Elimination of the consequences of pasture digression in the desert-steppe zone with the help of phytomelioration

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Abstract. The state of pasturelands within the borders of the Volgograd, Astrakhan regions and the Republic of Kalmykia, where the scale of degraded and unproductive land increases every year, is considered. At the moment, the area of degraded and unproductive farmland is 6819.6 thousand hectares. In particular, 2249.0 thousand hectares are subject to erosion, 88.8 thousand hectares to deflation, 4.7 thousand hectares to the combined manifestation of erosion and deflation. Unproductive saline lands are in the region of 1459.3 thousand hectares. The area of land with salt complexes reaches 2517.6 thousand hectares. Pastures are most at risk. Their productivity is 1-8 c / ha of dry weight, depending on the type of soil, the degree of its salinity, the mode of use, the stage of the process of desertification. The possibilities of practical use of phytomeliorants for improving the land reclamation status and restoring the fertility of zonal soils of the semi-desert-steppe zone of southern Russia are considered. Phytomeliorated forage lands are effectively used, produce stably, become zootechnically comfortable and provide an increase in the number of animals.

1. Introduction

The territory within the borders of the Volgograd, Astrakhan regions and the Republic of Kalmykia is part of the Subboreal Belt, including the steppe zone, the zone of dry steppes and the semi-desert zone. Harsh climatic conditions, low soil productivity and sparse vegetation cover characterize the region.

Degradation, i.e. deterioration of soil quality as a result of anthropogenic and natural factors leading to partial loss of accumulated organic substances by the soil, reduces the ability of the soil to perform resource and environmental functions. One of the signs of degradation is desertification. The most important factor in the desertification of the territory under consideration is a significant increase in the area of secondary saline soils.

There is practically no unsalted land here, and over the past 10 years, their areas have only increased. Soil salinization is a serious environmental problem, the reason for which is the close location of saline groundwater to the earth's surface, which through a system of capillaries moves salts to the upper layers of the soil. Most plants cannot grow in conditions of salinization of the soil, as the increased salt content negatively affects the root system, plant growth slows down, they give a low yield. In this regard, the identification of the possibility of phytomelioration of saline soils to varying degrees is of great scientific and practical importance. Often, several processes that lead to the
degradation of the soil and vegetation cover (salinization, deflation, erosion) occur simultaneously on the same territory. The region has 6819.6 thousand hectares of degraded and unproductive farmland, including 2249.0 thousand hectares degraded due to erosion, 88.8 thousand hectares of deflation, and 4.7 thousand hectares of combined erosion and deflation; unproductive saline 1459.3 thousand hectares; with salt complexes 2517.6 thousand hectares; waterlogged 222.6 thousand hectares; swampy 12.4 thousand hectares; stony 265.2 thousand hectares. Especially severe desertification is characteristic of sands and soils of sandy loam granulometric composition, and open sand massifs make up 20.5% of the total area of the region (319 thousand hectares) [1].

Pastures are most at risk, their productivity ranges from 1-3 to 7-8 kg/ha of dry weight depending on soil type, degree of salinity, usage, stages of the process of desertification. In a desolate area, the physical properties of the soil deteriorate, vegetation dies, the productivity of phytocenoses decreases, ground water is salinized, and the ability of the ecosystem to regenerate itself is disrupted. Degraded agrocenoses recover independently and reach a state that allows them to be used as pastures and hayfields only within 10-15 years [2, 3].

Phytomelioration of semi-desert-steppe communities (fixing the sands with grasses, semi-shrubs and woody plants, improving grasslands by substituting grasses, creating grasses, etc.) is one of the methods for restoring the agro-resource potential and improving the functioning of degraded lands with the help of herbaceous or woody vegetation. The efficiency of phytomelioration increases with the formation of an interacting ecosystem that uses the energy resources of plant phytomass throughout the agro-landscape territory. In arid semi-desert and steppe areas, phytomeliorative measures are more effective the larger the territory they cover [4-6].

The modern condition for increasing the sustainability of pasture nature management is the optimal selection of species for mono- and multicomponent crops, taking into account the manifestation of desertification. In this regard, an urgent task is to develop significant measures aimed at increasing the yield of mono- and multicomponent crops of forage grasses and the quality of forage in the zone of dry steppes and semi-deserts.

