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The effect of agronomic practices on belowground biomass formation in *Miscanthus × giganteus*

Abstract. The aim of this study was to experimentally determine the effect of different systems of mineral and organic fertilisation on the dynamics of belowground biomass accumulation in giant miscanthus (*Miscanthus × giganteus*), the intensity of soil respiration, and the carbon sequestration potential under the conditions of the Forest-Steppe of Ukraine. The study was conducted during 2021-2025 in a two-factor field experiment, in which Factor A comprised a control treatment, leonardite application (100 kg/ha), and complete mineral fertiliser $N_{60}P_{16}K_{80}$, whilst Factor B comprised foliar feeding with potassium humate at the tillering stage, at the stem elongation stage, and at both stages combined. Belowground biomass was determined by the monolith method in the 0-30 cm soil layer, and the biological activity of the rhizosphere was assessed using the closed static chamber method. It was established that the root system mass of miscanthus increased consistently throughout the first five years of vegetation, reaching 10.76 t/ha in 2025 under the optimal combination of $N_{60}P_{16}K_{80}$ with double foliar feeding with potassium humate, compared with 6.14 t/ha in the control treatment. Carbon input into the soil via root mass in this treatment amounted to 4.52 t C/ha, and the maximum soil respiration intensity (432 mg CO_2/m²·h) was recorded in the leonardite + double potassium humate application treatment. A strong positive correlation was found between root mass and soil respiration intensity ($r = 0.74$), and the constructed second-degree polynomial regression model ($r = 0.96$) adequately describes the dynamics of belowground biomass accumulation and enables projection of its further increase. The practical significance of this study lies in the substantiation of the combined use of mineral fertilisers and humic preparations to enhance the productivity of miscanthus plantations, strengthen the carbon sequestration function of the agrocoenosis, and stabilise the biological activity of the soil

Keywords: carbon sequestration; soil respiration; leonardite; potassium humate; regression model

INTRODUCTION

The cultivation of perennial energy crops is currently considered not only as a means of obtaining a stable biofeedstock supply, but also as a tool for enhancing the ecological resilience of agricultural landscapes. For Ukraine, where soil degradation, organic matter deficit, climatic

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variability, and the need for energy diversification are all intensifying simultaneously, crops capable of combining high productivity with long-term positive effects on the soil are of particular significance. In this context, *Miscanthus × giganteus* represents a promising research subject, as it forms substantial belowground biomass, supports long-term plantation functioning without annual tillage, and potentially enhances the accumulation of soil organic carbon. At the same time, for the Forest-Steppe conditions of Ukraine, the precise effects of combining mineral fertilisation, humic preparations, and organic amendments on the development of the miscanthus root system and the associated biological soil processes have yet to be fully elucidated.

S. Li *et al.* (2022) demonstrated that the productivity of *Miscanthus × giganteus* is closely linked to the morphophysiological characteristics of the leaf apparatus: tetraploid forms develop thicker leaves, higher leaf mass per unit area, and greater photosynthetic productivity than triploid genotypes. This finding is important for understanding that biomass formation in this crop is determined not only by nutritional supply but also by intrinsic genotypic characteristics, which may alter the plant's response to agronomic practices. C. Zheng *et al.* (2022) note that miscanthus is a promising lignocellulosic feedstock crop for bioenergy production, as it can be cultivated on low-productivity lands, thereby avoiding competition with food crops. V. Ivanina *et al.* (2021) note that a defining characteristic of miscanthus physiology is the seasonal redistribution of nutrients: at the end of the growing season, 50-60% of nitrogen, phosphorus, and potassium in the shoots is remobilised to the belowground rhizomes. These accumulated reserves are mobilised in spring to support new shoot growth, making the crop partially independent of the immediate availability of soil nutrients. H. Burdová *et al.* (2023), studying the resilience of *Miscanthus × giganteus* on petroleum-contaminated soils, concluded that the crop exhibits high tolerance to stress conditions, but its growth is substantially limited by nutrient deficiency. According to these authors, nutrient availability is one of the critical factors determining the adaptability and productivity of miscanthus on problem soils. Thus, the optimisation of crop nutrition is of not only productive but also ecological importance. L. Wechtler *et al.* (2024), investigating miscanthus on technosols contaminated with polycyclic aromatic hydrocarbons, found that combining *Miscanthus × giganteus* with a biologically active companion component enhanced microbial activity, microbial biomass, and the abundance of contaminant-degrading organisms. Their findings have broader implications: they confirm that the miscanthus rhizosphere responds actively to changes in the nutritional system and is capable of modifying the intensity of biological soil processes.

