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ORIGINAL RESEARCH PAPER in ECOLOGY

Productivity and Quality of Diverse Ripe Pasture Grass Fodder Depends on the Method of Soil Cultivation

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Abstract

In this study, we investigated the influence of soil cultivation method on the productivity and quality of pasture grass fodder. We found that increasing the depth of cultivation from 8–10 cm to 20–22 cm (using surface tillage with disk implements) improved the productivity of all the grass species studied – *Phleum pratense*, *Lolium perenne*, *Festuca orientalis*, *Dactylis glomerata*, *Bromus inermis*, *Phalaris arundinacea*, *Festuca rubra* – by an average of 2%–3% at an LSD_{05} of 0.30 t ha^{-1}, over a period of 3 years. On average, the most important factor influencing the production of 1 ha of dry mass appeared to be the species of grass, accounting for 57% of the variation. The depth of soil tillage was also important, accounting for 43% of the variation. Of all the species studied, the highest productivity was exhibited by *Lolium perenne* (0.35 t ha^{-1} of dry weight). Increasing the soil cultivation depth led to an increase in the content of crude protein and albumen (0.9%–1.1%). According to the analysis of organic matter content and digestibility of the fodder, across the different depths of soil cultivation, the early ripening species *Dactylis glomerata*, and the average ripening species *Festuca orientalis*, *Lolium perenne*, and *Bromus inermis*, performed best. Considering the different depths of soil cultivation, *Lolium perenne* [154 g; surface tillage (disking) 8–10 cm] and *Festuca orientalis* (152 g; ploughing 20–22 cm) provided the most fodder units with digestible protein.

Keywords

pasture grasses; productivity; chemical composition; fodder quality; cultivation

1. Introduction

Production of large quantities of meadow fodder at low cost requires intensive cultivation of high yielding, multicut, and high-quality sown meadow grasses. Previous studies have shown that the use of high yielding grasses when applying intensive care and usage cultivation techniques can reliably improve the productivity of meadow land by 1.5–2.0-fold and can significantly improve the quality of fodder compared to traditional single- and dual-cut methods (Kurgak, 2010; Tester & Langridge, 2010).

The insufficient production and availability of high-quality protein feed can lead to decreased animal productivity and is an urgent problem for animal husbandry. However, the widespread use of perennial legumes, which contain 17%–22% protein in their dry matter can solve the problem of providing livestock with feed protein, when their deficiency exceeds 30%. The inclusion of legumes as components of meadow phytocenosis can improve fodder productivity and can also serve as an effective method of increasing the crude protein content of feed (Cordeau et al., 2017; Ding et al., 2014; Sobko et al., 2012; Tilman et al., 2011).

The ratio of mineral elements in plant mass and feeding stuffs is an important factor, and depends on the rate of the biological absorption of chemical elements from the soil, which is determined by environmental factors, plant health, and the anatomical features of the species. The optimal use of organic nutrients only occurs when the feed contains a sufficient amount of minerals. In turn, the nutritional conditions of the soil and intensity of soil cultivation determine the mineral composition of the feed (Butenko et al., 2019; Lipińska et al., 2018; Prorochenko, 2017; Santín-Montanyá et al., 2016; Shiferaw et al., 2011; Tsyhanskyi et al., 2019; Vasileva, 2012).

One of the important developments in meadow cultivation is the creation of high-yielding forage based on perennial pasture grasses. If cultivated following the recommended methods, these grasses result in highly productive meadow biocenosis with improved longevity, production of high quality fodder, and due to the wide range of species and sorts, it is possible to organize optimal corridors of forage (Belesky & Malinowski, 2016; Menkir, 2008; Scherner et al., 2016).

Meadow grasses should be cultivated with the application of complete mineral fertilizers containing the appropriate dose of nitrogen. They can be cultivated on all types of meadows, however sufficient moisture is required (e.g., lowland, floodplains of small rivers, land with normal moisture levels) (Bogovin & Dudnik, 2001; Kashiani & Saleh, 2010; Meng et al., 2012; Staniak, 2016).

