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Influence of Organic Fertilizers on the Restoration of the Biological Resource Potential of Natural Degraded Pastures in the Steppe Zone of Northern Kazakhstan

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Abstract: The paper explores the opportunities for reducing the degradation of natural pastures and suggests an approach to their restoration using organic fertilizers. The work aims to determine the opportunities for restoring the biological resource potential of degraded pastures using organic fertilizers based on the principles of organic farming. In the steppe zone of Northern Kazakhstan, a study of the species composition of plants on degraded pastures was conducted. Species composition is an important factor in restoring degraded pastures and studying the effect of organic fertilizers on their productivity. Experiments utilized three types of organic fertilizers: Effluent, micropolydoc plus and BioMIX, compared against a control (unfertilized) site. The study showed the dominance of bluegrass, wormwood and feather grass communities, with *Festuca valesiaca* as the predominant species. The yield of the studied pastures ranged from 4.3-8.2 c/ha, while the lowest yield was noted at the control site (without fertilizers). Two-factor analysis of variance indicates that fertilizers have a significant impact on the yield (60.78%). The novelty of this research lies in its focused examination of organic fertilizers within a steppe ecosystem, highlighting significant improvements in pasture productivity.

Keywords: Ecology, Phytocenosis, Plant Species Composition, Yield, Soil Composition

Introduction

The integration of green technologies in agriculture, particularly through the adoption of biological and organic fertilizers, represents a pivotal shift in sustainable farming practices globally (Anokhina *et al*., 2020; Kashina *et al*., 2022). The drive towards minimizing chemical inputs, such as synthetic fertilizers and pesticides, is increasingly evident across various agricultural sectors, including crop and forage production (Dosmanbetov *et al*., 2020). Environmental (Kuderina *et al*., 2021) and social and economic (Ydyrys *et al*., 2023) factors of organic agriculture are of interest to many researchers (Rahmann and Böhm, 2005; Connor, 2008; Escribano, 2018; Hafez *et al*., 2021). Analysts predict an increase in demand for organic products from 10-30% per year. Minimizing the use of pesticides and synthetic fertilizers is popularized not only in grain and vegetable crops (Ramazanova *et al*., 2021; Kochorov *et al*., 2023; Mukhomedyarova *et al*., 2023) but also in forage crops, including pasture ones (Martin *et al*., 2020; Verma *et al*., 2020). To a greater extent, pastures are used for sheep breeding, horse breeding and to a lesser extent for cattle grazing (Konuspayeva and Faye, 2020). Natural pastures provide inexpensive feeding (Mukhambetov *et al*., 2023), where farm animals satisfy their needs for green feed (Waghorn and Clark, 2004).

However, as a result of irrational use, the intensification of animal husbandry and degradation of pastures are observed (Hankerson *et al*., 2019). The reason for degradation is the lack of a distribution system across the territory (Shayakhmetova, 2023) and the intensity of grazing (Nasiyev *et al*., 2019). The low content of essential nutrients and insufficient activity of soil enzymes are considered the main problems of degraded pastures (Syed *et al*., 2021).

Along with agrotechnical methods (Nasiyev *et al*., 2023a; Kunanbayev *et al*., 2024), one of the possible ways of agrobiological reclamation of pastures is the use of organic fertilizers (Santos *et al*., 2015). These fertilizers contain highly effective strains of microorganisms, such as *Azotobacter* and *Azospirillum*, which fix atmospheric nitrogen and increase the solubility of phosphorus (Thomas and Singh, 2019; Aasfar *et al*., 2021). They are produced on the roots in symbiosis with plants or in a free-living form in the soil (Hafez *et al*., 2021). Various raw materials are used for the production of organic fertilizers, including waste (Kaliyev *et al*., 2019). For example, for the production of such fertilizers, waste from the leather industry, meat and bone meal, rice husk, bio-coal from potato skins, sawdust, sewage from sewage treatment plants, ash and other kinds of waste are used (Majee *et al*., 2021; 2023; Kiruba and Saeid, 2022).