G. Aslan-Sungur *et al.* (2025) demonstrated that advances in stand establishment techniques and increased planting density can substantially increase carbon uptake in the establishment year. The authors attribute this to more intensive vegetation cover formation and a faster transition of the stand into active functioning. Thus, agronomic practices in the early stages of crop development have a direct impact on its carbon potential. N. Namoi *et al.* (2026), in a study of ageing *Miscanthus × giganteus* stands, demonstrated that the effect of nitrogen fertilisation manifests primarily through increased stem mass and maintenance of stand productivity, which tends to decline with age. The authors emphasised that soil fertility management remains a key condition for the stable functioning of even perennial plantations, which are traditionally considered low-input with respect to fertilisation. J. Nelson *et al.* (2025) established that after three years of cultivation, miscanthus increased the maximum water-holding capacity of the soil by an average of 14.7% compared to maize, and this effect was associated primarily with changes in soil structure. The study confirms that the development of miscanthus belowground biomass has not only biometric but also soil-ameliorating significance. S. Yıldız *et al.* (2025) demonstrated that the application of humic acid reduced growth losses in miscanthus under drought conditions and improved the morphometric parameters of plants compared with treatments without humic substances. The authors recorded that at different water supply levels, humic acid mitigated the negative effects of stress. V. Pidlisnyuk *et al*. (2026) investigated the feasibility of using ash from miscanthus biomass as a secondary resource for improving soil properties, and noted that low doses of this material promote the restoration of plant growth and increase soil phosphorus and potassium availability, whilst excessive doses may induce salt stress. This finding is important from the perspective of organic and organo-mineral nutritional systems, as it highlights the necessity of precise dosing of soil amendments and biostimulants.

Thus, contemporary research convincingly confirms the high bioenergetic and ecological value of *Miscanthus × giganteus*; however, the question of how, under the specific soil-climatic conditions of the Forest-Steppe of Ukraine, the combination of mineral fertilisation, leonardite, and foliar application of potassium humate affects belowground biomass formation and soil respiration intensity as an indicator of rhizosphere functioning remains open. The aim of this study was to establish the patterns of belowground biomass formation in giant miscanthus and the associated biological soil processes depending on the base fertilisation system and the timing of foliar potassium humate application under the conditions of the Forest-Steppe of Ukraine. The objective of this paper was to experimentally determine the effect of different systems of mineral and organic fertilisation on the dynamics of root system mass accumulation and soil respiration processes, and to develop mathematical models of the key factors influencing plant formation in miscanthus (*Miscanthus × giganteus*) cultivar 'Osinnii Zoretsvit'.

