EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology, 2025, 26(4), 121–129
https://doi.org/10.12912/27197050/200856
ISSN 2719–7050, License CC-BY 4.0

Received: 2025.01.19
Accepted: 2025.02.20
Published: 2025.03.01

Pro-ecological and energy-saving technologies for the use of meadow grasslands of different maturity, taking into account their biological characteristics and the environment

Uliana Karbivska[1], Yevheniia Butenko[2*], Yaroslava Hryhoriv[1], Nelia Dolynko[1], Nataliia Bielova[1], Vitalii Kovalenko[3], Olesia Danylchenko[2], Nataliya Tymchuk[4], Andrii Stavytskyi[5], Roman Bordun[6]

[1] Vasyl Stefanyk Precarpathian National University, Shevchenko Str., 57, Ivano-Frankivsk, 76018, Ukraine
[2] Sumy National Agrarian University, 160, H. Kondratieva Str., Sumy, 40021, Ukraine
[3] National University of Life and Environmental Sciences of Ukraine, 15, Heroiv Oborony Str., Kyiv, 03041, Ukraine
[4] Luhansk Taras Shevchenko National University, Koval Str., 3, 36003, Poltava, Ukraine
[5] Separate Structural Subdivision "Okhtyrka professional college of Sumy national agrarian University" Principal of College Sumy region, Okhtyrka, 46 Sumska Street, Sumy, 42700, Ukraine
[6] Institute of Agriculture of Northern East of National Academy of Agrarian Sciences of Ukraine, Parkova Str., 3, Sumy region, village Sad, Ukraine
* Corresponding author's e-mail: evg.butenko2011@ukr.net

ABSTRACT

The organisation of green and raw material conveyor systems depends on a variety of factors, such as the biological characteristics of meadow grasses, their early maturity, and environmental conditions. It also includes a set of agrotechnical measures, such as the choice of grass mixtures, selection of land plots and grassland management techniques, mowing, fertilisation and moisture regimes, as well as organisational measures for the creation, maintenance and rational use of sown cenosis. Green and raw material conveyor schemes are created based on cereals, legume-cereals, and mixed seeded and natural meadow grasses. Legume-cereal grass mixtures are the late link in the conveyor, and cereals are the early and mid-season link. When organising different types of conveyors on farms that are well supplied with nitrogen, the ratio between cereals and legume-cereals should be 2:1. And in farms with poor fertiliser supply 1:2. The type of green or raw material conveyor is determined by the purpose of the green mass. It has been proved that in the production of artificially dried grass fodder, nutrient losses are the lowest and amount to only 5–10%. And in the process of harvesting haylage 20–30%, silage 30–35% and in hay from 33–63%. However, the production of artificially dried grass fodder, which is an important concentrated feed for direct feeding of livestock and for use in the production of mixed fodder, requires large amounts of energy. Therefore, it is important to introduce energy-saving and advanced technologies, such as haymaking and haylage production, as well as pasture-based livestock management instead of stall-based. Based on the efficiency of growing fodder crops and the identification of the most competitive experimental options, a model of a raw material conveyor was developed. It is designed for the efficient organization of feed harvesting and providing livestock with high-quality fodder. Our modelling option focuses on the supply of raw materials for feed production using perennial legumes. These perennial legumes were cultivated on sod–podzolic surface-gley soils in the conditions of the Precarpathian region. Subsequently, they were used to make haylage for mono-feeding of 100 heads of cattle.

Keywords: biological feed resources, energy-saving technologies, green and raw material conveyor, leguminous and cereal grasses, grasslands, differently ripening species, ecological feed.

INTRODUCTION

The cultivation of various legumes and annual fodder plants, as well as their combinations, along with the optimisation of cultivation technologies, plays an important role in the production of fodder. Special attention is paid to the biological approach to the production of feed resources, the use of energy-saving technologies and the development of effective models of green conveyors. The main purpose of green and raw material conveyors is to provide a constant supply of grass fodder during the spring–summer and summer–autumn periods, as well as to supply raw materials for the production of hay, haylage, silage or artificially dried fodder in winter (Kurhak, 1995; Karbivska et al., 2020a).

When designing green and raw material conveyors, it is necessary to take into account the biological characteristics of herbs, their growth rate, environmental conditions, location, economic efficiency of cultivation and a range of agrotechnical measures (Kirilesko, 2012; Karbivska et al., 2022c; Tsymbal, 2023). This includes seed selection, land plot selection, fertilizer application, moisture management and crop use. Organisational measures are also required for the establishment, maintenance and use of fodder crops (Kolisnyk et al., 2024; Datsko et al., 2025).

Today, when developing technological maps and conducting calculations for fodder crop cultivation, the statement that green fodder is the cheapest is relevant only for the cultivation of perennial grasses in their second or third year of life. Silage made from milk–wax corn has a lower cost than green mass of this crop when used in a green conveyor. And the cost of producing green biomass from annual grasses can indeed reach the level of producing root crops (Pirhofer–Walzl et al., 2011; Voitovyk et al., 2023).

