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RESEARCH ARTICLE
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Livestock Grazing Technologies as the Leading Factor in Preserving the Quality of Pasture Ecosystems

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ABSTRACT

Intensive grazing leads to lower productivity and quality of pasture herbage and livestock feed shortages. The research goal was to assess the effect of using seasonal and intra-seasonal pasture areas on the yield and energy and protein content of pasture feed. The primary method was an experiment conducted in the semi-arid Bokey Orda District, West Kazakhstan Region. The available pastures in this area were used for the study. These were divided into two groups based on the grazing system applied. One group followed the traditional intensive grazing system, while the other used a rotational system involving alternating seasonal and intra-seasonal pasture areas. The effect of using seasonal and intra-seasonal pasture areas was assessed through the parameters of species composition of pasture herbage, herbage height, projective coverage, green mass yields, and the nutritional value of feed, including energy and protein content. The results show that grazing on seasonal and intra-seasonal pastures resulted in the formation of an herbage layer dominated by more valuable fodder species of pasture plants. The herbage of seasonal and intra-seasonal pastures was higher compared to the control. Reduced load on pastures also resulted in higher grass yields compared to intensive grazing pastures. In conclusion, in addition to better biometric and productivity indicators, the recommended grazing technologies ensured that the feed had stable nutritional value and energy and protein content, crucial elements in livestock diets.

Keywords: Pastures; Sustainable management; Grazing technologies; Grass yields; Nutritional value

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INTRODUCTION

The global population is projected to reach 9 billion by 2050 (Food and Agriculture Organization of the United Nations, 2021). Against the backdrop of climate change, this growth makes it critical to increase the sustainability of pastures, which are among the Earth's most important biomes and provide the economic foundation for animal husbandry and milk and meat production (Bengtsson et al., 2019; Kussainova et al., 2023).

The Republic of Kazakhstan is developing a plan to strengthen its agro-industrial sector, aiming to triple agricultural exports and achieve at least 90% self-sufficiency in all food products (Official Information Source, 2023). In addition to plans for the development of agriculture, the concept notes that the current development of animal husbandry does not account for the country's feed production capacity (Kleijn et al., 2019; Michalk et al., 2019).

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Kazakhstan currently produces 2 times less feed than required by zootechnical norms (Parliament of the Republic of Kazakhstan, 2021).

To solve the feed problem, it is vital to increase the sustainability of pasture ecosystems (Bureau of National Statistics, 2023). Kazakhstan holds the fifth place by pasture area in the world (187.55 million hectares), and pasture-based livestock production provides 90% of the meat, 97% of the wool, and 75% of the milk produced in the country. Agricultural ecosystems subjected to livestock grazing are more productive, stable, and resilient when their herbage and soil are biologically functional and serve their essential ecosystem functions (Baidalina et al., 2023; Saparov et al., 2024; Nasiyev et al., 2025). This fact calls for long-term measures to plan and adapt to changing environmental and economic conditions (Teague et al., 2013; Kenenbayev et al., 2023). Kazakhstan has now implemented several measures to address rational pasture use, including the Law of the Republic of Kazakhstan "On pastures", which establishes the order and procedures for pasture use (Parliament of the Republic of Kazakhstan, 2017).

Among the most pressing global environmental and socioeconomic problems are desertification and degradation, leading to the loss of biological productivity, reduced soil carbon sequestration, increased net greenhouse gas emissions, increased nitrogen leaching, and the loss of rangeland biodiversity. This global problem affects around 1/5th of the planet's population and concerns more than 100 countries (Russian National Public Library for Science and Technology, 2017; Kayser et al., 2018; Bardgett et al., 2021), with 49% of the world's total pasture area already degraded (Horn & Isselstein, 2022). Kazakhstan also experiences this issue. Depending on the region, the share of degraded pastures varies from 20% to 60% (Parliament of the Republic of Kazakhstan, 2021). A common cause of pasture degradation is destructive and intensive livestock grazing (Akash et al., 2022).

To achieve the desired production performance and obtain excellent raw materials, modern animal husbandry typically employs two grazing systems — continuous and rotational (Moscovici Joubran et al., 2021; Horn & Isselstein, 2022; Rearte et al., 2022).

Continuous concentrated grazing facilitates the proliferation of less tasty and more invasive grass species and the expansion of bare areas, ultimately compromising the environmental functions of pasture landscapes (Archer et al., 2017; Kuandykova et al., 2024), disrupting the aggregation and structure of the soil, reducing the rate of surface water infiltration and the amount of soil water available to plants, and promoting surface runoff, soil erosion, and other negative consequences. For this reason, great value is attributed to seasonal and intra-seasonal pasture areas, allowing plants to rest. Different studies suggest that longer rest periods have a positive effect on plant biomass, soil cover, and livestock weight gain (Machmuller et al., 2015; Dowhower et al., 2019; Hillenbrand et al., 2019; McDonald et al., 2019). Intra-seasonal paddocks allow to effectively expand the grazing area and the amount of feed available while distributing feed consumption more uniformly across the landscape. Additionally, intra-season paddocks increase the capacity of pastures, stabilize animal populations, and provide cash flow revenues (Nurgaziyev et al., 2024).

For many years, pastures in the semi-arid zone of West Kazakhstan have been used by residents to maintain self-sufficiency and food security (Beishova et al., 2024; Tleshpayeva et al., 2025). However, there is no documented research data on the impact of livestock grazing using seasonal and intra-seasonal pasture plots on important biometric and productive indicators of vegetation in pasture ecosystems in the considered area. Thus, the study aims to assess the current condition of vegetation in pasture ecosystems in the semi-arid zone of West Kazakhstan and to determine the dependence of this condition on livestock grazing on seasonal and intra-seasonal pasture areas.

MATERIALS & METHODS

Description of the Sites

Scientific research to evaluate the impact of grazing technology on the indicators of pasture vegetation in the semi-arid zone of West Kazakhstan was conducted in 2022–2024 at the Zhangir Khan West Kazakhstan Agrarian-Technology University under the state order of the Ministry of Agriculture of the Republic of Kazakhstan.

To assess the current condition of plants in pasture ecosystems depending on the employed livestock grazing technology, a field experiment was conducted at the Miras peasant farm in the semi-arid zone of West Kazakhstan relying on broadly recognized state-of-the-art methods and GOSTs (Table 1).

The studied plots are used as summer and spring-autumn pastures. The yields range from 2–4 to 5–6cwt/ha. In many places, vegetation is severely damaged and littered with thorny weeds as a result of overgrazing.

