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Efficiency of the Use of Lawn Grasses for Biology and Soil Conservation of Agricultural Systems under the Conditions of the Ukraine's Podillia

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ABSTRACT

The aim of this study was to scientifically substantiate the peculiarities of the formation of lawn cultural phytocenoses of the Podillia zone of Ukraine based on the analysis of the qualitative state of the existing grass stand. The conducted research is devoted to biodiversity, namely soil conservation, as well as modern trends in the development of adaptive technologies for growing lawn grasses, which are based on a number of basic directions, taking into account both the features of innovative changes and the technological renewal of mechanization tools, and the main trends in the development of green farming aimed at ensuring the environmental friendliness of the products obtained, soil conservation while ensuring the appropriate levels economic and energy efficiency. The use of lawn grasses as an integral aesthetic decorative element of landscape design is at the same time an ecological and remedial factor of influence on the surrounding natural environment, which is quite widely used in Ukraine and the world. Dense lawn coverings trap dust, increase air humidity, improve the microclimate of the environment due to the phytoncides released by them, thereby improving the air, preventing erosion and improving the agrophysical properties of the soil. Determination of agrophysical soil parameters of total porosity, capillary porosity and aeration porosity was carried out. It was established that the highest quality lawns form a grass stand with a density of more than 120 vegetative shoots per 1 dm^{-2}. The use of all types of plants contributed to the general growth of both the general sparability, including its subcategories, and the sparability of aeration. At the same time, the specified feature of the formation of spar was noted for gray forest soils under the conditions of the experimental field. This ultimately contributed to a decrease in soil density.

Keywords: soil, lawn structure, urboecosystem, balanced nature management, reclamation, soil porosity and density.

INTRODUCTION

Modern trends in the development of adaptive technologies for growing lawn grasses are based on a number of basic directions that take into account both the features of innovative changes and technological renewal of mechanization tools, as well as the main trends in the development of green farming aimed at ensuring the environmental friendliness of the products obtained, soil conservation while ensuring the appropriate levels of economic and energy efficiency (Mazur et al., 2021). It should also be noted that the importance of biologization of agriculture for soil conservation of landscape areas is an urgent issue of its successful implementation in the European space and enables to ensure the implementation of the goals of sustainable development in terms of guaranteeing the balanced use of nature in the state (Zhou et al., 2020). Vinnytsia National University is actively researching the issue of alternative fertilization systems, ensuring their ecological and soil protection component, transition to organically oriented fertilization systems, development of regulations for the use of biofertilizers and biopreparations of a growth-stimulating and growth-regulating nature within the framework of the implementation of the task of applied research on the topic "Development of bio-organic technologies for growing agricultural crops for the production of biofuels and ensuring

the energy independence of the agricultural sector" (state registration number 0123U100311). The successful formation of lawn cultural phytocenoses is ensured by optimizing the conditions of the water regime and balancing the elements of mineral nutrition of plants (Fatehi et al., 2021). A characteristic feature of improving the condition of lawn cultural phytocenoses is the use of low-lying perennial grasses and their varieties, which are maximally adapted to the natural and climatic conditions of Ukraine. Dense lawn coverings trap dust, increase air humidity, improve the microclimate of the environment due to phytoncides released by them and thereby saturate the air with oxygen, prevent erosion and improve the agrophysical properties of the soil (Mazur et al., 2020). The specified properties of lawns are extremely necessary under the conditions of a modern urbanized environment (Yu et al., 2021). In order to create a highly productive lawn, the grasses that will be used must meet a whole set of requirements, namely: have a high productivity of shoot formation, competitiveness in phytocenoses, evenly distribute shoots on the surface of the soil cover, be distinguished by high energy of seed germination and the ability to form a high project soil cover, have winter resistance and drought resistance, resistance to damage by pests and diseases, as well as exhibit high decorativeness of grass: low growth, intense color of shoots and good seed productivity (Bethany et al., 2019; Rudska et al., 2023).

The creation of highly decorative lawns with satisfactory aesthetic properties is possible only if there is a sufficient quantity of high-quality seeds of varieties of lawn grasses that are maximally adapted to the natural and climatic conditions of the growing area, a scientifically based selection of species that meet the specific requirements for lawn culture and constant improvement of the technology of care and maintenance lawn culturphytocenoses (Ouyang et al., 2021). Under the conditions of the Podillia zone of Ukraine, the issue of the lawn care system requires a detailed study, and the conduct of such studies is important both in a scientific and practical sense.

