Productivity of herbages of different varieties of variegated alfalfa (*Medicago varia L.)* under inoculation with nodule bacteria (S *inorhizobiummeliloti)* in the Republic of Karelia

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Abstract. The research was carried out in 2021-2024 in the conditions of the southern regions of Karelia. The soil of the experimental site is sod-podzolic, medium loamy, (pH — 5.8). The variability of weather conditions in the accounting years allowed to unlock the potential of the studied species. The purpose of the study is to evaluate the formed varietal-microbial systems based on the most adaptive varieties and cultivars of alfalfa to the conditions of the region, with medium-term hay use. The object of the study is variegated alfalfa varieties and cultivars of the breeding of the Federal Williams Research Center of Forage Production & Agroecology named after V. R. Williams Agnia VIC, Pastbischnaya 88, Taisiya, 506 (Lusya) and SGP-387 and a strain of nodule bacteria A-1, provided by the FSBSI All-Russian Research Institute of Agricultural Microbiology. It has been established that the most adapted to medium-term use for hay (mowing in the budding phase - the beginning of flowering) in the Republic of Karelia are the cultivar 506 (Lusya) and the Agnia VIC variety when inoculating seeds with a strain of nodule bacteria A-1.

1 Introduction

In modern conditions of agricultural production development, the need for the introduction of new technologies aimed at biologization and resource conservation is increasing, and therefore, special attention is paid to the variety [10] which is considered as an innovation and a dynamic biological factor contributing to the realization of the genetic potential of productivity in conditions of variability of environmental factors [4]. A number of scientists note that one of the conditions for obtaining high yields of good quality, the only profitable variety is without additional capital investments, through more effective use of agricultural

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background conditions. The variety cannot be replaced and its properties cannot be neglected [8, 5, 3].

Alfalfa, providing a high-quality and balanced feed, is widely distributed both abroad and in Russia [13]. The area of its growth is expanding due to new varieties, the temperature range of their geography ranges from -50°C in winter to +60°C in summer [14].

In our country, the promotion of alfalfa in the northern regions of the country began relatively recently, and helps to strengthen the food supply, especially in dry years. It is carried out through the development of technologies of conjugate symbiotic breeding, which ensures the production of material adapted to local soil and climatic conditions, capable of growing in the Republic of Karelia [12, 1, 2].

Currently, the variety specifics are important: acid resistance, ability to grow on saline, wetlands, and clean sands. Also, an important property of modern breeding varieties is increased responsiveness to inoculation with nodule bacteria strains [11]. The most valuable varieties are those that are able to ensure the formation of stable yields, having better protection from environmental stressors [6].

Legume varieties are variable in their responsiveness to inoculation by different strains and the reaction of different varieties to the same strain is heterogeneous [9]. Thus, the effective formation of varietal-microbial systems is possible by selecting new varieties with increased symbiotic properties and selecting a complementary strain for a particular variety [7].

The purpose of the study is to evaluate the interaction of plant (*Medicago varia L.*) and microbial (*Sinorhizobiummeliloti*) components and their contribution to increasing the productivity of varietal microbial systems.

2 Materials and Methods

The effect of inoculation of *Sinorhizobiummeliloti* seeds by strain A-1 on 3 varieties and 2 cultivars of alfalfa was studied in the experiment: Pastbischnaya 88 variety (obtained by the traditional method of selection), Agnia VIC and Taisia (obtained by the modern method of conjugate selection), cultivars SGP-387 and 506 (Lusya). The Taisiya variety was determined by control due to its adaptive ability to abiotic stress factors (high cold resistance, drought resistance, resistance to soil waterlogging in the spring period), which surpasses other domestic varieties previously studied and proved itself well in the conditions of the Republic of Karelia [12].

In the control plots, sowing was carried out with untreated seeds (without inoculation).

This two-factor experiment was laid down on the basis of the laboratory of agricultural technologies "Vilga" on June 26, 2021.

The area of the accounting plot is 10 sq. m., the repetition is 4 times, the placement of options is systematic. Accounting of the yield is continuous from the entire plot in the budding phase. The mowing mode is two-fold, in the first year of life – one-fold.

