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Current state of *Anabasis salsa* pasture varieties in Karakalpak Ustyurt (Uzbekistan) due to Aral Sea drying

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Abstract

This article is devoted to the study of the current state of 2 pasture varieties of the biyurgun type: *Anabasis salsa* with the participation of *Caroxylon orientale, Artemisia terrae-albae* and *A. kemrudica; A. salsa* with *C. orientale* and *A. terra-albae* and *Convolvulus fruticosus, Lycium ruthenicum, Anabasis brachiata, Nanophyton erinaceum, Nitraria schoberi, Malacocarpus crithmifolius* and *Xylosalsola chiwensis*, with single *Crambe edentula* specimens distributed across the territory of Karakalpak Ustyurt (Uzbekistan) under the influence of Aral Sea drying. The *A. salsa* pasture type occupies a larger area than that occupied by the other pasture types in Karakalpak Ustyurt (2 664 774 ha) and accounts for 36.4% of the total territory, which includes 9 pasture varieties. This type is common on takyr, loamy saline soils and, high-gypsum soils. The area of the studied pasture varieties, soil cover nature, projective cover percentage, landscape plant species, species placement, forage yield and recommended seasonality of use were determined. According to our observations the investigated pasture varieties are recommended for use as autumn-winter pastures.

Keywords

Aral Sea, biodiversity, climate change, desertification, Karakalpak Ustyurt; pasture difference

Introduction

Climate warming leads to changes in the composition, structure and functioning of plant ecosystems, especially in areas where heat and moisture are the limiting factors of vegetation existence (1). Climatic and weather conditions exert a decisive influence on the yield of agricultural crops and their quality, fertilizer efficiency and crop production cost, farm specialization and population density and social status. Additionally, climate change and anthropogenic factors towards aridization accelerate the rate of vegetation degradation and desertification, as well as biodiversity loss.

Pastures represent one of the main sources of the most inexpensive, yet most valuable, green fodder for farm animals. According to the literature (2), the total global pasture area accounts for approximately 26% of the total land area. Depending on the zonal distribution of fodder lands, livestock remain 130-160 days on pastures in the forest zone, 160-200 days in the forest-steppe zone, 180-200 days in the steppe zone, 220-280 days in the semi-desert zone, and almost year round in the tundra and desert zones. On average, pastures in the Republic of Uzbekistan are used for more than half of the year. Pasture grass is the least expensive and most biologically complete food. Green grass contains approximately 10 times more carotene than does hay, in addition to vitamins D, C, E etc. In many countries worldwide, pasture degradation leads to ecosystem destruction, biological diversity depletion and endangerment of vulnerable species. Unfortunately, pasture ecosystem degradation is gaining momentum year after year in Uzbekistan. According to one report, in the steppe pastures of Uzbekistan, the amount of green mass, especially plants with a high nutritional value, is declining (3). The yield of natural pastures is not high. Simultaneously, the decline in the yield of areas of large massifs, such as Kyzylkum, Karnobchul and Karakum, has greatly increased in recent years, a sign of the intensification of the desertification process. In successful rainfall years, only 3-4 centners per ha can be obtained.

The process of desertification is currently one of the most significant global and environmental problems faced by humans and is especially acute in arid territories, which occupy approximately 30% of the total land area. Arid areas worldwide account for approximately 80% of the irrigated land area; 170 million hectares is used for rainfed agriculture, and 3.6 billion hectares is used for pastures (4). According to one report, in Russia, a particularly unfavourable situation has developed in the Lower Volga region and the northwestern Caspian region, while in China, where the largest deserts of Central Asia are located, 80% of the desert land area occurs in the western part (the provinces of Xinjiang, Gansu, Ningxia and Inner Mongolia) (5).

Unfortunately, Uzbekistan also faces the problem of desertification. In Uzbekistan, where the desert natural environment dominates, desertification processes are intensifying at a rapid pace. One of the factors of the deterioration in the ecological conditions in Kyzylkum and the Aral Sea region is the catastrophic impact of Aral Sea drying. The impacts of catastrophic Aral Sea drying and various environmental, anthropogenic and anthropogenic factors significantly drive the transformation of individual components, especially the vegetation cover in the Kyzylkum and Aral Sea desert areas. The development of industry and agriculture and widespread development of natural areas could lead to disruption of the ecological balance. As a result, the risk of deterioration in the species composition of flora and loss of the plant gene pool increases. This phenomenon is especially pronounced in desert areas, where the desertification process is intensifying year after year.

