Optimum Number of Herbage Mix Components for Pastures in the Cryolithic Zone Near the Amga River Used for Haymaking and Grazing

N E Pavlov¹, A Z Platonova², N N Storozheva³

¹Department of Agronomy, Oktem branch of the Federal State Budgetary Educational Institution of Higher Education Arctic State Agrotechnological University, Republic of Sakha (Yakutia), Khangalassky ulus Moiseev lane 16, p. Oktemtsy and 678013, Russia
²Department of Agronomy, Oktem branch of the Federal State Budgetary Educational Institution of Higher Education Arctic State Agrotechnological University, Republic of Sakha (Yakutia), Khangalassky ulus Moiseev lane 16, p. Oktemtsy and 678013, Russia
³Department of Agronomy, Oktem branch of the Federal State Budgetary Educational Institution of Higher Education Arctic State Agrotechnological University, Republic of Sakha (Yakutia), Khangalassky ulus Moiseev lane 16, p. Oktemtsy and 678013, Russia

E-mail: agafya.platonova.2016@mail.ru

Abstract. This article presents the results of multiyear work on the establishment of the optimum number of herbage mix components in the cryomorphic alluvial soils of the Amga river. The authors provide recommendations on seeding rates and times for herbage mixes. They present the data on the dynamics of herbage yields. Herbage yield changes across the experiment options depending on the age of the herbage mix, vegetation periods, and the hydrothermal index. The authors recommend using the agroecological components of herbage mixes with the drought-tolerant crop of the Manchaary variety of psathyrostachys juncea. The authors establish the options that are guaranteed to produce 128-140 dt/ha of herbage on average without watering. Irrespective of the weather conditions during the research years, herbage mixes showed a weak negative correlation between the yields of herbages of different ages and the hydrothermal indices over the research years. In 4 and 5-component herbage mixes, the correlation coefficient shows an explicit negative correlation. This signifies that the Manchaary variety is a good choice for future forage grass mixes. The research mainly focused on recognized varieties of forage grasses. The conducted research showed that the Manchaary variety is sustainable and can be used over a long time both on its own or as part of complex herbage mixes of up to 5 components.

1. Introduction

Yakutia experiences problems with forage conservation every year. Natural communities of meadows and hayfields are relatively resilient against zoogenic and anthropogenic impacts. Following the recommendations of the All-Russian Williams Fodder Research Institute, producers should 3-6
components in herbage mixes (Kutuzova A.A., et al. 1994). To form artificial meadows and pastures for long and productive usage, herbage mixes must include grasses that would complement one another without competition in the same community and have different life-forms, phenological rhythm, and response to weather conditions. We developed herbage mixes containing the drought-tolerant crop of the Manchaary variety of psathyrostachys juncea and tried combining it with such forage grasses as awnless brome, Siberian wheatgrass, sickle lucern, and yellow melilot.

2. Relevance
Multiyear research showed that forage grasses are best suited for grassing-down during the short vegetation season in Yakutia. To form hayfields and grazing lands, grasses are sown in summer [1-8, 10-26]. The composition of herbage mixes for the risk farming zone is studied by the Yakutian Agricultural Research Institute and the Institute for the Biological Problems of the Cryolithic Zone of the Siberian Branch of RAS. There are some recommendations concerning the development of herbage mixes for the cryolithic zone [6,26]. Agriculture in Yakutia mainly focuses on ranching. Forage conservation here attracts the close attention of agricultural producers and the authorities of the Republic of Sakha (Yakutia). Thus, selecting herbage mix components is a relevant problem nowadays [6,7,26,27]. The study of the composition and the number of components of herbage mixes used in the agricultural sector of the region is in demand these days. That is why we tried to determine the optimum number of herbage mix components and the specific components to be used. We focused on the hayfield and grazing land herbage mixes to be used in the cryolithic zone of the Amga river.

3. Research goal and objectives
The key goal of the research is to determine the best herbage mix composition for hayfields and grazing lands. Research objectives included the development of forage grass herbage mix compositions for multiyear use in the cryolithic zone of the Amga river.

4. Research conditions and methods
Soil and weather conditions in central Yakutia
According to M.K. Gavrilova, Central Yakutia differs from European Russia by greater atmosphere transparency due to lower humidity and dust load in the air. The yearly average atmosphere transparency coefficient is 0.81. For St. Petersburg, it is 0.79. In June, the sun rises at 3 a.m. and sets at 10 p.m. Daytime on June 21 (summer solstice) is 19 hours 46 minutes. The sum of effective temperatures above 10°C is quite significant: 1300-1600°C on average. The climate of Central Yakutia is sharply continental. The yearly amplitude of summer and winter temperatures is 102°C.