It's known that the quality of grass fodder significantly affects the conditions and composition of cereal grasslands, as well as their utilization and fertilization, particularly in the conditions of the Forest-Steppe zone (Kovtun, 2016; Rieznik et al., 2021). Well-moistened perennial cereal grasses provide the main part of the fodder yield (Panakhyd, 2017).

Hayfields and pastures are considered to be a source of affordable and quality feed for livestock. They play an important role in strengthening the feed base of livestock farming, as they provide a significant share of the feed requirements for agricultural ruminant animals, both in the form of green fodder from pastures and hay from meadows, and in the form of silage and haylage (Finneran et al., 2012; Huyghe et al., 2014; Oenema et al., 2014). Hay remains an important component of animal diets as it promotes normal stomach and intestinal function. It's also the only roughage that contains vitamin D, which regulates mineral metabolism in animals' bodies (Katsumata, 2018; Karbivska et al., 2022a).

Grasslands play a key role in landscapes and are increasingly important due to their significant contribution to sustainable ecosystem development and positive environmental impact (Huyghe et al., 2014; Isselstein, 2014; Lindström, 2014a; Lindström, 2014b; Paz-Ferreiro, 2016; Ates et al., 2017). The issue of preserving and expanding production requires solving the problem of feed optimisation, which accounts for a significant share of livestock production costs (Klymenko, 2009; Karbivska et al., 2020b; Karpenko et al., 2019).

The production of affordable milk and meat, in particular for dietary and child nutrition, directly depends on the cultivation of nutritious and high–quality grass fodder for cattle. The primary role in this is played by the cultivation of perennial legumes and cereal grasses, as well as annual fodder crops and their combinations, along with the optimization of cultivation methods within the green (raw material) conveyor system (Tsymbal, 2017; Kovalenko et al., 2024a). Cultivated and natural grasslands of intensive type, which vary in their growth rate, play an important role in the formation of a sustainable forage base for livestock farming. With proper care and rational use, they allow for stable high yields and ensure a uniform supply of green mass during the summer period for constant animal nutrition and harvesting of various types of grass fodder for the winter (hay, silage, artificially dried grasses) This fosters the development of reliable green and raw material conveyor systems in meadows (Kurhak et al., 2014; Karbivska et al., 2022b; Kurhak et al., 2023).

The organization of green and raw material conveyor systems is determined by the growth characteristics of meadow grasses, their growth rate, ecological conditions of the growing area, and a complex of agronomic practices (selection of grass mixtures, land plot selection, haymaking technology, mowing regimes, fertilizer application, and irrigation), as well as organizational measures for the creation, care, and rational use of sown grass stands (Veklenko, 2003; Kovalenko et al., 2024b). One of the most important tasks of intensifying field fodder production is to improve the system of raw material conveyor, which ensures adequate feeding of ruminant animals during the growing season (Getman et al., 2012; Hryhoriv et al., 2021).

MATERIAL AND METHODS

The research was carried out in 2015–2018 on the experimental field of the Department of Agrochemistry and Soil Science of Vasyl Stefanyk Precarpathian National University. The experiment was conducted according to the generally accepted methodology on sod–podzolic surface glaze soil (Babych, 1994). In the arable layer of soil at a depth of 0–10 cm and 10–20 cm, the humus content ranged from 2.0 to 2.4%, respectively. The values of alkaline–hydrolysed nitrogen were 68.6–39.2 mg·kg^{-1}, P_2O_5 – 78–38 mg·kg^{-1}, K_2O – 60–52 mg·kg^{-1}, and the soil pH level was 4.20 and 3.75.

Weather conditions during the years of research (with sufficient rainfall) were favourable for the growth of perennial grasses in the experiment. Based on meteorological data obtained from the Ivano-Frankivsk Regional Hydrometeorological Center weather conditions during the years of research were evaluated. In 2015, the weather conditions were different from long-term pointers and yet favourable for the conformation of legume-cereal agrophytocenoses. During the growing season, the rainfall was by 86.9 mm below normal, and there was an increase in the average daily air temperature by 0.8 °C as compared to the average multi-year indicators. A decrease in temperature regime with average daily temperature by 0.6 °C below the long-term normal and increased rainfall by 18.9% above the normal were characteristic of the year 2016. Weather conditions in 2017 were close to mid-term. The analysis of weather conditions in 2018 shows that precipitation deficits were observed in April and September, at 19.6 and 23 mm respectively, which is by 27.4 and 22.0 mm less than the long-term average.

The main task of the green and raw material conveyors is to continuously provide green fodder for livestock feeding in the spring and summer and summer and autumn periods, as well as raw materials for the production of hay, haylage, silage or artificially dried fodder in the winter. When creating green (raw material) conveyors, we took into account the biological characteristics and early maturity of grasses, environmental conditions, location, economic efficiency of their cultivation and a set of agrotechnical measures (selection of grasses or mixtures, selection of land plots, fertilization and moisture regime and use), as well as a number of organizational measures for the creation, maintenance and use of grass stands.