MATERIAL AND METHODS

The research was conducted during 2020–2022 on the basis of the park zone of the Vinnytsia National Agrarian University under the conditions of the Podillia zone of Ukraine by means of records and observations regarding the condition of grass on lawns with the aim of theoretical and practical substantiation of care measures according to generally accepted methods. The green zone of the university within the city of Vinnytsia is more than 66 hectares. The experimental sites occupy gray forest soils. The plants growing on these soils receive a large amount of mobile phosphorus (214 mg/kg) and exchangeable potassium (104 mg/kg) for consumption (according to Chirikov). However, the content of easily hydrolyzed nitrogen is very low and amounts to 43.5 mg/kg. Determination of agrophysical soil parameters of total pore size, capillary pore size, aeration pore size, compaction density was carried out in accordance with standardized methods (Zhou et al, 2021). Determination of the specified parameters was carried out with the onset of physical maturity of the soil in the spring. The herbological situation in the field was assessed by quantitative-weight and structural-specific methods in accordance with generally accepted methods (Yanto et al., 2016). In the process of setting up experiments and their general methodological support, the peculiarities of conducting research with cultures were taken into account (Yang et al., 2019; Lutkovska, 2020). Statistical processing of research results was carried out in accordance with standard statistical methods (Jia et al., 2020; Farionik et al., 2023) using a package of appropriate computer programs.

The object of research involved the processes of formation of the economic and ecobiological structure of lawn grasses under the conditions of the Podillia zone of Ukraine.

On the structure (species, spatial, population) of lawn phytocenoses, phytocenotic descriptions were compiled according to proven methods. The quality of maintenance of lawns and the resistance of the lawn covering to the burning of lawn grass plants were determined according to the appropriate scales (Zhou et al., 2021).

The purpose of the work was to scientifically substantiate the peculiarities of the formation of lawn cultural phytocenoses under the conditions of the Podillia zone of Ukraine.

RESULTS AND DISCUSSION

The lawn, as the background of any landscape and architectural composition, plays an indispensable role in greening the urban ecosystem. Lawn coverings have an undeniable sanitary and

hygienic value for a modern city: they keep a significant amount of dust from moving, increase air humidity, and improve the microclimate of the environment due to the phytoncides they emit. By forming stable phytocenoses, sod-forming grasses prevent the spread of allergenic weeds, and regular mowing of grass stands leads to the disappearance of the generative phase of components in the process of grass stand development, which excludes the possibility of people becoming allergic to certain representatives of the grass family (Sengupta et al., 2017). The specific features of the introduction of lawn grasses, compared to perennial forage grasses, are due to various requirements that are put forward to biological and ecological features. The leading position in the creation of lawns for various purposes is occupied by perennial grasses. Types and varieties of lawn grass must meet a set of requirements (Xia et al., 2021; Honcharuk et al., 2023; Kaletnik et al., 2020).

It should be noted that a random assortment of perennial grasses is often used during landscaping. It has been scientifically substantiated and practically proven that the maximum effect and productivity of the lawn culture-phytocenosis can be achieved with the use of only certain ecobiomorphs of lawn-forming species (Lin et al. 2010; Zahorulko et al., 2023). One of the main roles in this issue is also played by the quality of seed material. In practical use, today mostly varieties of lawn grasses of foreign selection are sown, which are not adapted to the climatic conditions of Ukraine. All this leads to the creation of lawn coverings of mediocre and low quality, which not only reduce the overall aesthetic appearance of the territory, but also constantly require high costs for care and maintenance. Therefore, there is an urgent need to create a high-level seed base in the field of lawn science.

It has been proven that lawn grasses perform various functions: first of all, they improve the microclimate of the site; maintain an optimal level of moisture near the soil surface; absorb vibration, noise and dust; clean the air of harmful bacteria and inhibit the growth of weeds. The grass that remains after mowing the lawn is an excellent organic fertilizer (Honcharuk et al., 2022; Wan N., 2019; Kolisnyk et al., 2019; Bakhmat et al., 2023; Eisa, 2023).

Parterre lawns should be highly decorative and durable. The grasses for creating these lawns must be durable, resistant to mowing, adverse factors, diseases, and during the entire growing season, give a low, dense, evenly closed grass stand with a single-colored green color. Low-lying perennial grasses with a narrow leaf blade are used for this purpose (Alvaro-Fuentes et al., 2008; Xia et. al., 2021; Shkatula et. al., 2022). Lawn cultural phytocenoses are created from the grasses that can adapt to any conditions. These include, first of all, red fescue (*Festuca rubra* L.), meadow ryegrass (*Lolium perenne* L.), and meadow fescue (*Agrostis stolonifera* L.) (Fig. 1).

