PRODUCTIVITY OF VETCH-OAT MIX BY GYPSUM AND GREEN MANURE FERTILIZER APPLICATION ON SALINE SOILS OF CENTRAL YAKUTIA

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Abstract

The article describes results obtained from field studies on coherent utilization of saline soils in Central Yakutia. According to scientists data, nonsaline alkaline soils and alkaline soil takes up approximately 30% of the republic's total cropland area. The territory belongs to sulfur-sodium saline accumulation type. When chemically meliorated by gypsum the soil on 0-40cm layer activates the re-salinization process. With such treatment feeding crops yield was 14.4-20.2 t/ha with gypsum only; with green manure fertilizer at the background- 11,4-16,1 t/ha. Yield increased by 33-64 quintals per hectare, meaning being increased by 20,8-44,4%. By productivity means, vetch-oat mixes in gypsum treatment variant contained 0,66-0,79 feeding units, 94,15-123,11 digestible protein units and 16,78-17,80MJ of gross energy per 1kg of the dry component. Control samples'

exchange energy was 8,13MJ, wherein gypsum treated sample was 9,00-9,53MJ. Improved soil water permeability and aeration facilitated the increase in root uptake of calcium, potassium, phosphorus, and microelements in gypsum treated saline soils. Altogether, such way of soil treatment is very likely having a positive impact on feeding crops yield in saline soils of Central Yakutia.

Key words: *yield, productivity, digestible protein, vetch-oat mix, salinity, gypsum application, fertilizers, salinity, alkalinity*

Introduction

The overall territory of Republic Sakha (Yakutia) belongs to the zone of permafrost distribution. Soil processes regulating plants growth and development have seasonal character by developing in the soil layer specifically thawing during the summer season. In permafrost landscapes, this layer is described as active. The low temperature of active layer contribute to the normalized development of microbiological and biochemical processes inside the soil; the inhibited transformation of organic waste tend to decrease the activity rate in biological cycles of components and energy.

Researchers argue that permafrost possesses ability to significantly impact the pedogenesis via the limitation of water circulation within the active layer as well as deterrence of groundwater formation. Absence of weathering and soil formation products outstation to ground water lead to the shift from large geological circulation into the small biological cycles and limits its activity by seasonally melting active soil profile [1,2]. Such phenomenon explains the high salinity of soils under semiarid conditions in the studied area.

Presence of a water-impermeable permafrost layer excludes the possibility of salt washing by basement rocks. Permafrost obscures washing out processes; similarly, the prominent temperature gradient also influences salt migration. This leads to the limitation of water and salts migration to root-bearing layer at the summer period. Hence, the application of chemical melioration by gypsum treatment in claypan may replace the exceed of absorbed sodium [3].

Soil preservation and yield are likely to increase under cryolithozone conditions if being treated with gypsum and organic fertilizers, enhanced alkalinity may cooperate into the decrease of

salinity in permafrost saline soils and increase of organic and nutritive components; consequently, it may contribute to increases in productivity of feeding crops.

Methods

Experimental works were carried at irrigating perimeter "Moyodokh" of the agrological company "Nemyugyu", located on the second fluvial terrace of Lena river of Prilensk agro-zone in 2005-2008.

Plilensk agro-zone is characterized by significant heat availability and aridity. Transition to the average daily temperature above +10 ˚C (spring) takes place at the end of May. Additionally, the temperature sum above +10 ˚C was 1465 ˚C; duration of not freezing period in the soil is approximately 88 days. This period of heat availability during the summer is efficient enough to melt down the permafrost layer up to 2,0-2,5 meters. Precipitation rate at the temperatures above +10 ˚C is in average 118mm [4].

The soil in the field of study belongs to permafrost saline types that also develops parallelly with part of meadow-chernozemic saline soils. pH- 8,6; humus content in top horizon 3,14%, content of mobile fractions of nitrogen N_{nitr}- 0,38; mobile fractions of phosphorus P_2O_5- 13,4; potassium K_2O is high- 22,1 mg/100g.

