Bulgarian Journal of Agricultural Science, 27 (Suppl. 1) 2021
Agricultural Academy

Succession dynamics, quality, and production in improved and natural pastures in Northern Kazakhstan

Gani Stybayev[1], Nurlan Serekpayev[1], Hristina Yancheva[2], Aliya Baitelenova[3*], Adilbek Nogayev[1], Oktyabr Khurmetbek[1] and Nurbolat Mukhanov[1]

[1]*A.I. Barayev Research and Production Centre for grain farming, 020000 Shortandy, Kazakhstan*
[2]*Agricultural University of Plovdiv, 4000 Plovdiv, Bulgaria*
[3]*S. Seifullin Kazakh AgroTechnical University, Agronomy Faculty, 010000 Nur-Sultan, Kazakhstan*
[*]*Corresponding author:* baitelenova_alya@mail.ru

Abstract

Stybayev, G., Serekpayev, N., Yancheva, H., Baitelenova, A., Nogayev, A., Khurmetbek, O. & Mukhanov, N. (2021). Succession dynamics, quality, and production in improved and natural pastures in Northern Kazakhstan. *Bulg. J. Agric. Sci., 27 (Suppl. 1)*, 95–102

The field experiments were carried out during 2015-2018 in the Akmola region's dry-steppe zone, Northern Kazakhstan. The changes in plant species composition were studied to estimate the dynamics of successions in artificial pastures (AP) and partially artificial pastures (PAP) compared to Controls (natural grassland). All AP and PAP plots in all field experiments showed significant plant composition changes and pasture quality improvement compared to the Controls in two studied years. The succession dynamics were stable over the two years of study in field experiments, with a continual increase in the percentage of *Poaceae* grass species in AP and PAP. The replacement of significant species *Agropyron pectinatum* (M. Bieb.) P. Beauv to *Festuca valesiaca* Schleich. ex Gaudin was observed between AP and PAP in all three field trials. Pastures' biomass production, including fresh and dry weights and post-harvest plant and root remnants, were stable in each field trial over the two years. We concluded that pasture successions develop differently and depend on many factors, including the percentage of plant species and their composition and pastures' ability to recover after plant harvesting or grazing.

Keywords: pastures; succession; plant species composition; motley grass; *Poaceae* species; productivity
Abbreviations: Artificial Pastures (AP); Partially Artificial Pastures (PAP); Average Daily Temperature (ADT); Average Monthly Precipitation (AMP); Fresh Weight (FW); Dry Weight (DW)

Introduction

Pastures play an essential role in agriculture, providing livestock feed, either through grazing or grass cut for hay (Kandalova & Lysanova, 2010; Carboni et al., 2015; Hammouda et al., 2019). Kazakhstan is well suited to pasture production, with 188 million hectares of steppe landscape traditionally used mainly for sheep grazing. However, Kazakhstan's transition to a market economy in the post-Soviet Union era has often led to poor organization and extreme fluctuations in either under-or overgrazing of natural pastures. That refers to non-reversible changes in pasture phytocoenoses – the combined plant community specific to each geographical region. Dynamic successions occur, where some species disappear entirely, and the landscape shifted very quickly (Bazha et al., 2015; Zhang et al., 2017; Wu et al., 2019). Degraded pastures need significant agronomic investments for further recovery before using as regular pastures (Kandalova & Lysanova, 2010; Carboni et al., 2015). Authors from different countries reported the process of pasture successions (Fischer et al., 1989; Kutuzova et al., 2002; Andrade et al., 2008; Kandalova & Lysanova, 2010; Bazha et al., 2015; Zhang et al., 2017; Chen et al., 2019; Hammouda et al., 2019; Lazareva et al., 2020) and concluded that is important to control and optimize the pasture use and process of recovery for each region.

The botanical composition of the best natural pastures in Kazakhstan includes “Motley grass” and Poaceae species. Still, many of them are affected by high salinity, with a typical fresh weight of biomass 0.3-0.5 tons per hectare. Such pastures can also be used from early spring until late autumn for grazing. However, 60-70% of the pasture area in Kazakhstan is located in a semi-desert area with a very arid climate, a third of which have white alkaline soil with a medium to a high-level salinity. Therefore, in many Kazakh natural pastures, *Artemisia vulgaris* L. dominate and is avoided by grazing livestock. In pastures, a healthy stand of perennial grass will resist invasion and reduce this plant’s spread. Disturbed areas should be re-seeded to prevent the spread of absinth wormwood.