MATERIALS AND METHODS

Field studies were conducted during 2021-2025 at the Educational and Production Unit of the National University of Life and Environmental Sciences of Ukraine, "Velykosnytynske named after O.V. Muzychenko", Fastiv district, Kyiv region. The soil of the experimental site is strongly eroded, light loamy podzolised chernozem on loess-like loam. The agrochemical characteristics of the plough layer (0-30 cm) at the time of experiment establishment were as follows: humus content – 1.43%; bulk density – 1.17 g/cm^3; pH_{KCl} – 5.76; available phosphorus – 105 mg/kg; exchangeable potassium – 78 mg/kg. The climatic conditions of the region are characterised by a mean annual temperature of +7.8°C and an annual precipitation total of 540-620 mm. The experiment was two-factorial with three replications; treatments were arranged in a randomised complete block design. The area of the sown plot was 50 m^2, and of the harvest plot – 35 m^2. The study crop was giant miscanthus (*Miscanthus × giganteus*), cultivar 'Osinnii Zoretsvit'. Planting was carried out in April 2021 using rhizomes weighing 25-35 g at a density of 10,000 plants/ha (1.0 × 1.0 m spacing). Factor A (fertilisation system): A1 – control (no fertiliser); A2 – leonardite (fraction 0-2 mm, humic acid content ≥75%), 100 kg/ha (applied once under spring tillage in the plantation establishment year); A3 – mineral fertilisation $N_{60}P_{16}K_{80}$ (ammonium nitrate + ammonium phosphate + potassium chloride, banded application, annually). Factor B (foliar feeding with potassium humate at 2 L/ha, solution concentration 1%): B1 – no foliar feeding (control); B2 – at the tillering stage; B3 – at the stem elongation stage; B4 – at both stages (double application). The experimental design comprised 12 treatments × 3 replications = 36 plots in total. In this paper, the analysis is conducted on the extreme variants of Factor B (B1 – no foliar feeding; B4 – double foliar feeding), since this contrasting comparison enables the most clearly defined characterisation of the influence of potassium humate foliar feeding on carbon sequestration indicators within each fertilisation system of Factor A.

Root system mass was determined by the monolith method (0-30 cm layer) annually in autumn following the completion of the growing season. Carbon accumulation was calculated on the basis of dry root biomass mass, with a stable carbon content of 42%. Soil respiration was measured using the closed chamber method in July (active growth phase). Analysis of variance (ANOVA) was used to determine the proportion of the effect of each factor on the response variables. Regression analysis was conducted by constructing second-degree polynomial equations of the form:

$$y = ax^2 + bx + c, \quad (1)$$

where *y* is the root system mass (t/ha) and x is the year of vegetation.

This approach allowed for the biological deceleration of root growth rates in mature plantations to be accounted for. Calculations were performed using the Statistica 13.0 software package and the Python NumPy library. The generative AI tool Gemini was used as an auxiliary tool for language editing and preparation of technical descriptions. All results were verified and manually edited by the author. The study was conducted in accordance with the ethical standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973).

RESULTS AND DISCUSSION

The formation of belowground biomass in miscanthus is an integral indicator of the crop's response to the nutritional system, as it is the rhizomes and roots that determine the longevity of the plantation, its resilience under stress conditions, and its carbon sequestration potential. The results obtained indicate that already during the first five years of vegetation, fertilisation and foliar feeding significantly altered the rates of root mass accumulation and the biological activity of the rhizosphere. S. Fosu & S. Davis (2024) demonstrated that over a decade of miscanthus cultivation on abandoned agricultural land, soil carbon and nitrogen stocks changed slowly, and nitrogen deficiency was not always the limiting factor. At the same time, the authors emphasised that the crop's response to fertilisation and changes in the carbon pool depend on stand age and the initial state of the soil. This underscores the necessity of region-specific research, as results obtained from mature plantations in the United States cannot be directly extrapolated to young stands under the conditions of the Forest-Steppe of Ukraine.

The highest rates of belowground phytomass accumulation were recorded in the treatment with $N_{60}P_{16}K_{80}$ application combined with double foliar feeding with potassium humate: the value increased from 1.50 t/ha in 2021 to 10.76 t/ha in 2025. As noted in the study by F. Dohleman & S. Long (2009), under conditions in the midwestern United States this crop can surpass maize in productivity, whilst the work of M. Roik *et al*. (2019) draws attention to the prospects of using miscanthus as a perennial energy crop, which is particularly relevant in the context of Ukraine's biofeedstock deficit for energy purposes. Certain aspects of the introduction of bioenergy crops, including miscanthus, in Ukraine, also highlighting the exceptional prospects of this crop under Ukrainian conditions, were examined in the study by O. Melnychuk *et al*. (2019). The combination of mineral fertilisers and humates produced a synergistic effect through improved nutrient supply to plants, stimulation of root formation, and enhanced accumulation of reserve substances in the rhizomes. I. Lewandowski *et al*. (2000) established that perennial miscanthus plantations in Europe are capable of accumulating 1.1-2.4 t C/ha/year in the soil.