Experimental works were carried according to the method from field practice [5], the method of bioenergy assessment of feeding crops [6], assisted with phenological, biometrical observations and data analysis of soil and plants samples (GOSTU 26205-86). Laboratory experiments were done on the basis of laboratory of biochemistry and mass analysis with the usage of spectral analysis machine NIRSCANNER moLCE4250 (Pacific Scientific, USA).

The technique of soil processing was carried according to recommended by Yakut Research Institute of Agriculture [7]. Vetch-oat mix seeding was carried at the June decade with the norm: oat- 120kg, vetch- 70kg.

Experiment schemes for gypsum and green manure fertilizer (green mass of vetch-oat mix 4,0 t/ha) were carried during fall season soil processing in 2004.

Irrigation was carried by sprinkler plant KI-5 with norm 250 m^3/ha. The experiment was replicated r times, total plot area- 84m^2.

Results

The current study was focusing on effects of different amounts of gypsum treatment, in either pure form or with supplementary green manure fertilizers as background, on saline soils yield and vetch-oat mix productivity: control; gypsum 4 t/ha; gypsum 8 t/ha; gypsum 12 t/ha; green manure fertilizer 40 quintals per ha; green manure fertilizers+ gypsum 4 t/ha; green manure fertilizer + gypsum 8 t/ha; green manure fertilizer+ gypsum 12 t/ha.

Meteorological conditions of vegetative periods were varied throughout years of study. For instance, 2005 was beneficial for crops growth and hence initiated united reproduction and intensive growth of feeding crops at all plant growth phases. In mowing ripeness stage crops reached height 80-110 cm. Daily growth took place in stem elongation phase with ear emergence 0,7-2,8 cm.

All gypsum treatment variations were taller than control by 3-15 cm depending on treatment type. Vetch-oat mix yield was 23,0-29,0 t/ha with the highest produced by gypsum treatment variation of 12 t/ha.

In 2006 only second decade of May- 6,8 mm (with the norm 6 mm) and first decade of June – 14,6mm (10mm) were close to the long-term precipitation average.

The second decade of June was comparatively dry, with 0,3mm precipitation rate, but the second decade of August (99,5mm) exceeded long-term precipitation norm (13mm) by 7,6 times. Average decade air temperature during the crops growth phase was higher by 1,7-4,0 ˚C (15,5-29,2 ˚C) and the maximal temperature reached up to 28,0-37,0 ˚C.

Continuous rainfall shortage in June-July along with an intensive accumulation of effective temperature sums (650-690˚) exceeding the long-term average by 20-50˚, had negatively affected crops and accelerated interphase period of flowering-ear formation (6 days). At the same time, crops height reached 18,0-30,7 cm (flowering) and 23,9-46,6 cm (ear formation), daily growth was 0,3-1,3 cm. Crops height at the time of harvesting reached 35,5-67,8 cm. Crops from variations with gypsum and green manure fertilizers were generally taller than control grown crops by 3,4- 17,1cm.

Feeding crops' green mass yield accordingly to weather conditions was 6,2-8,8 t/ha.

The vegetative period in 2007 was characterized by early warm spring and rainy summer. The monthly average air temperature was close to semi-long-term average. Meteorological conditions

for the vegetative period were beneficial and provided high yield for the vetch-oat mix - 13,5-26,5 t/ha.

The meteorological conditions in the first half of vegetative periods were in particular dry. Precipitation on May and June, 4,9 mm and 16,2 mm, were two times lower than the long-term precipitation norm, 19,0 mm and 37,0mm respectively.

Intense accumulation of green mass was observed during favorable conditions continuing during the second half of summer; feeding crops yield varied from 12,6 to 17,4t/ha. An increase of green mass in treatment variations was between 1,6 and 4,8t/ha.