The area for the creation of green and raw material conveyors was selected in such a way that it was close to the feed storage site or farm with established access roads. In addition, we took into account the quality of the feed, the timing of the mass arrival, yield, daily animal requirements, and other factors. The main criteria for green and raw material conveyors are: compliance of green mass with quality standards; prolongation of the period of continuous supply of green mass; high productivity per hectare of feed area; and ease of organization of the conveyor.

Uncovered sowing of legumes, cereals and legume–cereal mixtures of perennial grasses involving one of the legume components (such as *Trifolium pratense* L., *Medicago sativa* L., *Lotus corniculanus* L., *Galega orientalis* L.) was carried out in spring 2015, where three levels of fertilisation were provided. Mineral fertilisers, according to the experimental design, were applied annually on the surface in early spring. The size of the sowing plots was 15 m^2, and the accounting plots were 10 m^2. The experiment was repeated four times. The following types and promising varieties of legumes and grasses were sown: *Trifolium pratense* variety Anitra, *Medicago sativa* variety Sinyukha, *Lotus corniculanus* variety Ajax, *Galega orientalis* variety Caucasian Captive, *Festuca rubra* L. variety Aira, *Bromus inermis* L. variety Mars, *Lolium perenne* L. variety Obriy, *Bromus riparia* (Rehm) Holub. variety Boyan, *Elytrigia intermedia* (Host) Nevski variety Khors. The thickness of grass management involved three mowing cycles. The first mowing was carried out in the earing phase of cereals and the budding stage of legumes, and the second mowing was carried out 35–45 days after the previous mowing.

RESULTS AND DISCUSSION

Efficient utilization of grasses cultivated within the green conveyor system plays a crucial role in the feeding of agricultural animals. The organisation of forage production on fodder lands helps to obtain not only large yields of sown meadow grasses with a constant supply of high-quality plant mass during the growing season for the production of various fodder (hay, silage, green fodder), but also contributes to a more rhythmic operation of forage harvesting machines compared to uniform growth rate grasses. This also improves the conditions for a significant reduction in nutrient losses during forage harvesting.

The basic models of green conveyors were developed at the Uman National University of Horticulture and Viticulture named after O.I. Zinchenko, the Department of Field Forage Production of the Research Centre "Institute of Agriculture of the National Academy of Agrarian Sciences" by Sarnatskyi, Vydrin, Nedozhdii (Sarnatskyi, 1988), Podilskyi State Agrarian Technical University named after M.I. Bakhmat (Puiu et al., 2019), Institute of Feed and Agriculture of Podillia of the National Academy of Agrarian Sciences of Ukraine by Petrychenko, Kvitka, Tsarenko and others (Petrychenko, 2008). In these models, each link (spring, summer, summer–autumn, late autumn) of the green conveyor involved the use of 10–15 crops and mixtures.

In today's crisis conditions, it is difficult to implement green conveyor schemes with a large number of crops, but there is no need for this, as most of the proposed components are biologically and feed-wise identical. In addition, after mowing, transporting and distributing, the chopped mass quickly loses its quality characteristics, which significantly affects the growth of the cost of livestock products. Therefore, it is better to focus on a combined green conveyor that combines mowing and pasture types.

During the selection of intensive thick-growing grass of different types of early maturity, agrobiological, economic and phytocoenotic features of meadow grasses were taken into account, in particular their resistance to appropriate mowing regimes, regrowth rates in spring and in after–drass, suitability of grasses to soil and climatic conditions, sensitivity to fertilisation and moisture, resistance to lodging, life expectancy, compatibility of species in cenoses, and their early maturity.

The main criteria for green and raw material conveyors are: compliance of the green mass of grass with the requirements of quality standards for the production of various types of grass feed; realistic extension of the period of continuous supply of green mass for direct feeding to animals in feeders during their stall keeping and as raw materials for the preparation of various types of grass feed. As well as high productivity per hectare of forage area; the simplicity of organizing a conveyor with a set of three to four differently maturing perennial grasses.

The selection of thick-growing grasses were based on a comprehensive assessment of the timing of green mass, feed quality, and yield, taking into account the economic and energy efficiency of their creation and use. In the process of determining the area required for thick–growing grasses in the conveyor system, the initial data were: the daily requirement of green mass for a group of cattle, etc.; productivity and distribution of the crop by mowing, taking into account technological losses during harvesting and feeding (15–20% of the gross economic yield). The schemes of green and raw material conveyors were created on the basis of cereals, legumes-cereals, and mixed seeded and natural meadow grasses of different maturity.