Floristic Composition of Experimental Plots

The pasture plots subjected to intensive grazing for the past 10 years lack typical grasses *(Stipa, Festuca,* etc.), having only a few individuals of *Agropyron desertorum*. Floristic diversity is composed of 16 species (background), including many

Table 1: Study design for pasture areas and grazing technologies

Pasture areas and grazing technologies	Variants of pasture management algorithms
Intensive grazing area (control)	Livestock grazing without rest in the spring, summer, and autumn, as well as in winter (in favorable years), i.e., unsystematically. Number of cattle — 120 heads. Plot area — 560ha.
Spring season grazing area	Livestock grazing only in spring according to the pasture rotation system. Number of cattle — 120 heads. Plot area—560ha.
Summer season grazing area	Livestock grazing only in summer according to the pasture rotation system. Number of cattle — 120 heads. Plot area—560ha.
Autumn season grazing area	Livestock grazing only in autumn according to the pasture rotation system. Number of cattle — 120 heads. Plot area —560ha.
Intra-season pasture areas (spring)	Livestock grazing only in spring on intra-season pasture plots. Number of cattle — 50 heads. Plot area — 235ha.
Intra-season pasture areas (summer)	Livestock grazing only in summer on intra-season pasture plots. Number of cattle — 50 heads. Plot area — 235ha.
Intra-season pasture areas (autumn)	Livestock grazing only in autumn on intra-season pasture plots. Number of cattle — 50 heads. Plot area — 235ha.

forbs, represented mainly by unsavory and weedy species (*Artemisia austriaca, Alyssum turkestanicum*, *Chenopodium album, Ceratocarpus arenarius,* etc.).

Seasonal spring, summer, and autumn grazing areas are inhabited by 14–16 (background) plant species. The most common are perennial grasses — *Stipa capillata, A. desertorum,* and *Leymus ramosus*. The pastures were classified as plain pastures of the class "Wormwood–Needle grass–Volga fescue on light chestnut soils".

Plant Surveys

The surveys and observations conducted at the experimental sites included the following:
1) Exploring the species composition of pasture herbage;
2) Assessing the yields of pasture herbage by seasons: spring, summer, autumn;
3) Determining the nutritional value, energy, and protein content of the feed base of pasture phytocenoses.

Transect Method

All routine observations as part of monitoring were performed on 100 by 50m transects.

Methods to Assess the Condition of Herbage

The occurrence and abundance of different pasture plant species were determined on additional geobotanical sites measuring 10.10m (Gorshkova, 1973).

Projective coverage was determined by eye estimation using a 10-point visual scale: 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100%. Estimation by eye is precise enough to determine the degree of projective coverage with 10% accuracy (Fig. 1).

Fig. 1: View of the intensive grazing pasture area of the semi-arid zone in the summer.

Nutritional value, including energy and protein content, was established by determining the content of crude nitrogen, crude fat, crude fiber, and crude ash.

The agrochemical analysis of plant samples was performed in an accredited laboratory of the Zhangir Khan West Kazakhstan Agrarian-Technology University.

Data Analysis. The Biometric and Productive Indicators of Pastures were processed with One-Way ANOVA

The mean values of the indicators were visualized with box plots. Plotting and ANOVA were performed using JASC® software. The analysis of the experiment required no additional methods because of the use of one-way ANOVA. ANOVA was sufficient to establish significant differences between the variants of the experiment. The influence of different factors on green mass yields by experiment variants was analyzed using one-factor regression analysis on the total sample (no groups). The obtained associations were visualized with correlation plots by experiment variants. The calculations and plotting were performed in JASP.

RESULTS

Parameters of Herbage in Pasture Ecosystems Depending on Grazing Technology

Changes in Species Composition

In the spring (late April), apart from ephemeral plants, all three seasonal pasture areas were dominated by *Artemisia lerchiana*, whose share in the composition of herbage increases with grazing load. Specifically, with 95-100% occurrence across all plots, the number of *A. lerchiana* bushes on the intensive grazing pasture was almost three times higher than on the seasonal pastures.

Ephemeral plants developed in spring across all four areas. Considering the floristic similarity of the areas, the most similar are the pastures under medium-intensity grazing (similarity coefficient of 66.1%), and the least similar are the plots with low-intensity grazing and continuous grazing (53.06%).

The species composition of pastures in spring also shows differences. The intensive grazing pasture area had 16 species, including ephemeral plants (bulbous bluegrass). The herbage of intensive grazing pastures was dominated by unpalatable plants with no value.

As a result of intensive grazing, the herbage lost the species considered most valuable as feed, such as *Kochia prostrata*, *Festuca valesiaca*, *L. ramosus*, *Koeleria cristata*, and *A. desertorum*. Furthermore, the ephemeral species *Túlipa* was not found on intensive grazing pastures altogether. In contrast, the ephemeral species *Poa bulbosa* and *Ritillária* were abundant in pastures under intensive grazing (Table 2).

The method of grazing also affects the abundance of ephemeral plants. The annual ephemeral grass *P. bulbosa*, similar to wormwood, becomes more prevalent (by 3–5 times) in pasture biocenoses as load increases. Other species that become more abundant under higher loads include *C. arenarius* and *T. achilleifolium,* the number of which on pasture with intensive grazing was 4–5 times higher than on other experimental plots.

In the summer, the quantitative and qualitative parameters of pasture phytocenoses also prove dependent on grazing technology. Due to the disappearance of ephemerals and ephemeroids in the summer, the number of plant species in pasture ecosystems somewhat decreased. The area under intensive grazing and seasonal pastures both had 12 species.

Despite the smaller number of species (11), the seasonal spring-autumn pasture had more pasture plants considered valuable in terms of feed and nutritional parameters.

The species composition of intra-seasonal pastures was at the same level as the primary sites, including 11–12 species.

Table 2: Abundance (ind./0.25m^2) and occurrence (%) of plant species in the spring season depending on grazing technology