However, the strong continental climate with its cold and wet winter and hot and dry summer is not the only factor determining pasture degradation. A much more devastating impact is from incorrect management through the overgrazing of livestock. Additionally, intensive grazing can negatively affect the soil surface with sod hillock formation and waterlog. That makes it difficult for phytocoenosis to recover and results in unpredictable succession development, increasing unwanted sedge species occurrence. Therefore, grazing management optimization is strongly required to achieve pasture recovery with minimal inputs (Bazha et al., 2015).

In Northern Kazakhstan, natural pasture’s potential productivity is relatively low and varies from 0.1 to 0.2 tons per ha of dry biomass. Also, there are severe problems for the Kazakh steppe’s territory’s continual degradation. The degradation due to the complex environment and local ecology and the poor agronomic management is over the last few decades. The recovery and reclamation of degraded natural pastures require a very long process since natural successions develop very slowly (Kandalova & Lysanova, 2010).

The improvements can trigger secondary successions and the recovery of affected pastures in two ways: through either fully - or partially-artificial recultivation by the sowing of new grass seed. Fully-artificial pastures (AP) (Chen et al., 2019) require financial, labor, and time investments for good results. In contrast, partially-artificial pastures (PAP) or semi-natural open habitats (Carboni et al., 2015) needless investment but more delicate works. Both AP and PAP strategies of pasture improvement are used world-wide (Shcherbakov & Kulakov, 2000; Carboni et al., 2015; Chen et al., 2019). They have different effects on novel or existing phytocoenoses, respectively, where sown grass and native plant species have different competition levels. The impact of botanical composition on grassland depends on the nutritive value and yield potential of the invasive species against those of the resident species (Kemp et al., 2001).

In this regard, this study aimed to compare changes in pasture plant composition and productivity in fully- and partially-artificial pastures with natural pastures to understand and better manage the secondary succession processes in pasture phytocoenoses. That can ultimately lead to the increased sustainability of pasture for productivity in the dry steppe zone of Northern Kazakhstan.

Materials and Methods

The field experiments were carried out over 2015-2018 in pastures located 200-300 km apart Akmola region’s dry-steppe zone, Northern Kazakhstan. The three following pasture fields were selected in 2015 from the active pasture Farms: (A) SC Food, Akkol district; (B) Agro-company BaiZher, Tselinograd district; and (C) Agro-company Akmola-Phoenix, Tselinograd district. The pasture field trials were selected based on detailed analyses of the plant species present in phytocoenoses, the environmental conditions, and grass yield following published field methods).

Three types of plots were established in each field trial. Fully-artificial pastures (AP) were prepared after complete recultivation of the soil using tractors with plows to turn-over soil in the field beds. Standard nitrogen fertilizer was applied with an N_{60} ratio. Seeds of four main grass species from local seed producing companies were used: *Agropyron pectinatum* (M. Bieb.) P. Beauv (cultivar Shortandinskaya 2), *Bromus inermis* Leyss (cultivar Limanny), *Festuca valesiaca* Schleich. ex Gaudin (cultivar Nevsky) and *Medicago falcata* L. (cultivar Raikhan). The seeds were sown in late April as a mix, with equal portions of each species and seed rate 18-20 kg per ha, and no further attention was provided.

Partially-artificial pastures (PAP) were prepared in field trials without destroying the existing plant species through manual cultivation of empty patches without plants. The size of recultivated patches varied from 1500 to 5000 m^2. Nitrogen fertilizer, agronomic procedures, seed mix, and sowing time were the same as described for the AP above.

Ungrazed and uncultivated”virgin grassland” plots were used as controls in each of the field trials. Over at least five years, the Controls were neither cultivated nor used for grazing.