2. Materials and methods
The studies were carried out according to the generally accepted methods of field experience. The possibilities of practical use of phytomeliorants for improving the land reclamation status and restoring the fertility of zonal soils of the semi-desert-steppe zone of southern Russia are considered. The experiments were carried out on light chestnut soils of the Astrakhan region. The terrain is flat. The dependence of the ratio of digestible protein and feed units in dry phytomass (g / kg) on the percentage of components of grass mixtures has been established. The share of phytomass of various species in grass mixtures (60% Fabaceae and 55% Poaceae; 75% Fabaceae and 40% Poaceae) was considered. Species of the family Fabaceae: Medicago falcata L., Trifolium repens L. Species of the family: Dactylis glomerata L., Festuca beckeri (Hack.) Trautv. Simulation of grazing of animals on pasture areas was carried out, where the shoot-forming ability and height of regrowth of the species Ceratoides papposa Botsch were determined.

3. Results and Discussion
To create cultural pastures in the desert-steppe zone, natural forage lands are used by surface or radical improvement. The fundamental improvement involves the creation of long-term artificial grass mixtures of different seasons of use on pastures with highly degraded vegetation, littered with weeds and poisonous species. In pastures, with the implementation of a radical improvement, the yield of grass stands increases 2-3 times compared to natural communities.

Soil salinization is a serious environmental problem, the reason for which is the close location of saline groundwater to the earth’s surface, which through a system of capillaries moves salts to the upper layers of the soil. Most plants cannot grow in conditions of salinization of the soil, as the increased salt content negatively affects the root system, plant growth slows down, they give a low yield. Radical improvement of pasture lands and restoration of saline soil fertility is possible with the
help of halophytes that can tolerate high levels of salinity (*Suaeda araucata* Bunge, *Suaeda Acuminata* (C. A. Mey.) Moq., *Atriplex cana* S. A. Mey., *Chenopodium album* L., *Salicornia europaea* L., *Kochia scoparia* L. Schrad., *Glycyrrhiza glabra* L., *Glycyrrhiza uralensis* Fisch., *Artemisia halophila* Krasch. and other types). *Medicago x varia* Martyn, *Agropyron cristatum* L. Beauv. subsp. pectinatum (Bieb.) Tzvel., *Elthytrigia elongata* (Host) Nevski) [7].

Surface improvement is carried out in areas with sparse grass up to 50-60%. When sowing, perennial species are used, which helps to increase the soil fertility and its anti-erosion resistance. As a result, the rate of desertification decreases. The creation of highly productive pastures on degraded lands of the desert-steppe zone provides replenishment of zonal soils with organic matter of roots and stubble up to 1.5-2.0 t / ha per year.

When creating multicomponent phytocenoses lands the spring-summer period of use the optimal ratio is as follows: shrubs – 60%, herb – 40%; for the pastures of the autumn-winter period of use: shrubs – 85% grass – 15% and year-round pasture shrubs – 75% grass – 25%.

For the soil and climatic conditions of the south of Russia, we recommend adapted multicomponent crops of herbs from the family *Chenopodiaceae* (Ceratooides papposa Botsch., *Camphorosma monspeliaca* L.), *Poaceae* (*Agropyron pectiniforme* Roem. Et Schult., *Agropyron desertorum* (Fisch. ex Link) Schult., *Psathyrostachys juncea* (Fisch.) Nevski), and other local species of natural and cultural flora. In the region, mixtures of *Medicago falcata* L. (a species of the *Fabaceae* family) with two or three species of the *Poaceae* family have proven themselves well.

When growing joint species of *Fabaceae* and *Poaceae*, the accumulation of phytomass and the removal of salts from the arable horizon occur with an increasing effect over the years. Due to the accumulation of organic matter, the energy potential of the soil increases, which increases the water resistance of soil aggregates. An increase in the root saturation of the soil contributes to an increase in gas exchange, an improvement in the water-air regime and the maintenance of optimal clumpiness of the soil. Soil decompression has a positive effect on the moisture capacity, water permeability and water lifting capacity of the soil.

Semi-shrubs and grasses form a high yield of the feed mass eaten from the second year of life and increase it within 4-8 years. Long-term cereal and legume agroecoses form 65% of the crop before July with a period of productive longevity of 4-6 years; semi-shrub communities reach the maximum yield during the summer-autumn period with a period of productive longevity of 16 years or more. The agrophytocenoses created from introduced semi-shrubs and grasses accumulate the highest stock of feed mass consumed and exceed the yield of natural pastures several times. The costs for the rehabilitation of severely desertified grassland is complex phytomeliorative pay for feed for 4-5 years.

