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PHOTOSYNTHETIC ACTIVITY, PRODUCTIVITY, AND NUTRITIONAL VALUE OF MOWING AND GRAZING PHYTOCENOSES DEPENDING ON THE SPECIES COMPOSITION OF GRASSES

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SUMMARY

Studies of the photosynthetic activity of perennial grass mixtures allow for describing the peculiarities of the formation of perennial grass species forage productivity in the dry steppe zone. The study aimed to evaluate the cumulative effect of perennial cereal and legume grasses as part of complex grass mixtures on photosynthetic activity, productivity, and nutritional value of mowing and grazing phytocenoses. Adapting multicomponent grass created from various species of perennial grasses to the continental climate of the steppe zone of Northern Kazakhstan commenced, capable of resisting biotic and abiotic stresses due to biological characteristics and positively influencing other species in the phytocenoses. The study determined photosynthetic activity, the yield of green and dry masses, dry matter content, crude protein, metabolizable energy of natural pasture, single-species sowing of awnless brome, and multicomponent grass mixtures. The communal herbage obtained as a result of the study contained a large amount of crude protein (20.6%–24.7%), crude fat (2.0%–4.2%), crude fiber (18.0%–22.7%), crude ash (7.1%–7.7%), and nitrogen-free extractive substances (35.0%–44.1%). The results further enunciated that the perennial grass herbage in question had an average photosynthetic potential of 1,450,330 m^2×day ha^{-1} in single-species awnless brome crops, while in grass mixtures the said potential was higher, ranging from 1,510,250 to 1,815,250 m^2×day ha^{-1}. The authors concluded that it was necessary to create mowing and grazing fields composed of productive and stable perennial grass mixtures on degraded pasture lands to increase available forage for farm animals and improve the system's resistance to adverse conditions.

Keywords: Perennial grasses and legumes, grass mixtures, pastures, hayfields, photosynthesis, green and dry yield, nutritional value, chemical composition

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Key findings: Multicomponent grass-and-legume concoctions of the first and second year of life ensure the formation of higher yields, the nutritional value of forage, and photosynthetic potential (PP) compared with single-species crops. Multicomponent grass mixtures with the participation of drought-, salt-, and frost-hardy crops (alfalfa, sainfoin, brome, wheatgrass) have high ecological adaptivity, grow and overwinter well, and have high viability, which allows for the successful use in improving old degraded hayfields and pastures.

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INTRODUCTION

The chief sector for animal husbandry development is developing a solid forage base. This type of management directly affects the possibility of increasing the number of livestock and productivity and output, improving quality, and reducing production costs. In recent years, the forage base development and maintenance has become challenging in expanding and advancing animal husbandry. The main factors of a weak forage base are low productivity of meadows and pastures, lack of surface and radical improvement, unsatisfactory quality condition of the land, lack of rational use, high cost of mineral and organic fertilizers, and poor forage quality (Yesmagulova *et al*., 2023).

Forming and utilizing highly productive cultivated hayfields and pastures are crucial in strengthening the livestock sector and their forage base north of the Republic of Kazakhstan (Nugmanov *et al*., 2022a). The species selection and assortment of herbs can play a significant role in creating highly productive hayfields and pastures. By selecting perennial grasses for composing grass mixtures, it is necessary to consider the biological features of the species, which has a significant impact on the dynamics of the forage crop during growing season and the productive longevity of seeded herbage (Nugmanov *et al*., 2022b).

For the steppe zone of Northern Kazakhstan, the valuable forage crops are cereals, i.e., red fescue, common meadowgrass, Russian wild rye, awnless brome, intermediate wheatgrass, and legumes like alfalfa, Hungarian sainfoin, and biennial white and yellow sweet clover. Their individual use and mixtures of a few species can give the highest yields of high-protein green mass (15–20 t/ha). In addition, these forage crops are also good as preceding crops in the crop rotation system, consumed by all kinds of animals, highly drought-resistant, have high winter hardiness and salt tolerance, used for pastures and haymaking, and are well-cultivated in grass mixtures increasing the yield and nutritional value of hay, creating conditions for better herbage after growth (Lazarev *et al*., 2020; Nugmanov *et al*., 2022a, b).