Knowledge of the genetic potential of perennial pasture grasses, their productivity, adaptability to zonal and local conditions, and efficiency in agrophytocenoses, as well as the mode of land use, and nature and intensity of cultivation, are all important for developing highly productive fodder land which provides an effective source of valuable grass forage (Brauer et al., 2002; Ding et al., 2014; Kots, 2011; Kurgak & Tovstoshkur, 2010).

It is known that perennial grasses species differ in their suitability for the production of certain grass fodders (mowing for hay, making hay, artificially dried grass fodders or green fodders, or grazing on green fodder). According to Kurgak (2010), early-ripening pasture grasses include *Dactylis glomerata*, *Alopecurus pratensis*, and *Poa pratensis*; middle-ripening pasture grasses include *Festuca orientalis*, *Lolium perenne*, *Bromus inermis*, *Festuca rubra*, and *Phalaris arundinacea*; and late-ripening varieties include *Phleum pratense*, *Agrostis gigantea*, and *Elytrigia repens*. The combined use of different grasses indicates the possibility of prolonging the optimal agrotechnical period of herb harvesting in each cycle of usage, and to organize green (raw or pasture) corridors for a continuous, steady flow of green mass for the production of different types of high quality grass fodder over 140–180 days (Kurgak & Tovstoshkur, 2008; Średnicka-Tober et al., 2016; Thornton et al., 2009).

Previous studies have shown that the quality of plant feed depends on its botanical composition. The amount of crude protein in the dry matter of grasses can increase by 2%–5% when the legume constituent in the component composition of agrophytocenosis increases. This could be attributed to the ability of legumes to fix nitrogen from the atmosphere, thereby promoting active formation of protein substances. The developmental phase in which grass is mowed also has an effect on the chemical composition of feed (Balayev et al., 2011; Bidgoli et al., 2006; Kolisnyk et al., 2019).

In the western forest-steppes of Ukraine, one of the most effective methods of preserving arable land not used for intensive farming is the cultivation of perennial grasses. This facilitates strengthening of the livestock feed base and preserves soil fertility (Moldavan, 2012).The aims of this study were to determine the effect of soil cultivation method and depth of soil cultivation on the productivity and quality of perennial pasture grasses, and to determine how the biochemical composition, nutritional quality, and productivity of green mass differs depending on the group ripeness and botanical composition of grasses.

2. Material and Methods

2.1. Research Conditions

The research was conducted in 2011–2013 at the stationary polygon of the Agro-Chemistry and Soil Science Department at the Vasyl Stefanyk Precarpathian National University. Experiments were conducted following the methods described by Dospekhov (1985) and Babych (1998). The land used for the experiment was characterized by sod-podzolic surface-gleyed soils; the area had a northwestern exposition and was sloped at a rate-of-rise of 1°–3°. Varieties of pasture grasses were seeded according to district and purpose: *Phleum pratense* – Carpathian, *Lolium perenne* – Kolomyia, *Festuca orientalis* – Menchulsk, *Dactylis glomerata* – Stanislavskaya, *Bromus inermis* – Kozarovitsky, *Phalaris arundinacea* – Smerichka, *Festuca rubra* – Menchulsk. The swards were cut in the preblossoming phase, and two cuts per year have been made.

An interaction of two factors were tested: A – type of grass by degree of ripeness; B – soil cultivation method: (***i***) Usual ploughing, to the depth of the humus level, 20–22 cm, (***ii***) shallow plowing, to a depth of 14–16 cm, and (***iii***) surface tillage, disking to a depth of 8–10 cm (Table 1). During the study, N90P60K60 was applied, containing ammonium nitrate (34% a.m.), potassium magnesium (29% a.m.), and superphosphate (19% a.m.). We studied the influence of soil cultivation methods on the productivity and feeding value of perennial pasture grasses in different degrees of ripeness. The experimental design is presented in Table 1. Statistical analysis of experimental data was conducted following Dospekhov (1985), using Microsoft Excel.

Table 1 Experimental.