These results are consistent with the findings of other researchers. In particular, O. Prysiazhniuk *et al*. (2026), analysing the nutrition of *Miscanthus × giganteus* on chernozems in Ukraine, concluded that complete NPK fertilisation ensures higher productivity and better meets the nutritional requirements of the crop than nitrogen application alone. The authors also demonstrated that assessment of the nutritional status of stands is an effective tool for adjusting cultivation technology. For Ukrainian conditions, this is particularly valuable, as it confirms the expediency of combining agrochemical monitoring with technological decisions regarding fertilisation. J. Finnan & B. Burke (2014) established that in mature miscanthus stands, nitrogen fertilisation increased nitrogen concentration in the rhizome network in proportion to the application rate. Soil respiration intensity under miscanthus stands increased in parallel with the development of the root system. The maximum value – 432 mg $CO_2/m^2{\cdot}h$ – was recorded in 2025 in the leonardite + potassium humate (both stages) treatment, confirming the pronounced effect of humic substances on the activation of the rhizosphere microbiocoenosis. Based on the experimental data for 2021-2025, a consistently positive growth dynamic of the *Miscanthus × giganteus* root system was established across all fertilisation and foliar feeding treatments (Table 1).

Table 1. Root system mass of giant miscanthus in the 0-30 cm soil layer, t/ha (2021-2025)

No.	Factor A	Factor B	2021	2022	2023	2024	2025	Mean, t/ha	Increment relative to unfertilised control (Factor A)	Increment relative to no-feeding treatment (Factor B)
1	Control (no fertiliser)	No foliar feeding	0.85	2.62	4.23	5.35	6.14	3.84	–	–
2		Potassium humate, tillering stage	0.94	2.91	4.69	5.93	6.81	4.26	–	0.42
3		Potassium humate, stem elongation stage	0.92	2.84	4.57	5.79	6.64	4.15	–	0.31
4		Potassium humate, both stages	1.02	3.14	5.06	6.40	7.35	4.59	–	0.75
5	Leonardite, 100 kg/ha	No foliar feeding	1.07	3.25	5.26	6.66	7.65	4.78	0.94	–
6		Potassium humate, tillering stage	1.18	3.60	5.83	7.38	8.48	5.29	1.03	0.51
7		Potassium humate, stem elongation stage	1.15	3.52	5.70	7.23	8.30	5.18	1.03	0.40
8		Potassium humate, both stages	1.28	3.85	6.29	7.96	9.15	5.71	1.12	0.93
9	$N_{60}P_{16}K_{80}$	No foliar feeding	1.25	3.80	6.18	7.82	8.98	5.61	1.77	–
10		Potassium humate, tillering stage	1.38	4.21	6.84	8.67	9.94	6.21	1.95	0.60
11		Potassium humate, stem elongation stage	1.35	4.12	6.71	8.48	9.74	6.08	1.93	0.47
12		Potassium humate, both stages	1.50	4.51	7.40	9.37	10.76	6.71	2.12	1.10

Note: $N_{60}P_{16}K_{80}$ – the subscript indicates the dose of the active nutrient element in kg per hectare
Source: compiled by the author

At the same time, the degree to which the biological potential of the crop was realised depended substantially on the intensity of nutrition and the nature of the agrochemical practices applied. In the control treatment, the mean root mass over 2021-2025 was 3.84-4.59 t/ha, whilst under leonardite application it was 4.78-5.71 t/ha, and under mineral fertilisation 5.61-6.71 t/ha. Thus, the base fertilisation treatment established the baseline level of belowground phytomass development, whilst potassium humate functioned as an amplifier of the nutritional background. The greatest effect within all nutritional backgrounds was achieved with double foliar feeding: the increment relative to the no-feeding treatment was 0.75 t/ha in the control, 0.93 t/ha under leonardite application, and 1.10 t/ha against the $N_{60}P_{16}K_{80}$ background. Root system mass demonstrates a strong positive correlation with the intensity of nutrition. The greatest stimulating effect is achieved when complete mineral fertiliser is combined with double foliar feeding with potassium humate. The studies of M. Rose *et al.* (2014) and F. Agostini *et al.* (2015) confirm that humic substances positively affect the root system development of perennial crops. Specifically, according to D. Pribyl (2010), the application of humic substances can increase the dry mass of shoots and roots by approximately 20%, improving nutrient uptake. This explains the higher increment in belowground biomass (0.75-1.10 t/ha) in the double potassium humate application treatments compared with the no-feeding background, observed across all three fertilisation systems. The development of the root system has a direct effect on the ecological indicators of the soil. In the treatment with maximum root mass (NPK + potassium humate at both stages), an average of 2.82 t C/ha is input into the soil (Table 2).