Botanical description of plant species and geobotany of plant number and composition

Plant species in pastures were identified and described using a standard procedure (Tomilov, 2001). Plant species were split into three groups depending on their importance and value in pasture quality: (1) *Poaceae* grasses which have the highest quality and nutrients; (2) ”Motley grass” or a mixture of grasses with a moderate or lower level of quality and nutrients; and (3) *Cyperaceae* sedges with the lowest quality and nutrients. The species *Artemisia vulgaris* L. had a particular position in the”Motley grass.” It was isolated as an additional section because the livestock cannot eat these plants due to their high terpenoid content.

Plant cover in pastures

Monitoring of natural pastures, with the determination of plant species composition in experimental plots, was carried out following Ramensky’s methodology. A-frame comprised of a 2 × 5 cm rectangle was used for visual estimation of plant cover in the pasture, and the average percentage from triplicate measurements was calculated in each field plot. The plant cover of the surveyed pasture area had a vegetation coverage of 82.7 (in trial B) to 88.2% (in trial A). The botanical species comprised 65% plants with a top-type canopy and the rest with a lower-type canopy. The surveyed areas of natural pastures can be classified as a mixture of *Poaceae* grass species and ”Motley grass” for both haymaking and grazing use, with an estimated range of fresh-cut grass from 1.9 to 5.3 tons per ha in the growing season under moderate conditions of moisture.

Experimental trial characteristics

In trial A, the soil’s first-meter layer’s productive moisture was 107.1 mm (an average moisture level). In contrast, the arable layer’s soil density was classified as medium-dense, which amounted to 1.14 g/cm^3. Due to the abundance of spring precipitation, the productive moisture in the first-meter layer of soil in trial B was with a higher level of 158.9 mm. In contrast, those in trial C did not differ from the average moisture (108.6 mm).

Soil sampling for agrochemical composition before experiments was carried out with an Izmail borer. Collected samples were dried and sieved for laboratory analysis. Chemical analysis of the soil was conducted in the Center for Agrobiological Research laboratory, and the main characteristics in the soil layers 0-20 and 20-40 cm are shown in Table 1. The dates showed that the top-soil of all studied pastures is dark chestnut and grey alkaline, medium-thick, and low-power soils.

Climate

The climate of the steppe zone of Northern Kazakhstan is dry and continental, with significant variability in precipitation and temperature throughout the summer season over many years. The average temperature recorded during winter 2015-2018 (January and February) was -21.4°C and -15.5°C, respectively (Table 2). During the spring months, the average temperature did not diverge from the average for the season (-8.3°C in March and +4.2°C in April). The precipitation in January was higher than average, 21.6 mm but slightly reduced in February (9.1 mm). The spring precipitation was 37.9 mm in March, 50.5 mm in April, and 35.8 in May (Table 3).

Statistical treatments

An ANOVA test was applied to calculate and analyse means, standard errors, significances, and LSD_{05} using the Snedecor V4 statistical software program (Little, 2005). All experiments were repeated three times (n = 3) for statistical treatments. Significant (P > 0.95) differences (n = 3) are calculated based on the Least significant differences (LSD_{05}) and shown by asterisks (*) compared to Controls for each

Table 2. Average daily temperature (ADT) in winter and spring 2015-2018 compared to the average for many years (°C)

Month	ADT	Field trials		
		A	B	C
January	-15.0	-17.6	-14.8	-16.9
February	-14.7	-13.6	-11.6	-10.3
March	-8.2	-9.1	-7.4	-7.3
April	4.3	3.0	4.8	4.9
May	13.1	9.9	11.0	9.7

Table 3. Average monthly precipitation (AMP) in winter and spring 2015-2018 compared to the average for many years (mm)

Month	AMP	Field trials		
		A	B	C
January	18.3	18.0	15.0	13.0
February	16.9	2.3	7.9	7.9
March	16.9	36.0	36.0	35.3
April	19.9	33.0	51.0	49.7
May	33.8	21.0	35.8	35.5

Table 1. Results of the laboratory soil chemical analysis from Agro-company BaiZher

Layer, mm	Humus, %	P_2O_2, mg/kg	K_2O, mg/kg	N, mg/kg	pH (salt based)	S, mg/kg	Zn, mg/kg	Cu, mg/kg	Mn, mg/kg	Co, mg/kg
0-20	1.98	12.31	483	34.7	7.25	6.5	0.32	0.15	29.6	0.14
20-40	1.16	5.96	331	35.8	7.25	5.25	0.31	0.30	20.2	0.19

group of plant species, in each field trial and each year separately.

