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Research article

Using irrigated multispecies pasture systems for sustainable horse grazing on degraded lands

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Abstract

Background and Aim. In southern Kazakhstan, pasture degradation and limited natural forage threaten sustainable horse breeding. The development of irrigated multicomponent pastures presents a potential solution. This study aims to evaluate the effectiveness of such pastures and rotational grazing systems in restoring forage productivity on degraded lands.

Materials and Methods. Research was conducted on 192,5 ha of farmland in the Kazygurt district, with 60 ha allocated for irrigated multicomponent pastures. These were seeded with a mixture of alfalfa, melilot, and cereals and divided into four rotational grazing fields. Electric fencing was used to implement a multi-cycle grazing system. Field productivity, grazing duration, and feed availability were monitored from March to December.

Results. The new system doubled forage productivity, producing over 200,000 centners of feed, enough to sustain 70 horses during the grazing season. The approach also improved soil conditions and provided jobs for 25 local workers. The seasonal net income reached approximately 15 million tenge, supported by the production of fermented mare's milk (kumys and saumal) and improved livestock health.

Conclusion. Irrigated multicomponent pastures combined with controlled multicycle grazing can significantly increase forage availability and economic returns. This method supports ecological rehabilitation and offers a scalable model for sustainable pasture use in arid and semi-arid regions.

Keywords: irrigated multicomponent pastures; forage capacity of pastures; multicycle pasture rotation; electric fence.

Introduction

Pastures cover 67% of Kazakhstan's territory. These lands encompassing 184.2 Mha, also significantly influence the ecological state of the republic as a whole. As Karynbaev et al. (2020) discovered, this vast natural pasture zone annually renews free and highly valuable fodder plant products, providing up to 28 Mt of feed units. The condition of these pastures directly impacts ecology and health of the population, as well as the state and development of animal husbandry [1].

Kazakhstan's pastures are characterized by heterogeneous landscapes, resulting in sustainable differences in their sustainable management [2]. For example, approaches suitable for the rational use of pasturelands in steppe, desert, and semi-desert zones are often unsuitable unacceptable for the foothill territory of South Kazakhstan. This region has a higher population density, hilly terrain and local water

sources. Areas of pastures suitable for plowing and irrigation have been converted into arable land. More than 80 percent of livestock are kept in small and medium-sized agricultural operations and private farms. The limited size and low productivity of current pasture territories cannot fully satisfy the need for pasture feed. Opportunities to expand pasture lands through unused lands or transport livestock to remote pastures in the summer are also limited. Currently, the development of horse breeding is gaining significant importance in the agro-industrial complex. Effective use of natural pastures can help reduce animal feeding costs, increase productivity, and improve horse health. However, traditional methods of pasture use often lead to their degradation, necessitating the search for new approaches to managing pasturelands. Land degradation has been and remains a crucial issue for many researchers and organizations involved in the development of mountainous regions. As noted in the review by *Kerven et al* (2012) [3], this is evidenced by the proportion of reports and projects focused on this issue in the total volume of existing project documentation [4]. The rational development of the agricultural sector is a fundamental achievement of economically developed countries; however, this problem has not been fully resolved in developing and post-Soviet countries [5].

The aim of this study was to develop and test effective methods for restoring the productivity of degraded pastures and ensuring sustainable horse grazing by establishing irrigated multicomponent pastures combined with a multicycle grazing system.

Materials and Methods

The article is based on the results of the project "Accelerated Increase of Productivity of Degraded Pastures to Improve the Well-Being of Local Communities," implemented jointly by the Kazakh Research Institute of Animal Husbandry and Feed Production and the Small Grants Program of the United Nations Development Programme in Kazakhstan (GEF) on the territory of "Karasha-Agro" LLP in the Kazygurt District of the Turkestan Region. The seeds of forage crops necessary for creating multicomponent pastures, materials for fencing pastures, and electric fence equipment required for multicycle grazing of horses were provided by GEF. "Karasha-Agro" LLP, using its own funds, carried out all fieldwork in timely manner.

"Kazakh Scientific Research Institute of Animal Husbandry and Forage Production" LLP conducts geobotanical surveys of pasturelands in accordance with the requirements of Article 9 of the RK Law "On Pastures" [6] and the order of the Deputy Prime Minister of the Republic of Kazakhstan – Minister of Agriculture of the Republic of Kazakhstan dated April 24, 2017 No. 173 "On Approval of the Rules for the Rational Use of Pastures" [7]. These surveys determined pasture productivity and carrying capacity, and developed a digital program for calculating actual loads and standards for horses.

