UDC 657.1:338.43-047.64
DOI 10.31521/2313-092X/2021-1(109)-1

Ukrainian Black Sea Region Agrarian Science
Vol. 25, No. 2

Potential resources and approaches to the management of organic raw materials of Ukraine to replenish humus reserves in grants

Ie. Skrylnyk,
доктор сільськогосподарських наук ORCID ID: 0000-0002-8642-8547

V. Hetmanenko,
кандидат сільськогосподарських наук ORCID ID: 0000-0001-9021-3373

A. Kutova,
кандидат сільськогосподарських наук ORCID ID: 0000-0003-2680-566X

V. Moskalenko

ННЦ "Інститут ґрунтознавства та агрохімії імені О. Н. Соколовського"

Abstract. Currently, the problem of global climate transformations, as well as natural environment, insufficient amount of food and energy, loss of biological diversity and sustainability of ecological systems are being actively reflected. The problem of imbalance of biogeochemical carbon cycles as a result of intensive or irrational agriculture is one of the fundamental aspects of global changes in the environment. Management of the processes of carbon cycling and sequestration in the soil is the main link in solving such urgent global issues as overcoming soil degradation and mitigating the effects of climate change. Development and involvement of methods of sustainable soil organic carbon management priority for soil protection in Ukraine. In turn, climate change and its consequent aspects have increased interest in calculating the quantitative assessment of changes in soil organic carbon reserves in agroecosystems in order to identify the carbon sequestration potential of arable soils. Thus, the purpose of the article is to provide an assessment of the supply of soil-climatic zones of Ukraine with sources of organic raw materials to increase the amount of humus reserves in the soil, as well as to highlight approaches to management in order to increase their efficiency. It was concluded that the systematic use of organic materials in agriculture will contribute to reducing the imbalance of biogeochemical carbon cycles, as well as increasing the stability of agrocenoses. The estimated supply of organic fertilizers in the regions of Ukraine under various scenarios was calculated. The characteristics of potential resources of organic raw materials of natural origin and organic waste from the standpoint of humus formation are given. Approaches to the management of organic materials to increase the efficiency of humus accumulation in soils are proposed

Keywords: organic raw materials, humus, zonal availability, approaches to resource management

INTRODUCTION

In the 21st century the problems of global changes in the natural environment and climate, shortage of food and energy, loss of biodiversity and sustainability of ecosystems are brought to the fore. The problem of the imbalance of biogeochemical carbon cycles as a result of intensive or irrational agriculture is a part of global changes in the natural environment. Soil organic matter (SOM) plays an important role in solving the problems of sustainability of agro-ecosystems, soil degradation and production of ecologically clean products. During the period 1850-2005, as a result of erosion, 74±18 Pg of carbon was lost, of which 79-85% fell on agricultural lands and pastures [1]. According to the Regional Assessment of Soil Changes in Europe and Eurasia [2], humus loss is observed on 23-70% of agricultural land areas. According to [3], arable soils

Article's History:
Received: xx.xx.2021
Revised: xx.xx.2021
Accepted: xx.xx.2021

Suggested Citation:
Skrylnyk, Ie., Hetmanenko, V., Kutova, A., & Moskalenko, V. (2021). Potential resources and approaches to the management of organic raw materials of Ukraine to replenish humus reserves in grants. *Ukrainian Black Sea Region Agrarian Science*, 25(2), 45-53.

contain 25-75% less organic carbon than their counterparts in natural ecosystems. Management of carbon cycle and sequestration processes in the soil is a key link in solving such urgent global problems as overcoming soil degradation and mitigating climate change [2].

Development and implementation of sustainable soil organic carbon management methods are extremely important for soil protection in Ukraine. The country joined the UN Convention to Combat Desertification, in which it made a voluntary national commitment to increase the organic carbon content of soils by at least 0.1% by 2030. Increasing SOM reserves improves the ecological properties of the soil, including the preservation and restoration of soil biota, optimizes the nutritional regime and the level of moisture, thereby increasing the long-term resistance of arable soils to degradation under the influence of anthropogenic factors.

Climate changes, disruption of ecosystem stability, degradation of soil resources have led to interest in measuring and quantifying changes in soil organic carbon reserves in agroecosystems in order to identify the carbon sequestration potential of arable soils. Carbon sequestration by soil is the subject of a wide range of research around the world. According to studies [4; 5], increasing the content of organic matter in the soil to a depth of 2 meters by 5-15% will reduce the concentration of CO_2 in the atmosphere by 16-30%. It is estimated that the total volume of annual absorption of carbon dioxide, including natural dynamics and the use of carbon-saving technologies, is 23-28% of annual emissions into the atmosphere within russia.