Results

Plant species composition and succession dynamic in pastures

The summary results of plant species composition shown in Table 4 for two years of study. The full botanical and taxonomic description of plant species in the 1st year of the analysis is presented in Table 5.

In the first year of study, clear and statistically-significant differences were found in the three groups of plant species in all three trials. In Controls ("virgin grassland"), the grasses of the family *Poaceae* had different percentages. In trial A, the *Poaceae* species were 81.4% and were gradually reduced to 75.8% and 54.6% in trials B and C, respectively. The portions of "Motley grass'" (18.1% - 22.4% - 38.7%) and *Cyperaceae* sedges (0.5% - 1.8% - 6.7%) proportionally increased from trial A to B and C, respectively (Table 4). These native unused plots can be characterized as high, medium, and low levels of pasture quality.

All AP and PAP plots showed significantly increased portions of valuable, highly competitive, and resistant *Poaceae* grasses than the corresponding Controls in all three trials. The exact opposite trend, with a decreasing percentage, was observed for "Motley grass". The exception was found for *Cyperaceae* sedges species, but their portions were low or very low amongst the other pasture plant species. Surprisingly, the comparison between AP and PAP plots did not show statistically significant differences after applying agronomic interventions. *Poaceae* grasses were slightly higher in representation (but not significant) in PAP (96.7%) than in AP (92.9%) in trial A. At the same time, a similar observation with a non-significant difference was observed for PAP (77.0%) compared to AP (72.9%) in trial C. Portions of "Motley grass" also varied insignificantly between AP and PAP plots in all three trials (Table 4). These results indicate a significant impact of agronomic improvements in AP and PAP compared to corresponding Controls. Still, unexpectedly, no significant differences were found between AP and PAP in all studied trials in the first year of the study.

In the second year of study, the dynamics of successions and changes in plant species compositions were not strong, and differences between the two years were non-significant. The pasture quality improvement was significant in increasing the *Poaceae* grasses for AP plots in trial B (from 88.7% to 92.6%) and trial C (from 72.9% to 76.2%) as well as for PAP in trial C (from 77% to 80%) only. For "Motley grass", we found the only significant reductions from 11.3% to 7.4% and 17% to 14.9% for AP in trials B and C, respectively (Table 4). The relatively small changes in plant species indicated slow dynamics in the pasture successions in the first year following agronomic applications. Moreover, the succession dynamics were strongly dependent on the type of studied trials. For example, in trial A, the most substantial plant composition improvement was observed in AP and PAP in the first year of study. This trend was maintained in the second year. The quality of pasture was also improved in trial B during the first year of research, and it continued to

Table 4. Summary results for the composition of three major groups of species indicated as a percentage: *Poaceae* grasses, "Motley grass"and *Cyperaceae* sedges, during the 1st and 2nd study years

Type of grasses	Field trial A			Field trial B			Field trial C		
	AP	PAP	*Con*	AP	PAP	*Con*	AP	PAP	*Con*
Summary of plant species composition in 1st year of study (%)									
Poaceae grasses	92.9*	96.7*	*81.4*	88.7*	88.0*	*75.8*	72.9*	77.0*	*54.6*
LSD_{05}	0.52	0.19	0.53						
Motley grass	7.1*	3.2*	*18.1*	11.3*	11.0*	*22.4*	22.9*	17.0*	*38.7*
LSD_{05}	0.20	0.19	0.52						
Cyperaceae sedges	-	0.1	*0.5*	-	1.0	*1.8*	4.2	6.0	*6.7*
LSD_{05}	0.13	0.18	0.19						
Summary of plant species composition in 2nd year of study (%)									
Poaceae grasses	94.0*	97.1*	*81.8*	92.6*	89.2*	*76.0*	76.2*	80.0*	*56.2*
LSD_{05}	0.19	0.51	0.52						
Motley grass	6.0*	2.8*	*17.7*	7.4*	10.3*	*22.0*	21.3*	14.9*	*37.8*
LSD_{05}	0.21	0.19	0.49						
Cyperaceae sedges	–	0.1	*0.5*	–	0.5	*2.0*	2.5*	5.1	*6.0*
LSD_{05}	0.13	0.17	0.21						

improve in AP in the second year of study.