The type of green or raw material conveyor is determined by the purpose of the green mass. In the production of artificially dried grass fodder, nutrient losses are the lowest and amount to only 5–10%, while in the process of harvesting haylage, they are 20–30%, silage 30–35% and hay 33–63% (Kurhak, 1995; Hryhoriv et al., 2024). However, the production of artificially dried grass fodder, which is a valuable concentrated feed used for direct feeding of livestock and as an ingredient in the production of mixed fodder, requires a large amount of significant energy. Therefore, energy–saving advanced technologies for the production of hay and haylage, as well as grazing livestock on pasture instead of stall housing, should be more widely used in production environments.

Based on the calculations of the economic and energy efficiency of growing fodder crops and the identification of the most competitive variants of the experiment, a model of a raw material conveyor was developed to effectively organise the harvesting of fodder and provide livestock with high–quality feed.

An analytical review of scientific sources, practical experience of farms and long–term records and observations make it possible to optimise the necessary set of crops of the mowing and pasture green conveyor for cattle in the conditions of the Precarpathian region.

Our proposed model for the supply of raw materials for the production of forage based on perennial leguminous grasses for haylage production during mono-feeding for 100 heads of cattle on sod-podzolic surface glaze soil is presented in Table 1. This model of the raw material conveyor, utilizing a two-cut system alongside the application of $P_{60}K_{60}$ in conditions of nitrogen fertilizer deficiency, with three differently maturing varieties of perennial leguminous grasses as a source of symbiotic nitrogen, can ensure reliable annual production of high-quality silage as a monofeed amounting to 1460 tons for feeding 100 adult cattle under confined year–round housing conditions.

The harvesting process with minimal provision of technical means for dual mowing in the optimal agronomic terms of grass cutting lasts 61 days. In this conveyor, the area of early-maturing perennial grasses based on *Lotus corniculatus* is 44 hectares, medium maturing based on *Trifolium pretense* is 38 hectares, and late maturing *Trifolium hybridum* is 44 hectares, with each comprising 30–35% of the total thickness of grass by maturity.

The total area of these differently maturing species of perennial grasses is 126 hectares. This universal conveyor can also be used to produce 3000 tons of high-quality green fodder as a green conveyor block or 500 tons of high-quality hay, saving the need for harvesting equipment.

An approximate model of a green conveyor based on perennial legume-cereal grasses with three times mowing to provide green fodder in the summer for feeding 100 heads of cattle on sod–podzolic soil is shown in Table 2.

This model of a green or raw material conveyor based on four perennial legume–cereal grasses of different maturity and annual grasses on sod-podzolic soils alongside the application of $P_{60}K_{60}$ for feeding 100 heads of dairy or beef cattle provides a continuous supply of green mass for 143 days. The total area of fodder crops is 32 hectares. Annual crops account for 3 hectares of this area. In this conveyor, the share of early-, medium-early-, medium- and late-ripening grasses dominated by legumes among the perennial thick-growing grass is 23–27% of each species by maturity.

Legumes and cereals dominated by *Lotus corniculatus* are sown as early-ripening grasses, *Trifolium pretense* is sown as medium-ripening, *Trifolium hybridum* is sown as mid-ripening and *Galega orientalis* is sown as late-ripening. The grass deficit that occurs at the end of July is covered by annual grasses, in particular a vetch-oat mixture. The conveyor is rarely used in this form in production. The excess mixture in the first and second mowings can be used for hay and haylage. At the end of July, there is a shortage of green mass, which must be covered by using annual fodder crops for this purpose. Considering this, one combined conveyor for the production of different types of feed can be designed, or two simple conveyors can be built: one for the production of green fodder or grass meal, and the other for hay and silage harvesting.

According to the research of Oleg Hoydenko and others (2017), the main problem that arises when cattle are fed green fodder indoors in summer is the uninterrupted supply of green fodder at the same level of nutritional value. The duration of use of one component of the green conveyor is approximately 15–20 days, due to the physiological aging of plants, an increase in their cellulose content and a sharp decrease in overall nutritional value. There is a need to start harvesting not at

Table 1. Model of a raw material conveyor based on perennial leguminous grasses for silage harvesting during monofeeding of 100 heads of cattle on sod–podzolic soil

Type of thick-growing grass by maturity, dominant component	Mowing	Term of alienation of the grass	Vegetation phase	Green mass $t \cdot ha^{-1}$	Area ha	Output, tonnes	
						Green fodder	Silage
Early maturing (*Lotus corniculatus*)	1	01–10.06	flowering	17.5	28	479	240
Medium-early maturing (*Trifolium pratense*)	1	11–20.06	flowering	17.0	29	479	240
Medium maturing (*Trifolium hybridum*)	1	21–30.06	flowering	15.0	32	479	240
Early maturing	2	21–31.07	budding	12.0	44	525	260
Medium-early maturing	2	1–10.08	budding	12.8	38	479	240
Late maturing	2	11–20.08	budding	11.0	44	479	240
Total		61 days		23.2	126	2920	1460

Note: the daily requirement of one head of cattle is 40 kg of haylage. Yields are reduced by 20% due to standard losses. Agrophone – $P_{60}K_{60}$.