5. Soil parameters of the experimental grounds
To accomplish the goals and objectives set, we conducted research based on multi-year experience. The experimental grounds were located on the left bank of the Amga river. The terrain of the field was even. The plot selected is typical for the region. It has a heterogeneous soil cover, which provided the accuracy of results. The soil in the experimental plot is cryogenic, chernozem, meadow, and saline. These soil types were formed under insufficient moisture conditions in the terraces above the flood plains of the Amga river. According to the mechanical characteristics, the soil is middle-loamy, with an alkaline soil solution reaction of pH 8.3. The quality of salinity: weak hydrocarbonate salinization and severe chloride-sulfate salinization. The availability of active forms of phosphorus and potassium is medium. The content of humus in the plowing horizon is high: between 5.3 and 8.6%. We can see that the soil of the selected plot is fertile. However, yields are unstable here because of the low precipitation levels.

5.1. Research methods
Field experiments and biometric observations and monitoring were carried out using the guidelines of VID (1979, 1985) and the All-Russian Horse-Breeding Research Institute (1985). The mathematical
treatment of research results was performed following B.A. Dospekhov using the SNEDECOR and Microsoft Office Excel 2007 software packages. The weather conditions in the research years are characterized by extremely cold winters (with temperatures up to -57°C in Central Yakutia) and more favorable conditions during the vegetation period.

During the multiyear experiment, we calculated the hydrothermal index (hereinafter referred to as the HTI) for integrity purposes for 10-day periods when the average air temperatures were above 10°C. Overall, the HTI for 1995-1999 varied between 0.34 and 1.15. There were two dry years: 1995 (HTI of 0.58) and 1996 (HTI of 0.54), and one very dry year, 1998 (HTI of 0.34). Two more years were humid: 1997 (HTI of 1.15) and 1999 (HTI of 0.77)

Experiment arrangements: Option 1 – reference (the Manchaary variety of psathyrostachys juncea); Option 2 (the Manchaary variety of psathyrostachys juncea+sickle lucern, Yakutian Yellow variety); Option 3 (the Manchaary variety of psathyrostachys juncea+sickle lucern, Yakutian Yellow variety+awnless brome, Ammachaan variety+Siberian wheatgrass, Kamalinsky variety No. 7); Option 4 (the Manchaary variety of psathyrostachys juncea+sickle lucern, Yakutian Yellow variety+awnless brome, Ammachaan variety + Siberian wheatgrass, Kamalinsky variety No. 7+ melilot, Alasovsky variety). The total area of the research grounds is 360 m². The field germination rate of the seeds of varieties in question after long storage was 82% for grasses and 75% for legumes.

6. Practical relevance
The authors suggest technology for the development of an optimal herbage mix using energy-saving agricultural techniques. This will help reduce herbage costs. Summer planting helps increase the yields of complex herbage mixes (3 perennial grass species and 2 legumes) up to 48=62%. The herbage yield of a 5-component mix increases by 3-5th year of dry-farming by 1.5-1.6 times compared to the yields of the reference plot of psathyrostachys juncea. Over 5 years, up to 128.5-140.8 dt/ha of herbage is generated on average. This figure for the reference plot is 86.5 dt/ha without watering.

6.1. Suggestions for producers
1. To eliminate as many weeds as possible from future herbage mixes, it is necessary to use sown (oats) or black fallow in the field for 2 years.
2. To produce herbage mixes with lower cauline-leaf grasses of the Manchaary variety, it is recommended to use mesophytic varieties sown in summer like the Ammachaan variety of awnless brome, the Kamalinsky No. 7 variety of Siberian wheatgrass, the Yakutian Yellow variety of sickle lucern, and the Alasovsky variety of yellow melilot
3. To obtain stable high herbage yields, we used the following seeding rate for the five-component herbage mix: 20 kg/ha for perennial grasses and 6 kg/ha for legumes. Alternatively, the composition per 1 unit can be expressed as follows: 0.28 of psathyrostachys, 0.08 of lucern, 0.28 of awnless brome, 0.28 of wheatgrass, and 0.08 of melilot.