The soil of the experimental site is sod-podzolic, well cultivated, medium loamy in granulometric composition, slightly acidic in acidity, pH 5.8, mobile phosphorus content 859 mg/kg is very high and exchangeable potassium 412 mg/kg – high.

The 2021-2024 field seasons differed in terms of heat and moisture availability. The growing season of 2021 was marked by a sharp shortage of moisture in June and July (12 and 55 mm less than the annual average), against the background of temperatures exceeding the annual average by 7.2 and 4°C, respectively. The temperature indicators of 2022 were close to the average annual data, and exceeded them by 1.6, 1.9, and 3.8°C in June, July and August, respectively, which characterized the growing season of the second year of plant life as heat-supplied and excessively humidified. 2023 is characterized as arid

at the initial stage of plant development due to lack of precipitation in May and June against the background of suspended temperatures and excessively humid in July. 2024 was marked as arid and excessively heat-supplied.

3 Discussion

The dynamics of linear growth reflects the biological characteristics, competitiveness of plants, availability of nutrients, and their struggle for environmental resources (Fig. 1). On average, over the years of research, cultivar 506 (Lusya variety) differed in the highest height of the herbage without inoculation of seeds, nevertheless, the Agnia VIC variety performed better when inoculating seeds. This is due to the uneven growth of plants over the years: the maximum height of plants in cultivar 506 (Lusya variety) without inoculation (33.0-46.9 cm) and inoculation (40.4-79.0 cm) was observed in 1 mowing during 3 years of research. In 2024, plants without inoculation were the highest in cultivar 506 (Lusya variety) – 79.2 cm, with inoculation in the variety Agnia VIC – 109.3 cm.

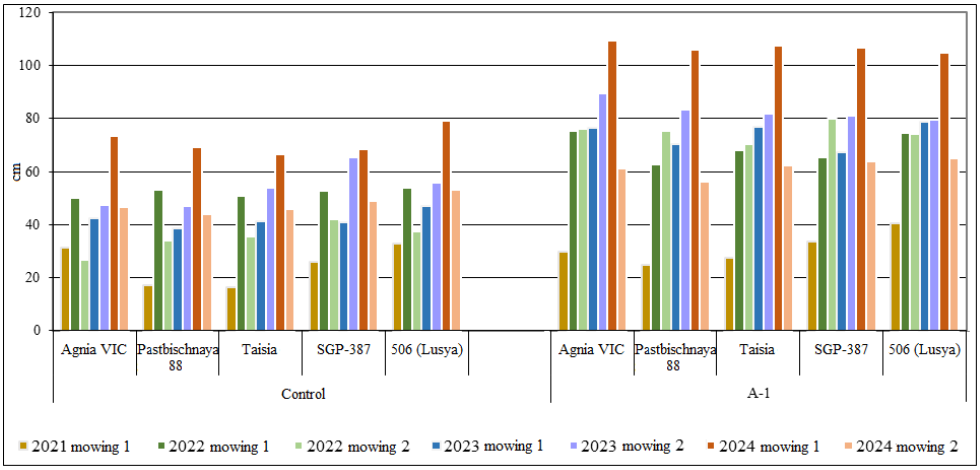

Fig. 1. The height of different varieties and cultivars of variegated alfalfa depending on the inoculation of seeds by nodule bacteria, 2021-2024.

The minimum height of the herbage on average for 2021-2024 was noted in alfalfa varieties Pastischnaya 88 - 43.2 cm without inoculation and 70.4 cm with inoculation of seeds.

Seed inoculation had a significant impact on the growth of variegated alfalfa plants, as a result, the height of herb stands during inoculation was 24.4–30.8 cm ahead of herbages without inoculation, which is explained by the better provision of nitrogen nutrition of plants due to symbiotic activity.

The shoot-forming ability is determined by the biological characteristics of the species and variety and the availability of nutrients. When studying the density of variegated alfalfa herbage, it was revealed that the cultivar 506 (Lusya) in most mowing provided the maximum indicator by year, on average 202 pcs/m^2, being inferior to other options only in fairly arid meteorological conditions (the year of sowing, and the second mowing in 2023 and 2024). The Pastbischnaya 88 variety in the control was characterized by minimum density values of 128 pcs/m^2, 1.5 times inferior to the cultivar 506 (Lusya). Inoculation had a positive effect on both linear characteristics and shoot-forming ability, increasing the average values from 1.5 to 3.1 times relative to the control. The most stable readings under

various meteorological conditions were provided by the varietal-microbial system based on the cultivar 506 (Lusya), reaching an average of 444 pcs/m^2. (Fig. 2).