Table 2. Model of a green conveyor based on perennial legume-cereal grasses with three times mowing for feeding 100 heads of cattle on sod-podzolic soils

Type of thick-growing grass by maturity, dominant component	Mowing	Term of alienation of the grass	Vegetation phase	Green mass, $t \cdot ha^{-1}$	Need		Output of feed units, t
					Green mass, t	Area, ha	
Early maturing (*Lotus corniculatus*)	1	20–31.05	branching – budding	14.9	66	5	11
Medium-early maturing (*Trifolium pratense*)	1	01.06–10.06	budding	12.8	60	5	10
Medium maturing (*Trifolium hybridum*)	1	11–20.06	budding – flowering	12.8	60	5	10
Late maturing (*Galega orientalis*)	1	21.06–30.06	budding – flowering	14.0	60	5	10
Early maturing	2	01–10.07	budding	10.6	60	6	10
Medium-early maturing	2	11–20.07	budding	9.8	60	7	10
Annual grasses (vetch-oat mixture)	1	21–31.07	earing – flowering	21.3	66	4	11
Medium maturing	2	01–10.08	budding	9.8	60	7	10
Late maturing	2	11–20.08	budding	8.5	60	8	10
Early maturing	3	21–31.08	budding	7.7	66	9	11
Medium-early maturing	3	01–10.09	budding	8.5	60	8	10
Medium maturing	3	11–20.09	budding	7.7	60	8	10
Late maturing	3	21–30.09	budding	6.4	60	10	10
Total		143 days			798	39	133

Note: the daily requirement for one head of cattle is 60 kg, for a group of 100 heads – 6 tonnes of green mass. The productivity is shown taking into account possible 15% losses of green mass yield when feeding it to livestock in feedlots or grazing on pastures. Fertiliser – $P_{60}K_{60}$.

optimal times, which provide maximum nutritional output, as done in the case of harvesting preserved feeds, but rather 7–10 days before this optimal time and continue using them for the same period after the optimal time. This leads to a significantly lower feed yield in terms of both nutritional value and physical weight, which in turn affects the cost of production.

According to the research of Puiu, Bakhmat and other scientists (2019), the longest-lasting element of the mowing and pasture green conveyor system in the region is cultivated pasture, which is used from early May to the third decade of October inclusive. This is the main source of affordable and nutritious fodder, especially from the first decade of May to mid–July, when grass growth is sufficient on pastures. However, in the subsequent period, the intensity of grass growth on pastures decreases, and other crops begin to meet the needs for green fodder. *Medicago sativa* plays a special role in this, providing three to four mows of green mass with a high content of protein, vitamins and minerals.

Such a conveyor can be extended for use in the autumn period if there is a need for grazing of beef cattle. In this case, it is necessary to have larger areas under differently matured thick-growing grass or a single thick-growing grass, which makes it possible to create a reserve of grass for use in the autumn and even in the late autumn period, up to a steady cold snap.

According to the results of the study by Tsymbal and Kushuk (2023), in addition to various types of green and haylage mass, concentrated feed is also included in the diet of animals. To simplify the process of purchasing seeds, you can use the same crops that are grown on conveyors, such as oats, triticale, corn, vetch and others. The grains of these crops are crushed into pieces and mixed in optimal proportions to make concentrated cow feed. To obtain better results, the seeding rate of these crops is set taking into account their morphological characteristics and growing conditions. According to research by many scientists, the diet of one cow per day should include 2.5–3 kg of concentrated feed. Grain crops such as corn, barley and oats at 12% moisture contain 9 to 13% protein, 1.5 to 2% fat and 2–3% fibre, while legumes have a higher protein (23 to 33%) and fibre (4.5 to 7%) content.

The model of a green conveyor based on perennial cereals grasses of intensive type with three

Table 3. Model of a green conveyor based on perennial cereals grasses of intensive type with three times mowing for 100 heads of cattle on sod–podzolic soils with the application of $N_{150}P_{60}K_{90}$

Type of thick-growing grass by maturity, dominant component of a grass mixture	Mowing	Term of alienation of the grass	Vegetation phase	Green mass, t·ha^{-1}	Need		Output of feed units, t
					green mass, t	area, ha	
Early maturing (*Dactylis glomerata*)	1	21–31.05	tubing – beginning of earing	12.0	66	6	130
Medium maturing (*Festuca orientalis*, *Bromopsis inermis*, or *Phalaris arundinacea*, *Lolium perenne*)	1	01–10.06	tubing – beginning of earing	12.5	60	5	140
Late maturing (*Phleum pratense*)	1	11–20.06	tubing – beginning of earing	12.5	60	5	150
Annual grasses (vetch-oat mixture)	1	21–30.06	earing – budding	25.0	60	3	110
Early maturing	2	01–10.07	tubing	10.5	60	6	100
Medium maturing	2	11–20.07	tubing	11.0	60	6	140
Late maturing	2	21–31.07	tubing	tubing	66	7	160
Annual grasses (vetch-oat mixture of the 2nd sowing period)		01–10.08	flowering	22.0	60	3	
Early maturing	3	11–20.08	tubing	9.5	60	7	130
Medium maturing	3	20–31.08	tubing	9.0	66	8	150
Late maturing	3	01–10.09	Tubing	7.0	60	9	160
Total		113 days			678	27	1490