The ability of the soil to stabilize and retain the carbon of organic matter, which arrived with organic materials, forms the carbon sequestration capacity of the soil. Carbon sequestration by soil resources is influenced by a complex of interconnected factors (climate, soil type, intensity of management), which determine the accumulation of carbon in the soil or its loss. The ability of the soil to hold carbon is controlled not only by the content of finely dispersed granulometric fractions of dust and clay with a size of <0.05 (0.02) mm [6], but also by the capacity of cation exchange, the mineral composition of the soil and depends on the level of moisture and the temperature regime [7].

Carbon sequestration depends on the level of soil carbon saturation. Management practices that will promote sequestration in one soil may not be effective in another where the carbon content is approaching a stable level. Such soil will accumulate less organic carbon and at a slower rate. This is important for planning and developing sustainable management actions and practices that maintain and increase SOM stocks. According to the results of long-term stationary experiments, it was established that the use of organic fertilizers contributes to the increase of organic carbon in the soil by 12-23% [8-10]. The average value of humus content for long-term manure application is lower than the value for short-term application, indicating a decrease in the rate of organic carbon sequestration relative to emission, as the total humus content approaches equilibrium.

Considerable attention of researchers is paid to the quantitative assessment of carbon reserves in soils, mechanisms of its stabilization with the use of organic materials to increase the reserves of organic matter in the soil. The introduction of organic raw materials with a certain biochemical composition balances the balance between sequestration and emission of organic carbon and is an effective measure for the restoration of SOM reserves [11-13]. Under the conditions of application of composts with an increased content of humic acids, slow mineralization of nitrogen in soils is observed, which improves not only soil fertility, but also conditions for humification of organic matter [9]. Quantitative and qualitative transformations of the constituent pools of SOM from the moment of their biosynthesis to full biological mineralization are closely related to the specific process of humification of the organic soil substrate. Humification is a process of biophysical and chemical fixation of organic substances in the form of stable fractions of humic substances, which protect organic matter from complete mineralization [6; 14]. During the decomposition of organic raw materials by soil microorganisms, 70% of organic carbon is lost in the form of CO_2 due to emission, 20% is transformed into humic compounds, and 10% is transformed into non-humic organic compounds and microbial biomass [15-17]. Common management practices that can contribute to soil carbon storage include the use of cover crops, crop rotation management, organic fertilization, and more efficient management of tillage activities.Minimizing the loss of humus in the soil can be ensured by arranging arable land by removing land unsuitable for plowing and conserving degraded land, implementing anti-erosion measures, and mandatory exclusion of practices of burning vegetation and its residues in the fields. The implementation of agricultural practices to increase the content of soil carbon depends on a complex of factors related to natural conditions (climate, soil), land use system, and also depends on the social and cultural context (farm specialization, market and availability of means of production, subsidies, education farmers and desire for change) [18].

Methods of increasing the accumulation of organic matter in the soil include the use of scientifically based fertilization systems, which will contribute to the arrival of a significant amount of carbon and its long-term stay in the soil. The material basis of the reproduction of soil carbon is organic fertilizers, which at the same time act as a leading factor in the sustainable development of ecologically balanced farming systems, in particular organic farming. In organic farming systems, the stock of stable carbon in the surface layer of the soil increases [19], thereby ensuring its sequestration [20].

The purpose of the work is to assess the supply of soil and climate zones of Ukraine with organic raw material resources for replenishing humus reserves in the soil and highlight approaches to management in order to increase their efficiency.

CONCEPTS IN THE MANAGEMENT OF ORGANIC RAW MATERIALS OF UKRAINE

Anthropogenic load and interference in natural soil processes disrupts the process of humus accumulation, which leads to a change in the ratio between the synthesis and mineralization of organic matter in the soil. The processes of dehumification cause deterioration of the agronomic properties of the soil and decrease in fertility, which can affect the functioning of the biosphere as a whole. A comparison of the humus content of the soils of Ukraine during the time of Dokuchaev (1882) with the current state shows that the loss of humus has reached the level of about 20%.

The weighted average indicator of humus content in the soils of Ukraine according to the results of the X round of agrochemical land certification (2011-2015) is 3.16%. This reflects a positive trend of soil humus compared to the data of the previous survey round, which revealed an average humus content of 3.14%. This trend is associated with the growth of organic substances entering the soil, mainly due to plant residues and siderates. So, over the past five years, 2.5-4.8 t/ha of straw and 11.6-16.6 t/ha of siderates were applied annually. In terms of soil and climate zones, the most significant increase in humus content in soils is observed in the Polissya zone – 4% (compared to 2006-2010), the smallest in the Forest Steppe zone - 0.6%. The developed crop production sector of Ukraine annually generates a large amount of the non-marketable part of the harvest, which in 2020 exceeded 139 million tons (Table 1). The non-marketable part of the harvest of agricultural crops is a source of reproduction of organic matter in the soil, a harvest and energy substrate for microorganisms, a producer of low-molecular soluble organic compounds that are of fundamental importance for soil metabolism. The agronomic efficiency of using straw as a fertilizer has been proven by numerous experiments and practice.