Plant species	Intensive grazing area		Spring season grazing area		Summer season grazing area		Autumn season grazing area	
	Ab.*	Occ.**	Ab.	Occ.	Ab.	Occ.	Ab.	Occ.
Kochia prostrata	0.25	20.00	0.60	35.00	0.40	38.00	0.75	41.50
Artemisia lerchiana	9.50	95.00	5.50	98.00	6.75	97.00	4.40	100
Artemisia austriaca	8.25	87.00	3.00	64.00	5.25	72.00	1.95	54.75
Ceratocarpus arenarius	11.00	97.25	5.00	75.00	7.50	80.00	4.80	72.85
Chenopodium álbum	0.15	21.25	0.10	20.75	0.12	21.00	0.07	20.00
Poa bulbosa	5.50	76.00	4.70	70.00	5.00	72.00	4.50	68.00
Tanacetum achilleifolium	4.00	82.15	1.90	51.00	2.85	68.00	0.95	41.85
Lipidium ptrfoliatum	2.20	40.00	1.00	48.00	1.75	45.00	0.75	50.50
Gypsophila paniculata	1.65	55.00	1.05	65.00	1.20	60.00	0.94	70.25
Polygonum aviculare	1.40	35.00	0.25	15.00	–	–	–	–
Láppula squarrósa	2.20	20.00	–	–	–	–	–	–
Thláspi arvénse	2.00	30.00	–	–	–	–	–	–
Ritillária	1.70	40.00	–	–	–	–	–	–
Alyssum Turkestanicum	1.00	45.00	–	–	0.75	15.00	–	–
Galium aparine	2.25	45.00	–	–	1.00	20.00	–	–
Agropyron desertorum	–	–	1.20	45.00	1.20	40.00	1.35	51.65
Stipa capillata	0.20	15.00	0.55	35.50	0.50	25.00	0.67	40.25
Festuca valesiaca	–	–	1.25	42.00	1.20	35.00	1.32	52.77
Leymus ramosus	–	–	0.50	30.75	0.45	25.25	0.55	34.95
Poa bulbosa	–	–	1.70	60.00	1.50	57.00	1.85	65.45
Total number of species	16	16	15	15	16	16	14	14

*Ab. — species abundance; **Occ. — species occurrence

Table 3: Abundance (ind./0.25m^2) and occurrence (%) of plant species in the summer season depending on grazing technology

Plant species	Intensive grazing area		Spring season grazing area		Summer season grazing area		Autumn season grazing area	
	Ab.*	Occ.**	Ab.	Occ.	Ab.	Occ.	Ab.	Occ.
Kochia prostrata	0.07	09.15	0.45	45.00	0.15	25.25	0.77	55.75
Artemisia lerchiana	3.70	100.0	2.65	97.25	2.85	98.15	2.50	95.25
Artemisia austriaca	2.18	88.00	1.75	62.45	2.00	72.75	1.45	45.87
Ceratocarpus arenarius	0.70	32.75	0.45	18.44	0.65	28.15	0.20	15.00
Chenopodium álbum	0.32	19.25	–	–	0.25	11.25	–	–
Lipidium ptrfoliatum	2.85	50.75	1.25	37.15	2.15	45.67	0.62	30.75
Gypsophila paniculata	3.45	60.50	1.15	47.45	2.25	57.12	0.65	40.45
Polygonum aviculare	1.95	50.80	–	–	1.25	35.25	–	–
Láppula squarrósa	3.15	40.75	–	–	1.75	22.75	–	–
Thláspi arvénse	1.99	50.25	–	–	1.05	15.44	–	–
Alyssum Turkestanicum	1.48	60.30	–	–	0.25	22.15	–	–
Galium aparine	2.95	50.75	–	–	0.75	17.85	–	–
Agropyron desertorum	–	–	0.75	35.25	–	–	0.90	42.75
Stipa capillata	–	–	0.45	27.12	–	–	0.62	39.60
Festuca valesiaca	–	–	0.22	18.75	–	–	0.35	28.45
Leymus ramosus	–	–	0.40	27.25	–	–	0.60	35.00
Koeleria cristata	–	–	0.08	7.00	–	–	0.10	10.00
Total number of species	12	12	11	11	12	12	11	11

*Ab. — species abundance; **Occ. — species occurrence

As a result of overgrazing, intensive grazing areas develop degraded sites, especially evident in summer. The degraded areas are mainly dominated by *A. lerchiana*. In addition, plants-indicators of digression, i.e., *Alhagi pseudalhagi*, *Euphórbia*, *Anabasis aphylla*, *Xanthium strumarium*, and *Datura*, are found everywhere on pastures under intensive grazing. The herbage is represented by the modified species *Anabasis* and *Euphorbia*, indicative of digression and severe trampling (Table 3).

By the end of the vegetation period, certain ephemeral plants reappeared on all plots, especially under intensive grazing. In autumn, the occurrence and abundance of plant species were virtually the same as in the summer period. At this stage, we considered only areas under intensive grazing and seasonal grazing. The species diversity of intra-seasonal areas was very close to that of seasonal plots.

Changes in the Projective Coverage of Pastures

Under intensive grazing in the control variant, the total projective coverage of plants in the autumn period amounted to 27%. The lower load on seasonal pastures allowed plants to achieve 62–72% projective coverage in the same season. The greatest projective coverage in autumn (67–75%) was observed in intra-seasonal pasture areas. Of these, pastures subjected to grazing in spring and autumn performed the best with 70% and 75%, respectively. The use of intra-seasonal pastures in the summer resulted in a lower projected coverage of 65%.

The results of the one-way ANOVA (Fig. 2) support the hypothesis that average projective coverage differs significantly among the different pasture types, with a significance level of $P<0.001$. Compared to the intensive grazing area (control), average autumn projective coverage increased by 45% in the autumn seasonal pastures, 43% in the spring intra-season pastures, 40% in the summer intra-season pastures, and 48% in the autumn intra-season pastures.

Changes in Herbage Height

In spring, the lowest herbage height (21.00cm) was observed in the control variant of intensive grazing pastures. In contrast, the grass in seasonal and intra-seasonal pasture areas was 11.75–13.10cm taller. The greatest herbage height of 34.10cm was observed in autumn intra-seasonal pasture areas.

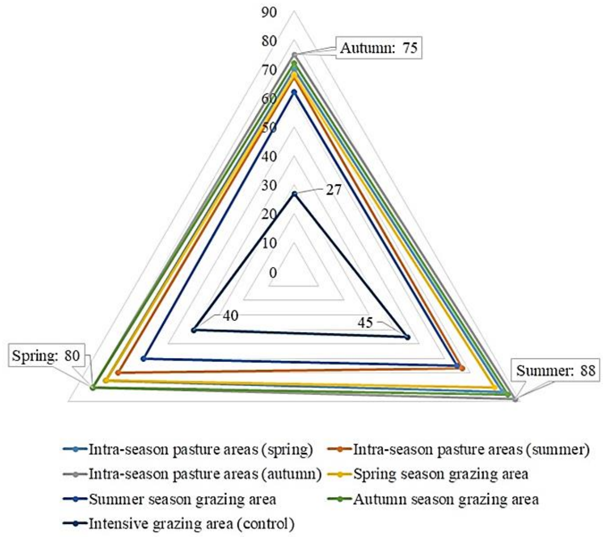

Fig. 2: Projective coverage of pasture grass depending on grazing technology.

In the summer period, the reduced load on seasonal and intra-seasonal pastures also demonstrated a positive effect on the height of pasture herbage. Specifically, compared to the control variant, herbage on seasonal pastures (spring, summer, and autumn) was 20.45% and 62.50% higher at plant heights of 26.50cm and 35.75cm, respectively.

