Agrobiological method of phytomelioration of degraded pastures using the cuttings of calligonum aphyllum and roll coulisses

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Abstract. Natural pastures, which occupy about 80% of the territory of the Republic of Kalmykia of the Russian Federation, are the basis of the fodder base for animal husbandry. Intensive and irrational exploitation of pastures disrupted the existing ecological balance and led to desertification of the territory. The most negative processes of land degradation were manifested in the Black Lands in the form of anthropogenic desertification. Such processes of anthropogenic desertification take place not only in the North-West Caspian Region of the Russian Federation, but also in a number of developing countries of the world. These regions located in the arid zone are in great need of realizing the potential of their land and plant resources. The experiments were carried out on sandy massifs on the territory of the Yashkul region of the Republic of Kalmykia of the Russian Federation. Accounting and observations were carried out according to the methods of All-Union Scientific Research Institute of fodder named after V.R. Williams and of All-Union Instruction for Geobotanical Research of Natural Foraging Sites and Compilation of Large-scale Geobotanical Maps. The method proposed by us is aimed at solving the problems of combating desertification, anthropogenic degradation of pastures by creating mechanical barriers for the movement of sands at the initial stage of growth and rooting of Calligonum aphyllum seedlings. The use of this technique has significantly increased the survival rate of Calligonum aphyllum seedlings (from 30 to 70%), and thus, in general, improve the effectiveness of phytomeliorative work.

1. Introduction
Natural pastures, which occupy about 80% of the territory of the Republic of Kalmykia of the Russian Federation, are the basis of the fodder base for animal husbandry (Gol’dvarg and Tsagan-Mandzhiev, 2010). Intensive and irrational exploitation of pastures disrupted the existing ecological balance and led to desertification of the territory. The most negative processes of land degradation were manifested in the Black Lands in the form of anthropogenic desertification. More than 500 thousand hectares of pasture land have been turned into open swept sandy massifs. Such processes of anthropogenic desertification take place not only in the North-West Caspian Region of the Russian Federation, but
also in a number of developing countries of the world. These regions located in the arid zone are in great need of realizing the potential of their land and plant resources (Drenge and Willis, 1983; Peoples and Johnson, 1983; Le Houeron, 1985; Rhoades et al., 1992; Kaur et al., 2002).

One of the most important areas of arid fodder production is the development and further improvement of methods for biological reclamation of degraded pastures and open sands with the aim of subsequently involving these lands in agricultural circulation (Gol'dvarg and Tsagan-Mandzhiev, 2010; Kosolapov et al., 2014).

When securing open sands on the Black Lands, such plants as Calligonum aphyllum, Eurotia ceratoaides, and Leymus racemosus have proved to be the best (Tsagan-Mandzhiev et al., 2016). In order to create full-fledged forage lands, valuable forage plants (Agropyron, Vitex agnus-castus, Camphorosma, etc.) are introduced into the inter coulisses spaces of the plants mentioned above (Thomas, 1989; Yanov and Eviev, 2015; Eviev et al., 2016).

Despite the positive results obtained to improve degraded pastures, many methods need to be improved.

2. Materials and methods
The experiments were carried out on sandy massifs, fixed by methods of phytomelioration by planting Calligonum aphyllum on the territory of the Yashkul region of the Republic of Kalmykia of the Russian Federation. Accounting and observations were carried out according to the methods of All-Union Scientific Research Institute of fodder named after V.R. Williams (1971, 1974, 1987) and of All-Union Instruction for Geobotanical Research of Natural Foraging Sites and Compilation of Large-scale Geobotanical Maps (1984).

3. Results and discussions
Phytomelioration as a way to combat desertification was first used in the Kalmyk steppes in the mid-eighties of the last century. At that time, the technologies developed by the Chernozemelsky experimental station of the Kalmyk Research Institute of Meat Cattle Breeding and the Kalmyk Branch of the All-Union Scientific Research Institute of caracul sheep breeding were used. Typical technologies that were proposed by agrarian science made it possible to achieve a fairly good effect (Tsagan-Mandzhiev and Nozhkina, 2006; Tsagan-Mandzhiev 2003, 2010).