In perennial grasses, increased productivity and resistance to abiotic stress factors can result from cultivating with grass mixtures. By composition, grass mixtures comprised cereals, grass-and-legume fusion, and legumes. By duration of use, these crops can divide into short-lived (up to four years), medium-lived (5–7 years), and long-lived crop plants (more than seven years). According to their use, these crops can also be haymaking plants (1–2 cuttings), multi-cut (three trimmings or more), and pasture plants. The suggestion to have a mixture of several types of grasses with different maturity (early, medium, and late ripening) will help extend the period of optimal grass harvesting and the uniformity of receiving raw mass during the season. By designing the grass mixtures and getting the maximum outcome, the following principles for use are the facilitation effect, when two or more species have a positive impact on each other and on other species, hydraulic lifting of water, symbiotic nitrogen fixation, and photosynthetic activity of the herbage (Zhang *et al*., 2010; Shen *et al*., 2013).

Herbal mixtures increase phytoavailability, acquiring limited resources, and the management of interaction between roots and rhizospheres can enhance the efficiency of resources used by crops. Signaling cascades of phytohormones regulating plant development are also activated (Ehrmann and Ritz, 2013; White *et al*., 2013). In mixed crops, as compared with a single-species crop, the activity of a wide range of enzymes increases significantly. The complex molecular bond between various species also stimulates plant growth (Zhou *et al*., 2011; Monteiro *et al*., 2012; Li *et al*., 2014).

Generally, the traditional farming systems and conditions in Northern Kazakhstan and forage production, in particular, are exceptionally diverse (Kantarbayeva *et al*., 2017). A continental climate situation is common in all zones of Kazakhstan, characterized in general by a lack of heat, a short vegetation season, late spring and early spring frosts, moisture deficiency, and variable meteorological factors over the years (Yessimbek *et al*., 2022). Thus, failure to comply with cultivation technology, a poor assortment of forage crops, poor use of landscape elements, and adaptive forage production lead to unstable forage manufacture. Therefore, the most urgent task is the creation of mowing and grazing perennial grass-and-legume mixtures adapted to the continental climate of Northern Kazakhstan. The purpose of the study is to evaluate the influence of the composition of perennial grass-and-legume mixtures in the complex grass combinations on photosynthetic activity, productivity, and nutritional value of mowing and grazing phytocenoses.

MATERIALS AND METHODS

The study ran in 2021–2022 at the steppe zone conditions of the Akmola region, a north-central part of Kazakhstan. It borders the Kostanay region in the west, the North Kazakhstan region in the north, the Pavlodar region in the east, and the Karaganda region in the south. The terrain of the territory is diverse, i.e., continental climate, most area occupying steppes, small hills, poorly broken lowlands, river valleys, and mountains covered with forests. Summers are very short and warm, while winters are long and frosty, with strong winds and blizzards. The minimum air temperature may be -40 °C or lower, with the maximum reaching +44 °C. Vegetation is representative of steppe species of various types of grasses (Figure 1).

Figure 1. Map of the region and the location of the experimental site.

The steppe soil is illustrative of ordinary average humus content 'chernozem' with a depth of 25–27 cm and a mean humus content of 4.7%. The arable soil layer has nitrate nitrogen content equal to 8.3 mg, phosphorus (25.7 mg/kg), and potassium (644 mg/kg). Consequently, the soil has an average nitrogen and phosphorus content and high potassium content by mechanical composition. The soil is heavy and loamy; the volume weight in the arable horizon is 1.19 g/cm^3, and the meter layer averages a volume of 1.30 g/cm^3. The humidity of permanent wilting is 12%–13%. The acidity analysis showed that the soils of the near-village pasture have a neutral environmental reaction.

Meteorological conditions

The vegetation conditions of the herbs during the first year (2021) were unfavorable; thus, plant viability was average, observing the best viability in the various forage species, i.e., Russian wild rye, awnless brome, intermediate wheatgrass, alfalfa, and sainfoin. The meteorological conditions during the study's second year (2022) corresponded to the continental climate definition. During the first year of life in April-May, rainfall was only 17 mm, 40.7 mm below the average long-term norm. Given these circumstances, the perennial crops passed the vegetation phases under harsh environmental conditions based on temperature regime and moisture availability, affecting the field germination of herbs. During the first year of perennial grasses (May to September 2021), rainfall was 115.7 mm, with the average long-term norm at 206.4 mm. The rainfall shortage was 90.7 mm. In the cold period (October to March), total precipitation was only 91.2 mm, 79.8% of the average annual norm. The limited precipitation during the critical period of plant development allowed for the formation of an average crop yield in this zone.

