the soil (Table 2).

Fertilization	**The end of the IV rotation (14 years aftereffect)**			
	pH_{KCl}	**Hg, mg-eq/100 g of soil**	**H^+_{exch}, mg-eq/100 g of soil**	**Al^{3+}, mg-eq/100 g of soil**
Without fertilizers (control)	4.6	3.36	0.056	1.39
$CaCO_3$ (5.0 t/ha)	5.1	2.27	0.03	0.17
Green manure + $CaCO_3$ (5.0 t/ha)	5.4	1.98	0.03	0.16
By-products + Green manure	5.0	2.48	0.05	0.28

Note: output data of 1992: pH_{KCl}–4.6; Hg – 3.6 mg-eq/100 g of soil.

Table 2. Physico-chemical parameters of Haplic Luvisols depending on agronomic measures, layer 0-20 cm.

It is proved that during long-term agricultural use of Haplic Luvisols, under the conditions of of by-products and green manure application the process of podzolization is not stopped, as evidenced by physicochemical parameters. Therefore, these soils need liming to optimize the properties and increase the productivity of crop rotations. It is established that liming at full dose (1.0 Hg) with combination of by-products and green manure in the arable layer of Haplic Luvisols provides as of the 14th year the optimum level of physical and chemical indicators: hydrolytic acidity - 1.98 mg-eq/100 g of soil, compared with the initial value of 3.6 mg-eq/100 g of soil, pH_{con} of the soil solution close to neutral (5.4-5.6), the content of mobile aluminum-0.16 mg/100 g of soil. After all, weakly acidic or close to neutral reaction of the soil environment is optimal for most crops, which is especially important in organic production.

Thus, with long-term agricultural use of podzolic soils in the northern part of the Forest-Steppe, under the conditions of only by-products and green manure application, the process of podzolization is not stopped, as evidenced by the deterioration of physical and chemical parameters. Therefore, these soils under organic farming require chemical reclamation in order to optimize the properties and increase the productivity of crop rotations.

Of course, the liming of Haplic Luvisols significantly affected the change of physical and chemical properties of the soil. According to research, there is a difference between options with liming and without the introduction of ameliorant. All indicators of Haplic Luvisols acidity with use of only by-products and green manure are worse in comparison with the limed variants but are better in relation to not limed and unfertilized control. This fact is explained, because of insignificant return to the soil of calcium and magnesium with a non-commodity part of the crop.

Structure of exchange cations of Haplic Luvisols (Table 3, 4) indicates that the use of liming (5.0 t/ha) on acidic soil contributed to the stabilization of the structure of exchange cations in soil absorbing complex and provided a better ratio of Ca^{2+} and Mg^{2+} in contrast to the variants without its application.

Fertilization	**the beginning of the III rotation (re-liming)**				**The end of the IV rotation (14 years aftereffect)**			
	Ca^{2+}	**Mg^{2+}**	**H^{+}**	**$\frac{Ca^{2+}}{Mg^{2+}}$**	**Ca^{2+}**	**Mg^{2+}**	**H^{+}**	**$\frac{Ca^{2+}}{Mg^{2+}}$**
Without fertilizers (control)	49	7	44	7.0	52	8	40	6.5
$CaCO_3$ (5,0 t/ha)	55	8	37	6.9	70	10	20	7.0
Green manure + $CaCO_3$ (5,0 t/ha)	67	9	24	7.4	71	12	17	5.9
By-products + Green manure	54	8	38	6.8	56	8	36	7.0

Table 3. Structure of exchange cations in the absorption complex of Haplic Luvisols, % to the absorption tank, (layer 0-20 cm).

Usage	**Ca^{2+}**	**Mg^{2+}**	**H^{+}**	**$\frac{Ca^{2+}}{Mg^{2+}}$**
Arable (without fertilizer)	52	8	40	6,5
Hayfield	65	8	27	8,1
Fallow	71	10	19	7,1

Table 4. Structure of exchange cations in the absorption complex of Haplic Luvisols for its various application, % to the absorption tank, (layer 0-20 cm).

For liming with a single dose, even on the 14th year after re-liming, the amount of calcium and magnesium in soil absorption complex is approximately 80%, and in natural analogues under hayfield - 73%, under fallow - 81%.

Thus, the main measures to preserve the fertility of Haplic Luvisols under conditions of organic farming are liming and maximum use of organic fertilizers, which contribute to the simple reproduction of fertility, reduce soil degradation.