Factor A – grass species by the group of ripeness		Factor B – soil cultivation
1. *Dactylis glomerata*	Early ripening grasses	Ploughing 20–22 cm (control)
2. *Festuca orientalis*	Average ripening grasses	Shallow ploughing 16–18 cm
3. *Lolium perenne*		Surface tillage (disking) 8–10 cm
4. *Bromus inermis*		
5. *Festuca rubra*		
6. *Phalaris arundinacea*		
7. *Phleum pratense*	Lately ripening grasses	

2.2. Soil

In the arable layer of soil, the humus content was 2.4%. However, this decreased rapidly with depth, and was 1.5% in the 20–30-cm layer. The soil reaction was strongly acidic (pH of salt extract was 4.4–4.8; hydrochloric acid was 5.8–6.0 mg-eq per 100 g of soil). The soil was not limed, as liming was deemed to have no positive effect, as the soils were subject to a high levels of washing off, and the area was characterized by high precipitation (i.e., rain, snow). The amount of absorbed calcium in the soil was 6.3 mg-eq, at a concentration of 2.5 mg-eq per 100 g of soil, which indicates low saturation. Due to the low humus content, the soils had low nitrogen. Furthermore, acidic reactions inhibited the nitrification processes. Therefore, the accumulated nitrogen available to plants was slow. The mobile phosphorus compound content was 78 mg and the exchangeable potassium content was 60 mg per 100 g of soil.

2.3. Weather Conditions

Meteorological data obtained by the Ivano-Frankivsk Regional Hydrometeorology Center was used to evaluate the weather conditions during the study period.

The agrometeorological conditions during the study period were characterized by significant fluctuations in temperature regime indices and irregularities in precipitation compared with long-term trends. In 2011, during April, March, and May the conditions were arid; the average monthly precipitation levels were 33.9 mm, 35.6 mm, and 4.9 mm, respectively, compared to the respective long-term averages of 81 mm, 57 mm, and 4.9 mm. During June and July, rainfall was closer to the long-term average. However, in June and July, the amount of precipitation exceeded the monthly norms (136% and 121%, respectively). Termination of plant leaf cover was observed on December 5, during which plants were in the bushing phase. The wintering conditions were favorable, indicating spring restoration of vegetation could begin at the optimum time (the third week of March).

The temperature conditions in 2012 were higher than the long-term average indices. Recorded temperatures had reached 2.7 °C by March, 1.8 °C by May, 2.2 °C by June, 2.6 °C by July, 1.3 °C by August, 1.5 °C by September, 1.2 °C by October, and 2.1 °C by November. The spring conditions were favorable for the optimal growth and development of grasses; in April, 69.3 mm of precipitation fell in comparison to the long-term average of 57 mm. This compensated for the low levels of precipitation in May and June (67.5 mm and 71.4 mm, compared to the long-term average of 87 mm and 106 mm, respectively). Precipitation levels during July and August were similar to the long-term average. September and October 2012 were characterized by warm weather; the average daily air temperature reached 15.3 °C for the sowing and seedling period, and 7.1 °C for the seedling and bushing period. October was characterized by warm weather during the day and lower temperatures at night, and only a few days were lightly frosty. The air temperatures ranged from 5.0 °C to 12.5 °C, with a maximum of 18.4 °C above zero, and a minimum of 1.0 ° below zero. During November, when bushing and the termination of leaf cover took place, conditions were characterized by overdampness, and the air temperatures reached above 10 °C on only a small number of days. In December, 59.5 mm of precipitation fell, 24.5 mm more than the long-term average, which was 75% of the norm.