6.2. Experiment results
The results of the experiment show that the winter hardiness of the herbage is good. The productive longevity of the 5-component herbage mix is 5 years or more. During the first research years, the highest yields were observed in Option 4 (up to 196 dt/ha, while the reference option was 67.1 dt/ha). The yield of a two-component mix with the Manchaary variety is up to 139.6 dt/ha. In the dry year of 1996, herbage yields of all options were reduced by 2 times. High grasses like the awnless brome and the Siberian wheatgrass facilitate a significant increase of herbage yield up to 124-182 dt/ha by the third and fourth year of the herbage mix life cycle. The herbage yields of the reference option show its great adaptation capabilities during the humid year with the HTI of 1.15 as its yields increased up to 93.5 dt/ha. This is 2.0 times higher than during the second year of the herbage life cycle (39.7 dt/ha). By the fifth year of the life cycle, herbage yields reduce compared to the 1st year. The yield of the four-component mix reduces up to 115.5 dt/ha, that of the five-component mix up to 118.2 dt/ha, and
that of the two-component mix up to 83.1 dt/ha. The reference option (single-crop sowing of the Manchaary variety of psathyrostachys juncea) remains at 93.3 dt/ha. (Table 1, Figure 1).

**Table 1.** The impact of the herbage mix composition and herbage age on the production of herbage by the hayfield and grazing land herbage mixes to be used in the cryolithic zone of the Amga river, dt/ha.

| Option | Herbage year | First | Second | Third | Fourth | Fifth |
|--------|--------------|-------|--------|-------|--------|-------|
| 1      | 67.1         | 39.7  | 93.5   | 139   | 93.3   |
| 2      | 139.6        | 49.2  | 49.7   | 54.6  | 83.1   |
| 3      | 161.5        | 54.6  | 129.3  | 182   | 115.5  |
| 4      | 196.4        | 83.1  | 124.7  | 182   | 118.2  |

**Figure 1.** Herbage yields depending on herbage mix components and age over 5 years of vegetation in the cryolithic zone of the Amga river.

A total of 432.6 dt/ha of the Manchaary variety of psathyrostachys juncea was produced over 5 years. Complex herbage mixes containing high grasses produced up to 642.9-704.4 dt/ha of herbage. The average herbage yield for 5 years is 86.5 dt/ha for the reference option, and 75.2-140.8 dt/ha for other options. The analysis of surplus in experimental options showed that options 3 and 4 produced
the highest gains. The average gain produced by the four-component herbage mix over 5 years is 48.6%, which is 1.5 times higher than the reference. The five-component mix also produced herbage yield gains (54.36 dt/ha or 162.8% of the reference). (Table 2).

**Table 2.** The impact of the herbage mix composition and herbage age on the production of herbage by the hayfield and grazing land herbage mixes to be used in the cryolithic zone of the Amga river.

| Option | Total for 5 years | Average for 5 years | ± of the reference | Over the reference, times |
|--------|-----------------|---------------------|--------------------|--------------------------|
| 1      | 432.6           | 86.52               |                    |                          |
| 2      | 376.2           | 75.24               | -11.28             | 86.96                    |
| 3      | 642.9           | 128.58              | 42.06              | 1.5                      |
| 4      | 704.4           | 140.88              | 54.36              | 1.6                      |

We studied the impact of the HTI on the herbage yield with respect to the herbage mix age to determine the correlation coefficient. This indicator showed a weak negative correlation of -0.2 on average across different options. We established that the single-crop sowing of the Manchaary variety of *psathyrostachys juncea* has a weak negative correlation of \( r = -0.1 \) with the age of the herbage. With the addition of high grasses (awnless brome and Siberian wheatgrass) and forage legumes, the correlation coefficient reduced up to 0.4, which means that this herbage mix composition is the best one for hayfields and grazing lands in the cryolithic zone of the Amga river. (Table 3).

**Table 3.** The correlations between the herbage mix composition and herbage age on the production of herbage by the hayfield and grazing land herbage mixes to be used in the cryolithic zone of the Amga river.

| Option | 1       | 2       | 3       | 4       | Medium   |
|--------|---------|---------|---------|---------|----------|
| Correlation rate | -0.1   | -0.15  | -0.2   | -0.4   | -0.2    |

7. **Conclusion**

The research shows that the optimum number of herbage mix components for pastures in the cryolithic zone near the Amga river is 4 or 5. The 4-component mix contains 3 forage grass species and one legume (the Yakutian Yellow variety of sickle lucern). The 5-component mix contains 3 forage grass species and 2 forage legumes. The Manchaary variety of *psathyrostachys juncea* is complemented by 2 forage grass species: the Ammachaan variety of awnless brome and the Kamalinsky 7 variety of Siberian wheatgrass, as well as 2 forage legumes (the Yakutian Yellow variety of sickle lucern, and the Alasovsky variety of yellow melilot). The plants were sown in summer in the cryolithic zone on the left bank of the Amga river, and in the Khangalassky district of Central Yakutia.

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