The research was conducted on the eastern side of the 70th km of the Shymkent-Tashkent highway in the Kyzylkiya rural district of the Kazygurt district in the Turkestan region, 12 km from the district center of the village of "Kazygurt" and 72 km south of the city of Shymkent, in the irrigation zone of the Ulken Keles canal (Figure 1). The experimental design included four fields with varying initial conditions. Pastures on a neighboring farm managed under traditional practices served as a control. The study complied with the requirements of the Law of the Republic of Kazakhstan 'On Pastures' and Order No. 173 (2017), with mandatory geobotanical and soil surveys. The coordinates of the study area are N 43°21'57", E 69°22'43".

The relief is characterized by a wide strip of sloping plains in the hilly foothills of the Western Tien Shan. The soil is gray-brown carbonate, with humus content ranging from 1,2% to 1,7% depending on the degree of degradation.

The climate in the area is sharply continental, with a mild, short winter that often warms up, and a hot, prolonged summer. The annual precipitation amounts to 400-500 mm, with up to 80% of it falling during the winter-spring period. The grazing period lasts 240-280 days, and the average duration of the frost season is 150-190 days. The snow cover is unstable, and soil freezing occurs only on the surface, which quickly melts with the onset of warm weather. In recent years, a vegetative winter has been observed due to global warming. In this case, pasture plants will continue to grow, albeit slowly, without ceasing to sprout. As a result, the grazing period here is extended in some years, and livestock can be grazed even in the winter months.

Methods included visual sward assessments, yield measurements, laboratory analyses, forage mass calculations, and the use of a digital grazing management program. The selection of perennial legumes (alfalfa, melilot) and cereals for establishing multicomponent pastures was based on their high forage value, ability to form dense swards, improvement of soil structure and fertility through nitrogen fixation, and their resilience to arid climatic conditions combined with responsiveness to irrigation. Laboratory analyses of forage samples revealed that the average crude protein content ranged from approximately 12.4% to 15.1% across pasture fields, with dry matter content between 25.8% and 29.3%. Fiber content (ADF) was estimated at 28-34%, suitable for horse nutrition. These values represent typical ranges for irrigated multispecies pastures under semi-arid conditions and are consistent with published estimates [8, 9]. These results confirm the high nutritional quality of the multispecies forage system.

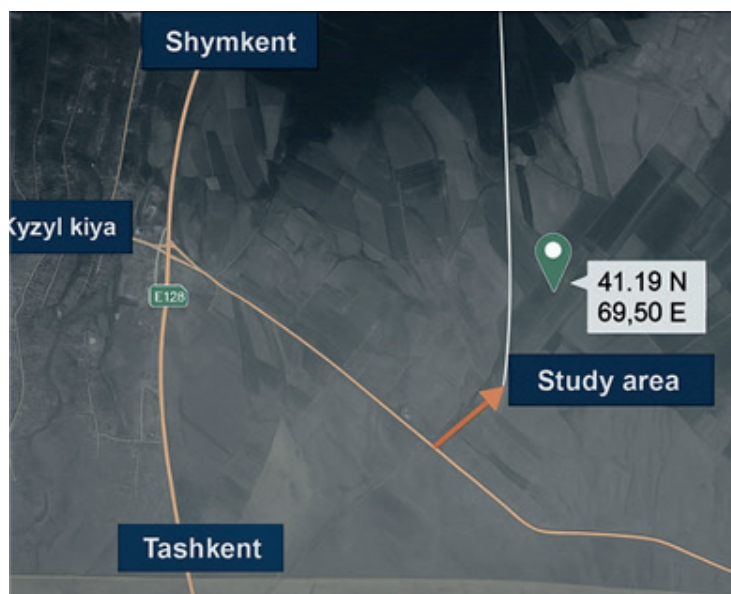


Figure 1 – Location of the study area

To determine irrigation norms for irrigated pastures, the widely used formula by *A.N. Kostyakov* was applied:

$$N = 100 \times \rho \times h \times (FMC - PWP)$$

where N is the irrigation norm (m^3/ha), ρ – bulk density of the soil (g/cm^3), h – soil depth (m), FMC – field moisture capacity (% by weight), and PWP – pre-irrigation moisture (% by weight).

Based on this formula and actual data for light sierozem soils with a bulk density of $1.3 g/cm^3$, irrigation norms were calculated depending on moisture levels. For practical use at "Karasha Agro" LLP pastures, recommended irrigation volumes are presented in Table 1.