In 1986, by the decision of the Government of the Russian Federation, the General Scheme for combating the desertification of the Black Lands and Kizlyar pastures was developed, which was given the status of a regional environmental program (Gol'dvarg, 2017).

The practical implementation of the General Scheme with permanent scientific support allowed the production enterprises performing a unique job in terms of scale and conditions of work - suppressing the avalanche-like (up to 60 thousand hectares per year) by methods of complex phytomelioration, and thereby preventing the total degradation of the natural forage lands of the region. On the degraded fodder lands, highly productive pastures were formed. The annual volumes of work on phytomelioration of fodder land and fixation of open sands in 1990-1993 were 90-100 thousand hectares (Table 1). The restored pastures were full-fledged multicomponent agrocenoses with a phytomass yield of 14-20 centners per hectare.

Currently, the measures to prevent desertification of pastures are carried out within the framework of the Federal Targeted Program for the Development of Land Reclamation of Agricultural Land in Russia for 2014-2020.

Annual volumes of phytomeliorative works on fixing open sands are planned on an area of 10 thousand hectares. The fulfillment of the planned volumes of phytomeliorative works allows ensuring a stable social and ecological situation in the region.

The task of continuing the active struggle against desertification is relevant to this day. Recently, new realities and problems have emerged, such as reforming land relations and changing the forms of ownership of land.
Table 1. Volume of phytomeliorative work performed in the region of Black lands and Kizlyar pastures in 1986-2001, thousand hectares

| Years | Republic of Kalmykia | Republic of Dagestan | Astrakhan region | Total    |
|-------|----------------------|----------------------|------------------|----------|
| 1986  | 7.8                  | 4.2                  | 1.1              | 13.1     |
| 1987  | 12.7                 | 7.1                  | 7.6              | 27.4     |
| 1988  | 25.2                 | 11.5                 | 12.2             | 48.9     |
| 1989  | 46.4                 | 9.1                  | 14.2             | 69.7     |
| 1990  | 45.8                 | 31.7                 | 21.6             | 99.1     |
| 1991  | 77.5                 | 6.6                  | 9.5              | 93.6     |
| 1992  | 84.2                 | 4.8                  | 7.3              | 96.3     |
| 1993  | 76.0                 | 11.3                 | 13.7             | 101.0    |
| 1994  | 50.5                 | 11.7                 | 6.1              | 68.3     |
| 1995  | 27.0                 | 5.0                  | 3.7              | 35.7     |
| 1996  | 5.4                  | 3.6                  | 1.0              | 10.0     |
| 1997  | 9.1                  | 4.8                  | 0.1              | 14.0     |
| 1998  | 1.7                  | 1.2                  | -                | 2.9      |
| 1999  | 13.1                 | 2.4                  | 1.4              | 17.0     |
| 2000  | 6.3                  | 1.2                  | 1.0              | 8.5      |
| 2001  | 4.6                  | 2.6                  | 1.4              | 8.6      |
| Total | 493.3                | 118.8                | 98.1             | 710.2    |

Over time, some elements of technologies for phytomeliorative work have undergone various changes and improvements. They are being improved to the present day. The method proposed by us is one of the stages of the continued improvement of phytomelioration technologies.

The most famous and proven solution to the problem of combating desertification is the gradual planting of Avena strigosa, Eurotia ceratoides and Calligonum aphyllum, and under their protection, the sowing of Kochia prostrate, Agropyrum sibiricum and Artemisia absinthium (Yanov and Eviev, 2016).

However, a significant drawback of this method of sand consolidation in comparison with the method we propose is a rather low percentage of plant survival due to falling asleep (burial) by sand, or exposure of the root system, and as a result, a significant loss of seedlings.

With this method, there is a great dependence on the wind regime during the planting season. The method proposed by us, this lack essentially excludes.