We studied multicomponent crops of herbs from the *Poaceae* and *Fabaceae* families: *Medicago falcata* L., *Trifolium repens* L., *Dactylis glomerata* L., *Festuca beckeri* (Hack.) Trautv. It was found that grasses sharply reduce washout and runoff, increase the humus horizon, and improve the permeability of heavy soils. Soil washout from the area sown with perennial species is much less than from the area occupied by annual species. Herbs accumulate in the soil 8-13 t / ha of dry roots, which contain 83-181 kg of nitrogen, 48-75 kg of phosphorus and 82-149 kg of potassium. This can be compared with the introduction of ammonium nitrate into the soil at a dose of 237-517 kg, double superphosphate at a dose of 96-150 kg and potassium salt at a dose of 182-331 kg / ha. The total amount of acids in the biomass of the herbs of the *Fabaceae* family reached 128-132 g / kg. The total amount of acids in the biomass of herbs of the *Poaceae* family is 48-50 g / kg. In multicomponent crops of herbs of the families *Poaceae* and *Fabaceae*, the total amount of acids was 65-72 g / kg.

The optimal ratio of energy to protein in the animal diet is 10-12 g of digestible protein per 1 MJ of energy. The most optimal value of this ratio is observed in mixtures of one or two species of the *Poaceae* family and two species of *Fabaceae* (table 1).

The protein content in the mixtures is influenced by the species composition of the mixtures, the number of cuttings, the percentage of components. With an increase in the amount of protein in plants, fiber decreases and, conversely, with a decrease in the amount of protein, the amount of fiber increases. Plants have the least fiber in the early stages of development (tiller, branching). By
autumn-winter, the amount of fiber in plants increases to 40%.

Multicomponent sowing of herbs of the Poaceae and Fabaceae families is a powerful means of restoring the soil structure, increasing agronomically valuable particles, and protecting the soil from water and wind erosion. It is possible to plan the harvest of grasses and increase the content of digestible protein in feed with the help of cultivation techniques, which include tillage methods, options for pre-sowing seed treatment, methods, rates and timing of sowing, mineral nutrition, irrigation regime, crop care and harvesting.

**Table 1.** Content of digestible protein and feed units in dry phytomass (g / kg) of grass mixtures depending on the percentage of components

| The composition of the mixture | Species ratio, % | Feed units | Digestible protein | Digestible protein / Feed units |
|-------------------------------|-----------------|------------|-------------------|-------------------------------|
|                               | 60* + 55**      | 75* + 40** | 60* + 75* + 55**  | 60* + 75* + 40**              |
| 1 species of the family *Fabaceae* + 1 species of the family *Poaceae* | 0.52           | 0.53       | 83                | 95                            | 160                           | 180                           |
| 2 species of the family *Fabaceae* + 1 species of the family *Poaceae* | 0.53           | 0.53       | 96                | 112                           | 181                           | 211                           |
| 1 species of the family *Fabaceae* + 2 species of the family *Poaceae* | 0.48           | 0.48       | 63                | 70                            | 131                           | 146                           |
| 2 species of the family *Fabaceae* + 2 species of the family *Poaceae* | 0.57           | 0.58       | 96                | 110                           | 168                           | 188                           |

Note: * species of the family *Fabaceae*; ** species of the family *Poaceae*.

The assessment of the potential of plants, taking into account their reaction to the properties of the soil, allows us to predict the productivity of phytocenes, to develop measures for the phytomelioration of saline pastures. Since the areas of saline pastures are increasing every year in order to improve the quality of pasture feed and expand the range of phytomeliorated land, it is necessary to exclude halodisperse species that lead to increased soil salinity.

Phytocenes from mixtures of plants with the participation of semi-shrubs and grasses are 1.5-2.0 times more productive than monopowings, more stable in culture, provide a nutritionally balanced feed and better use the ecological reserves of moisture, nutrients, etc.

On saline lands, it is recommended to grow species of the *Chenopodiaceae* family. They occupy a dominant or subdominating position in phytocenes, are well-suited for breeding and are suitable for rapid restoration of pastures. *Chenopodiaceae* are mainly xerophytes and classical halophytes, living in conditions of extreme dryness and extreme salinity of the soil. The exception is considered weed and ruderal species. The introduction of species of the *Chenopodiaceae* family into the communities is justified by their resistance to chloride salinization (up to 0.7-0.8% Cl). Their use makes it possible to increase the feed capacity to 1400-2000 feed units / ha, and to increase the load on 1 ha of pastures to 5-6 heads. At the same time, the ecological situation of pastures (as a habitat for animals and native vegetation) is significantly stabilized.

When modeling grazing on the grassland of *Ceratoides papposa* Botsch. in winter, the advantage of the option with the alienation of the aboveground mass at a height of up to 0.30 m is established (table 2).

To assess the ability of seed and vegetative renewal after the alienation of phytomass, the number of vegetative and generative shoots was taken into account (table 3).