Table 1. Volumes of the non-commercial part of the harvest of the main agricultural crops in farms of all categories of Ukraine (2020), million tons

Soil and climate zone	Wheat and other cereals	Corn for grain	Cereals and legumes	Soya	Rapeseed	Sunflower	Total
Forested	13.5	8.2	0.1	2.1	1.3	2.6	27.8
Forest steppe	34	21.4	0.3	3.2	1.5	11.2	71.6
Steppe	21.4	4.1	0.5	0.8	2.4	11.1	40.3
Across Ukraine	68.9	33.7	0.9	6.1	5.2	24.9	139.7

The disadvantage of the non-marketable part of the harvest of agricultural crops is the fact that the organic compounds in their composition are chemically stable and slowly decompose in the soil. According to the results of long-term stationary experiments of the NSC "Institute of Agriculture of the National Academy of Sciences", the use of only plant residues does not compensate for the loss of soil humus due to increased mineralization, which leads to losses of organic matter at the level of 1.27 t/ha [21]. A specific feature of the chemical composition of manure compared to root and crop residues is that it contains "ready-made" humus substances [22].

The general trend in recent years is a decrease in the volume of production and use of animal manure. Since 1985, the application of cattle manure to arable soils has decreased 16 times. Currently, the use of organic fertilizers by zone of Ukraine ranges from 0.13 to 1.20 t/ha. Over the past five years, the largest amount of organic fertilizers was applied in the Polissya zone (from 0.8 to 1.2 t/ha), the smallest – in the Steppe zone (from 0.13 to 0.25 t/ha). Organic fertilizers are mainly used for fodder crops, the least - for grain crops (except corn). According to statistical data, in 2020 manure was applied to only 1.9% (0.8 million hectares) of agricultural land. On the other hand, the transition of agriculture to an intensive path of development led to the emergence of powerful complexes of animal husbandry and poultry farming with a consistently high output. Violations of the ratio of the amount of organic waste generated on farms and animal husbandry complexes and the area for their application, imperfection of manure and litter removal and storage systems, non-compliance with the terms and norms of application of organic fertilizers carry the risk of environmental pollution with biogenic elements. The total annual output of manure and droppings in 2020 in farms of all categories is 106.2 million tons (Table 2).

Table 2. Volumes of animal manure in farms of all categories of Ukraine, 2020, million tons

Soil and climate zone	Cattle manure	Pig manure	Sheep manure	Poultry droppings of all kinds	Total
Forested	19.5	6.9	0.3	4.0	30.7
Forest steppe	28.7	9.9	0.3	11.7	50.6
Steppe	13.8	6.4	0.6	4.1	24.9
Across Ukraine	62.0	23.2	1.2	19.8	106.2

According to calculations, the use of the entire amount of animal manure and poultry droppings in terms of bedding manure, at the output level of 2020, will ensure the fertilization of agricultural land with traditional organic fertilizers in a dose based on dry matter in the Polissya zone – 1.9 t/ha, in in the forest-steppe zone – 1.5 t/ha, in the steppe zone – 0.5 t/ha (Table 3). In the case of plowing the entire volume of the available non-marketable part of the harvest of the main agricultural crops according to the data of 2020, application in the Polissia zone is possible at a dose of 4.9 t/ha, in the Forest Steppe – 6.4 t/ha, in the Steppe zone – 3.4 t/ha, which in terms of litter manure is 2.8 t/ha, 3.2 and 1.9 t of dry matter per hectare of sown area in the Polissia, Forest-Steppe and Steppe zones of Ukraine.

Table 3. Estimated annual supply of organic raw materials
for replenishing soil organic matter by regions of Ukraine