In recent decades, changes in climatic and environmental conditions have occurred in the territory of the Karakalpak part of the Ustyurt Plateau, which are associated with Aral Sea drying and industrial development. The main factors of the economic development of Karakalpak Ustyurt include the chemical and oil and gas industries (6), as well as the most important branch of agriculture, i.e., the transhumance sector, in which a very large number of livestock is maintained year round.

Ustyurt refers to a desert and plateau of the same name in western Central Asia, located between the Aral and Caspian Seas. The territory of the plateau includes the borders of Uzbekistan, Turkmenistan and Kazakhstan, and the territory covers an area of 20 million ha; approximately 35% (7 million ha) of the area is located in the territory of the Republic of Uzbekistan (Karakalpak Ustyurt). The eastern chink is a very large, morphologically rugged, arid rocky desert. The climatic conditions in the eastern chink are characterized by a highly distinct continentality. The Aral Sea, which is situated along the eastern chink, affects its climate. Fog is relatively common here, the air is very humid, and there occurs slightly more precipitation than that occurring in plateau areas, which are vulnerable to climate change with accompanying drought. Due to the decrease in the level of the Aral Sea, the air humidity in the coastal area has decreased. As a result, the eastern chink has dried, and the tendency for the removal of silty, saline particles across the plateau has intensified, and in the territory of the plateau adjacent to the chink, the soil alkalinity has increased. The negative effects of Aral Sea drying on the state of vegetation on the Ustyurt Plateau were described (7-10) and other researchers. It was determined that the initial drying stage of the Aral Sea (1960-1970) negatively contributed to vegetation development and the formation of successional processes.

Recent studies on the productivity of pastures in the deserts of Uzbekistan have demonstrated a notable decrease in plant biomass. This has been primarily attributed to global warming and catastrophic shrinkage of the Aral Sea, which plays an important role in regulating the regional climate. During the period from 1970 to 2020, certain trends were observed in Ustyurt, in which the temperature increased by 20 °C and the average annual precipitation amount decreased by almost 40 mm (11). Considering the intensification of Aral Sea drying, which arose as a result of climate change and the development of industry in the region, the purpose of this study was to assess the current state of pasture varieties of the biyurgun type in Karakalpak Ustyurt.

Materials and Methods

Territory of the study – Karakalpak Ustyurt. The objects of study are 2 pasture varieties belonging to the biyurgun type in Karakalpak Ustyurt: 1. *Anabasis salsa* with the participation of *C. orientale, A. terrae-albae* and *A. kemrudica* on outcrops of gypsum-bearing bedrock with both gentle and steep slopes; 2. *A. salsa* with *C. orientale* and *A. terra-albae* and *C. fruticosus, L. ruthenicum, A. brachiata, N. erinaceum, N. schoberi, M. crithmifolius* and *X. chiwensis*, with single *C. edentula* specimens on gypsum-bearing bedrock in the southern chink.

The *A. salsa* type occupies vast areas on takyr, loamy saline soils and, at some locations, high-gypsum soils in Karakalpak Ustyurt. Within the territory occupied by the *A. salsa* type (2664774 ha), a larger area is occupied than that associated with the other types in Karakalpak Ustyurt. According to the topographic map of the Republic of Uzbekistan (12), more than 60 wells and reservoirs are registered in this area, and at present, most of these wells and reservoirs require reconstruction. Most of these wells are located in the central part of Karakalpak Ustyurt.

Takyr, loamy saline and high-gypsum soils affect the intensive development of *A. salsa*, supporting pasture vegetation with a variegated colour pattern. The *A. salsa* of this series are characterized by a wide distribution of the *A. salsa* association proper, which occupies large areas. Associations involving the participation of other semi-shrubs and shrubs are of subordinate importance in *A. salsa* landscapes. The *A. salsa* in Ustyurt are distinguished by a very poor floristic composition. The general background of pasture areas always depends on *A. salsa*, which is the main pasture plant for camels, sheep, goats and horses under the conditions on the Ustyurt Plateau.