However, the application of organic fertilizers in the restoration of degraded pastures-a critical component of sustainable livestock management-remains underexplored, particularly within the unique climatic and ecological contexts of the steppe zones of Northern Kazakhstan. This research seeks to fill this gap by specifically investigating the effects of select organic fertilizers on the biological resource potential of these pastures.

The problem of pasture degradation exists in almost every country where agriculture is developing (Nugmanov *et al*., 2023). As the research results show, the problem is not solved at once but can progress for a long time. For example, according to the Committee on Land Management of the Ministry of Agriculture (CLMMA) (2021), the share of degraded pastures in Kazakhstan has increased by 15% compared to the 1980 and 1990s. Animal husbandry is one of the leading branches of agriculture in Kazakhstan (Shevchenko *et al*., 2023). The rational use, restoration and increase of productivity of natural pastures are the basis for creating a sustainable feed base (Yermekbayev *et al*., 2023) and developing livestock (Tokbergenova *et al*., 2018) sufficient for meeting the needs of Kazakhstan. Pastures occupy a significant area of about 1.9 million km^2, or 86% of the total area of agricultural land in Kazakhstan (FAOSTAT, 2020). Researchers note that the potential productivity of pastures reaches 25 million of feed units or more (Akhylbekova *et al*., 2022). The focus of our study is on the use of organic fertilizers on degraded pastures in the steppe, arid regions of Kazakhstan, since despite the ongoing research, the problem has not been solved and requires constant attention from researchers.

The work aims to determine the opportunities for restoring the biological resource potential of degraded pastures using organic fertilizers based on the principles of organic farming.

The paper includes a description of the study object, methods of chemical soil analysis, characteristics of the soil and climate at the experimental site and methods for assessing phytocenosis, calculating feed value and using statistical processing of the obtained results.

Based on the collected information, the diversity of species of the plant community of degraded pastures and their yields were determined and a bio-energetic assessment was carried out. This made it possible to determine the biological resource potential of naturally degraded pastures and the effect of organic fertilizers on productivity. The novelty of this research lies in its focus on the specific challenges associated with pasture degradation in arid and semi-arid regions and the tailored use of organic fertilizers as a remedial strategy.

As a result, we made conclusions about the opportunities for restoring the biological resource potential of naturally degraded pastures in the steppe zone of Northern Kazakhstan using organic fertilizers.

Materials and Methods

Description of the Study Pbjects

The experiments to restore the biological resource potential of degraded pastures using organic fertilizers based on the principles of organic farming were conducted in 2022-2023 by order of the ministry of agriculture of the Republic of Kazakhstan. Degraded natural pastures of the Zhaysan private farm were used as the study object. The farm is located in the Zerendi district of the Akmola region (N52°93.3161; E69°29.9401).

The study included the use of three types of organic fertilizers (Table 1). The experiment design is shown in Table 2.

Table 1: Description of organic fertilizer types

Organic fertilizer	Description
Effluent (Biotechkomp LLC, Russia)	Produced by anaerobic thermophilic fermentation of a mixture of cattle manure and food waste. It is a liquid fertilizer with solid particles in suspension, with chemical, physical and agronomic characteristics of a good fertilizer. The mass fraction of Nitrogen (N) is 1.4%, total Phosphorus (P_2O_5): 1.1%, potassium (K_2O): 1.5%, organic substances: 77%, pH: 7.4
Micropolydoc plus (SHANS)	Fertilizer in a liquid, chelated form enriched with a mixture of various macro- and micro-elements is intended for plant foliar dressing. It contains N (200 g/L), phosphorus (120 g/L), potassium (100 g/L), sulfur 1.5 (g/L), iron (1.1 g/L) and magnesium (1.1 g/L)
BioMIX (Bioefekts SIA, Latvia)	Universal organic fertilizer in the liquid form based on high-bog peat, vermicompost and charcoal. It contains macro-and microelements for the complex development of plants. The mass fraction of N is 1.4%, total P_2O_5: 0.8%, K_2O: 1.1%, organic substances: 53%, pH: 7.2. It is an immunostimulator of growth

Table 2: Experiment design for the restoration of the biological resource potential of naturally degraded pastures using organic fertilizers based on the principles of organic farming