On intra-seasonal pastures under grazing, herbage height reached 27.75–37.25cm, surpassing control (intensive grazing) by 5.75–15.25cm, or 26.14–69.32%. In autumn, the height of herbage also depended on grazing technology. The lowest herbage height of 14.70cm was observed on control pastures subjected to intensive grazing. In comparison, the grass on spring, summer, and autumn seasonal pastures was 7.30–11.60cm taller. Of these, the greatest herbage height of 26.30cm was achieved on autumn seasonal pastures.

The intra-seasonal use of pastures resulted in a herbage standing 19.40–28.50cm tall, i.e., 4.70–13.80cm taller than the control (Fig. 3). The differences in average herbage height are statistically significant for all grazing technologies limited to the season at the level of $P<0.001$. Importantly, the best pasture parameters, including projective coverage and herbage height, were achieved on the pastures and intra-seasonal areas used in the spring and autumn. On the other hand, pastures and intra-seasonal areas subjected to grazing in the summer did not show significant differences in herbage parameters (projective coverage and plant height) from the control variant of intensive grazing.

Green Mass Yield

The lowest green mass yield of 0.37t/ha was obtained in the control variant under intensive grazing. The reduction of load through seasonal grazing resulted in an increase in pasture herbage yields by 0.17t/ha (summer pastures with a yield of 0.54t/ha), 0.33t/ha (summer pastures with a yield of 0.54 t/ha), and 0.42t/ha (autumn pastures with a yield of 0.79t/ha). The yield of green mass on intra-seasonal pasture areas reached 0.72t/ha on spring plots, 0.55t/ha on summer plots, and 0.82t/ha on autumn plots. Thus, intra-seasonal pastures outperformed the control variant under intensive grazing by 0.18, 0.35, and 0.45t/ha, respectively. The results demonstrate that green mass yields depend on grazing technology as well. According to one-way ANOVA, the difference is significant at the level of $P<0.001$. These findings are visually supported by boxplots in Fig. 4.

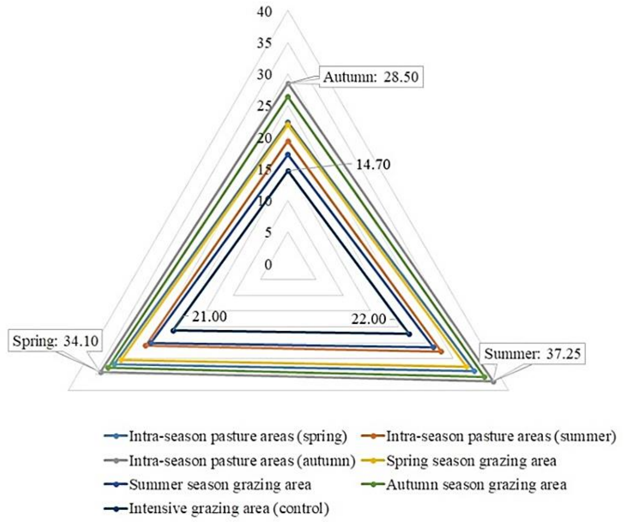

Fig. 3: Herbage height depending on grazing technology.

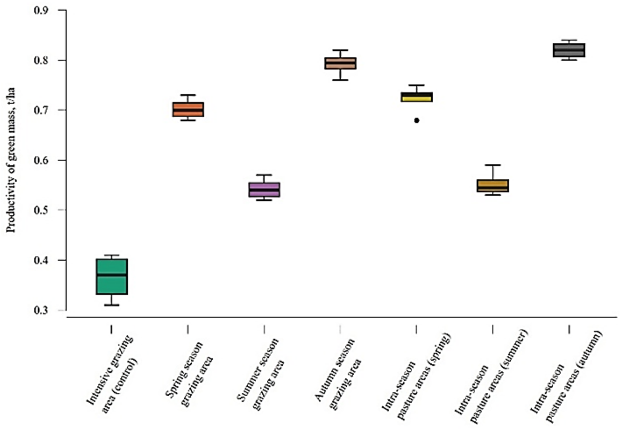

Fig. 4: Green mass yields from pasture herbage depending on grazing technology.

Changes in Feed Value and Energy and Protein Con

The studies reveal that the nutritional value and energy and protein content of herbage as pasture feed depend on grazing technology. In 2022–2024, the level of feed unit yield in the summer from pastures grazed in spring, summer, and autumn reached 0.10, 0.14, and 0.17t/ha, respectively. Under increased load due to intensive grazing, the productivity of the pasture cenosis in terms of feed units dropped to 0.05t/ha. Finally, intra-seasonal pasture areas (summer, spring, and autumn) again surpassed the control variant of intensive grazing by 0.06, 0.10, and 0.13t/ha, respectively. Thus, the yield of feed units from pastures proved dependent on grazing technology. One-way ANOVA confirms the significance of these differences at the level of $P<0.001$. The boxplots in Fig. 5 visually support these findings.

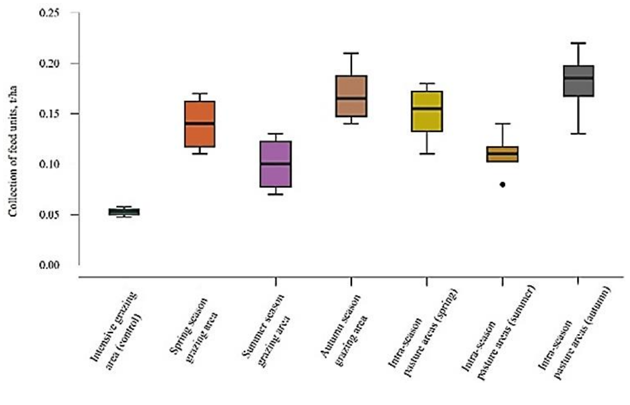

Fig. 5: Feed units yields from pasture herbage depending on grazing technology.

Next, the productivity of herbage on seasonal pastures in terms of digestible protein reached 0.004–0.018t/ha. The herbage of intra-seasonal pasture areas had a higher content of digestible protein with yields reaching 0.007, 0.015, and 0.019t/ha, besting control by 0.004, 0.012, and 0.016t/ha, respectively. The content of digestible protein per feed unit amounted to 106–109g. In the variant of intensive grazing, the output of digestible protein was lower than in all other variants at 0.003t/ha. The content of digestible protein per feed unit in this variant plummeted to 59g.

The yield of digestible protein thus proves dependent on grazing technology. One-way ANOVA confirms the significance of the differences at the level of P<0.001. The findings are illustrated by boxplots in Fig. 6.