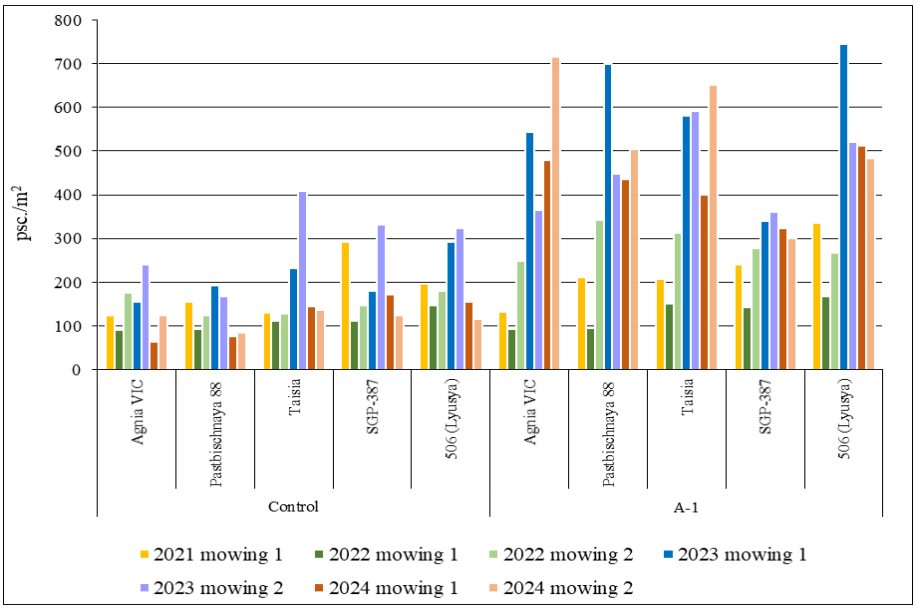

Fig. 2. Density of variegated alfalfa herbage of different varieties and cultivars depending on seed inoculation by nodule bacteria, 2021-2024.

According to the years of the study, the plants of the second mowing in 2022 stood out strongly, which were formed against the background of increased heat and moisture supply, whereas subsequent years were characterized as arid, which affected the final number of shoots.

To fully characterize the varieties, it is necessary to consider the competitiveness of plants, here the species composition of herbages is an important indicator (Fig. 3).

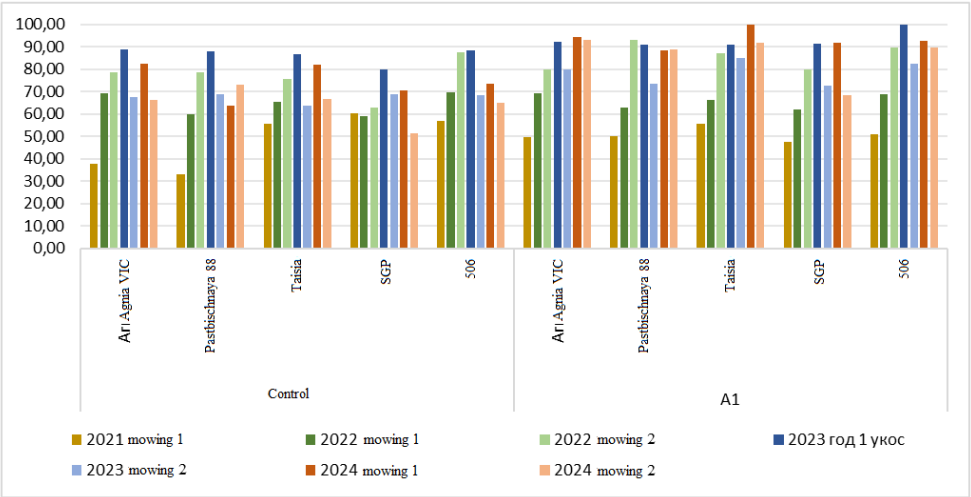

Fig. 3. The share of variegated alfalfa of different varieties and cultivars in the herbage, depending on the inoculation of seeds by nodule bacteria, 2021-2024.