No.	Variants	Method and dose
1	Natural degraded pasture (control variant)	-
2	Effluent	320 L/ha (fractional application of 50% in spring after regrowth, 50% after grazing)
3	Micropolydoc plus	200 L/ha working solution (fractional application of 50% in spring after regrowth, 50% after grazing)
4	BioMIX	10 L/ha working solution (Fractional application of 50% in spring after regrowth, 50% after grazing)

The organic fertilizers selected for this study were chosen based on their accessibility to farms in Northern Kazakhstan. These fertilizers are not only readily available for purchase by local farms but also cost-effective, making them economically viable for widespread use.

The area of the experimental site was 7,200 m^2. The repetition was fourfold. The area of one variant equaled 1,800 m^2 and the repetition area was 600 m^2. The placement of plots was systematic. Fertilization was carried out by dispersed spraying with a trailer-type boot sprayer (Fig. 1)

The application of fertilizers was guided by a state-of-the-art satellite navigation system, ensuring precise and efficient coverage of the pastures. This system allowed for the application of the fertilizers, avoiding overlap and ensuring that each section of the pasture received an optimal amount of treatment. The satellite navigation provided coordinates for the sprayer, which was equipped with a control system to adjust the flow rate and spread based on real-time geographical data, thus ensuring that the application of the fertilizers was both uniform and accurate.

Methods of Chemical Soil Analysis

To determine the mobile phosphorus compounds, we used the photometric method proposed by I. Machigin (Pronko *et al*., 2019). This method is based on the extraction of mobile phosphorus compounds from the soil using a solution of Ammonium Carbonate ($(NH_4)_2CO_3$) with a concentration of 10 g/dm^3 in a soil-to-solution ratio of 1:20. Next, phosphorus was determined in the form of a blue phosphorus-molybdenum complex using the AE-30 F photoelectrocolorimeter (ERMAINC, Japan). A photocolorimetric technique was used to determine the nitrate nitrogen content (Waheed and Naveed, 2023). This method is based on the formation of sodium picrate (picric acid salt) in the presence of disulfophenolic acid and sodium hydroxide. The resulting solution turns yellow, which allows for determining the amount of nitrate N. Potassium was determined using a flame photometer using a method based on the extraction of mobile potassium compounds from the soil using a solution of ammonium carbonate concentration of 10 g/dm^3. Soil samples weighing 5.0±0.1 g were placed in conical flasks and 100 cm^3 of ammonium carbonate solution with the same concentration was added. The soil mixture with the solution was mixed for 5 min and kept at a temperature of (25±2°C) for 18-20 h. After that, the suspension was shaken by hand and filtered through paper filters. This method uses a light filter with a maximum transmission in the range of 766-770 nm (Gabdulov *et al*., 2018).

Soil and Climate Characteristics of the Experimental Site

A significant part of the agricultural land is located in the northern regions of Kazakhstan. The prevailing pasture area is located in the steppe zone (Rachkovskaya and Bragina, 2012; Mazhitova *et al*., 2018), which is characterized by a lack of moisture (up to 350 mm of precipitation per year), a lack of heat and a short frost-free period (Karatayev *et al*., 2022). Plants of steppe pastures are mainly represented by a motley grass phytocenosis, with a predominance of perennial grasses (Koshen *et al*., 2020).

The soil of the experimental site is represented by chernozem with a humus content below average and low moisture retention capacity. The humus content was 4.7% and the amount of easily hydrolyzable N in the soil reached 41.0 mg/kg. The level of mobile phosphorus was estimated at 15.0 mg/kg of soil and exchangeable potassium at 350 mg/kg. The pH of the soil, measured at 7.3, indicates a neutral reaction in the soil environment.