In the study of pasture vegetation, geobotanical descriptions were made in all communities, according to the generally accepted method (13). The projective cover was visually determined (14). Per-kilometre visual recording facilitated the determination of the percentage of the various associations of complexes. These records were required along all routes, especially where the vegetation is subject to slight changes (15).

For each species, the degree of abundance and average height of medium-sized bushes (in cm) were noted. The methods used for species classification, the name of the pasture types and varieties, in addition to, determined productivity levels, and established pasture allotments, were given in accordance with the “Guidelines for Geobotanical Surveys of Natural Forage Lands in Uzbekistan” (16).

The Latin names of the identified plant species were retrieved from Plants of the World Online (17). Photographs of the plant species and plant communities in the field were obtained with digital cameras (Nikon D7500 and Nikon D80). In plant species identification, the "Key to Higher Plants of Karakalpakstan" was used (18).

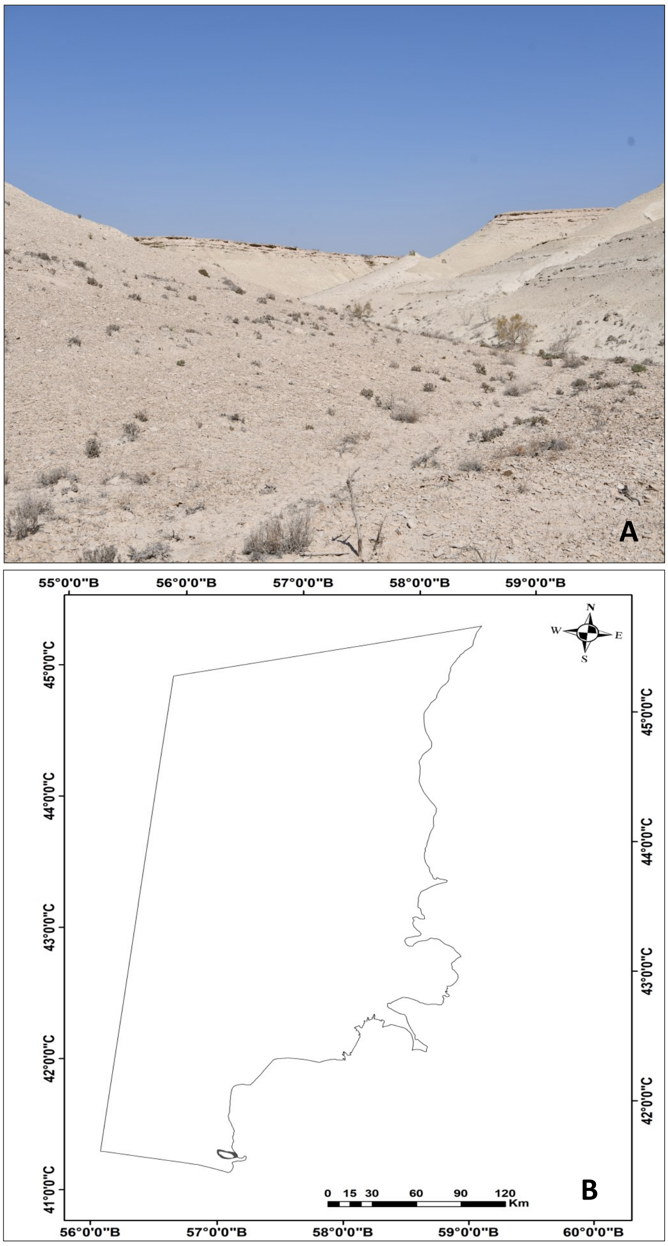

Fig. 1. *Anabasis salsa* pasture difference on outcrops of gypsum-bearing bed rock with gentle and steep slopes (**A**) and the layout of the occupied territory (**B**) (Photo by N. Rakhimova)