The aggravating factor contributing to the intensive evaporation of moisture was the less rainfall in April and May, compared with the long-term norm (80.3%) against the background of high temperatures. The average monthly air temperature was 2.7 °C above normal. On some days in May, the air temperature reached 40.0 °C. This factor influenced the after-growth and tillering phase of cereals and the branching phase of legumes. In 2022, rainfall was 198.5 mm during the growing season (April to September) of perennial grasses, and heavy rains fell in the summer months, allowing to approach the average long-term norm (206.4 mm) and positively affecting crop growth and development in the second year (Table 1).

Table 1. Indicators of weather conditions for 2021–2022 (Chaglinsky Weather Station).

Months	Precipitation (mm)			Air temperature (°C)		
	average long-term	2021	2022	average long-term	2021	2022
January	11.7	16.7	11.6	-16.4	-18.0	-12.4
February	14.0	26.1	18.5	-14.1	-14.8	-9.2
March	15.7	36.9	4.7	-5.7	-7.3	-9.0
April	22.7	9.2	5.5	+4.4	+4.8	+8.5
May	35.0	7.8	15.7	+11.9	+17.1	+13.6
June	42.4	25.5	49.6	+17.0	+17.2	+17.7
July	66.7	40.2	77.0	+20.1	+20.6	+19.9
August	36.2	28.0	44.1	+16.7	+19.9	+16.7
September	26.1	14.2	6.6	+10.5	+9.9	+13.0
October	25.5	13.6	13.6	+3.7	+4.3	+4.3
November	16.8	18.0	29.6	-5.5	-6.6	-8.3
December	12.7	4.8	7.3	-13.0	-9.5	-11.5
Total	325.5	241	283.8			

Table 2. The experimental design used in the studies.

No.	Variants
1	Natural pasture. Control (unimproved herbage)
2	Single-species crop. Awnless brome
3	Red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin
4	Red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin
5	Red fescue + common meadowgrass + awnless brome + alfalfa
6	Red fescue + common meadowgrass + awnless brome + alfalfa + Hungarian sainfoin
7	Red fescue + common meadowgrass + intermediate wheatgrass + alfalfa

Variants of the study

The genetic material comprised various perennial grasses and legume types cultivated in mixtures (Table 2). The combined grass construction was from lower and semi-tall types of perennial grasses for haymaking and pasture use, with different terms for mowing ripeness and grazing cycle. In the control phytocenoses, the vegetation cover was wormwood and a natural grass pasture consisting of sheep fescue, feather grass, and bulbous bluegrass. The cereal components of the grass fusions were tall grasses, such as, Russian wild rye, awnless brome, wheatgrass, and lower grasses, like red fescue and common meadowgrass. The legumes, alfalfa, and Hungarian sainfoin also belonged to the tall grass type.

Process of the study

Improving the old degraded pasture phytocenoses proceeded on the first day of May by the surface-level improvement method, consisting of double-disk shallow plowing of grass sod to a depth of 10–12 cm without soil overturning with the BDT-3 disk harrow (made by Agro-Resurs, the Republic of Belarus), followed by sowing of perennial grass-and-legume mixtures to a depth of 3–5 cm with the CH-16 integral planter (made by Agro-Resurs, the Republic of Belarus). After sowing, rolling occurred using a 3KSH-6 roller (made by Agromash, Russia). The leaf surface area determination employed the accelerated crop leaf surface area determination method using computer technology proposed by Dmitriev and Khusnidinov (2016). It allowed for determining the photosynthetic potential and the net productivity of photosynthesis.

The green mass yield determination included cutting, followed by weighing, wherein for each variant, the grass cutting was four times from four accounting sites, with a size of 2.5 m^2 each (1.0 m × 2.5 m). Having samples of each variant from all repetitions mixed, acquiring an average weight of 1.0 kg followed. When simulating the pasture grazing system, grass cutting ensues after reaching 10–12 cm. Determining the total yield was in terms of one hectare. During the haymaking use of the herbage, grass cutting began in the phase of cereal earring and at the beginning of flowering in legumes. Calculating the metabolizable energy content in the dry matter of the forage was by the chemical composition of the forage according to the following regression equation:

$$ME = 10.678 + 0.088 \times CP - 0.332 \times CFa - 0.075 \times CFi + 0.006 \times NFES$$

Where, ME is metabolizable energy, CP is crude protein, CFa is crude fat, CFi is crude fiber, and NFES are nitrogen-free extractive substances.