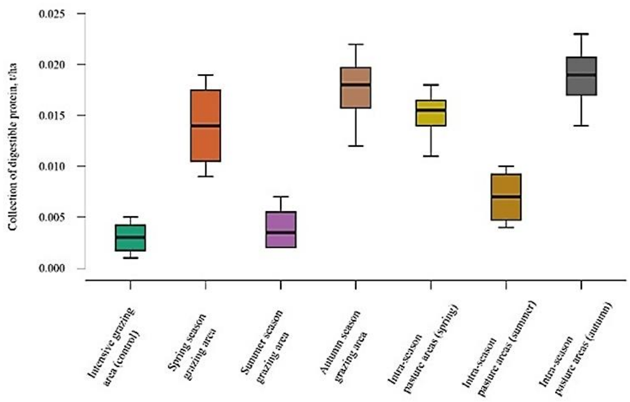

Fig. 6: Digestible protein yields from pasture herbage depending on grazing technology.

The output of metabolizable energy across all grazing variants ranged from 0.83 to 2.37 GJ/ha. The most productive in terms of energy content are seasonal pastures in the semi-arid zone and intra-seasonal pasture areas. Under intensive grazing, the yield of metabolizable energy was lower than in seasonal pastures by 0.61, 1.14, and 1.46 GJ/ha, or 42.36, 57.86, and 63.76%, respectively. Under intra-seasonal grazing, the content of metabolizable energy was higher than the control by 0.69, 1.19, and 1.54 GJ/ha, or by 45.39, 58.91, and 64.98%.

In conclusion, the yield of metabolizable energy has been found to depend on grazing technology. One-way ANOVA shows the differences to be significant at the level of P<0.001. The dependence is visually confirmed by boxplots in Fig. 7.

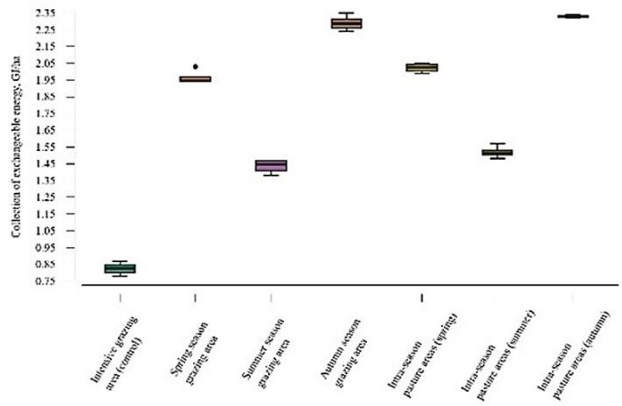

Fig. 7: Metabolic energy yields from pasture herbage depending on grazing technology.

DISCUSSION

The findings are further supported by the conclusions of Bell et al. (2021), who report that the energy content of pasture feed increases under regulated grazing and pasture management technologies (Kondo et al., 2011).

Thus, to improve the performance of pasture phytocenoses in the semi-arid zone of West Kazakhstan in terms of the parameters of pasture herbage, feed productivity, and energy and protein content, it is expedient to adopt the technology of grazing on seasonal and intra-seasonal pasture plots in spring and autumn, as this technology proves to be the best for sustainable pasture management (Nasiyev et al., 2023; Bulekova et al., 2025).

Studies unanimously confirm the ineffectiveness of unsystematic intensive grazing, showing that this technology is extremely detrimental to the biometric indicators and herbage yields of pasture biocenoses, as well as to the quality and nutritional value of pasture feed (Mukhambetov et al., 2023). Uncontrolled intensive grazing not only reduces herbage yields but also accelerates soil degradation and biodiversity loss. Continuous pressure from livestock compacts the soil, lowers water infiltration, and increases erosion risks, undermining the long-term stability of rangeland ecosystems. Recent studies confirm that heavy grazing accelerates degradation, whereas rotational and adaptive systems foster ecological recovery. For example, Ge et al. (2025) demonstrated that intensive rotational grazing promotes progressive vegetation succession in degraded grasslands, while Wang et al. (2025) emphasized that the grazing regime itself, rather than grazing intensity alone, plays a decisive role in preserving vegetation structure and resilience. Similarly, Liu et al. (2024a) reported that rotational grazing significantly enhances soil organic carbon compared to continuous grazing, supporting both soil health and climate mitigation. Collectively, these findings highlight that management strategies based on rest and rotation are essential to break the feedback loop of declining soil and vegetation quality that constrains the carrying capacity of pastures. These conclusions are further supported by the results of our previous and newer studies (Nasiyev, 2016).

Research also suggests that the most important biometric indicator of pastures is herbage height, as an herbage height of 20–30cm is associated with increased livestock productivity. Although intensive grazing, which consumes the main bulk of pasture biomass, improves the individual parameters of cattle and the quality of the carcass, it simultaneously compromises the biometric indicators of pastures, such as herbage height, projective coverage, and the yield and quality of pasture feed (Kunrath et al., 2015; Wesp et al., 2016; Wang et al., 2020).

The value of pastures lies not only in their productivity but also in the energy content of pasture feed. Studies indicate that middle-aged pastures have a higher herbage height than older pastures. This results in various plant species having different nutritional values, and this discrepancy can increase even further if the pastures are in poor condition (Bell et al., 2021), which is supported by our findings. Our previous studies demonstrate that the content of metabolizable energy in pasture feed is higher in the case of seasonal and intra-seasonal pasture areas (Nasiyev et al., 2021; Karynbayev et al., 2023).

Rotational grazing consistently improved both herbage height and pasture yield compared to intensive grazing. These improvements reflect the benefits of reduced grazing pressure and rest periods, which allow vegetation to recover and maintain higher productivity. This trend aligns with previous studies that also demonstrated the positive effects of rotational systems on biomass accumulation and forage quality (Kunrath et al., 2015; Comasseto et al., 2020; Wang et al., 2020). These trends are associated with the improvement of the biometric indicators of pastures, such as the height and projective coverage of herbage, achieved due to reduced load on pastures and biomass consumption by letting pastures rest as part of the rotation system. This also points to an association between herbage height and yields, consistent with the results of Comasseto et al. (2020), who established a linear relationship between the height and yield of pasture grass.

The linear relationship observed between plant height and green mass yield further supports the role of biometric indicators as predictors of pasture productivity. Our regression analysis indicates that even small increases in herbage height can lead to measurable gains in yield, highlighting the importance of maintaining optimal grazing intervals. The high coefficient of determination (R^2 = 92%) suggests a strong predictive power of the model, and the statistical significance ($P<0.001$) confirms the reliability of this relationship. These findings reinforce the idea that managing pasture height through controlled grazing not only enhances forage quantity but also contributes to more efficient pasture use.

