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Dependence of above-ground mass formation of sickle alfalfa on application of different doses of mineral fertilizers in terms of permafrost floodplain soils of Yakutia, Russia

Osipova Valentina Valentinovna

Doctor of Agricultural Sciences, Head of the Department of Agronomy of the Oktem branch of Arctic SATU, Yakutsk, Russian Federation

Email: luzerna: 2008@mail.ru

ABSTRACT

The experiments were carried out on the permafrost floodplain soils of the Khangalassky region of Yakutia to study the effect of different doses of mineral fertilizers on the formation of the forage mass of sickle alfalfa, the variety Yakutskaya yellow. The aim was to substantiate the effect of different doses of mineral fertilizers on the development of sickle alfalfa cultured in the permafrost floodplain neutral and carbonate soils in combination with floodplain saline soils. The tasks included the following ones: 1) to determine the effect of different doses of mineral fertilizers on the formation of the leaf surface of alfalfa plants; 2) to determine the dependence of alfalfa fodder mass yield on the application of mineral fertilizers. The size of the plots was 20 m^2, with fourfold repetition, systematic placement of variants, wide-row sowing method by row spacing of 45 cm. There were 5 variants with different doses of mineral fertilizers in the experiment: 1) Without fertilizers; 2) N_{30} $(PK)_{60}$; 3) N_{60} $(PK)_{90}$; 4) $(NPK)_{90}$; 5) $(NPK)_{120}$. After the conducted studies, it was revealed that the application of mineral fertilizers in the dose of N_{60} $(PK)_{90}$ provides the formation of the largest leaf area of alfalfa (37.2 thousand m^2 ha^{-1}). The maximum dose of mineral fertilizer $(NPK)_{120}$ contributes to plant foliage increase (up to 42%) and to the highest yield of crescent alfalfa dry weight (4.2 ton ha^{-1}). Sprouting of alfalfa does not show dependence on the application of different doses of mineral fertilizers. A complete relationship was established between the yield of forage mass and the area of alfalfa leaves ($r = 1$) with the regression coefficient of 0.6 ton ha^{-1}. A strong dependence of forage mass yield was observed on leafiness ($r = 0.9$) with the regression coefficient of 0.4 ton ha^{-1}, as well as an average negative dependence of the aboveground mass of alfalfa yield on the number of shoots ($r = -0.6$) with the regression coefficient of -0,5 ton ha^{-1}.

Key words: Cryolitic zone, Permafrost soils, Alfalfa, Leaf surface, Yield, Fodder.
Article type: Research Article.

INTRODUCTION

Alfalfa is the best precursor for grain and vegetable crops, and its crops are desirable in all types of crop rotation (Goncharov 1985). Salt and drought resistance is of great importance for the extreme conditions of Yakutia (Denisov 2000). With its wide introduction into culture, it will be possible to put many thousands of hectares of saline lands in the valleys of the river Lena at the service of agriculture, therefore the widespread industrial introduction of alfalfa on permafrost soils for agricultural use in Yakutia is a problem of primary importance (Pavlov 2012). Together with the ability to improve the water-physical and agrochemical properties of the soil, alfalfa can radically increase soil fertility. In the conditions of saline soil spread, lack of moisture and heat, the use of fertilizers is the main guarantor of obtaining high yields of cultivated crops (Klimashevsky 1991). Russian and foreign scientists have different opinions on the issue of mineral fertilizer application to alfalfa, and primarily nitrogen. Taking into account the fact that alfalfa is able to use the gaseous form of nitrogen for its nutrition due