Results and Discussion

One of the most environmentally friendly nature management methods is pasture animal husbandry, which plays a very important role in strengthening the forage base, increasing livestock production and reducing the production cost. Moreover, special attention is given in arid zones to desert pastures for the purpose of breeding karakul sheep, goats, and camels – the only expedient and cost-effective way of rationally and economically developing desert territories. However, despite the problem of degradation, the current state of pastures in arid regions has been unsatisfactorily assessed. Livestock production activities, including grazing, could increase the efficiency of economic growth. The ongoing measures and actions in the Republic of Uzbekistan in regard to the development of the astrakhan industry once again verify the need for measures to strengthen the fodder base of livestock pastures, identify degraded pasture areas and increase the productivity in these areas. Researches on the impact of climate change, as well as degradation of vegetation cover, are carried out in different countries (19–21), mainly in the desert regions of Uzbekistan (22–24). Scientifically substantiated practical results are required in assessing the current state of existing pastures for the further development of animal husbandry in the Republic of Uzbekistan. Due to this, in the course of field research from 2020-2021 in Karakalpak Ustyurt, 2 pasture varieties (PV) belonging to the *A. salsa* pasture type were studied. A brief description of these pasture varieties of the *A. salsa* type is provided below.

1. *A. salsa* PV involving the participation of *C. orientale, A. terrae-albae,* and *A. kemrudica* is located in the Kungrad region (geographical point: depression of a dry lake). The area of pasture difference is 4747 ha. The site is confined to gypsum-bearing bedrock on both gentle and steep slopes (Fig. 1 A, B). Fragments of stones are observed on the slightly fractured soil surface.

The total projective cover of this PV is 7%. During vegetation formation, the proportions of *A. salsa*, *C. orientale*, *A. terrae-albae* and *A. kemrudica* are 43%, 28% and

14%, respectively. As shown in this study, one of the characteristic features of the studied PV is a poor floristic composition. The poorness of the floristic composition could be explained by unfavourable conditions, while dryness adversely affected the development of the studied species. The cover is sparse and consists of small *A. salsa* bushes.

In the territory, in addition to *A. salsa*, a very valuable, high-yielding plant with a good fodder quality was observed – *C. orientale*. This plant is a halophilic plant with good fodder properties, high yield of the edible mass and notable resistance to grazing under harsh climatic conditions. Eighty to ninety large *A. salsa* bushes and 25-30 *C. orientale* specimens were observed. In addition, *A. terrae-albae* and *A. kemrudica* were found in small quantities. *Artemisia kemrudica* a differs from other types of *Artemisia* in that the lower stem leaves are very small and its occurrence is a good indicator of the presence high-gypsum and high-clay soils, often containing gravel. Unfortunately, almost all species at the site were poorly developed and the annual increase was insignificant.

Usually, adult pasture animals do not consume poisonous plants. The unpleasant smell or acrid taste of poisonous plants acts as a deterrent. Moreover, grazing was not observed in the study area, and poisonous and weedy species were absent.

The development of sheep breeding largely depends on the combination of economic use and the yield and fodder quality of vegetation. The yield of *A. terra-albae -A. salsa* pastures ranges from 1.0-1.5 c/ha (7). According to our calculations, the productivity of the aboveground mass of this PV largely depends on the development of the monodominant species *A. salsa.* Generative shoots develop only in years with good moisture, when the largest amount of the aboveground mass accumulates. In dry years, small vegetative shoots emerge, which quickly dry. In the current year, the edible proportion of the fodder mass of the *A. salsa* PV is low and ranges from 0.2 to 0.7 c/ha. Moreover, the edible proportion of forage species in autumn and winter is higher (ranging from 20% to 50%) than that in spring and summer and this affects the increase in yield of this PV during these seasons.

2. *A. salsa* PV containing *C. orientale* and *A. terra-albae* with the participation of *C. fruticosus, L. ruthenicum, A. brachiata, N.erinaceum, N. schoberi, M. crithmifolius* and *X. chiwensis*, with single *C. edentula* specimens on gypsum-bearing bedrock in the southern chink, located in the Kungrad region (geographic point: eastern shore of Lake Sarikamysh). The area of pasture difference was 1247 ha (Fig. 2 A, B).