In March 2013, weather conditions were unstable; the weather was mostly warm, precipitation was observed in the form of rain and snow, and heavy winds, snowstorms, and fogs were recorded. The average monthly temperature was 1.1 °C, with a maximum of 10.5 °C and a minimum of 17.2 °C below zero. Average precipitation was 92.5 mm, which is 58.5 mm more than the long-term average, or 172% of the norm. The first week of April was cold with precipitation, and therefore was unfavorable to most crops. Following a rise in temperature, the grasses renewed growth on April 4. However, conditions for fieldwork were unfavorable due to excessive soil moisture, and stagnation of water was observed in areas of the field at low elevations. The weather was warm with light frost and precipitation at night. Overall, weather conditions were sufficient for the growth and development of grasses. May was characterized by low precipitation, and towards the end of the month by an increase in air temperature and low humidity. This caused the formation of dry winds, which led to a decrease in the productive moisture levels of the arable soil. Reserves of productive moisture in the arable layer of soil were 9–31 mm and were 132–192 mm at a depth of 1 m, which is almost insufficient for plant growth. Precipitation in May was 44.2 mm, which is 42.8 mm below the expected level. June and July were cool and warm with some short-term precipitation and heavy rainfalls. However, weather conditions were sufficient for the growth and development of perennial cereals. Reserves in the arable layer of soil during June were within 21–46 mm, and were 135–193 mm at a depth of 1 m. The air temperature (18.5 °C) and precipitation (101.5 mm) were similar to the long-term average. In July, the weather was cool with light rain. Total precipitation was 82.8 mm, which is 33.2 mm below the long-term average, and the average air temperature was 18.8 °C, compared to the long-term average of 18.6 °C.

3. Results

When cultivated at different depths, the average productivity of single-species crops of perennial pasture grasses ranged between 5.59 and 6.84 t ha^{-1} of dry mass, containing on average 3.91–4.92 t ha^{-1} of feeding units, 0.82–1.08 t ha^{-1} of crude protein, and 45.3–56.8 GJ ha^{-1} of exchange energy. *Lolium perenne* was the most productive species, followed by (within the limits of experimental error; 0.35 t ha^{-1} of dry mass) *Dactylis glomerata*, *Festuca orientalis*, *Bromus inermis*, and *Phalaris arundinacea* (Figure 1). Cultivated under the same soil conditions, the late ripening grass, *Phleum pratense*, was characterized by an average level of productivity, and produced 0.34–1.12 t ha^{-1} of dry mass, which was 6%–20% less than that produced by *Lolium perenne*, *Dactylis glomerata*, *Festuca orientalis*, *Bromus inermis*, and *Phalaris arundinacea*. The least productive species appeared to be the average ripening grass *Festuca rubra*, which produced 0.43–1.25 t ha^{-1} less dry mass than *Lolium perenne*, *Festuca orientalis*, *Bromus inermis*, and *Phalaris arundinacea*.

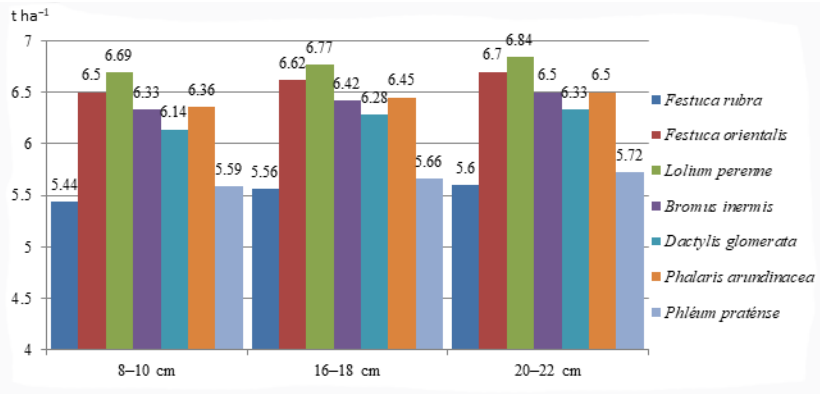

Figure 1 Productivity of perennial pasture grasses, t ha^{-1} on average over 3 years of growth.

When the cultivation depth was increased from 8–10 cm to 20–22 cm tillage (using surface cultivation with disk implements), the productivity of all studied species increased by an average of only 2%–3% at LSD_{05} 0.30 t ha^{-1} over the 3-year study period. The differences in productivity between the average tillage depth (16–18 cm), and the maximum (20–22 cm) and minimum studied depths (8–10 cm) were even smaller.

The influence of different tillage options on the formation of grass species over the years of research has differed significantly (Table 2). This trend was due to increased productivity of grasses and reduced impact of tillage.

In the first year of life of grasses, the influence of the grass factor was the smallest and amounted to 51.1%. In the second and third years, it increased to 59.2%–61.3%, respectively. The influence of tillage depth factor decreased in three years from 48.9% to 38.7%. The average was 43%.