Crop yield is an integral indicator of effective soil fertility, which is determined by a complex combination of soil, biological and weather conditions. Studies have shown that the benefits of integrated chemical reclamation, namely the improvement of physico-chemical, agrochemical properties of Haplic Luvisols, lead to an adequate response of crops in the crop rotation in the form of additional yield increases. At the same time, it is known how dependent the productivity of crops is on the weather conditions of the region during the growing season.

Studies have established the approximate limits of the effectiveness of organic fertilizers (by-products of the predecessor, green manure) for separate and joint application with a defecate on the productivity of crops on Haplic Luvisols (Table 5). The effectiveness of defecate on unfertilized soil is primarily due to its complex impact: both reclamation effect on soil properties and improvement of nutrient regime are manifested. Application of defecate only ($CaCO_3$ (5.0 t/ha)) contributed to an increase in productivity by 14%, and for the combination of liming with green manure (green manure+$CaCO_3$ (5.0 t/ha)) by 28%.

Fertilization	Winter wheat (14 years aftereffect)	Growth due to organic fertilizers and lime	White Lupine (14 years aftereffect)	Growth due to organic fertilizers and lime
Without fertilizers (control)	2.08	-	2.51	-
$CaCO_3$ (5.0 t/ha)	2.49	0.41	3.43	0.92
Green manure+$CaCO_3$ (5.0 t/ha)	2.75	0.26	4.47	1.04
By-products+Green manure	2.71	0.63	3.21	0.7
$LSD_{0.05}$	0.07		0.09	

Table 5. Productivity of crop rotation on Haplic Luvisols under organic farming, t/ha of grain units.

Optimization of physical and chemical parameters of the soil by combining by-products with green manure helped to increase crop yields by only 10% relative to unfertilized soil. Refusal to use mineral fertilizers on soils with low levels of nutrient supply has led to a decrease in crop productivity. In addition, the effectiveness of green manure was highly dependent on weather conditions.

It was found that during organic farming the productivity of winter wheat averaged 2.5 t/ha of grain units, and white lupine 3.4 t/ha of grain units, at the same time, the increase in liming variants of winter wheat was 0.4–0.7 t/ha of grain units, and white lupine - 0.9-1.04 t/ha of grain units, therefore, the application of by-products up to 5 t/ha per year, green manure - green mass of legumes 5 t/ha once for the crop rotation and liming allowed to obtain from 15% to 30% yield increase. Thus, the use of green manure not only increases the productivity of agricultural land, but also protects the soil from degradation, while improving its performance and overall improvement of the ecology of modern agriculture.

Analysis of research shows that the processes of acidification, decalcification and dehumidification are closely related, so in order to optimize the processes of soil formation requires their parallel solution. The main measures to increase fertility under conditions of organic farming are liming and sufficient use of organic fertilizers, which cause a simple reproduction of fertility and prevents soil degradation. To optimize the properties and to form an effective fertility in organic farming on Haplic Luvisols, the organic fertilizer system should include liming at full dose (1.0 Hg), which ensures stable crop rotation productivity.

In summary, it can be stated that the repeated chemical reclamation had a positive effect on the total content and reserves of soil humus (increase in humus content up to 20% compared to control without fertilizers), both individually and as part of organic fertilizer. Calcium and magnesium cations, which came with defecate, neutralizing excessive soil acidity, contributed to the increase of crop yield (increase on limed variants was 0.4–0.7 t/ha grain units), resulting in the predominance of humification processes over the mineralization of organic residues, which came with green manure, root crop residues, by-products of the predecessor and the consolidation of newly formed humic substances in the upper root layer of the soil.

Conclusion

Established the main conditions for the formation and protection of fertility in Haplic Luvisols under conditions of organic farming. It is proved that the cultivation of crops on coarse-dusty loamy Haplic Luvisols without the use of organic fertilizers and liming leads to its dehumidification–reducing the content and reserves of humus in the arable layer. Liming with a full dose helps to maintain the humus state of the Haplic Luvisols for the 14th year of aftereffect at the level of 1.50% (initial humus content 1.44%). Positive changes and the tendency to humus accumulation occur with green manure fertilizer on the background of repeated chemical reclamation with a full dose, where the humus content was 1.65%, the amount of calcium and magnesium in soil absorption complex is 80%.

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