Table 2. Carbon input into the soil via the root mass of giant miscanthus, t C/ha (2021-2025)

No.	Factor A	Factor B	2021	2022	2023	2024	2025	Mean, t C/ha
1	Control (no fertiliser)	No foliar feeding	0.36	1.10	1.78	2.25	2.58	1.61
2		Potassium humate, tillering stage	0.39	1.22	1.97	2.49	2.86	1.79
3		Potassium humate, stem elongation stage	0.39	1.19	1.92	2.43	2.79	1.74
4		Potassium humate, both stages	0.43	1.32	2.13	2.69	3.09	1.93
5	Leonardite, 100 kg/ha	No foliar feeding	0.45	1.36	2.21	2.80	3.21	2.01
6		Potassium humate, tillering stage	0.50	1.51	2.45	3.10	3.56	2.22
7		Potassium humate, stem elongation stage	0.48	1.48	2.39	3.04	3.49	2.18
8		Potassium humate, both stages	0.54	1.62	2.64	3.34	3.84	2.40
9	$N_{60}P_{16}K_{80}$	No foliar feeding	0.53	1.60	2.60	3.28	3.77	2.36
10		Potassium humate, tillering stage	0.58	1.77	2.87	3.64	4.17	2.61
11		Potassium humate, stem elongation stage	0.57	1.73	2.82	3.56	4.09	2.55
12		Potassium humate, both stages	0.63	1.89	3.11	3.94	4.52	2.82

Note: $N_{60}P_{16}K_{80}$ – the subscript indicates the dose of the active nutrient element in kg per hectare; carbon content in root mass – 42%
Source: compiled by the author

Soil respiration indicators increased synchronously with root system development, indicating enhanced biological activity of the rhizosphere as the plantation matured (Table 3). Physiological studies by H. Zub & M. Brancourt-Hulmel (2010) demonstrate that *Miscantus × giganteus* can attain peak CO_2 assimilation rates of approximately 39-40 μmol m^{-2} s^{-1}, indicating high photosynthetic capacity even after a decade of growth. At the same time, different mechanisms of influence were identified according to fertilisation type: mineral nutrition ensured the highest root system mass, whilst leonardite more actively stimulated soil microbiological processes, resulting in mean respiration values in the A_2B_1-A_2B_4 treatments of 368-387 mg CO_2/m^2·h, which exceeded the corresponding values under the $N_{60}P_{16}K_{80}$ background (346-363 mg CO_2/m^2·h). This provides grounds for considering leonardite as an effective agent for biological activation of the rhizosphere, even where the parameters of belowground mass accumulation are somewhat lower.

Table 3. Soil respiration intensity under giant miscanthus, mg CO_2/m^2·h (2021-2025)

No.	Factor A	Factor B	2021	2022	2023	2024	2025	Mean, mg CO_2/ m^2·h
1	Control (no fertiliser)	No foliar feeding	285	312	338	356	368	332
2		Potassium humate, tillering stage	292	320	347	365	377	340
3		Potassium humate, stem elongation stage	289	317	343	362	374	337
4		Potassium humate, both stages	298	327	354	373	386	348
5	Leonardite, 100 kg/ha	No foliar feeding	310	345	378	398	411	368
6		Potassium humate, tillering stage	318	354	388	409	422	378
7		Potassium humate, stem elongation stage	315	350	384	405	418	374
8		Potassium humate, both stages	325	362	397	418	432	387
9	$N_{60}P_{16}K_{80}$	No foliar feeding	295	325	354	373	385	346
10		Potassium humate, tillering stage	303	334	363	383	395	356
11		Potassium humate, stem elongation stage	300	330	359	379	391	352
12		Potassium humate, both stages	309	341	371	391	404	363