Fig. 1: Application of organic fertilizers on naturally degraded pastures (a: The spraying process; b: pouring the mixture into the sprayer)

The growing season of 2022 was characterized by uniform and abundant precipitation, especially in July, when more than half of the summer precipitation fell 77.0 mm. In general, 2022 was characterized by precipitation at the level of long-term average data. The average air temperature in the summer months was also recorded at the average annual level, in June equaling +17.7°C, in July +19.9°C and in August +16.7°C. In January and February 2023, the total precipitation amounted to 54 mm (exceeding the norm), while in April 37 mm of precipitation fell, which was twice the norm. Significant temperature fluctuations during the day proved to be a limiting factor for plant growth and development. The summer months (from June-August 2023) were characterized by an elevated temperature regime, with a maximum air temperature of up to 37°C in early June and several days in July and August when the temperature exceeded 30°C. However, during this period, precipitation was only 41.6 mm, which was 2.5 times lower than the average annual level. This lack of precipitation hurt certain stages of growth and development of the studied crops.

Based on the analysis, it can be argued that the hydrothermal conditions in 2022 were typical for this agricultural zone and 2023 was acutely arid.

Methods for Assessing Phytocenosis

The yield was determined on randomly selected test sites of 1 m^2 (1×1 m frame), where all plant species were cut with scissors and weighed. At each repetition, three records were made. Then the cut plants were placed in a drying cabinet for 48 h at 70°C. After reaching a constant weight, they were weighed.

A 0.5×0.5 m square was used to determine the projective coverage. The repetition on the site was threefold. The relative coverage of ea`ch plant species (percentage of coverage) was determined. The individual numbers of each species and the plant community were calculated.

The geobotanical survey included quantitative and qualitative accounting of pasture land plants and a scientifically based assessment of the correct organization and arrangement of the pasture territory (Nasiyevich, 2013; Nasiyev *et al*., 2021). The degree of participation of individual species in the herbage was determined using the accounting method based on their relative abundance using the drude scale (Table 3). According to this scale, scores are assigned to various degrees of abundance based on the smallest distances between the representatives of the species and their occurrence (Fang *et al*., 2009).

Feed Value Calculating Methods

Biochemical studies of plants were carried out in Dry Matter (DM). The Crude Ash (CA) was determined by firing the samples in muffle furnaces at a temperature of 500-600°C. The Kjeldahl method was used to determine the mass fraction of the protein. Crude Fiber (CFi) and Fat (CFa) were determined following the methods described in Bazarov *et al.* (2023). N-free extractive substances were determined by subtracting the content of protein, fat, fiber and microelements.

The nutritional value of the feed was assessed based on Gross Energy (GE) and Metabolic Energy (ME). The calculation of the GE content in the DM of the feed was performed by chemical analysis of the feed using the following formula:

$$GM\left(MJ\ /\ kg\right) = 23.95 \times CP + 39.77 \times CFa + 20.05 \times CFi + 1\,7.46 \times NFS \quad (1)$$

where, *CP* is crude protein (*kg*), *CFa* is crude fat, *CFi* is crude fiber, *NFS* is nitrogen-free substances (*NFS* = 100%-*CP*-*CFa*-*CFi*-*CA*) and *CA* is crude ash.

Then the *ME* was calculated:

$$ME\left(MJ\ /\ kg\right) = \left(0.73 \times GE\right) / DM \times \left(DM - CFi \times 1.05\right) \quad (2)$$

where, *GE* is the gross energy and *DM* is the dry matter content.

Statistical Processing of Experimental Data

The correlation and factor analysis (ANOVA) was performed using the AgCStat software package built into Microsoft Excel. To identify statistically significant differences in the yield between the variants, the Least Significant Difference (LSD_{05}) was calculated, which was recognized as significant at a 5% significance level. The factor load was calculated using the method of two-factor analysis of variance. Using two-factor analysis, we determined the degree of influence on the yield of the studied fertilizers (influence of factor A) and the conditions of the year (influence of factor B).

Table 3: The drude scales of species abundance in plant communities

Designation of abundance by Drude	Characteristics of abundance	Average smallest distance between representatives of the species (counting units), cm
Cop3 (Copiosae3)	Very abundant	No more than 20
Cop2 (Copiosae2)	Abundant	20-40
Cop1 (Copiosae1)	Quite abundant	40-100
Sp (sparsae)	Sparse	100-150
Sol (solitariae)	Solitary	More than 150

Results

Species Diversity in the Plant Community of Degraded Pastures

According to the surveys of the geobotanical composition on natural degraded pastures, the soil cover is represented by low-fertile soils in meadow and solonetz complexes.