Table 1 – Recommended irrigation norms based on soil moisture levels for light sierozem soils (Karasha Agro LLP)

Soil moisture condition	Soil moisture (% of oven-dry weight)	Pre-irrigation soil moisture reserve (m^3/ha)	Irrigation norm (m^3/ha)
Dry	10%	390	1100
Slightly dry	17%	660	830
Moderately moist	19%	740	750
Moist	60%	900	590
Very moist	80%	1200	290
Fully saturated (field capacity)	100%	1490	—

It is important to note that when applying high irrigation rates (above 350 m³/ha) using drum-type sprinkler machines, water runoff or surface pooling may occur, especially on hilly terrain. This can lead to water erosion and negatively impact pasture vegetation. To avoid this, a split irrigation strategy is recommended: two applications of 200–250 m³/ha with a 7-day interval (Figure 2)



Figure 2 – Irrigation using a drum-type sprinkler machine on cultivated pastures

Pressurized water sources, such as the hydrants of the Big Keles Irrigation Massif, are the most suitable for irrigation. Their utilization enables pasture irrigation without the use of pumping equipment, thereby substantially reducing material and financial expenditures and facilitating the production of pasture forage with low production costs.

Results and Discussion

The total area of the land managed by Karasha Agro LLP is 192.5 hectares, including 67.8 hectares of irrigated land and 124.7 hectares of low-productive hayfields and pastures. Due to irregular grazing practices, approximately 50% of these lands have been subjected to plant and soil degradation, with a significant portion of the area impacted by livestock trails. The seasonal pastures currently produce no more than 90,000 kg of feed units, which is sufficient forage for 70 horses for only 112 days. This supply covers just half of the annual feeding requirements of the company's livestock. To rapidly increase the productivity of degraded lands, 60 hectares were allocated for establishing irrigated multicomponent pastures (Figure 3). These areas were divided into four pasture plots based on soil and geobotanical surveys. Each plot was treated and sown according to its specific conditions: the first field was former cropland unused for 8 years, sown after double soil treatment with a heavy disc; the second field had been plowed two years ago and recently used for grazing, and was sown using a chisel seeder without additional soil treatment; the third field was a sloped pasture suitable for irrigation, treated with disc harrows and sown with a chisel seeder to preserve natural grasses; the fourth field was a severely degraded sloped pasture, treated with a disc plow along contour lines to prevent erosion, and then sown with a chisel seeder. Water for these pastures is supplied from the Big Keles Main Canal via underground pipelines, ensuring reliable irrigation.

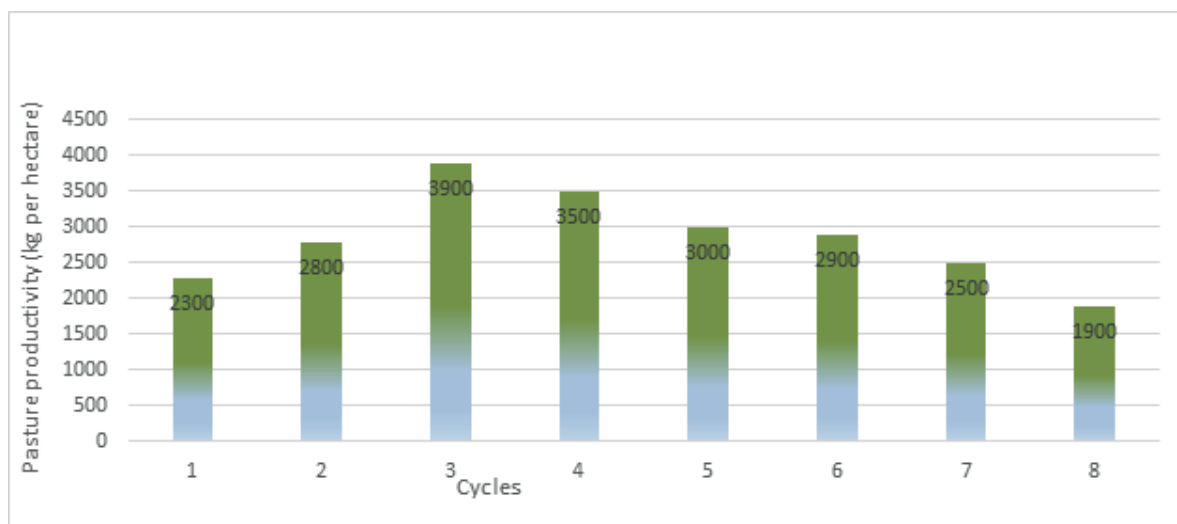


Figure 3 – Dynamics of forage mass production on irrigated pastures

The high-yield forage mass from these pastures enabled the development of a multicycle rotational grazing system using electric fencing (Figure 4a, 4b) Irrigation was applied 8-9 times between April and November through high-pressure drum irrigation systems. This approach provided 2.300-3.900 kg/ha of green mass during various seasons, accumulating over 200,000 kg of feed units across the grazing season.