The tasks for which the proposed method is aimed at is combating desertification, anthropogenic degradation of pastures and creating mechanical barriers for the movement of sands. As a result, an increase in the efficiency of phytomeliorative work is achieved. This is facilitated by the use of roll coulisses of reed ordinary (Phragmites communis) on open sand massifs.

The technical solution of the problem is achieved by the fact that the work is carried out on open sands with the use of Calligonum aphyllum as a sand-retaining culture followed by sowing of Kochia prostrata and Agropyrum sibiricum under the protection of the coulisses of reeds. Large cuttings of Calligonum aphyllum are planted with soot along the axes of the ribbons, then in order to protect the cuttings of Calligonum aphyllum from sanding, we use coulisses laid along the rows and secured from drifting by wire with wire pins.

Depending on the optimal timing of work in winter, the preparation of the soil for planting seedlings of Calligonum aphyllum is carried out in the autumn, in September-October. When performing the work, the following technical parameters are observed: tillage is carried out to a depth of 35-40 cm with strips of width 1.4 m, and the distance between the axes of the ribbons is 5 m.
Further in the same time frame the following technological operations are carried out:

- Preparation of seedlings of Calligonum aphyllum for planting. In this case, pruning and trimming of the trunks at the base, and processing of the lower internodes in the manure-earth slurry are carried out.
- Planting cuttings. The MTZ-80 with SL4-1 unit is used for this technological operation. Large cuttings of Calligonum aphyllum are planted on the axes of the ribbons. Further, in order to protect Calligonum aphyllum seedlings from sanding, roll coulisses laid on the surface of the soil along the rows and secured from drift by wire pins are used. The innovative use of cheap roll coulisses from reed can be used as a mechanical barrier to the wind, will reduce wind speed, prevent sand from falling asleep, and protect their root system, which will reduce the death of cuttings of Calligonum aphyllum. During the planting, workers level the cuttings; control the optimal placement in the soil, the work is done mechanically. For the creation of pastures, in future years in the territories protected from sand by means of roll coulisses and plantings of Calligonum aphyllum, it is planned to introduce arid fodder plants, including Kochia prostrata and Agropyrum sibiricum in the grass stand.

- The economic effect (result) is achieved due to:
  - increasing the survival rate of Calligonum aphyllum seedlings from 40% to 75%;
  - vegetation of fodder crops, preserved on the pastures adjacent to the foci of desertification, as a result of protection against falling asleep by sand;
  - the stability of multi-component pastures in comparison with degraded lands on which the process of overgrowing occurs naturally;
  - additional livestock products obtained by increasing the productivity of fodder land through agro-biological phytomelioration.

4. Conclusion

All technological methods used in phytomelioration are mainly aimed at reducing the harmful effects of the extremely unfavorable climatic factors inherent in the semi-desert zone on the cultivated plants. A sharply continental climate with hot dry summers and a cold, little snowy winter, frequent dry winds combined with low rainfall prevent the achievement of high results in combating desertification. The tasks to solve the invention are to combat desertification of lands, anthropogenic degradation of pastures by creating additional mechanical barriers for the movement of barchan (dune) sands.

The technical result is an increase in the efficiency of phytomeliorative works carried out using roll coulisses of reed ordinary (Phragmites communis) and Calligonum aphyllum on open sand massifs.

The use of roll coulisses of reed ordinary (Phragmites communis) on open sand massifs, where the cuttings of Calligonum aphyllum are planted, contribute to the creation of a more gentle wind regime. Thus, coulisses protect young plants from blowing and falling asleep with sand, ensuring a high plant survival rate.

The innovation of the proposed invention consists in the use of cheap roll coulisses from reed ordinary, which serve as a mechanical barrier to the wind, can reduce wind speed, prevent sand from falling asleep plants, protect their root system, and reduce the likelihood of death of planted cuttings of Calligonum aphyllum.

The use of this technique has significantly increased the survival rate of Calligonum aphyllum seedlings (from 30 to 70%), and thus, in general, improve the effectiveness of phytomeliorative work.

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Conflict of Interest
The authors have no conflict of interest to declare.

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