Soil and climate zone	Potential resource for application to the soil in terms of litter manure, t per hectare of sown area											
	The non-marketable part of crop production		Animal manure and poultry droppings involvement		A potential resource in the case of involving the full amount of manure, the non-marketable part of the harvest of legumes, corn, sunflower share of cereal straw							
					80 %		60 %		40%			
Forested	11.0**	2.8***	7.5	1.9	16.9	4.2	15.2	3.8	13.5	3.4		
Volynska	10.1	2.5	6.1	1.5	14.6	3.7	12.9	3.2	11.2	2.8		
Zhytomyrska	9.8	2.5	4.0	1.0	12.3	3.1	10.8	2.7	9.3	2.3		
Zakarpattia	8.7	2.2	18.4	4.6	25.9	6.5	24.7	6.2	23.4	5.9		
Ivano-Frankivska	10.9	2.7	9.3	2.3	18.7	4.7	17.1	4.3	15.5	3.9		
Lvivska	10.6	2.7	6.7	1.7	15.9	4.0	14.4	3.6	12.9	3.2		
Rivnenska	10.7	2.7	5.3	1.3	14.5	3.6	12.9	3.2	11.3	2.8		
Chernihivska	16.4	4.1	2.9	0.7	16.4	4.1	13.5	3.4	10.6	2.6		
Forest steppe	12.8	3.2	4.7	1.2	15.4	4.2	13.3	3.8	11.2	3.4		
Vinnytsia	11.1	2.8	5.8	1.5	15.0	3.8	13.1	3.3	11.2	2.8		
Kyivska	10.9	2.7	5.6	1.4	14.6	3.7	12.8	3.2	10.9	2.7		
Poltavska	13.3	3.3	3.0	0.8	14.1	3.5	11.9	3.0	9.6	2.4		
Sumska	18.3	4.6	3.0	0.8	18.1	4.5	15.0	3.7	11.9	3.0		
Ternopilska	14.5	3.6	4.5	1.1	16.7	4.2	14.4	3.6	12.1	3.0		
Kharkivska	11.2	2.8	2.6	0.7	11.7	2.9	9.7	2.4	7.6	1.9		
Khmelnytska	15.7	3.9	4.9	1.2	18.1	4.5	15.7	3.9	13.2	3.3		
Cherkasska	9.4	2.4	5.5	1.4	13.3	3.3	11.7	2.9	10.1	2.5		
Chernivetska	10.9	2.7	7.2	1.8	16.7	4.2	15.2	3.8	13.8	3.5		
Steppe	7.5	1.9	2.0	0.5	8.2	2.0	6.8	1.7	5.5	1.4		
Luhanska	6.7	1.7	1.3	1.7	6.8	1.7	5.5	1.4	4.3	1.1		
Dnipropetrovska	7.4	1.9	2.5	1.9	8.6	2.1	7.2	1.8	5.8	1.5		
Donetska	8.0	2.0	2.3	2.0	8.8	2.2	7.4	1.8	5.9	1.5		
Zaporizhzhska	7.4	1.9	1.5	1.9	7.6	1.9	6.3	1.6	5.0	1.2		
Kirovohradska	6.9	1.7	1.5	1.7	7.3	1.8	6.1	1.5	4.9	1.2		

Table 3, Continued

Soil and climate zone	Potential resource for application to the soil in terms of litter manure, t per hectare of sown area									
	The non-marketable part of crop production		Animal manure and poultry droppings involvement		A potential resource in the case of involving the full amount of manure, the non-marketable part of the harvest of legumes, corn, sunflower					
					share of cereal straw					
					80 %		60 %		40%	
Mykolayivska	6.3	1.6	1.4	1.6	6.5	1.6	5.4	1.3	4.2	1.0
Odeska	5.1	1.3	2.3	1.3	6.5	1.6	5.5	1.4	4.6	1.1
Khersonska	9.2	2.3	1.7	2.3	9.5	2.4	8.0	2.0	6.5	1.6
Across Ukraine	10.2	2.6	3.5	2.6	11.9	3.0	10.2	2.6	8.5	2.1

Notee*: * Based on the conditional standard - cattle manure bedding 75% moisture; ** on raw substance; ***per dry matter*

The forecast possible application of organic fertilizers, taking into account the entire available yield of manure and the non-marketable part of the harvest of agricultural crops in Ukraine, is for the Polissia zone – 4.7 t of dry matter in the equivalent of litter manure per 1 ha of sown area, for the Forest Steppe – 5.9 t/ha, in the Steppe zone – 2.5 t/ha. At the same time, the norm for ensuring a deficit-free balance of humus, depending on the soil and climate zone, should be from 8 to 14 t/ha.

The potential annual resource of organic raw materials for application to the soils of Ukraine under the scenario of using the entire volume of manure, non-marketable part of the crop of legumes, corn for grain and sunflower with the involvement of 40% of the annual volume of cereal straw varies from 1.4 t/ha in the Steppe to 3.4 t/ha in the Forest-Steppe and Polissia zone of Ukraine (equivalent to the dry matter of litter manure per hectare of sown area). In the case of involving 60% of the annual volume of grain straw, in addition to manure and the non-marketable part of the harvest of other crops, the application dose can reach 2.6 t/ha. The maximum application of organic raw materials (in the case of plowing 80% of the annual volume of grain straw) at the output level of 2020 in Ukraine can be 3 tons per 1 ha of the sown area in the equivalent of the dry matter of litter manure.

In connection with the shortage of traditional organic fertilizers, the role of attracting organic raw materials of various origins to replenish humus reserves is growing significantly. Sapropel, leonardite, processing industry waste (sewage sludge, biochar, biogas plant waste) are alternative sources of organic matter entering the soil and raw materials for the production of organic fertilizers.

Sapropel deposits in Ukraine have total reserves of 97 million tons, and are concentrated mainly in the Volyn region. The average productivity of local lakes is more than 1,000 tons per hectare. The mass fraction of dry matter of sapropel is 14-15%, the content of organic matter varies from 15 to 95% of the mass of dry matter with an organic carbon content of 35-38% (Fig. 1).