Figure 4a – Electrified fencing for livestock control

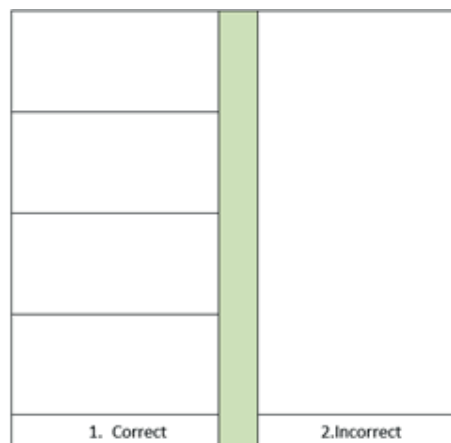


Figure 4b – Layouts of Portable Electric Fencing within the Grazing Paddock

A quantitative grazing program was designed to match seasonal productivity, allowing 70 horses to be grazed for 22-46 days per cycle over eight cycles within a 267-day grazing period. Electric fencing ensured uniform grazing, efficient pasture use, and facilitated animal movement between plots while enabling rest and regrowth phases between cycles (Table 1, Figure 5).



Figure 5 – Irrigated pastures

Table 1 – Quantitative Program for Organizing Multi-Cycle Grazing Rotation

Cycles	60% of gross forage and livestock production per cycle, kg/ha		Feed units obtained per cycle from 60 ha of pasture, kg	Daily feed unit requirement for 70 horses, kg	Standard grazing period on 60 ha of pasture, days	Standard grazing period per 15 ha, days			
			(c*0.25*60)	(0.11*70)	(d/e)				
a	b	c	d	e	f	1	2	3	4
1 st cycle 23.03.-14.04.	2300	1380	20700	770	27	7	6	7	7
2 nd cycle 14.04.-16.05.	2800	1680	25200	770	33	8	8	9	8
3 rd cycle 16.05.-30.06.	3900	2340	35100	770	46	12	11	11	12
4 th cycle 30.06.-09.08.	3500	2100	31500	770	41	10	10	10	11
5 th cycle 09.08.-12.09.	3000	1800	27000	770	35	8	9	9	9
6 th cycle 12.09.-15.10.	2900	1740	26100	770	34	9	9	8	8
7 th cycle 15.10.-12.11.	2500	1500	22500	770	29	7	7	8	7
8 th cycle 12.11.-03.12.	1900	11400	17100	770	22	5	6	6	5
Total			205200		267	67	66	68	67

Descriptive statistics revealed a substantial variation in forage yield across grazing cycles, ranging from 1,900 to 3,900 kg/ha with a mean of $2,850 \pm 641$ kg/ha. Similarly, feed unit availability ranged from 1,140 to 2,340 kg per 60 ha, with an average of $1,710 \pm 385$ kg (Figure 6)