The organic matter content of the dry mass, in particular that of crude protein, albumen, crude fat, crude fiber (without nitrogenous extractives), and the digestibility of the dry mass, did not change substantially when subjected to different depths of basic soil tillage between 20–22 and 8–10 cm (Table 3). However, the content of crude protein and albumen in the dry mass increased slightly with increasing depths of basic soil tillage.

Of all species, *Dactylis glomerata* and *Lolium perenne* had the highest levels of crude protein content, which ranged between 15.3% and 15.8%, and which was 0.9%–1.1% higher with LSD_{05} 0.6% than *Phalaris arundinacea*, which accumulated the lowest amount. Relative to the species tested, *Festuca orientalis*, *Bromus inermis*, *Festuca rubra*, and *Phleum pratense* had an intermediate crude protein content. However, the differences between these species were small.

A similar trend in protein content was observed across all methods of soil cultivation. The crude fat content in the dry mass of the studied pasture grasses under different methods of soil cultivation ranged from 2.8% to 3.7%. *Dactylis glomerata* had the highest crude fat content, while *Lolium perenne* and *Phleum pratense* had the lowest.

Table 2 Influence of grass species and soil tillage factors on the yield of perennial pasture grasses, t ha^{-1}.

Grass species	Depth of soil tillage, cm	Years		
		2011	2012	2013
Early ripening grasses				
Dactylis glomerata	20–22	5.99	6.40	6.61
	16–18	5.95	6.33	6.55
	8–10	5.80	6.22	6.40
Average		5.91	6.32	6.52
Average ripening grasses				
Festuca orientalis	20–22	6.50	6.78	6.81
	16–18	6.41	6.70	6.79
	8–10	6.30	6.58	6.63
Average		6.40	6.69	6.74
Lolium perenne	20–22	6.90	7.30	6.51
	16–18	6.85	7.25	6.20
	8–10	6.80	7.12	6.15
Average		6.85	7.22	6.29
Bromus inermis	20–22	6.08	6.63	6.79
	16–18	6.00	6.55	6.73
	8–10	5.87	6.43	6.67
Average		5.99	6.54	6.73
Festuca rubra	20–22	5.35	5.70	5.75
	16–18	5.32	5.65	5.70
	8–10	5.20	5.51	5.63
Average		5.29	5.62	5.69
Phalaris arundinacea	20–22	6.07	6.68	6.75
	16–18	6.00	6.62	6.72
	8–10	5.91	6.51	6.67
Average		5.99	6.60	6.72
Lately ripening grasses				
Phleum pratense	20–22	5.75	5.75	5.66
	16–18	5.7	5.68	5.65
	8–10	6.6	5.54	5.53
Average		5.68	5.66	5.61
LSD_{05}, t ha^{-1} by factors				
Grasses		0.38	0.35	0.32
Depth of soil tillage		0.25	0.23	0.21
Ratio of factors, %				
Grasses		51.10	59.20	61.30
Average		57.20		
Depth of soil tillage		48.90	40.80	38.70
Average		42.80		

The content of crude fiber in the dry mass of the grasses ranged from 29.0% to 30.4% and did not change naturally depending on the type of grass. The percentage of non-nitrogenous extractives (NNE) in the dry mass of the different grasses ranged between 41.9% and 45.9%. The lowest and highest NNE content were found in *Dactylis glomerata* and *Phleum pratense*, respectively. The digestibility of the dry fodder mass varied from 55% to 59% depending on the type of grass.

The chemical composition of the fodder produced by the pasture grasses was compared with the standard requirements (SSTU 4674, 4684, 4685, 4782, 8528) for the production of hay, fresh silage, silage, green fodder, and artificially dried grass fodder, based on the crude protein and crude fiber contents. It was found that the

Table 3 Average content of organic matter in fodder and digestibility of pasture grasses depending on the depth of main soil tillage, % in dry mass, from 2011 to 2013.