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to its symbiosis with nitrogen-fixing microorganisms, many researchers consider it ineffective to introduce mineral nitrogen during its cultivation (Ambrus 1973; Reulets 1975; Moga 1987; Voloshin 1989; Goff 1990; Ashoori 2019; Vladimirovna Demina *et al.* 2020; Bagheri *et al.* 2020). Other scientists are of the opinion that the application of nitrogen in a dose of 100-240 kg ha^{-1} significantly increases the productivity of alfalfa (Denisenko 1990; Qi *et al.* 2011). Some researchers argue that during the initial periods of alfalfa development, starting doses of nitrogen of 30-40 kg ha^{-1} are required. In their opinion, the fodder productivity of alfalfa does not increase with the introduction of nitrogen fertilizers, since this reduces the formation of nitrogen-fixing bacteria (Mac Leod 1965; Gavlak 1987; Tesar 1988). The researchers have found that alfalfa especially needs a sufficient supply of phosphorus compounds in the forms accessible to it (Pang *et al.* 2010; Montemayor *et al.* 2012). Some researchers note that alfalfa needs potassium fertilizers, since it removes a large amount of potassium from the soil, with a lack of which leaves turn yellow and necrotic spots appear on them (Mac Leod 1965; Malhi 2011; Migbgwa *et al.* 2011). An important condition for crop obtaining is the use of fertilizers on permafrost soils of the cryolitic zone, characterized by weak biological activity and low fertility. The goal was set in our studies to substantiate the effect of different doses of mineral fertilizers on the development of sickle alfalfa in permafrost-floodplain neutral and carbonate soils in combination with floodplain saline soils. So, we tried to determine the effect of different doses of mineral fertilizers on the formation of alfalfa plant leaf surface; and to determine the dependence of alfalfa fodder mass yield on the application of mineral fertilizers.

MATERIALS AND METHODS

The experiments with alfalfa were carried out in the educational farm of the Oktem branch of the Arctic SATU. In terms of geomorphological zoning, the educational economy belongs to the Central Yakut accumulative plain. The climate is temperate continental. Average annual rainfall is 200 mm. The total radiation is 95 kcal cm^{-1}. The absolute maximum air temperature in summer is + 38 ºC; the prevailing wind directions are northern, and northeastern. The average monthly temperature in January is -40 ºC. The farm is located on the left bank of the Lena River, with a river network density of 0.3 - 0.5 km. Basically, permafrost floodplain neutral and carbonate (floodplain sod, including sod-gleyed) soils prevail in combination with floodplain saline soils. The experience was performed on July 5, 2013. The aim of the present srtudy was to examine the crescent alfalfa Yakutskaya yellow variety, zoned across the republic.

The predecessor was potatoes. The size of the plots was 20 m^2, the replication was fourfold, the placement of variants was systematic. The experiment included five variants with different doses of mineral fertilizers: 1) without fertilizers; 2) N_{30} $(PK)_{60}$; 3) N_{60} $(PK)_{90}$; 4) $(NPK)_{90}$; 5) $(NPK)_{120}$, the row spacing was 45 cm.

RESULTS AND DISCUSSION

The experimental data showed that the largest leaf surface area over two years on average was formed by the plants with the dose of N_{60} $(PK)_{90}$, where the excess was 37.8% as compared to the control. The smallest leaf surface area was noted in the 5th variant with the dose of $(NPK)_{120}$, where the area was 10.4% lower than in the control. For other options, this indicator was at the control level.

Table 1. The value of the leaf surface area of alfalfa, depending on the mineral nutrition, thousand m^2 ha^{-1}.

Variants	Years of life		For all years on average	
	IInd, 2014	IIIrd, 2015.	thousand m^2 ha^{-1}	In % from kK
1.(control)	18.9	35.0	27.0	100
2.($N_{30}(PK)_{60}$)	12.3	39.0	25.6	94.8
3.($N_{60}(PK)_{90}$)	29.4	45.0	37.2	137.8
4.$(NPK)_{90}$	15.9	43.0	29.4	108.9
5.$(NPK)_{120}$	15.3	33.0	24.2	89.6
HCP_{05}	7.1	6.8	4.5	-

Fertilization at the dose of $(NPK)_{120}$ provided the highest leafiness (42%), which exceeded the control by 27.2% (Table 2). Alfalfa sowing made it possible to obtain a dry mass harvest since the 2nd year of use, and one cut over the summer. On average, over two years, the largest dry matter yield was provided by the option at the dose of $(NPK)_{120}$: 4.2 ton ha^{-1}, and the smallest dry matter yield by the option $(NPK)_{90}$: 2.4 ton ha^{-1} (Table 3).

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Table 2. Leafiness of alfalfa plants depending on mineral nutrition (%).

Variants	Years of life		In two years on average	
	2014	2015	%	In % from kK
1.(control)	30.0	36.0	33	100
2.($N_{30}(PK)_{60}$)	34.0	35.0	34	103
3.($N_{60}(PK)_{90}$)	39.0	37.0	38	115.1
4.$(NPK)_{90}$	30.0	35.0	32	96.9
5.$(NPK)_{120}$	45.0	39.0	42	127.2
HCP_{05}	9.2	6.1	7.3	-

Table 3. Productivity of dry matter (ton ha^{-1}).