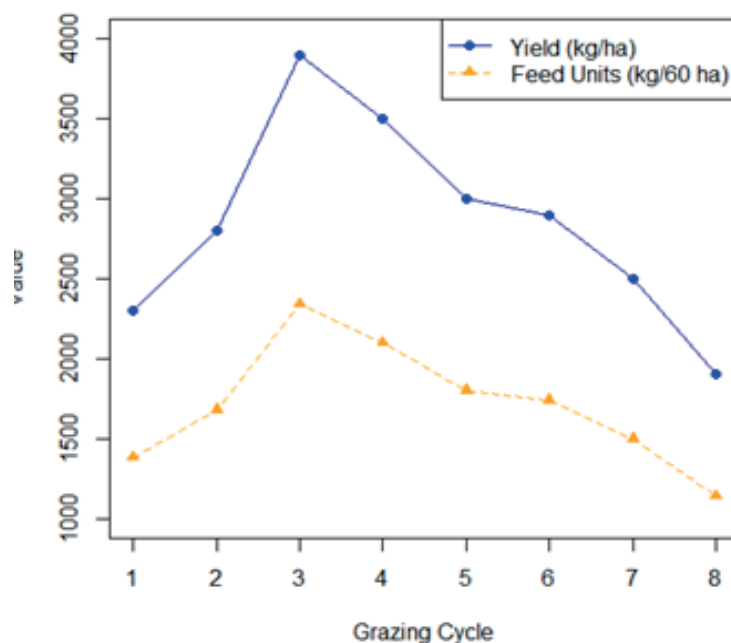


Figure 6 – Seasonal dynamics of forage yield and feed units

In figure 6, forage productivity peaked in the third cycle (mid-May to late June) and declined steadily toward late autumn. This seasonal trend reflects the natural growth pattern of forage crops and their response to climatic conditions. Feed unit availability followed a similar pattern, showing a strong dependence on biomass yield.

A linear regression analysis was conducted to explore the trend in forage yield across grazing cycles. The model suggested a decreasing trend in yield of approximately 92.86 kg/ha per cycle, the relationship was not statistically significant ($p = 0.39$, $R^2 = 0.13$). This indicates that factors other than the grazing cycle number, such as weather conditions or irrigation efficiency, may have influenced yield variability.

In contrast, a Pearson correlation analysis revealed a strong positive linear relationship between forage yield and feed unit production per 60 ha ($r = 1.00$, $p < 0.001$). This strong association confirms the internal consistency of the dataset and supports the use of feed units as a reliable proxy for assessing pasture productivity in the multicycle system.

The system resulted in additional weight gains of up to 50 kg (25 kg of pure meat) per horse and the production of 27,000 liters of saumal from 30 milking mares. The estimated net income from this system reached 15 million tenge per season. Furthermore, the project created 25 jobs related to pasture management and the production of therapeutic dairy products such as kumys and saumal. The approach contributed to soil fertility restoration through nitrogen fixation and improved soil structure. These findings align with international studies that emphasize the ecological and economic benefits of rotational grazing and modern pasture management [10, 11, 12, 13]. In addition, meta-analytical reviews highlight the high productivity of multispecies rotational grazing systems [14]. The integration of digital tools and precision grazing practices corresponds to best practices in sustainable rangeland management [15, 16]. The model supports regional strategies for addressing pasture degradation and improving resilience to climate change impacts, consistent with the recommendations of *Kerven et al.* (2012) [3] and *Tokbergenova et al.* (2018) [5]. The new approaches outlined in this study form the basis for the development of a pasture management and utilization plan for Karasha Agro LLP in the Kazygurt District of Turkestan Region for the years 2021-2022 [17]. Their broad implementation represents a technological breakthrough in pasture use practices in the southern region, contributing to increased livestock production and enabling a twofold increase in income. Future research should focus on long-term soil monitoring, biodiversity impacts, and cost-benefit analyses to enhance understanding of these systems and facilitate broader adoption.

Conclusion

The findings from these extensive studies conclusively indicate that employing contemporary scientific and technological methods in the development and management of multi-component irrigated pastures on degraded lands results in over a twofold enhancement in forage productivity. This technique also enables the establishment of a seasonal feed reserve, essential for the sustainable and long-term advancement of horse breeding in areas with restricted natural grazing supplies. Similar approaches using legume–cereal mixtures have demonstrated significant improvements in pasture productivity in northern Kazakhstan [18].

The incorporation of digital technology, specifically the implementation of the Multicyclic Grazing system, has the potential to improve the agrotechnical industry. This innovative approach corresponds with the goals of the national initiative "Digital Kazakhstan," which seeks to modernize and enhance the efficiency of the nation's economy through digital transformation. This grazing format is characterized by its adaptability and ease of use: it can be stored and accessed on a mobile device, enabling users to precisely ascertain and oversee the standard grazing period in any field location based on real-time conditions and data.

The regulated implementation of electric fence systems, designed based on scientifically established quantitative criteria, guarantees the efficient and recurring (multi-cycle) utilization of irrigated pasture areas. This approach markedly enhances the economic yield from horse breeding by producing a net seasonal income surpassing 215,000 tenge per horse.

Statistical analysis confirmed a consistent pattern of forage production across cycles and revealed a strong correlation ($r = 1.00$) between forage yield and feed unit availability, validating the internal consistency and reliability of the multicycle grazing system.