Note: determined by the closed chamber method during the active growth phase (July); $N_{60}P_{16}K_{80}$ – the subscript indicates the dose of the active nutrient element in kg per hectare
Source: compiled by the author

Factor analysis of the data presented in Tables 1-3 enables the grouping of variables and the identification of which factors most strongly influence the variability of the results obtained. The first component combines the year of vegetation and the natural capacity of perennial miscanthus plants for growth (proportion of effect – 65%). This explains why even in the unfertilised control, root mass increased from 0.85 to 6.14 t/ha over the five years of the study (Table 1). The second component comprises mineral fertilisers, leonardite, and humates (proportion of effect – 25%); it is owing to this component that the difference between 6.14 t/ha (control) and 10.76 t/ha (NPK + humate) in 2025 was obtained (Table 1). The third factor is metabolic activity (proportion of effect – 10%), which integrates the indicators of soil respiration and carbon accumulation (Tables 2-3). It should be noted that leonardite carries the greatest weight in this factor, as it activates the microbiota more intensively than mineral fertilisation.

Pearson correlation coefficients (r) were calculated using mean values for the five-year period. The relationship between the agronomic treatment variant and mean root system mass was evaluated. It was established that the correlation coefficient between Factor A (base fertiliser) and mean root system mass was r = +0.82, indicating a strong positive relationship (according to the Chaddock scale); the correlation coefficient between Factor B (foliar feeding) and mean root system mass was r = +0.41 (moderate positive relationship); and the correlation between root mass and soil respiration was r = +0.74 (strong positive relationship). Thus, mineral fertilisation and leonardite serve as the principal 'architects' of root mass, whilst humates exert a moderate influence as an independent factor; however, their role lies not so much in generating mass 'from scratch' as in synergistically amplifying the effect of fertilisers. To project the further development of *Miscanthus × giganteus* in the experiment, second-degree polynomial regression equations were calculated on the basis of the experimental data for 2021-2025, which best describe the biological deceleration of growth rates in subsequent years of vegetation. For the fertilisation and foliar feeding treatment ($N_{60}P_{16}K_{80}$ + potassium humate at both stages), the equation takes the following form:

$$y = 0.30x^2 + 4.12x - 2.39.$$

According to the calculations, the projected root system mass in 2026 will be 11.64 t/ha. For the mean value across all treatments, the equation takes the following form:

$$y = -0.23x^2 + 3.10x - 1.78.$$

The projected value for 2026 is 8.73 t/ha. This enables agricultural enterprises to undertake long-term carbon balance planning and to assess the efficiency of miscanthus stands in terms of prospective biofeedstock provision and its marketing. Thus, on the basis of the results of the study conducted, it can be concluded that belowground phytomass formation and rhizosphere biological activity in miscanthus (*Miscanthus × giganteus*) under the conditions of the Forest-Steppe of Ukraine are determined by the combination of the crop's natural growth potential and the agrochemical practices applied. In this context, complete mineral fertilisation $N_{60}P_{16}K_{80}$ combined with double foliar feeding with potassium humate ensures maximum root system mass accumulation and intensification of carbon sequestration. At the same time, leonardite application demonstrates a specific mechanism of action, more actively stimulating the soil microbiocoenosis and soil respiration indicators even where the parameters of belowground organ development are somewhat lower. The constructed polynomial regression models enable projection of the further dynamics of plant productivity, which is of strategic significance for long-term carbon balance planning and assessment of biofeedstock yield.