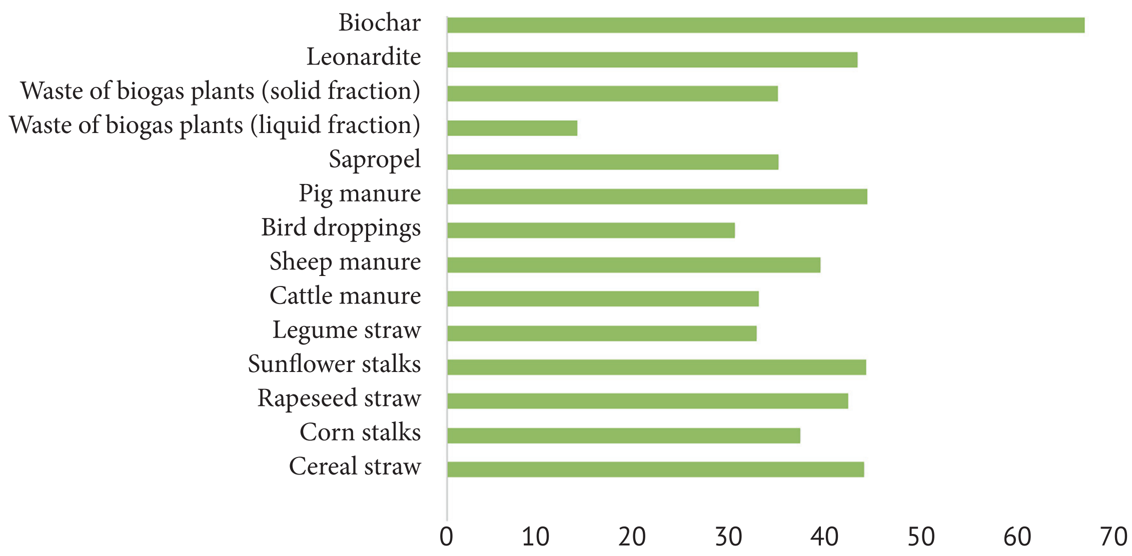

Figure 1*. The average content of total carbon in organic raw materials of different origins*

Coal reserves in Ukraine amount to almost 117 billion tons, of which the share of lignite is 6-8% (7.1-9.4 billion tons). Oxidized lignite (leonardite) is used in agricultural production as a raw material for obtaining humates. The organic matter of leonardite contains from 37.4 to 48.5% of carbon on dry matter, the content of humic substances is 76-96% of the total carbon content.

Biochar is an organic raw material with a high carbon content (64-70%). With optimal pyrolysis, biochar retains more than 50% of the carbon contained in the original biomass [13]. Due to the resistance to decomposition by microorganisms when applied to the soil, which can take thousands of years, the release of organic carbon in the form of CO_2 slows down [23].

SOURCES OF FILLING THE SOIL WITH ORGANIC SUBSTANCES

A variety of organic wastes, which are part of the waste structure of all regions, can be considered as a resource for replenishing soil organic matter. In Ukraine, only 3-5% of the 3 million tons of PES are used in agriculture. While the utilization of PES in agriculture is a common practice in Portugal – 87% of the volume of PES, Spainx – 65%, Great Britain – 69% and the USA – 47% [24; 25]. Since the direct utilization of PES entails great environmental risks, in the presence of high concentrations of heavy metals, the world considers it more rational to use composts from these wastes in order to ensure the sanitary and hygienic standards of the final product. Anaerobic technologies for the processing of organic raw materials for energy needs generate waste that is environmentally friendly [26] and has a sufficiently high content of organic carbon (from 11.5 to 33.5%). An organic fertilizer is a product ready for application to the soil that meets the specified requirements (does not contain pathogens, viable weed seeds, toxic substances and heavy metals above the maximum permissible concentration (MPC), has an optimal environmental response, etc.). Effective use of organic fertilizers should be based on the exclusion of contamination of surface and underground waters, soils, translocation of nitrates into agricultural products.

A systematic solution to the problem of production and application of fertilizers based on organic waste is connected with the need to develop a legal framework and expand research on the development of adaptive technologies for their processing that meet environmental requirements and modern market conditions of product manufacturers. The involvement of organic raw materials of various origins in the production of organic and organo-mineral fertilizers (OMF) is a promising way of saturating arable soils with organic carbon. The production of long-acting OMF based on livestock and poultry waste, which gradually release nutrients during interaction with the soil during the growing season of plants, is one of the rational ways to reduce the negative impact of waste on the environment (soils, ground and surface water, etc.).

The processes of transformation of organic raw materials in the soil largely depend on its composition. Composting straw, manure, manure and other sources of organic raw materials changes the quality of the final product. The organic matter of mature composts is of particular value for potential humus formation in soils because it contains humic substances resistant to decomposition, characterized by a high molecular weight [27]. The production of composts based on waste of organic origin is of great environmental importance, as it allows for the safe disposal of waste and the maximum involvement of biogenic elements in the biological cycle.