In conclusion, the implementation of novel techniques for the creation and maintenance of horse pastures enhances the effective and judicious use of natural resources while alleviating ecological stress on vulnerable ecosystems. Simultaneously, these strategies enhance the total productivity and profitability of equine breeding operations. Ongoing scientific inquiry and the customization of pasture management strategies to the unique climatic, soil, and topographical characteristics of various regions are crucial for guaranteeing the enduring success and sustainability of these methods.

Authors' contributions

KK, KSh, and NM: Conceptualized and designed the study. MT, KK: Conducted a comprehensive literature search, analyzed the collected data, and drafted the manuscript. AS, NM: Conducted the literature search and proofread the manuscript. All authors read, reviewed, and approved the final version of the manuscript.

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Тозған жерлерде жылқыларды тұрақты жайылыммен қамтитын суармалы көп компонентті жайылым жүйелерін қолдану

Кушенов К.И., Тастыбай М.Б., Мелдебекова Н.А., Шанбаев К.Б.,
Сейтбатталова А.И.

Түйін

Алғышарттар мен мақсат. Қазақстанның оңтүстігінде жайылымдардың тозуы мен табиғи жайылымдардың жетіспеушілігі жылқы шаруашылығының тұрақты дамуына қауіп төндіруде. Соңғы жылдары суармалы көп компонентті жайылымдарды құру перспективалық шешім ретінде қарастырылуда. Зерттеудің мақсаты – тозған жерлерде жылқылар үшін тиімді жайылымды ұйымдастырудың заманауи тәсілдерін бағалау.

Материалдар мен әдістер. Зерттеу жұмыстары Түркістан облысы Қазығұрт ауданындағы «Караша-Агро» ЖШС 192,5 га жерінде жүргізілді. Оның 60 га жоңышқа, түйежоңышқа және астық дақылдарының қоспалары себілді. Төрт учаскеде жоғары қысымды барабанды суару және электр қоршауларымен көп циклді жайылым жүйесі енгізілді. Бақылау наурыздан желтоқсанға дейін жүргізілді.

Нәтижелер. Көп циклді жайылым және суармалы жайылымдарды қолдану арқылы өнімділік екі есеге артты. Маусым барысында 200 000 кг астам мал азығы өндіріліп, 70 бас жылқы толық қамтылды. Шамамен 15 млн теңге таза пайда алынды. Жердің құнарлылығы жақсарды, 25 жұмыс орны ашылды.

Қорытынды. Көп компонентті суармалы жайылымдар мен ротациялық жайылым жүйесі жайылым өнімділігін арттырып, тұрақты жылқы шаруашылығын қамтамасыз етуге мүмкіндік береді. Бұл тәсіл құрғақ аймақтарда да тиімді және кеңінен қолдануға жарамды.

Кілт сөздер: суармалы көп компонентті жайылымдар; жайылымның малазықтық сыйымдылығы; мультициклді жайылым айналымы; электрленген қоршау.

Использование орошаемых многокомпонентных пастбищных систем для устойчивого выпаса лошадей на деградированных землях

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Аннотация

Предпосылки и цель. Деграляция пастбищ и нехватка естественных угодий являются актуальными проблемами устойчивого коневодства на юге Казахстана. В последние годы перспективным решением стало создание орошаемых многокомпонентных пастбищ. Цель настоящего исследования – оценить эффективность современных методов создания и использования таких пастбищ на деградированных землях для повышения продуктивности кормовых угодий и устойчивого выпаса лошадей.

Материалы и методы. Исследования проводились на территории площадью 192,5 га, принадлежащей ТОО «Караша-Агро» в Казыгуртском районе Туркестанской области. На 60 га деградированных земель были засеяны многокомпонентные смеси люцерны, донника и злаков. Были организованы четыре опытных участка с капельным и барабанным орошением. Система многоциклового выпаса с электроизгородями позволила контролировать нагрузку и периоды восстановления угодий. Наблюдения велись с марта по декабрь.

Результаты. Внедрение многоциклового выпаса и орошаемых пастбищ позволило более чем в два раза увеличить продуктивность. Было получено свыше 200 000 кг кормовых единиц, обеспечено кормление 70 голов лошадей, чистый доход составил около 15 млн тенге за сезон. Улучшилось состояние почвы, создано 25 рабочих мест.

Закключение. Орошаемые многокомпонентные пастбища и ротационный выпас значительно повышают продуктивность и устойчивость пастбищного хозяйства. Этот подход может быть масштабирован и применён в засушливых регионах для экологически устойчивого коневодства.

Ключевые слова: поливные многокомпонентные пастбища; кормовая емкость пастбищ; мультицикловой пастбищный оборот; электроизгородь.