Note: the daily requirement for one head of cattle is 60 kg of green mass. The productivity is shown taking into account possible 15% losses of green mass yield when feeding it to livestock in feedlots or grazing on pastures. Fertiliser – $P_{60}K_{60}$.

times mowing for 100 heads of cattle on sod-podzolic soils with the application of $N_{150}P_{60}K_{90}$ is shown in Table 3.

It is suitable for feeding 100 head of cattle in a stall and provides a continuous supply of green mass for 113 days. In this conveyor, the area of early-maturing perennial grasses based on *Dactylis glomerata* is 7 hectares (26%), medium–maturing grasses based on *Festuca orientalis* or *Bromopsis inermis*, *Phalaris arundinacea* or *Lolium perenne* is 8 hectares (30%), late-maturing grasses based on *Phleum pratense* is 9 hectares (33%) and annual grasses (vetch-oats mixture) is 3 hectares (11%).

It should be noted that this conveyor does not take into account the occurrence of excess or deficit of grass mass. The excess in the first and second mowings can be used for hay or haylage. The grass deficit that occurs at the end of July must be covered by using annual grasses.

Considering this, one combined conveyor for the production of different types of feed can be designed, or two simple conveyors can be built: one for the production of green fodder or grass meal, and the other for hay and silage harvesting.

CONCLUSIONS

The developed green (raw material) conveyors based on differently matured sown agrocenoses ensure a uniform supply of high-quality fodder biomass within 61–143 days. Thus, the proposed innovative model of a green conveyor in the conditions of the Precarpathian region ensures stable conveyor production of high quality and inexpensive grass fodder, optimises the required set of crops and increases the resource potential of the territory.

REFERENCES

1. Adamovičs, A, Beča, M, & Spružs, J. (2005). Racionāla zālaugu bioloģskās daudzveidības izmantošana kvalitatīvas lopbarības ieguvei rational use of herbage biological diversity for hight–quality forage production. *Environment. Technology. Resources*, 77–84.
2. Ates, S., Keles, G., Yigezu, Y.A., Demirci, U., Dogan, S., Isik, S., & Sahin, M. (2017). Bioeconomic efficiency of creep supplementation of forage legumes or concentrate in pasture based lamb production

system. *Grass and Forage Science*, *72*, 81–83.