Variants	Years of life		In two years on average	Deviation from K (t)	from K (%)
	2014	2015			
1.(control)	3.4	1.8	2.6	0	100
2.($N_{30}(PK)_{60}$)	4.0	2.1	3.0	+0.4	115.3
3.($N_{60}(PK)_{90}$)	5.4	2.2	3.8	+1.2	146.1
4.$(NPK)_{90}$	2.3	2.5	2.4	-0.2	92.3
5.$(NPK)_{120}$	6.0	2.4	4.2	+1.6	161.5
HCP_{05}	0.81	0.18	0.14	-	-

For two years of use, alfalfa plants formed a small number of shoots due to air and soil drought. Over two years, the number of shoots per plant was 12-13 pieces on average.

Table 4. Shoot formation of alfalfa depending on mineral nutrition (pcs/plant).

Variants	Years of life		In two years on average	
	2014	2015	pcs/plant	from K (%)
1.(control)	11	14	13	100
2.($N_{30}(PK)_{60}$)	13	13	13	100
3.($N_{60}(PK)_{90}$)	11	12	12	92.3
4.$(NPK)_{90}$	11	13	12	92.3
5.$(NPK)_{120}$	12	11	12	92.3
HCP_{05}	3.0	4.8	3.2	-

The results of the correlation analysis showed as follows. The dependence of the green mass yield value on the leaf area was established to be strong - r = 1.0. The regression coefficient showed that with leaf area increase per unit on 1 thousand m^2 ha^{-1}, the yield of green mass increases by 0.6 ton ha^{-1}. They determined a strong dependence of green mass yield on the percentage of leafiness - r = 0.9. When determining the dependence of green mass yield on the number of shoots, an average negative relationship was established - r = -0.6. In addition, the regression coefficient showed that once the number of shoots increase by 1 piece, the yield increased by 0.5 ton ha^{-1}. Thus, after the studies, contradictory data were obtained at first glance, showing a strong dependence of green mass yield of alfalfa on the leaf area, while the highest leaf surface (37.2 thousand m^2 ha^{-1}) was noted at the dose of N_{60} $(PK)_{90}$, and the highest yield of alfalfa fodder mass was formed when applying the maximum dose of mineral fertilizer, i.e. $(NPK)_{120}$. Our data are consistent with the opinion that by elevating the leaf surface, the PPP of crops decreases and this gives reason to speak of the optimal area at which the intensity of photosynthesis is high and the maximum yield is formed (Denisov & Osipova 2013). In addition, we should not forget by upraising the leaf surface area, the degree of mutual shading of plants elevates, the intensity of assimilation of carbon dioxide drops and, therefore, the cenosis PPP is lower. As Alekseenko (1965) notes, it is necessary to find the answer to the following question: "What should be the optimal or, perhaps, maximum leaf area in the herbage, so that their strong shading does not lead to excessive suppression of the photosynthetic process among plants and, thus, to their productivity decrease."

CONCLUSION

1. The largest leaf area (37.2 thousand m^2 ha^{-1}) is formed by sickle alfalfa plants at the dose of N_{60} $(PK)_{90}$.
2. The highest yield of dry fodder mass of alfalfa (4.2 ton ha^{-1}), as well as a high level of plant foliage (42%), is provided by the dose of mineral fertilizer (NPK)120.
3. The introduction of different doses of mineral fertilizers does not have a significant effect on the formation of crescent alfalfa shoots.
4. There was a complete relationship between the yield of forage mass and the area of alfalfa leaves (r = 1) with the regression coefficient of 0.6 ton ha^{-1}; strong dependence of the yield of alfalfa aboveground mass on leafiness

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(r = 0.9) with the regression coefficient of 0.4 ton ha^{-1} and an average negative dependence of alfalfa forage mass yield on the number of shoots (r = -0.6) with the regression coefficient of -0.5 ton ha^{-1}.

REFERENCES

Ashouri, M 2019, Nitrate pollution reduction using biological fertilizers in paddy fields, the South Caspian Sea basin, Guilan Province, Iran. *Caspian Journal of Environmental Sciences*, 17: 63-71.