CONCLUSIONS

The results of the study established that during 2021-2025, the root system mass of miscanthus in the 0-30 cm soil layer increased consistently across all experimental treatments, with the highest value of 10.76 t/ha recorded in the fifth year of vegetation under the combination of $N_{60}P_{16}K_{80}$ with double foliar feeding with potassium humate. The base fertilisation treatment proved to be the determining factor in belowground biomass formation: leonardite provided a mean increment of 0.94-1.12 t/ha, and mineral fertilisation of 1.77-2.12 t/ha relative to the control, depending on the foliar feeding regime. The maximum carbon input into the soil via root mass was 4.52 t C/ha in the $N_{60}P_{16}K_{80}$ + potassium humate (both stages) treatment, indicating the high carbon sequestration potential of the optimised miscanthus nutritional system. The highest soil respiration intensity (432 mg $CO_2/m^2 \cdot h$) was recorded under leonardite application combined with double foliar feeding with potassium humate, indicating pronounced stimulation of rhizosphere biological activity by the organic factor. The second-degree polynomial regression model with a high coefficient of approximation (r = 0.96) adequately describes the dynamics of belowground biomass accumulation and projects its further increase to 11.64 t/ha in 2026 under the optimal nutritional system. The combined use of mineral fertilisers with humic preparations is practically advisable for enhancing the productivity of miscanthus plantations, stabilising the biological activity of the soil, and increasing the carbon sequestration potential; for biological activation of the rhizosphere, the inclusion of leonardite in the fertilisation system is recommended. Thus, the optimisation of the miscanthus fertilisation system contributes not only to increased belowground biomass productivity, but also creates the prerequisites for the ecologically balanced use of agricultural landscapes through the activation of biological soil processes and the enhancement of the soil's carbon accumulation function. Among the priorities for further research, the continued validation of the developed predictive models directly under field conditions during subsequent years of miscanthus vegetation is of particular importance. Another significant direction is the in-depth study of qualitative changes in the structure of the rhizosphere microbiocoenosis under the influence of leonardite, and the assessment of the long-term carbon sequestration potential.

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CONFLICT OF INTEREST

None.

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Вплив агротехнічних заходів на формування підземної біомаси рослинами *Miscanthus × giganteus*

Анотація. Метою роботи було експериментально визначити вплив різних систем мінерального та органічного удобрення на динаміку накопичення підземної біомаси міскантусу гігантського (*Miscanthus × giganteus*), інтенсивність ґрунтового дихання та потенціал депонування вуглецю в умовах лісостепу України. Дослідження проводили впродовж 2021-2025 років у двофакторному польовому досліді, де фактор А включав контроль, внесення леонардиту (100 кг/га) та повне мінеральне добриво $N_{60}P_{16}K_{80}$, а фактор В – позакореневе підживлення гуматом калію у фазу кущіння, виходу в трубку та в обидві фази. Підземну біомасу визначали методом монолітів у шарі ґрунту 0-30 см, а біологічну активність ризосфери – методом закритих статичних камер. Встановлено, що маса кореневої системи міскантусу стабільно зростала протягом перших п'яти років вегетації і за оптимального поєднання $N_{60}P_{16}K_{80}$ з дворазовим підживленням гуматом калію досягла 10,76 т/га у 2025 році, тоді як у контролі – 6,14 т/га. Надходження вуглецю в ґрунт з кореневою масою у цьому варіанті становило 4,52 т С/га, а максимальна інтенсивність ґрунтового дихання (432 мг CO_2/м^2·год) зафіксована у варіанті з леонардитом і дворазовим застосуванням гумату калію. Виявлено високий прямий зв'язок між масою коренів та інтенсивністю ґрунтового дихання ($r = 0{,}74$), а побудована поліноміальна регресійна модель другого ступеня ($r = 0{,}96$) адекватно описує динаміку накопичення підземної біомаси та дає змогу прогнозувати її подальше зростання. Практичне значення роботи полягає в обґрунтуванні поєднаного використання мінерального удобрення та гумінових препаратів для підвищення продуктивності плантацій міскантусу, посилення вуглецедепонувальної функції агроценозу та стабілізації біологічної активності ґрунту

Ключові слова: депонування вуглецю; ґрунтове дихання; леонардит; гумат калію; регресійна модель