In contrast, both AP and PAP in trial C showed prolonged significant improvement in both the first and second years of study, increasing the portion of *Poaceae* species that improve pasture quality. The composition of *Poaceae* species in each of three field trials over the three types of plots in the first year of study is presented in Table 5. The dominant grass species was crested wheatgrass, *Agropyron pectinatum (*M. Bieb.) P. Beauv, distributed in Controls as 81.4%, 50.2%, and 48.0% of the total plant species in field trials A, B, and C, respectively, confirming the high, medium, and low-quality level of the original pastures.

The agricultural manipulation in PAP plots did not significantly change the major *Poaceae* species distribution in all three field trials. Simultaneously, the presence of *A. pectinatum* (M. Bieb.) P. Beauv was markedly increased to 93.6%, 62.6%, and 68.5% in field trials A, B, and C, respectively, compared to corresponding Controls.

Dramatic changes in major grass species occurred in all AP plots. *Festuca valesiaca* Schleich. ex Gaudin assumed a leading role over *A. pectinatum* (M. Bieb.) P. Beauv with 86.8%, 78.1%, and 65.9% in three field trials A, B, and C, respectfully. Despite the total proportion of *Poaceae* species remaining unchanged, the replacement of one leading species with another was an important characteristic of AP (Table 5).

Mugwort, *Artemisia vulgaris* L. is an undesirable non-edible plant species that spread rapidly and indicates pasture degradation. It was naturally present in Control plots in A, B, and C field trials at 0.6%, 2.2%, and 6.1%, respectively. The presence of mugwort plants again confirms the high, moderate, and low level of pasture quality in the three studied trials. However, both AP and PAP establishment have very different effects on pasture successions: the percentage of *Artemisia vulgaris* L. in AP and PAP plots was increased up to 1.3-1.2% in high pasture quality field trial A, remained unchanged (2.3-2.2%) in moderate pasture quality trial B, and decreased up to 1.9-1.2% in low pasture quality trial C, respectively. The only case showing a reduction of *Artemisia vulgaris* L. plants in trial C was statistically significant compared to the corresponding Control. In contrast, changes in field trials A and B were non-significant but showed the trend of pasture successions (Table 5).

Sedge plants were grouped and presented a minor portion of Control field trials A and B (0.5% and 1.8%, respectively). Still, they were higher (up to 6.7%) in Control field trials C.

Table 5. Comparative botanical and taxonomic analysis of plant species composition during the 1st year of study in three experimental pasture trials

Plant species	Field trial A			Field trial B			Field trial C		
	AP	PAP	*Con*	AP	PAP	*Con*	AP	PAP	Con
Grass species – *Poaceae* (%)									
Agropyron pectinatum (M. Bieb.) P. Beauv	6.1	93.6	*81.4*	5.0	62.6	*50.2*	5.0	68.5	*48.0*
Bromus inermis Leyss.	–	3.1	–	5.6	25.4	*12.6*	2.0	4.5	*4.5*
Festuca valesiaca Schleich. ex Gaudin	86.8	–	–	78.1	–	*13.0*	65.9	4.0	*2.1*
LSD_{05}	0.19	0.21	0.22						
"Motley grass"- Grasses from different families (%)									
Artemisia vulgaris L.	1.3	1.2	*0.6*	2.3	2.2	*2.2*	1.9	1.2	*6.1*
Chenopodium album L.	0.7	–	*2.0*	0.7	0.1	*2.8*	2.8	4.5	*5.3*
Echium vulgare L.	3.5	–	*1.3*	–	–	–	3.5	–	*1.3*
Filago arvensis L.	–	0.6	–	–	1.1	–	5.5	1.8	*2.0*
Galium verum L.	–	0.5	–	–	–	–	0.5	2.5	*2.0*
Linaria vulgaris Mill.	1.3	–	*12.1*	1.3	–	*10.7*	1.4	1.0	*10.6*
Medicago falcate L.	–	–	–	4.5	3.8	–	–	–	–
Plantago scabra Moench	–	–	–	–	–	–	0.5	1.2	*3.3*
Potentilla recta L.	–	0.9	–	2.2	2.2	*3.5*	4.5	0.9	*5.0*
Sisymbrium officinale (L.) Scop.	0.3	–	*2.1*	0.3	1.6	*3.2*	2.3	3.9	*3.1*
LSD_{05}	0.19	0.21	0.22						
Sedge species – *Cyperaceae* (%)									
Carex sp.	–	0.1	*0.5*	–	1.0	*1.8*	4.2	6.0	*6.7*
LSD_{05}	0.12	0.13	0.19						

Results of AP establishment have changed the pasture successions, accompanied by the disappearance of sedge plants either completely (Field trials A and B) or significantly (Field trial C).