Other researchers have also obtained similar results on changes in projective coverage, recommending that pasture resources be rationally managed by choosing the most efficient grazing technologies that prevent degradation and improve the pasture environment to achieve greater herbage height and yields with optimal quality parameters (Imani et al., 2010; Shamsutdinov et al., 2014). In the alpine ecosystem of Hol municipality in the south of Norway, Austrheim et al. (2014) obtained high yields by achieving a higher projective coverage of 80–89%. Similarly, in our experiments conducted in 2022–2024 in the semi-arid zone of West Kazakhstan, grazing on seasonal (spring, summer, and autumn) and intra-seasonal pasture plots resulted in relatively high projective coverage of grasses, which reached 65–88%, and ensured greater green mass yields of 0.54–0.82 t/ha.

The advantages of increased herbage height and yields can only be gained through proper pasture management that ensures satisfactory livestock productivity, leaves enough plant residue to protect the soil, and supports pasture regrowth. According to Anghinoni et al. (2011), adjustment of grazing intensity allows to achieve improved root-shoot-leaf ratios and has a positive effect on soil organic matter content in integrated systems. More efficient and high-quality grazing technologies, such as seasonal and intra-seasonal pastures, are also marked by a general positive impact of diversification on the agricultural ecosystem (Anghinoni et al., 2011). More recent studies further demonstrate that grazing management strongly influences ecosystem functions at a global scale: intensive grazing has been shown to reduce plant productivity, water conservation, and carbon sequestration significantly (Science of the Total Liu et al., 2024b). In contrast, rotational grazing enhances both total and active soil organic carbon, thereby strengthening soil health and increasing the resilience of grasslands to climate variability (Niu et al., 2025). These findings highlight that efficient grazing technologies, such as seasonal and intra-seasonal systems, contribute not only to productivity but also to the long-term sustainability of agricultural ecosystems.

Conclusions

The findings evidence that, compared to continuous intensive grazing, the newly developed and recommended grazing technologies benefit the biometric indicators of pastures, increasing the share of leaves in the structure of the harvest to 25.12–46.47% and the height of herbage to 26.50–37.25cm with a projective coverage of up to 65–88%.

Under the technologies of seasonal and intra-seasonal pastures, as a result of resting the semi-arid pastures of West Kazakhstan, yields were restored from 0.37 to 0.82t/ha, the output of nutritional value was increased to 0.10–0.18t/ha of feed units, and the energy and protein content of pasture feed was brought to a non-deficit level of 0.014–0.019t/ha of digestible protein and 1.97–2.37GJ/ha of metabolisable energy.

The practical contribution of the research consists of the fact that the developed and recommended grazing technologies can be applied by researchers and farmers who seek to preserve and restore pasture ecosystems and increase the efficiency of their use and management. These technologies will ensure the production of sustainable, high-quality, safe, and competitive animal products.

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Author's Contribution: BN: conceptualization, supervision, drafting of manuscript; ZhM: field experiment design, data collection; PY: statistical analysis, interpretation of results; NZh: coordination of research, revision of manuscript; ZhN: literature review, editing of introduction; AB: laboratory analysis of plant samples; NKh: visualization of results, preparation of figures; AO: data processing and software support; AB: assistance with field surveys; VSh: methodological support; RN: contribution to discussion and conclusion; AK: verification of references and formatting; AS: preparation of tables and supplementary data; AK: contribution to discussion and conclusion.

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REFERENCES

Akash, Hoque, M., Mondal, S., & Bisht, D. (2022). Sustainable livestock production and biodiversity. In S. Mondal, & R. L. Singh (Eds.), Emerging Issues in climate-smart livestock production (pp. 91–108). Academic Press. http://dx.doi.org/10.1016/B978-0-12-822265-2.00012-0

Anghinoni, I., Assmann, J., Martins, A., Costa, S., & Carvalho, P.C.F. (2011). Nutrient cycling in integrated crop–livestock systems. *Synergismus Scyentifica, 6*(2), 1-8.

Archer, S.R., Andersen, E.M., Predick, K.I., Schwinning, S., Steidl, R.J., & Woods, S.R. (2017). Woody plant encroachment: Causes and consequences. In D. Briske (Ed.), Rangeland systems (pp. 25–84). Cham: Springer. https://doi.org/10.1007/978-3-319-46709-2_2

Austrheim, G., Speed, J.D., Martinsen, V., Mulder, J., & Mysterud, A. (2014). Experimental effects of herbivore density on aboveground plant biomass in an alpine grassland ecosystem. *Arctic, Antarctic, and Alpine Research, 46*(3), 535–541. https://doi.org/10.1657/1938-4246-46.3.535

Baidalina, S., Baidalin, M., Khusainov, A., Kazydub, N., & Baiken, A. (2023). Photosynthetic activity, productivity, and nutritional value of mowing and grazing phytocenoses depending on the species composition of grasses. *SABRAO Journal of Breeding and Genetics, 55*(3), 825–835. https://doi.org/10.54910/sabrao2023.55.3.18

Bardgett, R.D., Bullock, J.M., Lavorel, S., Manning, P., Schaffner, U., Ostle, N., Chomel, M., Durigan, G., Fry, E.L., Johnson, D., Lavallee, J.L., Le Provost, G., Luo, S., Png, K., Sankaran, M., Hou, X., Zhou, H., Ma, L., Ren, W., Li, X., Ding, Y., Li, Y., & Shi, H. (2021). Combatting global grassland degradation. *Nature Reviews Earth & Environment, 2*(10), 720–735. https://doi.org/10.1038/s43017-021-00207-2

Beishova, I., Nametov, A., Shamshidin, A., Belaya, A., Ulyanova, T., Kovalchuk, A., Tegza, I., Traisov, B., Yuldashbaev, Y., Akhmetaliyeva, A., Abylgazinova, A., Beishov, R., & Batyrgaliyev, Y. (2024). Effectiveness of the use of genetic markers of meat productivity in the Kazakh White-Headed breed identified using genome-wide association study. *OnLine Journal of Biological Sciences, 24*(4), 624–632. https://doi.org/10.3844/ojbsci.2024.624.632

Bell, M.J., Huggett, Z., Slinger, K.R., & Roos, F. (2021). Effect of pasture cover and height on nutrient concentrations in diverse swards in the UK. *Grassland Science, 67*, 267–272. https://doi.org/10.1111/grs.12306

Bengtsson, J., Bullock, J.M., Egoh, B., Everson, C., Everson, T., O'Connor, T., O'Farrell, P.J., Smith, H.G., & Lindborg, R. (2019). Grasslands — More important for ecosystem services than you might think. *Ecosphere, 10*(2), e02582. https://doi.org/10.1002/ecs2.2582

Bulekova, A., Gumarova, Z.H., Gubasheva, B., Limanskaya, V., Satayev, A., Maidanova, M., Kairgalieva, G., Sungatkyzy, S., Akkereyeva, E., & Sharafieva, Z.H.M.A. (2025). Environmental factors influence on the productivity of cultivated plants. *SABRAO Journal of Breeding and Genetics, 57*(4), 1708–1717. https://doi.org/10.54910/sabrao2025.57.4.37