There is no permanent runoff in the territory and only seasonal surface runoff occurs fed by atmospheric precipitation. In early spring and late autumn, large amounts of water usually accumulate in depressions and low places. In addition, Lake Sarikamysh notably influences the climate in the chink. Fog frequently occurs in this area, and the air is very humid. A significant part of the chink consists of limestones in the upper part, gypsum-bearing clays in the lower part, and outcrops of bedrock

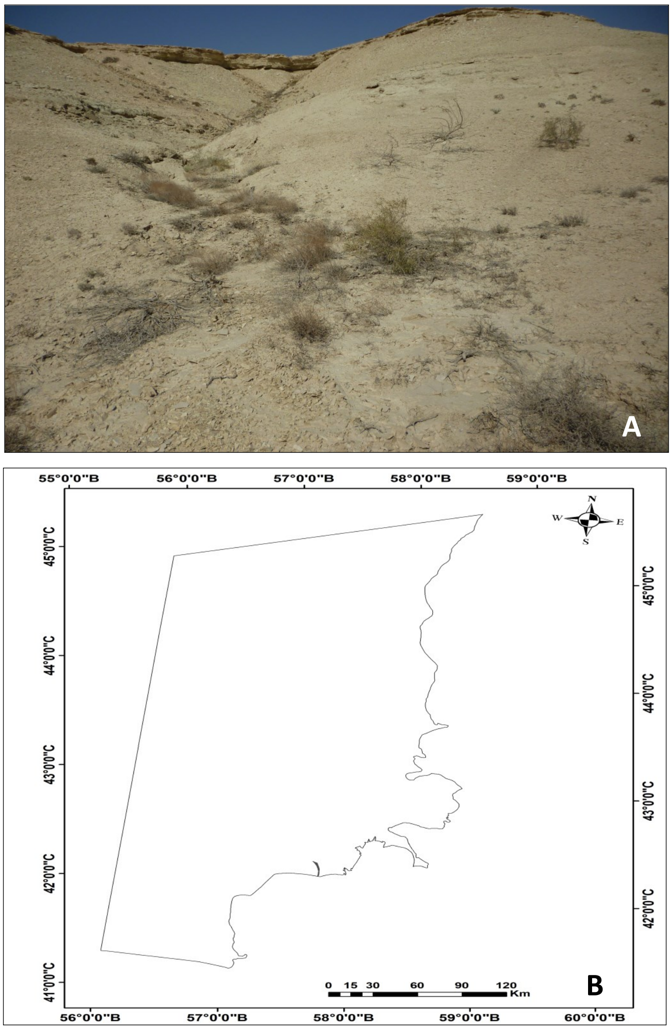

Fig. 2. *Anabasis salsa* pasture variety with *Caroxylon orientale* and *Artemisia terra-albae* with the participation of *Convolvulus fruticosus* on gypsum-bearing bedrock in the southern chink (**A**) and the layout of the occupied territory (**B**) (Photo by N. Rakhimova).

predominate. Very often, low ridges are exposed, and gypsum can be observed at the surface. Between the ridges, there are wide inter-ridge depressions.

The total projective cover of this PV reached 7%. In vegetation monitoring, the share of *A. salsa* was 57%, that of *C. orientale* was 28%, that of *A. terrae-albae* was 14%, and that of *C. fruticosus, L. ruthenicum, A. brachiata, N. erinaceum* and *N. schoberi* each was 7%.

The slopes were sparsely vegetated, mainly including various species: *C. fruticosus, L. ruthenicum, A. salsa, C. orientale, A. terrae-albae, A. brachiata, N. erinaceum* and *N. schoberi* (Table 1). The dominant species, *A. salsa,* was developed along the surface of hillocks. The second most dominant species was *C. orientale* and *A. terrae-albae* fulfilled a significant role. Within an area of 1 ha, 2 large *C. fruticosus* bushes (up to 60 cm tall) were observed on average, in addition to *N. schoberi* (also a shrub) and *L. ruthenicum* (halophyte). Petrophils *(A. brachiata* and *N. erinaceum*) played a major role in the eroded parts of the slopes and tops of the ridges.