During agronomic manipulations in AP and PAP plots, all or about half of native plants were destroyed, respectively. The pasture phytocoenoses in AP were wholly renewed with artificially-sown plant species. Approximately half of the PAP plot areas remained untouched and only bare patches within each plot were recultivated with new plant species. As a result, PAP plots represent mixtures of native and artificially introduced grass species.

In our presented results (Table 5), the absence of significant differences in plant species composition between AP and PAP was observed and consistent among the three studied field trials (A, B, and C) regardless of the original plant species and pasture quality. These results were confirmed in the second year of the study. The gradual improvement of pasture quality and plant species composition was observed, especially in field trials B and C. Nevertheless, no significant differences between AP and PAP were still recorded in all three field trials, even in the second year of the study. We conclude that agronomists can expect very similar results if they choose either complete or "partial" pastures' recultivation. Perhaps for Kazakhstan and other countries with broad flat expanses of territory, the first strategy of completely recultivating pasture and AP establishment makes economic sense using appropriate heavy tractors and other machinery. Smaller field trials may be restricted for natural reasons. For example, locations between ponds, rivers, forests, hills, and human-made railways, roads, and many other features are more suitable for "partial" cultivation using light agricultural machinery. It will save native habitat and plant species in local pastures. Our presented results indicate that proper grass composition will be similar during the first and second years.

Both AP and PAP use the sowing of new plant species presumed to be valuable pasture grasses. However, every pasture represents a phytocoenosis, with natural competition amongst plants of various species. Successions or dynamic changes in plant species and their composition are unavoidable processes in each pasture, regardless of their native or artificial origin (Kandalova & Lysanova, 2010; Bazha et al., 2015). The agronomist's role includes selecting the optimal strategy to stop and reverse the pasture degradation and support and improve existing pastures (Carboni et al., 2015). Therefore, the composition of new grass species used for pasture improvement could play an essential role due to biological processes in pasture succession development (Chen et al., 2019). Our results showed that the replacement of crested wheatgrass, *Agropyron pectinatum* (M. Bieb.) P. Beauv with *Festuca valesiaca* Schleich. ex Gaudin in all three trials had no significant effect on AP and PAP pasture quality because of the similar nutrients content, but it improved compared to Controls. However, the impact of plant species replacement could be much more dramatic for phytocoenoses and their successions over subsequent years.

In our presented results, the portion of mugwort plants was increased in AP and PAP in field trial A, indicating sub-optimal agronomic procedures for this location and uncontrolled succession development. Reducing mugwort plants in AP and PAP in field trial C could be estimated as a positive step but is still far from the perfect improvement. Sedge plant species have low nutrient value for pasture quality, but our presented results indicate that it is not easy to remove or destroy such plants, even by the second year of study. The sedge plant species' portion remained practically unchanged in PAP of field trial C, indicating that this species can be a strong competitor in pasture phytocoenoses.

Pasture biomass production

Above-ground biomass was collected in all three field trials (A, B, and C) of AP, PAP, and Controls, during the first and second years of the study to estimate pasture biomass production. In a separate experiment, post-harvest plant and root remnants were collected in the same trials and plots during the second year of the study only (Table 6).

The highest FW and DW of plant biomass were observed in AP and PAP in trial B. These results were consistent over two years, with very similar results from plants and roots' remnants after harvest. The field trial C with both AP and PAP was in the second position for biomass production, with approximately 2× higher FW and DW of sampled plants than AP and PAP in field trial A, but only in the first year of study. In the second year of study, we found no significant differences for either FW or DW between the corresponding PAP and AP in field trials A and C. This observation could indicate different dynamics of pasture succession development after complete or "partial" agronomic improvement in other geographic locations over the two years of the study (Table 6).