Ambrus, P 1973, Efektivnost dusicateno hnojenia lucernu. *Ppstl. Voroba*, 19: 713-720 (In Russian).

Bagheri, S, Zare-Maivan, H, Heydari, M, Kazempour Osaloo, SH 2020, Relationship between broadleaved mixed forest understory species groups with soil and elevation in a semi-arid Persian oak (*Quercus brantii* L.) ecosystem. *Caspian Journal of Environmental Sciences*, 18: 157-170.

Denisenko, AI, Kulchikhin, VV & Malykhina, VF 1990, Nitrogen fertilizing of alfalfa. *Agriculture*, 5: 9-39.

Denisov GV & Streltsova VS 2000, Lucerne in Yakutia. *Siberian Publishing Company "Science" RAS*, Novosibirsk (In Russian).

Denisov, GV & Osipova, VV 2013, Photosynthetic activity of alfalfa crops in permafrost conditions. *Bulletin of the International Academy of Agrarian Education*, 1: 19-22.

Gavlak, RC 1987, Establishishing alfalfa successfully. Utah Farmer. *Stockman*, 107: 5-9.

Goff, N & Florenko, N 1990, Productivity and fodder value of alfalfa depending on the methods of basic tillage and fertilization rates during irrigation. *Siberian Bulletin of Agricultural science*, 1: 18-23.

Goncharov, PL & Lubenets PA 1985, Biological aspects of alfalfa cultivation. *The Publishing house "Science"*, Novosibirsk (In Russian).

Klimashevsky, EL 1991, The genetic aspect of the mineral nutrition of plants. Moscow, Agropromizdat, 415 p.

Pang, J, Tibbet, M, Dentol, M & Lambers, H 2010, Variation in seeding growth of 11 perennial legumes in response to phosphorus supply. *Plant and Soil*, 328: 133-143.

Pavlov, NE 2012, Seed growing and cultivar study of perennial grasses in Yakutia. Yakutsk Publishing House: "Tuymaada", 112 p.

Mac Leod, LB 1965, Effect of nitrogen and potassium fertilization of the yield, regrowth and carbohydrate content of the storage organs of alfalfa and grasses. *Agronomy Journal*, 57: 366-368.

Malhi, SS 2011, Relative response of forage and seed yield of alfalfa to sulfur, phosphorus and potassium fertilization. *Journal of Plant Nutrition*, 34: 888-908.

Migbgwa, GW, Krall, JM & Legg, DE 2011, Depth of sowing foa Larammie medic (*M. rigidula*) seedings emergence. *Journal of Sustainable Agriculture*, 35: 624-638.

Moga, I 1987, Cercetari si resultate obtinute in domeniul technologiei de ciltura la platelet Jurajere pentru saminta. Fn. Inst. Cerc., Cereale Plante Tehn. Fundulea Bucurest, pp. 229-238.

Montemayor, TJA, Woo, RJL, Munguia, LJ, Lopes AR, Segura, CMA, Yecas, CP, Frias, RE 2012, Produccion de alfaalfa (*Medicago sativa* L.) cultivada con riego sub-super. *Revista Mexicana de Ciencias Agrícolas*, 3: 1321-1322.

Qi, Y, Huang, V, Wang, Y, Zhao, J & Zhang, J 2011, Biomass and its distribution in four species of meadow plants at different nitrogen levels. Shengtai Xiebao = *Acta Ecologica Sinica*, 31: 5121-5129.

Reulets, VV & Tukalova, EI 1975, The influence of mineral fertilizers on the yield of alfalfa under irrigation conditions. The reserves of irrigated agriculture. Chisinau: Shtiintsa, pp. 80-90.

Tesar, MB & Marble, VL 1988, Alfalfa establishment. *Agronomy*, 29: 303-332.

Vladimirovna Demina, G, Borisovna Prokhorenko, N, Ravilevna Kadyrova, L 2020, The influence of soil quality on the vitality of Trifolium Pratense L. cenopopulations in the subzone of deciduous forests of Tatarstan, Russia, *Caspian Journal of Environmental Sciences*, 18: 411-419.

Voloshin, MI & Alekhina, MN 1989, Technology of alfalfa cultivation for seeds in France. *Selection and Seed Production*, 2: 57-60.

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