3. Babych, A.O. (1994). Methods of conducting experiments on fodder production. *Vinnytsia*, *96* (in Ukrainian).
4. Datsko, O., Butenko, A., Hotvianska, A., Pylypenko, V., Nozdrina, N., Masyk, I., Bondarenko, O., Lemishko, S., Litvinov, D., & Toryanik, V. (2025). Influence of agroecological methods on biometric indicators of corn. *Ecological Engineering & Environmental Technology*, *26*(2), 264–271. https://doi.org/10.12912/27197050/199324
5. Finneran, E., Crosson, P., O'Kiely, P., Shalloo, L., Forristal, P.D. & Wallace, M. (2012). Economic modelling of an integrated grazed and conserved perennial ryegrass forage production system. *Grass and Forage Science*, *67*(2), 162–176. https://doi.org/10.1111/j.1365–2494.2011.00832.x.
6. Getman, N.Y., & Susha, S.K. (2012). History of the development of scientific research on conveyor production of green fodder on arable land. *Feeds and feed production*, *74*, 269–272 (in Ukrainian).
7. Haydenko, O., Chipliak, S., & Podlesky, M. (2017). How to launch a green conveyor. *Agribusiness today*, 1–4 (in Ukrainian).
8. Hryhoriv, Y., Butenko, A., Nechyporenko, V., Lyshenko, M., Ustik, T., Zubko, V., Makarenko, N., & Mushtai, V. (2021). Economic efficiency of Camelina sativa growing with nutrition optimization under conditions of Precarpathians of Ukraine. Agraarteadus, 32(2), 232–238. https://doi.org/10.15159/jas.21.33
9. Hryhoriv, Y., Butenko, A., Solovei, H., Filon, V., Skydan, M., Kravchenko, N., Masyk, I., Zakharchenko, E., Tykhonova, O., & Polyvanyi, A. 2024. Study of the Impact of Changes in the Acid-Base Buffering Capacity of Surface Sod-Podzolic Soils. *Journal of Ecological Engineering*, *25*(6), 73–79. https://doi.org/10.12911/22998993/186928
10. Huyghe, C., De Vliegher, A. & Golinkski, P. (2014). European grasslands overview: temperate region. EGF at 50: the future of European Grasslands. Proceedings of the 25 general meeting of the European grasslands federation, *19* (September, 7–11, 2014). *Aberystwyth, Wales*, 29–40.
11. Isselstein, J. & Kayser, M. (2014). Functions of grasslands and their potential in delivering ecosystem services. EGF at 50: the future of European Grasslands. Proceedings of the 25 general meeting of the European grasslands federation, *19* (September, 7–11, 2014). *Aberystwyth, Wales*, 199–214.
12. Karbivska, U., Butenko, Ye., Nechyporenko, V., Shumkova, O., Shumkova, V., Tymchuk, D., Tymchuk, N., Litvinov, D., Hotvianska, A., & Toryanik, V. (2022a). Ecologicalc and economic efficiency of growing on dark gray soils of bean–ceneral grasses. *Agraarteadus, 33*(2), 404–409. DOI: 10.15159/jas.22.25.
13. Karbivska, U., Kurgak, V., Gamayunova, V., Butenko, A., Malynka, L., Kovalenko, I., Onychko, V., Masyk, I., Chyrva, A., Zakharchenko, E., Tkachenko, O., & Pshychenko, O. (2020a). Productivity and quality of diverse ripe pasture grass fodder depends on the method of soil cultivation. *Acta Agrobotanica*, *73*(3), 1–11. https://doi: 10.5586/aa.7334
14. Karbivska, U., Masyk, I., Butenko, A., Onychko, V., Onychko, T., Kriuchko, L., Rozhko, V., Karpenko, O., & Kozak, M. (2022b). Nutrient Balance of Sod–Podzolic Soil Depending on the Productivity of Meadow Agrophytocenosis and Fertilization. *Ecological Engineering & Environmental Technology*, *23*(2), 70–77. https://doi.org/10.12912/27197050/144957
15. Karbivska, U.M., Kurgak, V.G., Kaminskyi, V.F., Butenko, A.O., Davydenko, G.A., Viunenko, O.B., Vyhaniailo, S.M., & Khomenko, S.V. (2020b). Economic and Energy Efficiency of Forming and Using Legume–Cereal Grass Stands Depending on Fertilizers. *Ukrainian Journal of Ecology*, *10*(2), 284–288. doi: 10.15421/2020_98.
16. Karbivska, U.M., Kovalenko, I.M., Onychko, T.O., Radchenko, M.V., Pshychenko, O.I., Tykhonova, O.M., Vereshchahin, I.V., Bordun, R.M., & Tymchuk, D.S. (2022c). Economic and energy efficiency of growing legume grasses. *Modern Phytomorphology, 16*, 21–26. https://doi.org/10.5281/zen
17. Karpenko, O.Yu., Rozhko, V.M., Butenko, A.O., Masyk, I.M., Malynka, L.V., Didur, I.M., Vereshchahin, I.V., Chyrva, A.S., & Berdin, S.I. (2019). Post–harvest siderates impact on the weed littering of maize, *Ukrainian Journal of Ecology*, *9*(3), 300–303. DOI: 10.15421 / 2019_745
18. Katsumata, M., Kobayashi, H., Ashihara, A., & Ishida, A. (2018). Effects of dietary lysine levels and lighting conditions on intramuscular fat accumulation in growing pigs. *Animal Science Journal, 89*, 988–993 (in Ukrainian).
19. Kirilesko, O.L. (2012). Agroecological bases of production and use of grassy fodder: Monograph. *Kharkiv: National Technical University "KhPI"*, 309 (in Ukrainian).
20. Klymenko, A.A. (2009). Cost management at agricultural enterprises. *Economics and management*, *4*(8), 51–57 (in Ukrainian).
21. Kolisnyk, O., Yakovets, L., Amons, S., Butenko, A., Onychko, V., Tykhonova, O., Hotvianska, A., Kravchenko, N., Vereshchahin, I., & Yatsenko, V. (2024). Simulation of High–Product Soy Crops Based on the Application of Foliar Fertilization in the Conditions of the Right Bank of the Forest Steppe of Ukraine. *Ecological Engineering & Environmental Technology*, *25*(7), 234–243. https://doi.org/10.12912/27197050/188638
22. Kovalenko, V., Kovalenko, N., Gamayunova, V.,

Butenko, A., Kabanets, V., Salatenko, I., Kandyba, N., & Vandyk, M. (2024a). Ecological and Technological Evaluation of the Nutrition of Perennial Legumes and their Effectiveness for Animals. *Journal of Ecological Engineering*, *25*(4), 294–304. https://doi.org/10.12911/22998993/185219