Bureau of National Statistics. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2023). Statistics of agriculture, forestry, hunting and fisheries. Retrieved from: https://stat.gov.kz/en/industries/business-statistics/stat-forrest-village-hunt-fish/

Comasseto, D.S., Dornelles, R.R., Faleiro, E.A., Pinto, A.G., Castagnara, D.D., Oaigen, R.P., Del Valle, T.A., & Azevedo, E.B. (2020). Effects of cutting height management on yield and composition of different annual pastures. *Revista Brasileira de Saúde e Produção Animal, 21*, e2121282020. https://doi.org/10.1590/S1519-99402121282020

Dowhower, S.L., Teague, W.R., Casey, K.D., & Daniel, R. (2019). Soil greenhouse gas emissions as impacted by soil moisture and temperature under continuous and holistic planned grazing in native tallgrass prairie. *Agriculture, Ecosystems & Environment, 286*, 106647. https://doi.org/10.1016/j.agee.2019.106647

Food and Agriculture Organization of the United Nations (FAO) (2021). FAOSTAT Database. Retrieved from: http://www.fao.org/faostat/en/#data

Ge, J., Liu, X., Zhang, Y., & Li, H. (2025). Intensive rotational grazing promotes progressive vegetation succession in degraded grasslands. *Agriculture, Ecosystems & Environment, 386*, 109932. https://doi.org/10.1016/j.agee.2025.109932

Gorshkova, A.A. (1973). Pastbishcha Zabaykal'ya [Pastures of Transbaikalia]. Irkutsk: Vostochno-Sibirskoye knizhnoye izdatel'stvo.

Hillenbrand, M., Thompson, R., Wang, F., Apfelbaum, S., & Teague, R. (2019). Impacts of holistic planned grazing with bison compared to continuous grazing with cattle in South Dakota shortgrass prairie. *Agriculture, Ecosystems & Environment, 279*, 156–168. https://doi.org/10.1016/j.agee.2019.02.005

Horn, J., & Isselstein, J. (2022). How do we feed grazing livestock in the future? A case for knowledge-driven grazing systems. *Grass and Forage Science, 77*(3), 153–166. https://doi.org/10.1111/gfs.12577

Imani, J., Tavili, A., Bandak, I., & Gholinejad, B. (2010). Assessment of vegetation changes in rangelands under different grazing intensities: A case study in Charandow, Kurdistan province. *Iranian Journal of Range and Desert Research, 17*(3), 393-401.

Karynbayev, A., Nasiyev, B., Kuzembayuly, J., Zhumadillayev, N., & Zhumadillayev, N. (2023). Development of a methodology for determining the nutritional value of pasture feed considering the fractions of easily digestible carbohydrates in the desert zone of Southern Kazakhstan. *Online Journal of Biological Sciences, 23*(4), 458–469. https://doi.org/10.3844/ojbsci.2023.458.469

Kayser, M., Müller, J., & Isselstein, J. (2018). Grassland renovation has important consequences for C and N cycling and losses. *Food and Energy Security, 7*(4), e00146. https://doi.org/10.1002/fes3.146

Kenenbayev, S., Yessenbayeva, G., Zhanbyrbayev, Y., Bekturganov, A., Dutbayev, Y., & Toktay, H. (2023). Influence of climate conditions and biofertilizers on soybean yield in Southeastern Kazakhstan. *International Journal of Design & Nature and Ecodynamics, 18*(6), 1391–1398. https://doi.org/10.18280/ijdne.180612

Kleijn, D., Bommarco, R., Fijen, T.P., Garibaldi, L.A., Potts, S.G., & Van Der Putten, W.H. (2019). Ecological intensification: Bridging the gap between science and practice. *Trends in Ecology & Evolution, 34*(2), 154–166. https://doi.org/10.1016/j.tree.2018.11.002

Kondo, J., Hirobe, M., Uugantsetseg, K., Amartuvshin, N., Fujita, N., Sakamoto, K., & Yoshikawa, K. (2011). Effects of livestock grazing on the surface soil properties in Mongolian steppe ecosystems along an aridity gradient. *Journal of the Japan Society of Revegetation Technology, 36*, 406–415. http://dx.doi.org/10.7211/jjsrt.36.406

Kuandykova, E., Bekezhanov, D., Nessipbaeva, I., Rzabay, A., Jumabayeva, K., & Zhuldybayeva, A. (2024). Regulation of mechanisms for management of environmental issues of rational use of natural resources and pastures. *International Journal of Sustainable Development and Planning, 19*(11), 4509–4517. https://doi.org/10.18280/ijsdp.191138

Kunrath, T.R., Carvalho, P.C.F., Cadenazzi, M., Bredemeier, C., & Anghinoni, I. (2015). Grazing management in an integrated crop-livestock system: Soybean development and grain yield. *Revista Ciência Agronômica, 46*(3), 645–653.

Kussainova, M., Toishimanov, M., Syzdyk, A., Tamenov, T., Nurgali, N., & Chen, J. (2023). Influence of time conditions on the soil temperature indicators in Kazakhstan. *Caspian Journal of Environmental Sciences, 21*(5), 1117–1122. https://doi.org/10.22124/cjes.2023.7399

Liu, Y., Zhang, R., Wang, Q., & Zhou, M. (2024a). Rotational grazing enhances soil organic carbon and improves grassland resilience under climate variability. *Scientific Reports, 14*(1), 68277. https://doi.org/10.1038/s41598-024-68277-y

Liu, Y., Zhang, M., Wang, X., & Wang, C. (2024b). The impact of different grazing intensity and management measures on soil organic carbon density in Zhangye grassland. *Scientific Reports, 14,* 17556. https://doi.org/10.1038/s41598-024-68277-y

Machmuller, M.B., Kramer, M.G., Cyle, T.K., Hill, N., Hancock, D., & Thompson, A. (2015). Emerging land use practices rapidly increase soil organic matter. *Nature Communications, 6*, 6995. https://doi.org/10.1038/ncomms7995

McDonald, S.E., Lawrence, R., Kendall, L., & Rader, R. (2019). Ecological, biophysical and production effects of incorporating rest into grazing regimes: A global meta-analysis. *Journal of Applied Ecology, 56*(12), 2723–2731. https://doi.org/10.1111/1365-2664.13496

Michalk, D.L., Kemp, D.R., Badgery, W.B., Wu, J., Zhang, Y., & Thomassin, P.J. (2019). Sustainability and future food security — A global perspective for livestock production. *Land Degradation & Development, 30*(5), 561–573. https://doi.org/10.1002/ldr.3217

Moscovici Joubran, A., Pierce, K.M., Garvey, N., Shalloo, L., & O'Callaghan, T.F. (2021). Invited review: A 2020 perspective on pasture-based dairy systems and products. *Journal of Dairy Science, 104*(7), 7364–7382. https://doi.org/10.3168/jds.2020-19776

Mukhambetov, B., Nasiyev, B., Abdinov, R., Kadasheva, Z., & Mamyrova, L. (2023). Influence of soil and climatic conditions on the chemical composition and nutritional value of Kochia prostrata feed in the arid zone of Western Kazakhstan. *Caspian Journal of Environmental Sciences, 21*(4), 853–863.