The pasture quality does not always correlate with biomass production. In our presented results, the highest FW level, DW, and post-harvest plant and root remnants were found in AP and PAP of the field trial B, with moderate pasture quality. Therefore, the optimal composition of new species must be carefully assessed to ensure the best combination of pasture quality and biomass production (Zhang et al., 2017).

The presented results are focused on harvested grasses for animal feed. These results are still applicable for a graz-

Table 6. Fresh weight (FW) and dry weight (DW) of plant biomass and post-harvest plant and root remnants during the 1st and 2nd years of the study in three field trials

	Field trial A			Field trial B			Field trial C		
	AP	PAP	*Con*	AP	PAP	*Con*	AP	PAP	*Con*
Biomass productivity of pastures 1st year (tons/ha)									
FW	1.93*	1.85*	*0.97*	5.36*	4.05*	*1.35*	3.68*	2.15	*2.14*
LSD_{05}	0.021	0.030	0.026						
DW	1.52*	0.67*	*0.38*	2.31*	1.68*	*0.54*	2.49*	1.14	*1.15*
LSD_{05}	0.026	0.020	0.022						
Biomass productivity and post-harvest plant and root remnants in 2nd-year pastures (tons / ha)									
FW	0.78*	1.19*	*0.93*	0.77*	2.75*	*0.90*	0.75*	1.10*	*0.82*
LSD_{05}	0.022	0.021	0.026						
DW	0.44*	0.37*	*0.30*	0.45*	0.84*	*0.28*	0.46*	0.34*	*0.19*
LSD_{05}	0.020	0.021	0.026						
Post-harvest plant and root remnants	5.04*	4.11*	*3.23*	6.28*	4.96*	*4.51*	4.14*	4.20*	*3.70*
LSD_{05}	0.038	0.032	0.035						

ing style of animal feeding. Even, many more components must be into consideration, such as duration and intensity of grazing in pastures, frequency of animal movement, seasonal pasture use (winter in addition to summer), and others (Kandalova & Lysanova, 2010; Carboni et al., 2015; Hammouda et al., 2019). Successions can be changed through plant species composition, the reduction or disappearance of some species, the structure of dominance, pasture quality, and production (Bazha et al., 2015; Zhang et al., 2017). Therefore, a reasonable balance between grazing and recovering processes is required for stable and sustainable pastures production and quality. The results in our current study support this conclusion and are in accordance with other authors (Kandalova & Lysanova, 2010; Zhang et al., 2017; Zhang et al., 2021).

Conclusion

Based on our results, we concluded that pasture successions develop differently and depend on many factors, including the percentage of plant species and their composition and pastures ability to recover after plant harvesting or grazing. We have to continue our research to identify the best management practices that will change plant composition and will improve the productivity and quality of pastures in the dry-steppe zone of Northern Kazakhstan.

Acknowledgments

We thank Yuri Shavrukov and Carly Schramm for their help with manuscript preparation and critical comments. We also thank the staff and students of S. Seifullin Kazakh Agro-Technical University, Nur-Sultan (Kazakhstan), for supporting this research. This research has been supported by the Ministry of Education and Science, Kazakhstan, Research program No AP05131226 “Development of controlled methods for succession processes in pasture phytocoenosis and the improvement of their sustainability and productivity in the semi-arid steppe zone of Northern Kazakhstan” (GS).

References

Andrade, C. M. S. & Valentim, J. F. (2008). Induced plant succession as a strategy to reclaim degraded pastures in the Brazilian Amazon. In: *Proceedings of the XXI International Grassland Congress and the VIII International Rangeland Congress, VolumeI, 726*.

Bazha, S. N., Gunin, P. D., Danzhalova, E. V., Drobyshev, Y. I., Kazantseva, T. I., Ariunbold, E., Myagmarsuren, D., Khadbaatar, S. & Tserenkhand, G. (2015). Invasive successions as the indicator of desertification of dry steppe by way of example of Central Mongolia. *Russian Journal of Biological Invasions, 6 (4),* 223-237. doi:10.1134/S2075111715040025

Behrendt, K. (2015). The value of modeling botanical composition change in grasslands, The 23rd International Grassland Congress. Sustainable use of Grassland Resources for Forage Production, Biodiversity, and Environmental Protection, New Delhi, India, ID: 374.

