Study and evaluation of varieties of non-traditional forage crops in the conditions of the cryolithozone

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Abstract. In the Republic of Sakha (Yakutia), where the main focus of agriculture is animal husbandry, there is a problem of providing cattle with high-quality feed. Currently, the productivity of natural hayfields in Yakutia, due to their irrational use, has decreased from 1.5-1.7 t/ha of hay in the 50s and 60s of the last century to 0.5-0.7 t/ha. Traditional annual and perennial forage crops do not provide the full amount of dry and juicy feed needed. In this regard, research has been conducted on the permafrost floodplain soils of Yakutia to study and search for varieties of non-traditional forage crops that would guarantee a high annual yield of forage mass. The varieties of mogara Altaysky 23, common millet Barnaulskoye 98, Barnaulskoye 18 and Africanskoye K-157 were studied. Experiments have shown that in the conditions of the cryolithozone, the development of mogara plants and common millet plants proceeds slowly and reaches the beginning of flowering phase at the end of the growing season, Africanskoye K-157 millet has more accelerated development and it stops at the beginning of seed maturation. The most leafy millet variety Africanskoye K-157 - (160.4 cm^2/plant) provides the highest productivity of green mass (39.8 t/ha); the studied varieties of non-traditional forage crops are rich in protein content (12.5-14.3%), feed units (0.50-0.55 g per 1 kg), exchange energy for ruminants animals (7.1-7.4 MJ/kg).

1 Introduction

The Republic of Sakha (Yakutia) is included in the zone of risky agriculture due to extremely low temperatures in winter, large annual, seasonal and daily fluctuations in air temperatures, dry and short, frost-free periods, low-temperature permafrost breed and cold soils with low fertility [13]. In addition, the agricultural zone of the republic is the northernmost zone of possible cultivation of not only annual cereals and potatoes, but also forage crops. And when cultivating them, it is necessary to consider as fully as possible all environmental factors that affect the size and quality of the crop [16, 17, 18]. Winter in Yakutia is harsh. The lowest temperatures are observed in January, when the absolute

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minimum reaches minus 62°C, the average monthly air temperature according to long-term data is minus 43°C. In Central Yakutia, the average date of stable snow cover formation is noticed at the end of the first decade of October. At the beginning of winter, the snow cover thickness is usually small (about 10 cm). The snow cover reaches its maximum height (28-30 cm) at the end of February. The duration of the snow cover period is 205-210 days here. In late April – early May, the stable snow cover collapses and usually in the first decade of May the snow completely disappears. The transition of the average daily temperature through 5.0°C is noted in mid–May, and the duration of the period with temperatures of –5.0°C is 115-120 days. Frosts up to minus 3.0°C, and in some years up to minus 10.0°C can be observed until the end of May. For the beginning of spring, the period of stable transition of air temperature through 0°C starts here and it is 150-165 days, and the duration of the frost-free period is 75-100 days. The annual amount of precipitation is 180-270 mm, of which 105-135 mm falls during the warm period. Precipitation falls here unevenly throughout the year and the main limiting factor in crop production in the republic is moisture [1-5].

The main branch of agriculture in Yakutia is animal husbandry, including dairy cattle breeding, where the primary problem is to provide animals with juicy and green feeds. Scientists of the Yakut Research Institute named after M.G. Safronov conducted a number of studies of annual forage crops, including non-traditional ones for the conditions of the North. Thus, in the research of the feed production laboratory, research was conducted on the creation of a green conveyor and the production of haylage from annual crops. The optimal species composition of mixed crops was determined, optimal sowing dates and the mode of use of annual crops were established [10]. The results of research by Pestereva E.S., Pavlova S.A. [11] on the study of annual forage crops against the background of different doses of mineral fertilizers in Yakutia proved the possibility of obtaining high yields of sunflower 34.0 t/ha, oil radish 12.5 t/ha, common millet 11.5 t/ha and Sudan grass 16.7 t/ha of green mass at application of fertilizers at a dose of NPK of 90 kg/ha a.d. Yakutia scientists have selected varieties and types of high-yielding forage crops, developed a technology for their cultivation on various types of permafrost soils of the cryolithozone [8, 9, 12, 14,19]. Nevertheless, due to the wide variety of permafrost soils in the agricultural regions of the republic, as well as the decrease in their fertility over the past decades, it is necessary to search for new forage crops capable of forming a high yield of green mass in the conditions of the cryolithozone [4, 10].