In the accredited Agro Complex Expert agrochemical laboratory, determination of the mass fraction of protein was by the total nitrogen content in the analyzed sample, crude protein by the calculation method using a coefficient of 6.25, and also for the crude ash, fiber, and fat content (Baidalin *et al.*, 2017).

Statistical analysis

Statistical analysis employed the SNEDECOR software package for the processing of experimental data. The significant differences among the variants for various traits were determined by using the least significant difference (LSD) test. The actual differences between the variants were higher than the LSD, which means that the differences between the variants were substantial.

RESULTS

In perennial grasses' growth and development processes, the competitiveness in agrophytocenoses of different herbage densities and optical densities were critical biotic factors, and abiotic factors served both to suppress the growth processes. The tiered arrangement of the tall and lower grass species ensures the healthy development of spatial niches, resulting in more efficient use of environmental components occurring in the arid zone.

With an external improvement of old tainted hayfields and pastures, phenological seeding of crops with a different ripening time in the growing season and different tiered preparation of perennial grass-and-legume mixtures contributed to producing phytomass during the whole growing season. Consequently, it formed high productivity based on the optimized phytocenotic sowing arrangement, compared with the single-species awnless brome crop (Table 3).

Seeded phytocenoses based on the studied perennial cereals and legumes in the years of the study had the following productivity characterized these. In the first year of experimentation, the most productive and effective crop mixture was multicomponent grasses consisting of red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin, and red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin, with a yield of 5.04 and 4.41 t ha^{-1}, respectively, with the single-species awnless brome crop yielding only 3.00 t ha^{-1}. In the second year, the same pattern showed in yield, and the most productive was the grass mixture of red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin (6.01 t ha^{-1}), and red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin (5.29 t ha^{-1}).

The nutrient content and energy value are essential indicators of forage quality in planning animal feed. The studied multi-component grass mixtures were distinct in good quality and high nutritional value of the forage, which fully rewarded the physiological needs of the farm animals. These herbages contained a large amount of crude protein (20.6%–24.7%), crude fat (2.0%–2.65%), crude fiber (18.0%–22.7%), crude ash (7.1%–7.7%), and NFES (35.0%–44.1%). However, the highest protein content (24.7%) resulted in the grass fusion of red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin (Table 4).

During the study period, the inconsistency of legumes shared in the composition of the studied agrocenoses also affected the nutritional value of the forage mass. Thus, in the second year, with an increase in the mass fraction of alfalfa and Hungarian sainfoin, the nutritional value of the forage improved significantly. The cultivation of perennial grasses with the addition of legumes contributed to producing forage mass with a high content of metabolizable energy, ranging from 7.3 to 8.4 MJ. Inversely, in the control variant and single-species sowing of awnless brome, the metabolizable energy equaled to 3.67 and 4.02 MJ, respectively.

Providing plants with necessary nutrients for growth and development and high-quality crop formation belongs to photosynthesis, forming 95% of organic compounds. The studies also confirmed that the better the conditions for the photosynthesis process, the higher the productivity and final output of the crop plants. The activity of photosynthetic processes depends on environmental factors and the competitive relations of plants in phytocenoses. The optimal species composition of the herbage showed consistently distributed leaves, contributing to much complete use of light energy.

Table 3. The herbage yield in the first and second years (2021–2022) of the life of perennial mowing and grazing grass crop mixtures, depending on the species composition (t/ha).

Variants	Green mass	
	1st year of life	2nd year of life
Natural pasture. Control (unimproved herbage)	1.01	1.06
Single-species crop. Awnless brome	3.00	4.02
Red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin	5.04	6.01
Red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin	4.41	5.29
Red fescue + common meadowgrass + awnless brome + alfalfa	3.54	4.26
Red fescue + common meadowgrass + awnless brome + alfalfa + Hungarian sainfoin	3.58	4.29
Red fescue + common meadowgrass + intermediate wheatgrass + alfalfa	3.40	4.08
$LSD_{0.05}$	0.26	0.35

Table 4. Nutritional and energy value of the herbage of perennial pasture grass mixtures, depending on the species composition (average for 2021–2022).