To regulate the humus state of arable soils, it is necessary to control the amount and quality of the supply of carbon compounds and, no less important, the processes of their transformation in the soil. It was established that the humification coefficients of organic fertilizers are significantly affected by the rate of their application [28]. With an increase in manure rates against the recommended ones, the mineralization of organic matter increases with a simultaneous decrease in the intensity of humus formation. Only with a uniform distribution of manure organic substances in the soil mass can the maximum yield of newly formed humus be achieved. The depth of application of organic fertilizers has an unequivocal effect on humification; if they are applied to a depth of 20-30 cm, the humification coefficient increases to 60%. After the combined application of manure, according to the recommended zonal norms, and mineral fertilizers, the humification coefficients increase by 10% [29]. However, you can hope for such an increase in the degree of humification only after applying mineral fertilizers together with fresh straw or semi-rotted manure. Applying mineral fertilizers with ready-made compost, rotted manure or humus does not increase this coefficient. In the NSC "Institute of Soil Science and Agrochemistry named after O.N. Sokolovsky" developed generalized standards for the humification of organic raw materials, which are equal to 30% for manure, 25% for the non-marketable part of legumes, 17% for corn, sunflower, and 15% for grain straw. Norms are developed for soils of heavy granulometric composition. For medium-loamy soils, the given standards are reduced by 10%, light loamy soils by 20%, sandy loamy soils by 50%, clay-sandy soils by 85% [30].

The pace and degree of saturation of the soil with organic carbon depend not only on the quantity and quality of organic raw materials, but also on the rate of fixation of organic substances. Saturation with organic carbon depends on physical and chemical properties, which are not identical in different soil types. As a result, the real dimensions of sequestration are possible only up to a certain level, which corresponds to the limit of soil saturation with organic carbon, above which the arrival of fresh organic matter does not lead to an increase in carbon.

CONCLUSIONS

The systematic use of organic materials in agriculture will help reduce the imbalance of biogeochemical carbon cycles and increase the stability of agrocenoses. The calculation of the approximate supply of different soil and climatic zones of Ukraine with traditional organic fertilizers showed a deficit of the available volume of manure formation and the non-marketable part of the harvest of the main agricultural crops for replenishing the soil with organic matter. Even the maximum involvement of these materials does not ensure the recommended zonal norms of introduction into the soil. According to the scenario of using the entire amount of manure, the non-marketable part of the harvest of grain and leguminous crops, corn and sunflower, and with the involvement of 40% of the annual amount of cereal straw, the forecasted dose of organic fertilizers application on average in Ukraine reaches 2 t/ha (equivalent to the dry matter of litter manure per hectare of cultivated area).

In the context of replenishment of organic carbon reserves in the soils of Ukraine, taking into account the shortage of traditional organic fertilizers, the role of attracting organic raw materials of various origins (sapropel, leonardite, organic waste from the processing industry, municipal economy, etc.) is significantly increasing. Organic waste is characterized by the possibility of processing and elimination by thermal methods for energy needs. However, it is proposed to consider them primarily as a source of carbon-containing compounds and nutrients for plants after appropriate technological decisions have been made.

In order to carry out targeted, scientifically based optimization of the humus state of soils, it is necessary to control the quality of organic fertilizers, taking into account the characteristics of the organic component, which is an important factor influencing the processes of mineralization-humification of carbon in the soil. The implementation of bioconversion technologies of organic materials, in the process of which the substrate undergoes a significant transformation with the formation of a humified product, is considered promising. It is equally important to regulate the processes of transformation of organic materials in the soil. In arable soils, in order to intensify the processes of humus formation, it is important to manage the introduction of organic fertilizers by placing them deeper (>20 cm) and combining them with mineral fertilizers.

Involvement of raw resources of organic origin in the production of fertilizers, implementation of processing technologies to improve their remedial properties, compliance with recommended doses, application methods and the optimal ratio between organic and mineral fertilizers in specific crop rotations and soil-climatic conditions will increase the efficiency of fertilizer application to replenish soil organic carbon . A balanced zonal scientific-methodical approach to the management of organic raw materials in the context of increasing the carbon content in the soil will contribute to preserving the fertility of the soils of Ukraine, rational nature management and environmental protection.

The modern tasks of studying soil organic matter are to reveal the mechanisms of chemical (biophysical and chemical) processes of humification of organic materials, to develop more effective indicators of humus state and composition, as well as to create and develop organic carbon management technologies. The implementation of the latest technologies for increasing the content of organic carbon in the soil, for which there are currently technological and economic barriers, will have a significant potential for carbon sequestration in the soil in the long term, in case of deepening of research and availability of economic incentives.

Considering the importance of the indicator of the content of organic matter for diagnosing changes in the humus state during soil monitoring, it is necessary to conduct a broad discussion of the need and method of converting organic carbon into humus in order to optimize the work of the agrochemical service of Ukraine and create an informative database of the qualitative state of soils.