Festuca rubra L. (Table 1) belongs to the family of leguminous (cereals). It is mainly used as a valuable feed for animals. Some of the varieties are often used as lawn grasses. A low-growing grass up to 60 cm tall, has thin stems with a large number of basal gray-green bristle-like, folded with two grooves, rough leaves. The inflorescence is a weakly branched, spike-shaped panicle with large 5–6 flower spikes. Extremely frost-resistant and drought-resistant. In the spring, it grows 5–10 days earlier than other cereals. In the fall, it gives otava, which goes into the winter in a green state. It lasts tens of years in grass stands. The patterns of plant growth and development in the second year of grass life have

Figure 1. Species composition of lawn cultural phytocenoses under the conditions of the Podillia zone of Ukraine
Lolium perenne L. used for greening urboecosystems and arranging
turf coverings under conditions of anthropogenic load

Table 1. Agrobiological characteristics of lawn cultural phytocenoses under the conditions of the Podillia zone of Ukraine

Species	The character of the structure	Agrobiological characteristics
Festuca rubra L.	Low-growing, rhizomatous grass with thin stems and good foliage	It develops well on all soils, except for very dry ones, and grows abundantly. It grows slowly in the year of sowing
Lolium perenne L.	Low-growing, bushy grass, bushy, with good foliage	It grows well on moderately moist loamy soils
Agrostis stolonifera L.	Root, rhizome and bush cereal	Grows on various soils, including saline soils. Worse on dry soils

changed somewhat, depending on the varieties. However, in general, as in the first year of vegetation, the plants of reed sedum dominated in height red sedum and thin-leaved sedum. According to scientists, the herbage of this plant is dominated by numerous rosette basal vegetative shoots with narrow (1.5–2.0 mm), longitudinally folded leaf plates 30–60 cm long, owing to which the herbage of significant density is formed (Puyu et al., 2021; Ivanyshyn et al., 2021; Ivanov et al., 2019; Bulgakov et al., 2023; Kaletnik and Lutkovska, 2020; Branitskyi et al., 2022).

Such a distribution by species composition will allow carrying out types of maintenance work in a more reasonable manner, since different categories of lawns in terms of quality require different maintenance systems.

Taking into account the bioecological features of the studied species and their belonging to certain growth conditions, some types of herbaceous plants were classified according to a number of indicators (Table 2). Accordingly: according to the relationship to light, lawn grasses can be divided into the following heliomorphs: heliophytes (No) – obligate light plants; heliosciophytes (NeSc) – facultative light plants; sciogeliophytes (ScNe) are facultative shade plants; sciophytes (Sc) – obligate shade plants) (Bethany et al., 2019).

The aggregated balance of lawn areas in terms of quality makes it possible to approach the use of agrotechnical measures in a more expedient and justified manner. The total area of lawns, for which the directions of maintenance and restoration work were determined, is presented in Table 3.

For a more detailed analysis and substantiation of measures, types of work and systems for care and maintenance, lawns on the university territory were conventionally divided into three categories according to their quality. The first category is lawns with good quality. These are landscaped parterre lawns that require only the work necessary to maintain an aesthetic appearance. The second one is in a satisfactory condition, requiring additional agrotechnical measures for their superficial improvement. The third category of lawns is in unsatisfactory condition. A fundamental re-planning should be organized here.

It has been established that the highest quality lawns form a grass stand with a density of

Table 2. Ecological characteristics of the most used gas-forming species

Species	Fastidiousness to soil	Relation to light	Assessment of drought resistance	Life form
Festuca rubra L.	mesotrophs	ScHe	5	St
Lolium perenne L.	mesotrophs	ScHe	5	Pr
Agrostis stolonifera L.	mesotrophs	ScHe	2	Pr

Table 3. Summary balance of the area of lawns with different quality conditions in the park zone of Vinnytsia National Agrarian University (average for 2020–2022)

Object of study	Area, m^{-2}	The state of the grass stand					
		good		satisfactory		unsatisfactory	
		S, m^2	%	S, m^2	%	S, m^2	%
Central part	92292	28942	32	41593	45	21757	23
Botanical Garden 'Podillya'	59740	19253	32	28059	47	12428	21
Together	152032	48195	32	69652	46	34185	22

more than 120 vegetative shoots per 1 dm^2. A grass stand of excellent quality is formed with a density of 100–120 pieces/dm^2, good quality – with a density of 75–100 pieces/dm^2, satisfactory – 50–75 pieces/dm^2, unsatisfactory – with a density of 25–5 pieces/dm^2. On the basis of the calculations of the density of grass on the parterre lawns in front of educational buildings No. 1–2, it was found that the studied areas according to the indicators belong to the categories of good, satisfactory and unsatisfactory quality (Table 4). Since the number of shoots of lawn grass per 1 dm^2 did not exceed 250 pcs., the categories of the highest and excellent quality according to the Table 4 were not included.