The proportion of variegated alfalfa in the period 2021-2024 in the control variants did not exceed 90%, varying between 64.9-72.8%, while inoculation increased this figure to 93.5%, on average, in some years reaching 99.9% (506 (Lusya)). There was a tendency to increase the proportion of alfalfa from the first mowing to the second, and by years of life, which indicates its high competitiveness, nevertheless, the arid conditions during the formation of the second mowing in 2023 and the rather dry field season in 2024 somehow corrected this pattern, both in control and in varietal-microbial systems.

Evaluation of varieties and the interaction of plant and microbial components and their effectiveness in the Republic of Karelia is impossible without yield. The yield of variegated alfalfa is influenced by the indicators discussed above, as well as the meteorological conditions of the growing season, the adaptive characteristics of varieties and cultivars, and inoculation (table 1).

Table 1. The yield of variegated alfalfa of different varieties and cultivars depending on seed inoculation by nodule bacteria, 2021-2024.

Strain		2022			2023			2024		
		1 mowing	2 mowing	total for 2 mowing	1 mowing	2 mowing	total for 2 mowing	1 mowing	2 mowing	total for 2 mowing
Control (without inoculation)	Agnia VIC	1.7	1.0	**2.7**	1.9	2.4	**4.3**	2.4	2.2	**4.6**
	Pastbischnaya 88	0.9	0.9	**1.7**	1.7	2.6	**4.3**	2.5	2.7	**5.8**
	Taisia	0.9	1.0	**1.8**	1.7	2.9	**4.6**	1.7	2.6	**4.2**
	SGP-387	0.9	0.9	**1.8**	1.5	3.2	**4.8**	1.6	1.5	**3.7**
	506 (Lusya)	0.7	0.9	**1.6**	1.5	2.9	**4.4**	2.2	2.8	**5.1**
A-1	Agnia VIC	2.0	3.2	**5.3**	3.7	5.5	**9.2**	5.2	5.5	**11.8**
	Pastbischnaya 88	1.6	1.8	**3.4**	2.8	5.3	**8.1**	4.1	4.2	**8.4**
	Taisia	1.1	2.2	**3.3**	3.2	6.6	**9.8**	4.3	5.5	**10.0**
	SGP-387	1.9	2.0	**3.9**	2.5	5.1	**7.6**	3.9	3.5	**8.5**
	506 (Lusya)	2.3	2.8	**5.2**	3.8	5.4	**9.2**	4.8	5.5	**10.3**
$LSD_{0.05}$		0.42	0.34	**0.26**	0.25	0.71	**0.48**	0.43	0.55	**1.5**
$LSD_{0.05\ A}$		0.19	0.25	**0.22**	0.24	0.26	**0.25**	0.34	0.28	**0.32**
$LSD_{0.05\ B}$		0.28	0.43	**0.61**	0.87	1.14	**1.62**	0.75	0.92	**0.86**

Since the first year of grass life is not indicative for yield, it was considered in the experiment in the period 2022-2024. In the variants without inoculation, the amount of dry weight varied on average from 3.4 to 4.2 t/ha, whereas under the influence of *Sinorhizobiummeliloti*, this indicator increased by 1.7–2.2 times, providing yields at the level of 6.6-8.7 t/ha of dry weight. The alfalfa yield increased from the first year to the next, providing maximum values by the fourth year of life, confirming the fact that alfalfa is a promising long-term crop capable of growing in one place for a long time, forming a sufficient yield.

4 Conclusion

The conducted studies have shown that inoculation has a positive effect on the variegated alfalfa yield in the conditions of the Republic of Karelia, providing an increase in the collection of dry matter up to 2.2 times per area unit. The most productive were varietal microbial systems with strain A-1 and Agnia VIC variety (on average 8.7 t/ha) and with cultivar 506 (Lusya) – 8.2 t/ha of dry weight.

Acknowledgments

The work was carried out within the framework of the scientific topic of the State task FMEN-2022-0013
Reg. no. NIOKR 122031000202-1

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