23. Kovalenko, V., Tonkha, O., Fedorchuk, M., Butenko, A., Toryanik, V., Davydenko, G., Bordun, R., Kharchenko, S., & Polyvanyi, A. (2024b). The Influence of Elements of Technology and Soil–Dimatic Factors on the Agrobiological Properties of Onobrychis viciifolia. *Ecological Engineering & Environmental Technology*, *25*(5), 179–190. https://doi.org/10.12912/27197050/185709
24. Kovtun, K.P., Veklenko, Yu.A., & Kopaihorodska, H.O. (2016). Chemical composition and quality of forage degenerate grassland meadow grasses in different ways of their improvement in the conditions of the Forest–Steppe Right–bank. *Kormy i kormovyrobnytstvo, 82*, 204–209 (in Ukrainian).
25. Kurgak, V.G. (1995). Organisation of conveyors on sown meadows. *Animal husbandry of Ukraine*, *4*(6), 26–27 (in Ukrainian).
26. Kurhak, V.G., Tsymbal, Y.S., & Yakymenko, L.P. (2014). Cultivation of fodder crops in the green conveyor system in organic production. *Collection of scientific papers of the National Scientific Centre "Institute of Agriculture of NAAS"*, *1*(2), 116–125 (in Ukrainian).
27. Kurhak, Volodymyr, Šar unait˙e, Lina, Arlauskien˙e, Aušra, Karbivska, Uliana, & Tkachenko, Anton. (2023). The Impact of Management Practices on the Stability of Meadow Communities on a Mountain Slope. *Diversity*, *15*, 605. https://doi.org/10.3390/d15050605
28. Lindström, B.E.M., Frankow–Lindberg, B.E., Dahlin, A.S., Watson, C.A., & Wivstad, M. (2014). Red clover increases micronutrient concentrations in forage mixtures. *Field Crops Res*, *169*, 99–106.
29. Lindström, B.E.M., Frankow–Lindberg, B.E., Dahlin, A.S., Wivstad, M., & Watson, C.A. (2014). Micronutrient concentrations in relation to phenological development of red clover (*Trifolium pratense* L.), perennial ryegrass (*Lolium perenne* L.) and timothy (*Phleum pratense* L.). *Grass Forage Sci., 69*, 276–284.
30. Oenema, O., de Klein, C. & Alfaroc, M. (2014). Intensification of grassland and forage use: driving forces and constrains. *Crop and Pasture Science*, *65*(6), 524–537. https://doi.org/10.1071/CP14001.
31. Panakhyd, H.Ia., & Konyk, H.S. (2017). The main indicators of quality of forage legumes and cereals sown grass. *Kormy i kormovyrobnytstvo*, *83*, 145–149.
32. Paz–Ferreiro, J., & Fu, S. (2016). Biological Indices for Soil Quality Evaluation: Perspectives and Limitations. *Land Degradation & Development*, *27*, 14–25. DOI: 10.1002/LDR.2262
33. Petrychenko, V.F., Kvitko, G.P., & Tsarenko, M.K. (2008). Scientific basis of intensification of field fodder production in Ukraine. *Vinnytsia: FOP Danilyuk V.G.*, 240 (in Ukrainian).
34. Pirhofer–Walzl, K., Søegaard, K., Høgh–Jensen, H., Eriksen, J., Sanderson, M.A., Rasmussen, J., & Rasmussen J. (2011). Forage herbs improve mineral composition of grassland herbage. *Grass Forage Sci., 66*, 415–423.
35. Puyu, V.L., Bakhmat, M.I., Rikhlivskyi, I.P., & Shcherbatiuk, N.V. (2019). Optimisation of conveyor production of green fodder. *World Science*, *7*(47), 32–39.
36. Rieznik, S. Havva, D., Butenko, A., & Novosad, K. (2021). Biological activity of chernozems typical of different farming practices. Agraarteadus, 32(2), 307–313. DOI: 10.15159/jas.21.34.
37. Sarnatsky, P.L., Vidrin, Y.V., & Nedozhdiy Y.P. (1988). The green conveyor. *Kyiv, Urozhay*, *72* (in Ukrainian).
38. Tsymbal, Y.S. (2017). Organisation of a green conveyor based on perennial grasses and mixtures of annual crops. *Bulletin of Agrarian Science*, *6*, 19–23 (in Ukrainian).
39. Tsymbal, Y.S., & Kushuk, M.A. (2023). Green (raw material) conveyor in organic fodder production based on perennial grasses and mixtures of annual crops. *Agrarian Week*, 1–3.
40. Veklenko, Y.A. (2003). Economic evaluation of low–cost methods of creation and use of sown mowed pasture grasslands. *Feed and fodder production*, *51*, 235–237 (in Ukrainian).
41. Voitovyk, M., Butenko, A., Prymak, I., Mishchenko, Yu., Tkachenko, M., Tsiuk, O., Panchenko, O., Slieptsov, Yu., Kopylova, T., & Havryliuk, O. (2023). Influence of fertilizing and tillage systems on humus content of typical chernozem. *Agraarteadus*, *34*(1), 44–50. DOI: 10.15159/jas.23.03