REFERENCES

[1] Naipal,V.,Ciais,Ph.,Wang,Y.,Lauerwald,R.,Guenet,B.,& Van Oost,K.(2018).Global soil organic carbon removal by water erosion under climate change and land use change during AD 1850-2005/.*Biogeosciences*,15,4459-4480.

[2] FAO and ITPS. Status of the World's Soil Resources (SWSR) – Main Report. (2015). Retrieved from: http://www.fao.org/documents/card.

[3] Lal, R. (2010). Managing Soils and Ecosystems for Mitigating Anthropogenic Carbon Emissions and Advancing Global Food Security. *Bio Science*, 60, 708-721. doi: 10.1525/bio.2010.60.9.8.

[4] Kell, D.B. (2011). Breeding crop plants with deep roots: their role in sustainable C, nutrient and water sequestration. *Annals of Botany*, 108, 407-418.

[5] Xiao, C. (2015). Soil Organic Carbon Storage (Sequestration) *Principles and Management. Potential Role for Recycled Organic Materials in Agricultural Soils of Washington State*. Retrieved from https://apps.ecology.wa.gov/publications/documents/1507005.pdf/

[6] Semenov, V.M., & Kogut, B.M. (2015). *Soil organic matter*. moscow: GEOS.
[7] Kudeyarov V.N. (2015). Modern state of the carbon balance and the limiting capacity of soils to absorb carbon on the territory of Russia. *Soil Science*, 9, 1049-1060.
[8] Degtyarev, V.V. (2011). *Humus of chernozems of forest-steppe and steppe of Ukraine*. Kharkiv: Maidan.
[9] Skrylnyk, E.V., Hetmanenko, V.A., & Kutova, A.M. (2018). *Agricultural waste as a resource for restoring carbon balance in soils of Ukraine*. Kyiv: Center for Environmental Education and Information (2020). Reproduction of fertility of chernozems of Ukraine under conservation agriculture. Agrobiology, 1, 67-75. doi: 10.33245/2310-9270-2020-157-1-67-79.
[10] Paustian, K., Six, J., Elliott, E.T., & Hunt, H.W. (2000). Management option for reducing CO2 emissions from agricultural soils. *Biogeochemistry*, 48, 147-163.
[11] Seadi, T.Al., & Lukehurst, C.T. (2012). Quality management of digestate from biogas plants used as fertilizer. *IEA Bioenergy*, 3, 38-42.
[12] Brassard, P., Godbout, S., & Lévesque, V. (2019). Biochar for soil amendment. *Char and Carbon Materials Derived from Biomass*, 109-146. doi: 10.1016/B978-0-12-814893-8.00004-3.
[13] Orlov, D.S. (1985). *Soil chemistry*. moscow: moscow State University.
[14] Semenov, V.M., & Tulina, A.S. (2011). Comparative characteristic of mineralizable pool of organic matter in soils of natural and agricultural ecosystems. *Agrochemistry*, 12, 53-63.
[15] Sokolov, M.S., Spiridonov, Yu.Ya., Toropova, E.Yu., Glinushkin, A.P., & Semenov, A.M. (2018). Ecological and phytosanitary functions of soil organic matter (problem-analytical review). *Agrochemistry*, 5, 79-96.
[16] Li, J., Wen, Ya., Li, X., Li, Ya., Yang, X., Lin, Zh., Song, Zh., Cooper, J.-M., & Zhao, B. (2018). Soil labile organic carbon fractions and soil organic carbon stocks as affected by long-term organic and mineral fertilization regimes in the North China Plain. *Soil and Tillage Research*, 175, 281-290. doi: 10.1016/j.still.2017.08.008.
[17] Lorenz, K., & Lal, R. (2018). Importance of Soils of Agroecosystems for Climate Change Policy. Carbon Sequestration in Agricultural. *Ecosystems*, 357-386.
[18] Blanco-Canqui, H., Francis, C.A., & Galusha, T.D. (2017). Does organic farming accumulate carbon in deeper soil profiles in the long term? *Geoderma*, 288, 213-221. doi: 10.1016/j.geoderma.2016.10.031.
[19] Abdelrahman, H., Cocozza, C., Olk, D.C., Ventrella, D., Montemurro, F., & Miano, T. (2020). Changes in labile fractions of soil organic matter during the conversion to organic farming. *Journal of Soil Science and Plant Nutrition*, 20, 1019-1028. doi: 10.1007/s42729-020-00189-y.
[20] Litvinov, D.V. (2016). Short rotation crop rotations in modern farming systems. *Manual of the Ukrainian Farmer*, 1, 218-221.
[21] Kononova, M.M. (1968). Processes of transformation of organic matter and their relationship with soil fertility. *Soil Science*, 8,17-27.
[22] Woolf, D., Solomon, D, & Lehmann, J. (2018). Land restoration in food security programs: synergies with climate change mitigation. *Climate Policy*, 1260-1270. doi: 10.1080/14693062.2018.1427537.
[23] Seiple, T.E., Coleman, A.M., & Skaggs, R.L. (2017). Municipal wastewater sludge as a sustainable bioresource in the United States. *Journal of Environmental Management*, 197, 673-680. doi: 10.1016/j.jenvman.2017.04.032.
[24] Shkvirko, O.M., Tymchuk, I.S., & Malyovanyi, M.S. (2019). Adaptation of the world experience of sewage sludge utilization to the ecological conditions of Ukraine. *Scientific Bulletin of NLTU of Ukraine*, 29(2), 82-87. doi: 10.15421/40290216.
[25] Tarasov, S.I., Kovalev, D.A., & Karaeva, Y.V. (2018). Application of effluent biogas plant as a fertilizer for organic agriculture. *Bulletin of the Ulyanovsk State Agricultural Academy*, 1, 91-97.
[26] Biala, J. (2011). The benefits of using compost for mitigating climate change. Retrieved from https://www.researchgate.net/publication/292149826_The_benefits_of_using_compost_for_mitigating_climate_change.
[27] Unlocking the Potential of Soil Organic Carbon – Outcome Document of the Global Symposium on Soil Organic Carbon, (2017). Retrieved from http://www.fao.org/3/i7268e/i7268e.pdf.
[28] Kogut, B.M., & Semenov, V.M. (2020). Assessment of soil organic carbon saturation. *Bulletin of the Soil Institute named after V.V. Dokuchaev*, 102, 103-124. doi: 10.19047/0136-1694-2020-102-103-124.
[29] Skrylnyk, Ie.V., Kutova, A.M., Hetmanenko, V.A., Artemieva, K.S., & Nikonenko, V.M. (2019). Influence of fertilizers application systems on soil organic matter and agrochemical characteristics of the chernozem typical. *Agrochemistry and Soil Science*, 88, 74-78. doi: 10.31073/acss88-10.
[30] Kravchenko, Y.S. (2020). Reproduction of fertility of chernozems of Ukraine under conservation agriculture. *Agrobiology*, 1, 67-75. doi: 10.33245/2310-9270-2020-157-1-67-79.