Our research was aimed at studying and evaluating varieties and hybrids of alternative annual crops cultivated for the purpose of obtaining fodder mass.

The purpose of the research was to evaluate varieties of alternative forage crops - mogara and common millet and determine the possibility of their cultivation in the cryolithozone using the example of permafrost floodplain soils of the Khangalassky region of Yakutia.

The objectives of the research included the following:

- to determine the features of the growth and development of varieties of mogara and common millet in the conditions of the northern summer;
- to study the nature of the leaf surface development of mogara and millet plants;
- to establish the feed productivity of the studied varieties of mogara and millet;
- to determine the chemical composition and nutritional value of the feed mass of the studied varieties of mogara and millet.

2 Materials and methods of research

The research was carried out in the educational farm of the Oktem branch of the FSBEI HE the Arctic State Agrotechnological University.

The soils of the site are permafrost-floodplain meadow sandy loam. The agrochemical composition of the soil is characterized by a low humus content of 2.0%, mobile phosphorus 189 mg/kg, mobile potassium 44 mg/kg, pH 8.3.

The objects of research were: mogar Altaisky 23, common millet Barnaulsky 98, common millet Barnaulsky 18, millet Africanskkoye K-157. The common millet Barnaulsky 98 variety was adopted as the standard, since this crop is recommended for cultivation for silage in the Republic of Sakha (Yakutia).

The accounting area of plots is 10 m^2 in 4-fold repetition, the placement of options is randomized. The sowing method is wide-row with a row spacing of 30 cm.

Phenological observations of plant growth and development were carried out on two non-adjacent repetitions of each variant [6].

The leafiness level was determined at the first mowing by the percentage of leaves and stems [7].

The productivity of the green mass was established during the period of complete ear emergence (ear formation) - the beginning of flowering by the method of continuous mowing of grass throughout the plot.

The linear growth of the stem was determined by the phases of development on 10 plants of each variant from two non-adjacent repetitions with the calculation of the average value; the height of the herbage was considered before each mowing and before harvesting for seeds by measuring in 10 places in two non-adjacent repetitions of each variant [6].

The leaf area of plants was determined by the method of measurements [15].

The degree of lodging of alfalfa herbage was considered by eye on a 5-point scale in two non-adjacent repetitions of each variant [6].

The chemical composition of the alfalfa feed mass was determined in the phases of ear emergence (ear formation) - the beginning of flowering with sampling from two non-adjacent repetitions of variants at each mowing [6, 15].

3 Results and discussion

Phenological observations of the growth and development of the studied crops have shown that in conditions of permafrost floodplain soils, plants of mogara and millet varieties develop relatively slowly, remain in the flowering phase in autumn. The growing season from full shoots to harvest ripeness for food (the beginning of flowering) lasts from 44 (millet Africanskoye K-157) to 52 (millet Barnaulskoye 18). Comparatively complete plant formation is observed in millet Africanskoyw K-157, in which plant development reaches the beginning of seed maturation (Table 1).

Thus, it can be argued that in relatively favorable years for the growth and development of field crops in permafrost soils of Yakutia, the development of plants mogara Altaisky 23, millet Barnaulsky 98 and Barnaulsky 18 reaches the phase of the flowering beginning. Millet Africanskoye K-157 develops comparatively better than the rest, its development stops at the beginning of seed maturation.

The leaf area of forage crop varieties was determined at the time of the increase in the largest aboveground mass. As shown in Table 1, the largest leaf area is occupied by millet Africanskoye K-157-160.4 cm^2/plant, Barnaulsky millet 18 is inferior to it in leaf surface by 30.1 cm^2. Mogar Altaisky 23 and common millet Barnaulsky 98 increase the leaf area of plants to 117.4 and 115.6 cm^2/plant, respectively. The index of the leaf surface is highest in millet Africanskoye K-157 – 2.4.

Table 1. Leaf area of plant varieties.

№	Type, grade	cm^2/plant	Index of the leaf surface
1	Mogar Altaisky 23	117.4	1.8

2	Common millet Barnaulsky 98 - st	115.6	1.7
3	Millet Barnaulsky 18	130.3	1.9
4	Millet Africanskoye K-157	160.4	2.4

In mid-July and August, heavy rains with hail and strong winds often fall in Yakutia, which causes severe lodging in many crops. The varieties we studied showed excellent resistance to lodging (Table 2).