In the course of research, a rare plant species for Central Asia was found, known thus far only to occur at a few locations, i.e., a relict species of a monotypic genus – *M. crithmifolius*. This plant typically grows along the slopes of mountain gorges in rock crevices. The distribution of

Table 1. List of species recorded in the studied pasture varieties

№	Plant name	Abundance degree, %	
		Anabasis salsa* with *Caroxylon orientale, Artemisia terrae-albae, A. kemrudica	***Anabasis salsa* with *C. orientale, A. terra-albae* and with the participation of mixed shrubs**
Shrubs			
1	*Convolvulus fruticosus* Pall.	-	+
2	*Lycium ruthenicum* Murray	-	+
3	*Nitraria schoberi* L.	-	+
4	*Malacocarpus crithmifolius* (Retz.) Fisch. & C.A. Mey.	-	+
5	*Limonium suffruticosum* (L.) Kuntze	-	+
Bushes			
6	*Kalidium caspicum* (L.) Ung.-Sternb.	-	+
Sub-shrubs			
7	*Anabasis salsa* (Ledeb.) Benth. ex Volkens	3	4
8	*Xylosalsola chiwensis* (Popov) Akhani & Roalson	-	+
Semi-shrubs			
9	*Artemisia terrae-albae* Krasch.	1	1
10	*Artemisia kemrudica* Krasch.	1	-
11	*Anabasis brachiata* Fisch. & C.A. Mey. ex Kar. & Kir.	-	+
12	*Anabasis eriopoda* (Schrenk) Paulsen	-	+
13	*Caroxylon orientale* (S.G. Gmel.) Tzvelev	2	2
14	*Nanophyton erinaceum* (Pall.) Bunge	-	+
Herbaceous perennials			
15	*Crambe edentula* Fisch. & C.A. Mey. ex Korsh.	-	+

this species is limited and the number of individuals is small. In addition, in deep gorges, according to the Red Data Book of Ustyurt, *X. chiwensis* (endemic of Central Asia) was found, which typically grows on limestone and gypsum outcrops in the southern chink, as well as dried single specimens of a rare species – *C. edentula*. Due to indiscriminate grazing of pasture grass, which includes poisonous plants, hungry animals are more likely to be poisoned than are well-fed animals. Moreover, no poisonous or weed species were noted in the vegetation composition in the study area.

The seasonal palatability of plants largely depends on various factors, particularly on the floristic richness of a given pasture area. According to the fodder yield of *A. salsa* with *C. orientale, A. terrae-albae* pastures ranges from 5.7–6.2 c/ha (25). Depending on the meteorological conditions throughout the year, a high PV productivity can be observed in autumn (0.9 c/ha), and at this time, many species reach their maximum growth level. Due to the low value of the established edible mass of certain forage species, the PV yield in spring and summer can range from 0.2–0.4 c/ha (Table 2).

Table 2. Productivity of the fodder mass (by seasons) of the studied pasture varieties

Pasture difference	Seasonal yield (c/ha)			
	spring	summer	autumn	winter
Anabasis salsa with *Caroxylon orientale, Artemisia terra-albae* and *A. kemrudica*	0.2	0.3	0.7	0.7
Anabasis salsa involving *Caroxylon orientale* and *A. terra-albae* with the participation of mixed shrubs	0.2	0.4	0.9	0.8

Conclusion

Thus, due to unfavourable weather conditions, low precipitation, notable dryness and late spring occurrence, a significant decrease in species composition of the vegetation cover was observed. The northern part of Karakalpak Ustyurt can be represented by a very homogeneous landscape across a vast area. The vegetation composition remains homogenous due to *C. orientale*, *A. salsa* and *A. terrae-albae* complexes. Owing to a lack of moisture available to the dominant species *(A. salsa, A. terrae-albae,* and *C. orientale),* low annual growth (up to 1 cm) was noted, and these species occurred in a constrained state. Consequently, the productivity of these pasture varieties, as revealed in recent years, differed markedly from data obtained by local researchers in the 1970s. The seasonal yield of the fodder mass of the first PV ranged from 0.2 to 0.7 c/ha, while that of the second PV ranged from 0.2 to 0.9 c/ha. According to estimates of the yield of the edible part (c/ha), the studied PV are recommended for use as autumn-winter pastures.

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Authors contributions

NKR did field research, studied common methods. TR established pasture allotments. JSS determined the seasonal yields and created schemes for the border of pasture differences. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors do not have any conflicts of interest to declare.

Ethical issues: None.

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