The largest phytomass is formed after the first year of alienation, both on the control and on all variants. From the second year, the growth of phytomass decreases by 15-30%. An important advantage after rejuvenating pruning is the availability of annual shoots for grazing. With complete alienation, 40% more phytomass is formed than with control and partial alienation.
Table 2. Growth height of *Ceratoides papposa* Botsch. in grazing simulation, m

| Years             | Without alienation of phytomass (control), m | Alienation of phytomass from a height, m |
|-------------------|---------------------------------------------|------------------------------------------|
|                   | 0.25-0.30                                   | 0.15-0.25                                | 0.00-0.05                                |
| 1st year of regrowth | 1.15                                        | 0.63                                     | 0.48                                     | 0.32                                     |
| 2nd year of regrowth | 1.26                                        | 1.38                                     | 1.29                                     | 0.97                                     |

Table 3. Increase (+) and decrease (-) in the raw edible mass of *Ceratoides papposa* Botsch., gram / bush

| Variants                              | 1st year of regrowth after alienation | 2nd year of regrowth after alienation | % change in phytomass |
|---------------------------------------|---------------------------------------|---------------------------------------|-----------------------|
| Without alienation of phytomass       | 124.80                                | 108.11                                | -13.4                 |
| (control), m                          |                                       |                                       |                       |
| Alienation of phytomass from a height  | 137.75                                | 103.11                                | -25.1                 |
| of 0.25-0.30 m                        |                                       |                                       |                       |
| Alienation of phytomass from a height  | 135.66                                | 112.73                                | -16.9                 |
| of 0.15-0.25 m                        |                                       |                                       |                       |
| Alienation of phytomass from a height  | 162.00                                | 142.92                                | -11.8                 |
| of 0.00-0.05 m                        |                                       |                                       |                       |
| Calculation of the least-significant  | 15.07                                 | 11.08                                 | -                      |
| difference for control (L-SD)         |                                       |                                       |                       |

When studying the shoot-forming ability, it was revealed that vegetative shoots predominate, which form the main phytomass and form the habit of the bush, table 4.

Table 4. Shoot-forming capacity of *Ceratoides papposa* Botsch., pieces

| Variants                              | plot 1                                      | plot 2                                      | % of generative shoots |
|---------------------------------------|---------------------------------------------|---------------------------------------------|------------------------|
|                                      | 1st year of regrowth after alienation | 2nd year of regrowth after alienation | Average for the 1st year of regrowth |                      |
| generative shoots                     | Without alienation of phytomass (control), m | 20                                           | 19                     | 17                     | 19.5                   | 55.6                  |
| vegetative shoots                     | 35                                          | 35                                          | 35                     | 35                     | 35.5                   |                       |
|                                     | Alienation of phytomass from a height of 0.25-0.30 m | 21                                           | 21                     | 21                     | 21.5                   | 47.4                  |
| generative shoots                     | 39                                          | 39                                          | 39                     | 39                     | 39.0                   |                       |
| vegetative shoots                     | Alienation of phytomass from a height of 0.15-0.25 m | 15                                           | 15                     | 15                     | 15.5                   | 28                    |
|                                     | Alienation of phytomass from a height of 0.00-0.05 m | 15                                           | 15                     | 15                     | 15.0                   |                       |
| generative shoots                     | 48                                          | 48                                          | 48                     | 48                     | 48.0                   |                       |
| vegetative shoots                     | 51                                          | 51                                          | 51                     | 51                     | 51.0                   |                       |

4. Conclusion
The increasing rate of desertification of arid pastures, reflecting the impact of degradation factors, leads to the need to eliminate the consequences of pasture digression and wind erosion, including
through the implementation of phytomeliorative technologies. The phytomelioration of semidesert-steppe pastures is a necessary impulse to restore the ability of disturbed ecosystems to regenerate themselves.

Since natural coenotic full-member phytocenoses have stable and self-regulating properties, the phytomeliorative designs of agroecosystems should be based on zonal typical natural phytomeliorants. To increase the productivity of pastures, it is important to select and introduce into the culture plants that are resistant to extreme environmental conditions of the region (drought -, salt - and frost-resistant, etc.).

Multicomponent phytocenoses with the participation of shrubs and grasses of the Chenopodiaceae, Fabaceae and Poaceae families are promising, which are 2-3 times more productive than single crops, are more stable in culture, provide nutritionally balanced feed and better use ecological reserves of moisture and nutrients. For the practical use of phytomelioration of saline pastures, passive phytomeliorants are recommended, which do not affect the migration of salts in the soil, as well as accumulating phytomeliorants, which can be used to brine the upper soil horizons and increase biodiversity.

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