Measuring the height of plants before mowing to a green mass (Table 2) shows the stunting of plants mogara Altaisky 23 and millet Barnaulsky 98, in which the herbage reaches 95.6 and 97.0 cm, respectively. Barnaulsky 18 millet plants form cenoses with a height of 112.5 cm. The tallness of the plants is distinguished by millet Africanskoye K-157 (133.1 cm).

The highest foliage of plants is mogar Altaisky 23- 42.4%, in plants of other studied varieties and species of forage grasses, the percentage of foliage reaches 34.8-36.9. As can be seen, the low-growing mogar Altaisky 23 and millet Barnaulsky 98 are characterized by high foliage of plants.

Considering the yield allowed to reveal that the tallest grass stands of millet Africanskoye K-157 provide the highest productivity of green mass – 39.8 t/ha. The remaining studied varieties and hybrids also create a significant yield of feed mass for cryolithozone conditions – from 17.2 to 27.0 t/ha.

Table 2. Economic and biological indicators of varieties.

№	Type, grade	Yield of green mass, t/ha	Plant height, cm.	Foliage %	Lodging resistance, score
1	Mogar Altaisky 23	17.2	95.6	42.4	5.0
2	Common millet Barnaulsky 98-st	25.6	97.0	36.9	5.0
3	Millet Barnaulsky 18	27.0	112.5	35.8	5.0
4	Millet Africanskoye K-157	29.8	133.1	34.8	5.0
	LSD_{05}	0.19	-	-	-

Based on the results of the chemical analysis of the feed mass (Table 3) it was found that all varieties of the studied crops are rich in protein content (12.5-14.3%), feed units (0.50-0.55 g per 1 kg), exchange energy for ruminants (7.1-7.4 MJ/kg), which is at the nutritional level of local feeds.

Thus, it can be argued that in the conditions of the cryolithozone on permafrost floodplain soils, crops such as mogar and common millet can be grown, providing high yields of feed mass 1.5-2.0 times higher than the harvest of traditional annual fodder crops (oats + vetch, oats + peas).

Table 3. Chemical composition and nutritional value of feed.

№	Indicator	Type, grade			
		Mogar Altaisky 23	Common millet Barnaulsky 98 - st	Millet Barnaulsky 18	Millet Africanskoye K-157
	Chemical composition, %				
1	Protein	12.5	14.3	12.5	12.7
2	Fiber	27.8	24.7	23.7	26.8
3	Fat	1.7	1.9	1.6	1.3
4	Nitrogen-free extractives	37.0	41.4	43.0	38.5
5	Ash	11.6	9.4	9.9	10.4

1 kg of feed contains, g					
1	Feed units	0.53	0.55	0.54	0.50
2	Digestible protein	75.0	87.0	76.0	77.0
3	Carotene, mg	79.0	141.4	58.2	39.5
4	Sugar	8.5	26.5	44.0	12.5
5	Of digestible protein in 1 k. units	141.9	157.0	139.7	155.3
ОЭ, MJ/kg					
1	Ruminants	7.4	7.4	7.2	7.1

4 Conclusions

Studies on the evaluation of varieties and hybrids of alternative forage crops in permafrost floodplain soils of the cryolithozone allow to establish the following:

- The development of plants mogara Altaisky 23, millet Barnaulsky 98 and Barnaulsky 18 proceeds slowly and reaches the phase of flowering beginning. The periods of growth and development of millet Africanskoye K-157 are more accelerated in the conditions of the northern short summer, the plants remain in the autumn in the phase of seed maturation beginning.

- The largest leaf surface is formed by plants of millet Africanskoye K-157-160.4 cm^2/plant, millet Barnaulsky 18 is inferior to it in leaf surface by 30.1 cm^2. The highest index of leaf surface is provided by millet Barnaulsky K-157 – 2.4.

- All studied varieties and hybrids of forage crops are resistant to lodging, millet Africanskoye K-157 (133.1 cm) is distinguished by the tallness of the plants.

- Millet Africanskoye K-157 provides the highest productivity of green mass – 39.8 t/ha. The remaining studied varieties and types of forage grasses also create a high yield of feed mass for cryolithozone conditions – from 17.2 to 27.0 t/ha.

- All tested varieties of non-traditional forage crops are characterized by a high protein content (12.5-14.3%), feed units (0.50-0.55 g per 1 kg), and metabolic energy for ruminants (7.1-7.4 MJ/kg).

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