Carboni, M., Dengler, J., Mantilla-Contreras, J., Venn, S. & Török, P. (2015). Conservation value, management, and restoration of Europe’s semi-natural open landscapes. *Hacquetia 14 (1),* 5-17. doi:10.1515/hack-2015-0017

Chen, F., Xia, H. & Qin, X. J. (2019). Effect of mixture sowing on biomass allocation in the artificially-planted pastures, Southeastern Tibetan. *Journal of Mountain Science, 16 (1),* 54-63. doi:10.1007/s11629-018-5062-7

Dospekhov, B. A. (1979). Methods of field trial study. Moscow, Kolos (Ru).

Fischer, D. (1989). What brings the manure on pasture. *Landw Z.*

Rheinland, 156 (43), 559-560 (Ru).

Hammouda, R. F., Huguenin, J., Julien, L. & Nedjraoui, D. (2019). Impact of agricultural practices and some pastoral uses on vegetation in Algerian steppe rangelands. *Rangeland Journal, 41(2),* 97-107. doi:10.1071/RJ18081

Kandalova, G. T. & Lysanova, G. I. (2010). Rehabilitation of steppe pastures of Khakassia. *Geography and Natural Resources 31 (4),* 356-361. doi:10.1016/j.gnr.2010.11.009

Kemp, D. R. & King, W. M. (2001). Plant competition in pastures - Implications for management. In: Tow PG, Lazenby A (eds) *Competition and succession in pastures*. CABI Publishing, Wallingford, 85-102.

Kutuzova, A. A., Raev, A. P. & Teberdiev, D. M. (2002). Technologies available for recultivating non-used pasture lodes into agricultural pastures. *Pastures and Grass Production, 7*, 14-18 (Ru).

Lazareva, V. G., Bananova, V. A. & Van Zung, N. (2020). Dynamics of modern vegetation for pasture use in the Northwestern Pre-Caspian Region. *Arid Ecosystems*, *10(4),* 276-283.

Little, R. E. (2005). Mechanical reliability improvement. Probability and statistics for experimental testing. Chapter 6. Statistical Analysis of Variance (ANOVA), N.Y.: Marcel Dekker Inc., 231-307.

Maksimova, V. F. & Neronov, V. V. (2013). Impact of anthropogenic factors upon the dynamics of vegetation of the chernozem region in Kalmykia in the second half of the last century. *Proceedings of Moscow State University. Part 5. Geography, 2*, 38-45.

Neronov, V. V. (2006). Dynamics of biological diversity of the degraded arid ecosystems during their natural restoration (after the example of Chernye Zemli, Kalmykia). *Izvestiya Akademii Nauk, Seriya Geograficheskaya, 2*, 111-119 (Ru).

Shcherbakov, M. F., & Kulakov, V. A. (2000). Correct improvement of natural pastures. *Agronomy (Moscow), 1,* 16-17 (Ru).

Tomilov, V. P. (2001). Experimental methods in plant growing. Astana: Agro-Technical University, 106-107 (Ru).

Wu, N., Liu, A., Wang, Y., Li, L., Chao, L., & Liu, G. (2019). An assessment framework for grassland ecosystem health with consideration of natural succession: A case study in Bayinxile, China. *Sustainability*, *11 (4),* 1096. doi:10.3390/su11041096

Zhang, J., Zuo, X., Yang, Y., Yue, X., Zhang, J., Lü, P., Zhou, X., Lian, J., Liu, L. & He, Z. (2017). The response of plant community functional traits in different grasslands to enclosure and grazing in Horqin sandy land. *Transactions of the Chinese Society of Agricultural Engineering, 33 (24),* 261-268 (Ch). doi:10.11975/j.issn.1002-6819.2017.24.034

Zhang, R., Wang, J. & Niu, S. (2021). Toward a sustainable grazing management based on biodiversity and ecosystem multifunctionality in drylands. *Current Opinion in Environmental Sustainability*, *48*, 36-43.

Received: May, 19, 2021; *Accepted:* June, 25, 2021; *Published:* September, 2021