Variants	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Crude ash (%)	NFES (%)	Metabolizable energy (MJ)
Natural pasture. Control (unimproved herbage)	13.1	3.5	27.5	5.0	34.4	3.67
Single-species crop. Awnless brome	16.2	4.2	26.8	6.8	35.0	4.02
Red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin	23.7	2.6	19.8	7.45	35.0	8.40
Red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin	24.7	2.6	20.0	7.3	41.0	7.30
Red fescue + common meadowgrass + awnless brome + alfalfa	20.6	2.0	18.0	7.7	42.9	8.02
Red fescue + common meadowgrass + awnless brome + alfalfa + Hungarian sainfoin	21.5	2.6	20.2	7.3	42.9	7.70
Red fescue + common meadowgrass + intermediate wheatgrass + alfalfa	23.8	2.5	22.7	7.1	44.1	8.04

The study of the photosynthetic activity of perennial grasses has shown that the most definite reactions of plants to growing conditions are a change in the area of their leaf surface (LS), the ratio of the part of leaves and dry biomass of plants, an increase in the relative rate of biomass growth, and indicators' value, such as, photosynthetic potential (PP) and net photosynthesis productivity (NPP). The achieved highest photosynthetic activity was by a rational ratio of the leaf surface and photosynthetic potential per unit of leaf area in mixed crops of the perennial grass mixtures (Table 5). Herbage formation in the first and second years in arid conditions influenced the growth and development of plants and, accordingly, the area of the assimilation surface. Analysis of the size of the assimilation apparatus of plants showed that in the studied variants, the maximum leaf surface area formed resulted in the awnless brome crop, equaling 26,260 m^2 ha^{-1}. In multi-component crops of grass mixtures, by the time of cutting, the leaf surface area was 23,120–24,620 m^2 ha^{-1}.

The results further revealed that the perennial grass herbage had an average photosynthetic potential of 1,450,330 m^2×day ha^{-1} in single-species awnless brome crops; however, in grass mixtures, the said potential was higher and equaled 1,510,250 to 1,815,250 m^2×day ha^{-1}. One of the most valuable indicators of the photosynthetic activity of crops is the net photosynthesis productivity, which exhibits the accumulated level of the dry mass yield concerning the lead surface area over a certain period. The net photosynthesis productivity differentiates the

Table 5. Photosynthetic activity of perennial grass mixtures depending on species composition (average for 2021–2022).

Variants	LS Area (000 m^2 ha^{-1})	NPP ($g/m^2/day$)	PP (000 m^2 ha^{-1})
Natural pasture. Control (unimproved herbage)	1.45	1.7	1,000.62
Single-species crop. Awnless brome	26.26	3.33	1,450.33
Red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin	24.62	4.87	1,815.25
Red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin	23.12	4.80	1,775.22
Red fescue + common meadowgrass + awnless brome + alfalfa	24.00	4.70	1,655.57
Red fescue + common meadowgrass + awnless brome + alfalfa + Hungarian sainfoin	24.45	4.78	1,540.66
Red fescue + common meadowgrass + intermediate wheatgrass + alfalfa	23.20	3.85	1,510.25

LS Area: Leaf surface area, NPP: Net photosynthesis productivity, PP: photosynthetic potential.

sowing structure rationality and the ability of plants to use solar energy effectively.

According to the presented results, on average and over two years of herbage life, the highest net photosynthesis productivity rates appeared in grass mixtures of red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin (4.87 $g/m^2/day$); red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin (4.80 $g/m^2/day$); red fescue + common meadowgrass + awnless brome + alfalfa + Hungarian sainfoin (4.78 $g/m^2/day$); and red fescue + common meadowgrass + awnless brome + alfalfa (4.70 $g/m^2/day$). In a natural pasture and a single-species crop, the average over two years of herbage life equaled 1.7 to 3.33 $g/m^2/day$.