Grass species	Depth of soil tillage, cm	Crude protein	Albumen	Crude fat	Crude fiber	Non-nitrogenous extractives	Digestibility
Early ripening grasses							
Dactylis glomerata	20–22	15.6	10.9	3.7	30.0	41.9	58
	16–18	15.6	10.9	3.6	30.2	42.8	58
	8–10	15.3	10.8	3.6	30.4	42.0	57
Average ripening grasses							
Festuca orientalis	20–22	15.1	10.5	3.2	30.0	44.0	56
	16–18	15.0	10.4	3.2	30.2	43.8	57
	8–10	15.0	10.4	3.2	30.1	44.0	57
Lolium perenne	20–22	15.8	10.9	2.9	29.0	44.5	59
	16–18	15.7	10.9	2.9	29.2	44.4	58
	8–10	15.6	10.9	2.8	29.3	44.6	58
Bromus inermis	20–22	14.9	10.4	3.4	30.2	43.1	56
	16–18	14.8	10.3	3.4	30.3	43.2	56
	8–10	14.8	10.2	3.3	30.3	43.4	55
Festuca rubra	20–22	14.7	10.2	3.0	30.0	44.8	57
	16–18	14.6	10.2	3.0	30.2	44.7	56
	8–10	14.6	10.2	3.0	30.3	43.5	56
Phalaris arundinacea	20–22	14.5	10.2	3.5	30.0	43.6	57
	16–18	14.4	10.1	3.5	30.3	43.5	55
	8–10	14.4	10.0	3.4	30.2	43.7	56
Lately ripening grasses							
Phleum pratense	20–22	14.8	10.3	2.9	29.0	45.8	59
	16–18	14.9	10.2	2.9	29.3	45.4	58
	8–10	14.7	10.2	2.8	29.2	45.9	58
LSD_{05}, t ha^{-1} by factors							
Grasses		0.6	0.5	0.1	1.6	2.9	2
Depth of soil tillage		0.7	0.6	0.1	1.7	2.8	2
Ratio of factors, %							
Grasses		68	69	73	56	70	59
Depth of soil tillage		32	31	27	44	30	41

dry mass of the pasture grasses primarily met the requirements of high-quality grass fodders and was determined to be suitable for the production of hay, fresh silage, and green fodder of first and second grades.

The content in the dry mass of fodder units of the different pasture grasses, cultivated at varying depths of basic soil tillage varied from 68% to 72% (Figure 2).

The provision of fodder units with digestive protein ranged within 140–154 g across the different species of perennial pasture grasses studied. Across the tillage depths, *Dactylis glomerata* and *Lolium perenne* provisioned the most fodder units with digestive protein, while *Phleum pratense* and *Festuca rubra* provisioned the least. The content of the feeding units, and thus the exchange energy, did not change naturally with the different depths of soil tillage. Slightly lower nutritional parameters were found in *Phalaris arundinacea*, whereas other types of pasture grasses did not naturally differ in these indexes.

4. Discussion

The analysis of the obtained data showed that the productivity of grass species depends on a favorable combination of hydrothermal and soil conditions, the individual reactions of the crops to environmental factors, as well as the condition of the seed layer of the soil. It is known that the condition of the arable and sowing

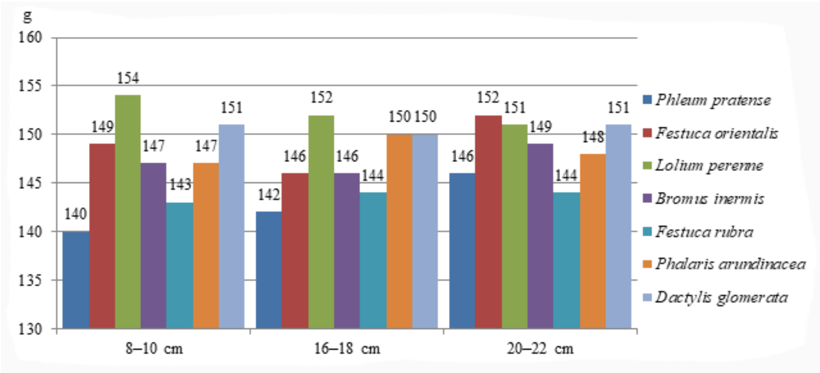

Figure 2 Average provision of feeding units with digestible protein from perennial pasture grasses, depending on the depth of main soil tillage, from 2011 to 2013.

layer of the soil is significantly affected by tillage, which is performed by different types of tools, and depends on the optimal growing conditions of the plants (Kovalenko et al., 2018).