According to the results of the studies of the parterre lawns located on the territory of the educational institution, it was determined that the grass in sections 2, 3, 8 needs to be partially restored, since its density does not meet

Table 4. The density of shoots and the quality of the grass stand of lawn grasses on the parterre lawns of Vinnytsia National Agrarian University (average for 2020–2022)

№ areas	Length, m	Width, m	Area, m^2	Density of shoots, pcs./dm^2	The state of the grass stand		
					good	satisfactory	unsatisfactory
1	32	6	192	56		+	
2	24	20	480	18			+
3	35	9	315	16			+
4	20	24	480	92	+		
5	33	30	990	89	+		
6	26	35	914	98	+		
7	24	14	336	86	+		
8	10	14	140	22			+
9	28	19	532	67		+	
10	30	31	930	77		+	

Table 5. Cracking and density of gray forest soil averaged for the stage of physical maturity of the soil (average for 2020–2022)

Crackling	Depth, cm	Control	Lawn cover	LSD_{05}
General	0–10	42.5	49.0	1.39
	10–20	40.2	44.9	1.20
	20–30	38.7	42.6	0.90
	0–30	40.5	45.6	1.18
Capillary	0–10	23.0	27.0	0.81
	10–20	22.3	24.9	0.69
	20–30	21.9	23.7	0.47
	0–30	22.4	25.2	0.67
Non-capillary	0–10	19.2	21.9	0.80
	10–20	17.6	19.9	0.59
	20–30	16.5	18.7	0.57
	0–30	17.8	20.2	0.72
Aeration	0–10	20.3	23.3	1.43
	10–20	17.4	19.1	1.44
	20–30	13.7	15.6	1.07
	0–30	17.1	19.3	1.37
Density g/cm^3	0–10	1.38	1.32	0.04
	10–20	1.48	1.34	0.05
	20–30	1.55	1.44	0.04
	0–30	1.47	1.36	0.04

aesthetic requirements. The total area of such plots is 935 m^2. On plots 1, 9, 10 with an area of 1.654 m^2, the density of grass-forming grass shoots is satisfactory, but here it is necessary to carry out reasoned measures to improve and restore the grass stand. On plots 4–7 with a total area of 2.720 m^2, the density of the lawn is good, but some agrotechnical measures are needed to create optimal conditions for high-quality weeding and grass growth.

From a practical point of view, it was established that the composition of lawns in the territory of the park zone of the Vinnytsia National Agrarian University includes mainly perennial grasses, sown in accordance with theoretically based recommendations. The given balance of lawn areas in terms of quality makes it possible to approach the use of agrotechnical measures to determine the directions of work and restoration in accordance with each type of lawn in a more expedient and motivated way.

The research results showed a significant difference in the influence of different types of lawn plants on the basic indicators of the physical properties of the soil – porosity and density in the section of the studied layers of the arable horizon (0–30 cm) (Table 5) before the start of the main technological operations.

The use of all types of plants contributed to the general growth of both the general sparability, including its subcategories, and the sparability of aeration. At the same time, the specified feature of the formation of spar was noted for gray forest soils under the conditions of the Vinnytsia National Agrarian University experimental field. This ultimately contributed to a decrease in soil density.

The most positive effect on this nature of changes was noted on average during the period of research with the use of lawn grasses, which ensured, in the variant of conventional row sowing on gray forest soils, an increase in the total porosity in the 0–30 cm soil layer by 8.1%, capillary by 9.4%, non-capillary – by 6.3%, pore aeration – by 13.0%.

CONCLUSIONS

An important issue of the modern problem of preserving biodiversity and rational use of plant resources is the enrichment of the assortment of ornamental plants. It was established that the total lawn area on the territory of the Vinnytsia National Agrarian University is 152.032 m^2, including 92.292 m^2 in the central part, and 59.740 m^2 on the territory of the Podillia Botanical Garden, which is part of the structure of the Vinnytsia National University and directly adjacent to the central parts. On the territory, parterre lawns, which are in good condition in terms of quality and belong to category 1, occupy an area of 2720 m^2 and require minor agrotechnical maintenance measures; the lawns that are in satisfactory condition – category 2 – cover 1.654 m^2 and require enhanced agrotechnical measures to restore grass; category 3 – the lawns in unsatisfactory condition occupy 935 m^2 and require radical improvement. Thus, it was found that the use of lawn grasses – red fescue (*Festuca rubra* L.), meadow ryegrass (*Lolium perenne* L.), and meadow fescue (*Agrostis stolonifera* L.) is an effective means of regulating the agrophysical properties of the soil, controlling segetal vegetation and biologicalization of soil nutrition. The most positive effect on this nature of changes was noted on average during the period of research with the use of lawn grasses, which ensured, in the variant of conventional row sowing on gray forest soils, an increase in the total porosity in the 0–30 cm soil layer by 8.1%, capillary by 9.4%, non-capillary – by 6.3%, pore aeration – by 13.0%.

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