The main species growing in the study area were bluegrass, wormwood and feather grass communities. The predominant species in this phytocenosis was the Volga fescue, also known as sheep fescue (*Festuca valesiaca*). It is a perennial herbaceous plant widespread in steppe zones. It belongs to the genus Fescue (*Festuca*) of the grasses family (*Poaceae*). The projective coverage of the sheep fescue was 50% (Fig. 2) and the abundance according to the drude scale of droude was cop1.

The crested wheatgrass (*Agropyron cristatum*) was represented in a slightly smaller abundance. It is a perennial herbaceous plant from the grass family (*Poaceae*). The projective coverage was 25% and abundance on the drude scale was cop.1-sp.

In the studied area, the Lessing feather grass (*Stipa lessingiana*) is less common compared to the crested wheat grass and its projective coverage was 15%. This may indicate a less intense influence of this species on the vegetation of this area. However, plants of this species can be important for biodiversity and the ecosystem. It is a perennial herbaceous plant from the grass family (*Poaceae*) typical for steppe and semi-desert regions. The abundance of Lessing feather grass on the drude scale, estimated as sp., indicates a scattered coverage of pastures with these plants.

The grass covering 8% of the pastures in the study area is mainly represented by ephemeroids. The projective coverage of field wormwood (*Artemisia lercheana*) was 2%. This low value may indicate a limited distribution of this species in this ecosystem. However, the presence of field wormwood can have important environmental consequences. This plant can be an indicator of soil degradation or changes in humidity. When it occurs as scattered or solitary, it may indicate unfavorable conditions for other plants, as well as the adaptability of field wormwood to more severe conditions.

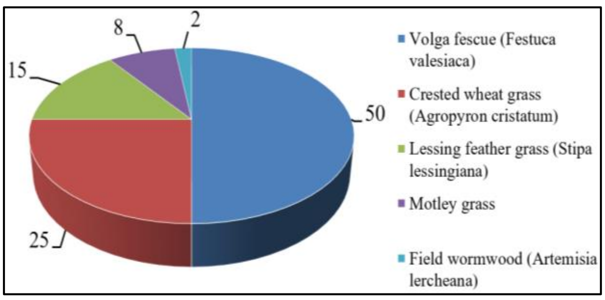

Fig. 2: The projective coating of degraded pastures before and after treatment with organic fertilizers

Based on the data of the geobotanical survey, the development of effective strategies for the restoration of degraded pastures becomes more substantiated and directed. Priority should be given to sustainable methods, such as organic farming, to restore biological resource potential and ensure the long-term sustainability of pasture ecosystems.

Yield and Biological Energy Assessment

The results of our studies indicate the influence of various processing methods on the DM yield (Table 4). In the untreated variant (control), the yield was 4.3 c/ha on average during the study period. In 2022, the yield was 32.4% higher than in 2023. The decrease in productivity is explained by a lack of precipitation and elevated temperatures in the summer months.

In all variants of the experiment, productivity exceeded the control level, which is confirmed by an excess of +2.2 to +3.9 c/ha. The most significant increase in yield was noted when using micropolydoc plus, where productivity had increased by +3.9 c/ha and amounted to 8.2 c/ha. This may indicate the effectiveness of this organic fertilizer in stimulating the growth of plants of this phytocenosis. A significant increase in yield was also observed with effluent treatment, where an increase of +3.0 c/ha was noted. The variant with the use of BioMIX showed the smallest difference from the control variant. The statistical significance is confirmed by the significant LSD.

To determine the degree of influence of the studied fertilizers (factor A) and the conditions of the year (factor B) on the yield, a two-factor analysis of variance was carried out. According to statistical calculations, fertilizers had the greatest impact on the productivity of degraded plants. The effect of this factor equaled 60.78% (Table 5). The conditions of the year had a lesser impact (4.95%). The interaction of factors A and B is insignificant. The influence of organic fertilizers had a selective effect on productivity, which emphasizes the complexity of the interaction of factors affecting the structure and development of biological communities in this ecosystem.