Differences in the tillage methods at depths of 8–10 to 20–22 cm for different groups and types of grasses allowed us to find ways to improve productivity and feed quality. Our research determined the level of influence of these factors in the studied soil and climate conditions. In addition to the set of measures that were evaluated with the aim of increasing the productivity of hayfields and pastures, there is also the possibility of improving agrophytocenoses by harnessing the genetic potential of different types of grasses (Solyanyk et al., 2000).

In this regard, especially relevant is knowledge about species and varieties, especially the characteristics of perennial grasses, their response to the agroecological conditions of cultivation, and identification of basic patterns of formation of agrophytocenoses. Additionally, the development of effective methods of managing their productivity based on improving the species composition of grass mixtures in agrophytocenoses (Moldavan, 2007; Moysienko, 2002).

This study addressed the optimization of the watering regimes of the soil, identification of those agronomic techniques that reduce moisture loss, techniques to increase water accumulation and preservation to compensate for reduced precipitation in the fall–winter and spring periods.

Tillage systems change periodically, one changing to another (Sobko et al., 2012), but our study confirmed the findings of other researchers that the main types of basic tillage, such as plowing and shallow tillage, effectively improve the agrophysical conditions of soil (Kovalenko et al., 2018; Kurgak & Tovstoshkur, 2010; Moldavan, 2012). This has become an integral part of obtaining high-quality feed from perennial grasses in the first years of life.

The nutritional content and energy capacity of the fodder dry mass obtained from the experiment primarily met the requirements of the modern state standards of Ukraine (SSTU 4674, 4684, 4685, 4782, 8528) for the production of hay, fresh silage, silage and green fodder that conforms to the first and second classes. The biomass of the pasture grasses is not typically suitable for the production of high quality, artificially dried grass fodders based on nutritional quality and energy capacity.

However, *Dactylis glomerata* and *Lolium perenne* provisioned the most fodder units with digestive protein. These types of grasses begin to vegetate very early in the spring, growing quickly after mowing and grazing, and are resistant to trampling. Leaf production in early spring is almost 60%–80% of full capacity, so the nutritional value at a young age is very high (Kurgak, 2010). Whilst *Phleum pratense* and *Festuca rubra* provisioned the least.

Factors affecting the quality of feed of plant origin included: selection of species, subspecies, varieties, hybrids of forage grasses (high protein, high lysine, high chemical composition and digestibility of nutrients); methods and depths of tillage; fertilization of crops during the growing season; and the combination of plant species in agrophytocenoses (Kostenko et al., 2008).

Analysis of the macroelement content of the fodder dry mass from the different pasture grasses revealed that many of the zootechnical standards for cattle feeding were met. However, the fodder from some species contained insufficient levels of magnesium.

5. Conclusions

On average, over the 3-year study period, the most important factor influencing the production of dry mass per ha appeared to be the grass species, accounting of 57% of the variation. Meanwhile, the depth of soil tillage had a share of 43% of the variation. Of all the species studied, *Lolium perenne* (0.35 t ha^{-1} of dry weight) was the most productive. On average, increasing the depth of soil cultivation led to increased levels of crude protein and albumen (+ 0.9%–1.1%) in the dry mass. Based on the organic matter content and digestibility of the fodder, across the different depths of soil cultivation, the early ripening species *Dactylis glomerata*, and the average ripening species *Festuca orientalis*, *Lolium perenne*, and *Bromus inermis* performed best.

Considering the different depths of soil cultivation, *Lolium perenne* [154 g; surface tillage (disking) 8–10 cm] and *Festuca orientalis* (152 g; ploughing 20–22 cm) provided the most fodder units with digestible protein. The depth of soil tillage did not significantly affect the chemical composition, nutritional quality, or energy capacity of grass fodder dry mass.

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