Потенційні ресурси та підходи до управління органічною сировиною України для поповнення запасів гумусу в грунтах

Є. В. Скрильник,
доктор сільськогосподарських наук ORCID ID: 0000-0002-8642-8547

В. А. Гетманенко,
кандидат сільськогосподарських наук ORCID ID: 0000-0001-9021-3373

А. М. Кутова,
кандидат сільськогосподарських наук ORCID ID: 0000-0003-2680-566X

В. П. Москаленко
ННЦ "Інститут ґрунтознавства та агрохімії імені О. Н. Соколовського"

Анотація. Наразі знаходять активне відображення проблеми глобальних трансформацій клімату, а також природного середовища, недостатньої кількості продовольства і енергії, втрати біологічного розмаїття та стійкості екологічних систем. Проблема дисбалансування біогеохімічних циклів вуглецю у результаті інтенсивного або нераціонального сільського господарства є одним з основоположних аспектів глобальних змін у довкіллі. Керування процесами кругообігу та секвестрації вуглецю в ґрунті є головною ланкою у вирішенні таких нагальних питань загальносвітового масштабу, як подолання деградації ґрунтів та применшення наслідків кліматичних змін. Розроблення та залучення методів сталого управління органічним вуглецем ґрунту пріоритетними для охорони ґрунтів Україні. У свою чергу, кліматичні зміни та наслідкові від цього аспекти посилили інтерес до обрахування кількісної оцінки змін запасів органічного вуглецю ґрунту в агроекосистемах задля виявлення потенціалу секвестрації вуглецю орними ґрунтами. Таким чином, метою статті є надання оцінки забезпеченості ґрунтово-кліматичних зон України джерелами органічної сировини для посилення кількості запасів гумусу в ґрунтах, а також висвітлення підходів до управління з метою підвищення їх ефективності. Зроблено висновок, що систематичне використання органічних матеріалів у землеробстві сприятиме зменшенню розбалансування біогеохімічних циклів вуглецю, а також підвищенню стійкості агроценозів Проаналізовано наявні ресурси органічної сировини для поповнення запасів органічного вуглецю ґрунтів у різних ґрунтово-кліматичних зонах України. Було розраховано орієнтовну забезпеченість органічними добривами областей України за різних сценаріїв. Наведено характеристику потенційних ресурсів органічної сировини природного походження та органічних відходів з позиції утворення гумусу. Запропоновано підходи до управління органічними матеріалами для підвищення ефективності акумуляції гумусу в ґрунтах

Ключові слова: органічна сировина, гумус, зональна забезпеченість, підходи до управління ресурсами