DISCUSSION

Grass-and-legume mixture is the only strategy to combat the dry summer by collecting water in the soil profile using hydraulic lifting of water by crops with deep tap roots and carrying out hydraulic redistribution of moisture to plants with the shallow root system (Xu *et al*., 2008; Mao *et al*., 2012). Such a fusion of grasses and legumes also improves nutrient mobilization and metabolism, increasing the activity of soil microbial communities (Prieto *et al*., 2012; Hortal *et al*., 2013). The growth of forage productivity of the grass mixtures under different modes of utilization occurs mainly due to the leaf apparatus activation caused by improving the assimilate distribution strategy in the plant throughout the ontogenesis (Kutuzova *et al.*, 2019). In this study, the cultivation of various types of legumes and cereals in the hay and pasture field ensures the production of nutritionally balanced forage with a metabolizable energy content ranging from 7.3 to 8.4 MJ and an uninterrupted forage supply for livestock throughout the vegetation season, starting from early spring until late autumn for 130–150 days**.** The innovative study identified the most productive, environmentally adaptive perennial grass-and-legume mixtures with a crude protein content of up to 20.6%–24.7% in dry matter. A high level of forage mass yield, energy productivity, and optimal indicators of the nutritional value of hay and pasture forage resulted from the following grass-and-legume mixes, i.e., red fescue + common meadowgrass + Russian wild rye + Hungarian sainfoin (6.01 t ha^{-1}) and red fescue + common meadowgrass + Russian wild rye + alfalfa + Hungarian sainfoin (5.29 t ha^{-1}).

In perennial grass-crop mixtures, the basis of photosynthetic activity is mainly on the growing season's environmental conditions (temperature and precipitation), species characteristics, the herbage structure, and the method of use (haymaking and pasture). In the second-year crop mixtures, with haymaking and pasture use of grass, multi-component grass mixtures with one/two legumes formed a larger leaf surface area and photosynthetic potential than a single-species awnless brome crop. According to past studies, the optimal photosynthetic potential was at least 2,000 $m^2 \times day\ ha^{-1}$ (Anatolyan, 2017). The herbage formation in the first and second years of life emerged in arid conditions, which eventually influenced crop plants' growth and development and, accordingly, photosynthetic activity.

The concerned study detailed the average values for the leaf surface area equaling 23,120–26,260 m^2 ha^{-1}, with a photosynthetic potential of 1,510,250 to 1,815.250 $m^2 \times day\ ha^{-1}$ and net photosynthesis productivity of 3.33–4.87 g m^2/day. With the higher rates of leaf surface area in crops, the lighting conditions of the leaves worsened (especially the lower tiers), revealing a decrease in the photosynthesis intensity, the lower leaves' death, stem stretching, plant lodging, and a decrease in yield. In past studies, high yields of grass mixtures obtained had a leaf index equal to 2–7 m^2/m^2 (leaf area, m^2 per 1 m^2 of sowing) (Kasatkina, 2017). In earlier studies, established optimal parameters of the leaf surface area showed during the stem extension of cereals and budding of legumes, ensuring effective photosynthetic activity of highly productive forage grass stands, for single-species cereal crops equaling 25–54 and for grass-and-legume mixtures 42,000–52,000 m^2 ha^{-1} (Zubarev, 2002). From the presented data can derive a conclusion that among the controlled factors affecting the yield, nutritional value, and photosynthetic activity of grass mixtures, the main factor was selecting the optimal composition of grass mixtures and meteorological conditions. As a practical conclusion, the results of the conducted research recommend the principles of selection and increase in the nutritional value of perennial legumes and grasses to farms of the steppe zone of the Akmola region for the organization of a mowing and grazing field.

CONCLUSIONS

The productivity, nutritional value, and photosynthetic activity of the perennial grass-and-legume crop mixtures depend on the growing season environmental conditions, the crop species characteristics, herbage structure, and its method of use. Multi-component grass-and-legume mixtures in the first and second year of life ensure the formation of higher yields, the nutritional value of forage, and photosynthetic potential compared with single-species crops. Multi-component grass mixes with the participation of drought-, salt-, and frost-hardy resistant crops (alfalfa, sainfoin, brome, and wheatgrass) have high ecological adaptivity, grow well over winter, and have the highest viability, allowing for their successful use in improving old degraded hayfields and pastures. Economically, for the steppe zone environmental conditions of Northern Kazakhstan, the most preferred mode was the single-cutting mode in the first year of life, while the suggested method in the second year was double-cutting and grazing. The limiting factor in creating a year-round raw material field in the conditions of the steppe zone of Northern Kazakhstan is the absence of early-ripening and late-ripening varieties of perennial grasses and legumes approved for use in Kazakhstan's northern regions. The prospects for further research in this area involve studies on legumes' symbiotic nitrogen fixation process in mixed crops.

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