As a result of the field experiments, data were obtained indicating the effect of organic fertilizers on the feed value of naturally degraded pastures. The bio-energetic value, as well as the yield, depended, among other things, on hydrothermal conditions. In 2023, GE accumulation was 26.2% lower than in 2022. In the control variant, this indicator was at the level of 6.9 GJ/ha (Table 6). In all the studied variants, an increase in this indicator was noted in comparison with the control variant. The best results were achieved using micropolydoc plus. The variant produced 13.3 GJ/ha of GE, which exceeds the control values by 1.9 times, or 92.8%. In the variant with Effluent, an increase in GE accumulation was noted by 71.0% and in the variant with BioMIX, by 52.2%.

Table 4: The yield of the phytocenosis of degraded pastures, depending on the treatment with organic fertilizers

No.	Sample	2022	2023	Average	Deviation from st
1	Natural degraded pasture (st)	4.09	3.07	4.03	
2	Effluent	8.03	6.03	7.03	+3.0
3	Micropolydoc plus	9.08	6.07	8.02	+3.9
4	BioMIX	7.01	5.09	6.05	+2.2
	Ffact.	56.78	37.86		
	LSD05	0.92	0.74		

Table 5: The effect of fertilizers and the conditions of the year on the yield of degraded pastures

Variation source	Sum of squares	Degrees of freedom	Variance	Ffact	Ftab095	Influence, %
Factor A	50.56	3	16.85	27.72	3.6	60.78
Factor B	04.12	2	02.06	03.39	4.0	04.95
A and B interaction	00.53	6	00.09	00.15	4.0	00.64

Table 6: Bioenergetic assessment of degraded pastures depending on treatment with bioorganic fertilizers, GJ/ha

		GE accumulation			ME accumulation		
No.	Variants of the experiment	2022	2023	Average	2022	2023	Average
1	Natural degraded pasture	5.9	7.9	6.9	4.3	3.1	3.7
2	Effluent	10.1	13.4	11.8	7.2	5.4	6.3
3	Micropolydoc plus	10.7	15.8	13.3	8.5	5.7	7.1
4	BioMIX	9.4	11.5	10.5	6.2	5.0	5.6
	Average	9.0	12.2	10.6	6.6	4.8	5.7

The highest ME yield per ha was in the variant with micropolydoc plus (7.1 GJ/ha), which is 91.9% higher than the control variant. In the variants with effluent, a 70.3% increase in this indicator was noted and in the variant with BioMIX, it equaled 51.4%.

Discussion

Biological Resource Potential of Natural Degraded Pastures

The geobotanical survey indicates that *F. valesiaca* is the predominant plant in the studied phytocenosis of naturally degraded pastures. This plant is considered typical for steppe and dry steppe zones and is one of the best pasture plants (Fırıncıoğlu *et al*., 2009). It tolerates trampling and active grazing by cattle well. It recovers favorably and has good aftergrass. *A. cristatum* is also of interest as a forage plant for pastures. This plant has an adaptive nature and can grow in conditions of low humidity and high temperatures. Its roots can penetrate the soil deeply, which makes it resistant to periods of drought (Copete *et al*., 2018). Feed-wise, the Lessing feather grass is the best kind of feather grass. It is considered mainly a pasture plant but is also used for haymaking. It is eaten well by animals in early spring. It contains a significant amount of protein and a small amount of fiber (Koshen *et al*., 2020). Due to a certain bio-diversity, these plants are of primary interest in terms of feeding on natural pastures.

In addition, the studied areas are partially represented by ephemeroids. They represent a special ecological group of herbaceous plants characterized by a very short growing season (Abduvasievna, 2020). These plants can respond quickly to changes in the environment, which makes them an important component for maintaining biodiversity in the ecosystem of steppe pastures. Field wormwood can play a role in the phytomelioration of degraded areas (Rachkovskaya and Bragina, 2012) due to its ability to adapt to adverse conditions and resistance to pasture pressure.