Nasiyev, B. (2016). The study of the processes, degradation factors and the selection of crops for the restoration of bioresources capacity of the grassland of semi-desert zones. *Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7*(3), 2637–2646.

Nasiyev, B.N., Zhanatalapov, N.Z., & Shibaikin, B. (2021). Assessment of the elements of the Sudan grass cultivation technology in the zone of dry steppes. *OnLine Journal of Biological Sciences, 21*(1), 172–180. https://doi.org/10.3844/ojbsci.2021.172.180

Nasiyev, B., Karynbayev, A., Mukhambetov, B., Ongayev, M., Nurgaziyev, R., Akhmetaliyeva, A., Sungatkyzy, S., Auzhanova, M., & Okshebayev, A. (2025). Development of agriculture under the influence of ESG principles: Opportunities for sustainable soil management. *International Journal of Sustainable Development and Planning, 20*(5), 2115–2125. https://doi.org/10.18280/ijsdp.200527

Nasiyev, B., Nurgaziev, R., Irmulatov, B., Shegenov, S., Sattybaeva, Z., Syzdykova, G., Belgibayeva, A., & Alenov, Z. (2023). Improving degraded pastures in Northern Kazakhstan through moldboard plowing and grass seed mixtures. *International Journal of Design & Nature and Ecodynamics, 18*(5), 1207–1213. https://doi.org/10.18280/ijdne.180522

Niu, W., Ding, J., Fu, B., Zhao, W., & Eldridge, D. (2025). Global effects of livestock grazing on ecosystem functions vary with grazing management and environment. *Agriculture, Ecosystems & Environment, 378*, 109296. https://doi.org/10.1016/j.agee.2024.109296

Nurgaziyev, R., Irmulatov, B., Nasiyev, B., Simic, A., Zhanatalapov, N., Bekkaliyev, A., Khiyasov, M., & Aidarbekova, T. (2024). Influence of organic fertilizers on the restoration of the biological resource potential of natural degraded pastures in the steppe zone of Northern Kazakhstan. *Online Journal of Biological Sciences, 24*(4), 848–857. https://doi.org/10.3844/ojbsci.2024.848.857

Official Information Source of the Prime Minister of the Republic of Kazakhstan (2023). More than 1,700 new investment projects to be implemented in Kazakhstan agribusiness sector by 2030. Retrieved from: https://primeminister.kz/en/news/more-than-1700-new-investment-projects-to-be-implemented-in-kazakhstan-agribusiness-sector-by-2030-22868

Parliament of the Republic of Kazakhstan (2017). Law of the Republic of Kazakhstan of February 20, 2017, No. 47-VI ZRK "On pastures". Retrieved from: https://adilet.zan.kz/rus/docs/Z1700000047

Parliament of the Republic of Kazakhstan (2021). Law of the Republic of Kazakhstan of June 30, 2021, No. 59-VII ZRK "On introducing amendments and additions to some legislative acts of the Republic of Kazakhstan on the development of land relations". Retrieved from: https://adilet.zan.kz/rus/docs/Z2100000059

Rearte, R., Corva, S.G., de la Sota, R.L., Lacau-Mengido, I.M., & Giuliodori, M.J. (2022). Associations of somatic cell count with milk yield and reproductive performance in grazing dairy cows. *Journal of Dairy Science, 105*(7), 6251–6260. https://doi.org/10.3168/jds.2021-21504

Russian National Public Library for Science and Technology (2017). Opustynivaniye – global'naya problema okruzhayushchey sredy [Desertification: A global environmental issue]. Retrieved from: https://www.gpntb.ru/vystavki-v-gpntb-rossii/2017-2/113-chitatelyam/6/5079-opustynivanie-globalnaya-problema-okruzhayushchej-sredy.html

Saparov, G., Dutbayev, Y., Amanzholkyzy, A., Islam, K. R., Tireuov, K., Hakimov, N., Zudilova, E., Shichiyakh, R., Shoykin, O., Ganiyev, B., Otcheskiy, I., Trushin, M., & Kozlov, A. (2024). Assessing heavy metal contamination for soil reclamation: Implications for sustainable urban development. *International Journal of Design & Nature and Ecodynamics, 19*(6), 2197–2204. https://doi.org/10.18280/ijdne.190636

Shamsutdinov, Z.S., Ubaydullaev, S.R., Shamsutdinov, N.Z., & Nasiev, B.N. (2014). Productivity of grass plants in the phytogenic field of black saxaul (Haloxylon aphyllum (Minkw.) Iljin) in the Karnabchul desert. *Arid Ecosystems, 4*(3), 169–177. https://doi.org/10.1134/S2079096114030081

Teague, R., Provenza, F., Kreuter, U., Steffens, T., & Barnes, M. (2013). Multi-paddock grazing on rangelands: Why the perceptual dichotomy between research results and rancher experience? *Journal of Environmental Management, 128*, 699–717. https://doi.org/10.1016/j.jenvman.2013.05.064

Tleshpayeva, D., Bondarenko, N., Leontev, M., Mashentseva, G., Plaksa, J., Zharov, A., Stepanova, D., & Karbozova, A. (2025). Assessment of economic management of land resources to enhance food security. *Qubahan Academic Journal, 5*(1), 159–168. https://doi.org/10.48161/qaj.v5n1a1048

Wang, J., Zhao, C., Zhao, L., Wen, J., & Li, Q. (2020). Effects of grazing on the allocation of mass of soil aggregates and aggregate-associated organic carbon in an alpine meadow. *PLoS One, 15*(6), e0234477. https://doi.org/10.1371/journal.pone.0234477

Wang, Z., Chen, L., Zhao, Y., & Huang, J. (2025). Grazing regime outweighs grazing intensity in protecting vegetation of semi-arid grasslands. *Ecological Indicators, 168,* 109987. https://doi.org/10.1016/j.ecolind.2025.109987

Wesp, C.L., Carvalho, P.C.F., Conte, O., Cadenazzi, M., Anghinoni, I., & Bremm, C. (2016). Steers production in integrated crop-livestock systems: Pasture management under different sward heights. *Revista Ciência Agronômica, 47*, 187–194.