The Effect of Bioorganic Fertilizers on Productivity

The use of naturally degraded pastures to restore biological resource potential is a promising strategy for reducing the environmental loads of crop production (Yesmagulova *et al*., 2023). When implementing the principles of organic farming, it is also important to consider natural and climatic conditions (Han *et al*., 2024). Larney and Angers (2012) emphasize the role of various organic fertilizers in the reclamation of degraded lands and strengthening phytocenoses and their resistance to adverse climates. The use of organic fertilizers is one of the effective ways of reclamation of degraded lands (Gafurova and Juliev, 2021; Juliev *et al*., 2022).

In our study, the use of organic fertilizers had a positive effect on the yield (from +2.2 to +3.9 c/ha) and bioenergetic value. Comparing the research results, we confirm the results of the influence of organic preparations on the productivity of phytocenosis. However, the increase in the yield is influenced by climate and weather, the composition of herbage and the species biodiversity of the territory. For example, this is confirmed by the results of the study (Song *et al*., 2019), which indicate an increase in the yield of herbage of easily degraded pastures by 2.05 times and the CP content by 46.32%. Furthermore, the productivity of heavily degraded pastures increased by 1.83 times. The treatment of degraded pastures with biological preparations in combination with N fertilizers contributed to an increase in feed production by 24.7% in Brazil (Hungria *et al*., 2016). Double fertilization of pastures with organic and mineral fertilizers in the steppe of Western Kazakhstan contributed to an increase in the yield by 13.26% (Nasiyev *et al*., 2023b). Fertilizers with bacterial strains enhanced the phytoremediation of the soil. In particular, the removal of up to 85% of hydrocarbons was observed (Hussain *et al*., 2018).

Limitation of the study. First, we were limited in the choice of producers of organic fertilizers (we used those that could be freely purchased in Kazakhstan). Second, the results of the study could be influenced by weather conditions and the species composition of plants. This should be considered by other researchers when interpreting the results of the study.

The prospects of the study are related to the search for further ways to develop agrotechnical and agrobiological methods of restoring pastures.

Conclusion

Species composition is an important factor considered in the restoration and management of degraded pastures. The bluegrass, wormwood and feather grass communities are determined to be dominant.

When restoring the biological resource potential of degraded pastures in the steppe zone of Northern Kazakhstan, it is recommended to use organic fertilizers based on the principles of organic farming. The greatest positive effect was noted when using micropolydoc plus with a working solution rate of 200 L/ha with fractional application.

Our findings reveal that all tested organic fertilizers significantly improved pasture yields over the control. Notably, Micropolydoc Plus produced the highest yield increase, enhancing productivity by approximately 90.7%, which underscores its potential as a highly effective soil amendment under the arid conditions characteristic of the region. Additionally, the application of these fertilizers has shown to improve the bioenergetic value of the pastures, indicating enhanced soil health and sustainability. These results suggest that integrating organic fertilizers into pasture management practices could substantially mitigate the degradation issues prevalent in steppe ecosystems, providing a scalable and environmentally friendly solution for improving pasture productivity and maintaining ecological balance.

The conducted study is of practical importance, as its results can be recommended for farmers, agronomists and livestock workers, as well as government agencies related to the development of agriculture and livestock.

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Author’s Contributions

Rashit Nurgaziyev: Conducted the literature review, drafted sections of the manuscript and validated the results.

Bakyt Irmulatov: Acquired data, drafted the manuscript and critically revised it for significant intellectual content.

Beybit Nasiyev: Conceived and designed the study, drafted the manuscript and interpreted the data.

Aleksandar Simic: Curated data, prepared figures and tables and edited the manuscript.

Nurbolat Zhanatalapov: Supervised the project, managed administration and gave final approval for the manuscript to be published.

Askhat Bekkaliyev: Acquired data and critically revised the manuscript for significant intellectual content.

Madiyar Khiyasov: Analyzed data, interpreted results and made substantial contributions to the methodology.

Toizhan Aidarbekova: Conducted experiments, collected data and performed statistical analysis.

Ethics

This article is original and has not been published elsewhere. The corresponding author confirms that all co-authors have reviewed and approved the final version of the manuscript prior to submission. Additionally, there are no ethical concerns associated with this publication.

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