Chemical melioration by gypsum treatment initiates soil desalinization at layer 0-40 cm; wherein feeding crops yield treated with gypsum was 14,4-20,2 t/ha and with green manure fertilizer on background- 11,4- 16,1 t/ha. End results resulted in a yield increase by 3,1 to 5,6 quintets per hectare, meaning that the experimental treatment improved yield by 12,0-40,2% (Tab.1).

Table 1

Vetch-oat mix green mass yield. t/ha

Variants	Yield by years				Average	Increase
	2005	2006	2007	2008		
Control	23,0	6,2	13,5	14,8	14,4	-
Gypsum 4 t	25,0	7,5	21,0	17,4	17,7	3,3
Gypsum 8 t	28,0	7,6	26,2	14,8	19,2	4,8
Gypsum 12 t	29,0	7,0	26,5	18,4	20,2	5,8
Green manure (control)	-	7,1	14,5	12,6	11,4	-
Green M. + gypsum 4 тt/ha	-	8,1	20,4	14,6	14,5	3,1
Green M. + gypsum 8 t/ha	-	8,2	22,1	15,2	15,2	3,8
Green M. + gypsum 12 t/ha	-	8,8	25,2	14,2	16,1	4,7
$НСР_{05}$	5,73	1,7,1	5,57	8,98		

The productivity of vetch-oat mix per 1kg of dry mass in gypsum treated variations was in following: 0,66-0,79 feeding units, 94,15-123,11 units of digestible protein and gross energy of 16,78-17,80 MJ. Control crops exchange energy rate was 8,13 MJ, wherein gypsum treated crops were 9,00-9,52MJ (Tab.2).

Table 2

Vetch-oat mix green mass productivity

Variants	Average yield of green mass, t/ha	Per 1kg of dry pass				Digestible protein in g/1 feeding unit.
		Feeding units	Digestible protein, g	Exchange energy, MJ	Gross energy, MJ	
Control	14,4	0,54	89,48	8,13	16,87	165,70
Gypsum 4 t	17,7	0,71	94,79	9,53	17,64	133,50
Gypsum 8 t	19,2	0,66	123,11	9,06	16,78	186,53
Gypsum 12 t	20,2	0,69	103,64	9,21	17,29	150,20
Green manure (control)	11,4	0,70	94,15	9,15	17,02	134,50
Green M. + gypsum 4 тt/ha	14,5	0,73	113,15	9,35	17,01	155,0
Green M. + gypsum 8 t/ha	15,2	0,79	105,85	9,00	17,80	133,99
Green M. + gypsum 12 t/ha	16,1	0,75	97,90	9,50	17,45	130,53

Experimental results demonstrated that gypsum treatment of saline soils assisted to the improvement in root uptake for calcium, potassium, phosphorus, and microelements due to the enhanced water permeability and aeration, consequently refining the feeding crops yield quality.

Based on the data from agrochemical analysis on sodium (Na) content in 0-40cm soil layer at differently treated plots, the improvement of yield in saline soils was clearly demonstrated. Exchange Na decreased by 40,4-71,2%; exchange Ca increased 1,5-2,0 times and exchange Mg seemingly reduced. Gypsum treatment by its application helps to upsurge feeding crops yield up to 40% and desalinate soil at the 0-40cm top layer. In so doing, the percentage of replaced sodium from its summary content was up to 62,3% and pH decreased by 1,1 (7,54).

Economic evaluation of haylage preparation after investigated treatment showed that net income increased by two times from control. Application of 8t/ ha of gypsum may bring the highest income- documented 17539 rub/ha.

Conclusion

Therefore, gypsum application enables the feeding crops to increase its yield up by 40% and initiate the desalinization of soil at the 0-40cm top layer. Additionally, the sodium was replaced by up to 62,3% and decreased its pH by 1,1 (7,54).

With chemical melioration gypsum application to the field with seeded feeding crops facilitate the desalinization of top soil layer at 0-40cm. Moreover, the yield for vetch-oat mix was improved by 14,4-20,2 t/ha and with the background of green manure fertilizer- 11,4-16,1 t/ha during the years of this study. Yield increased by 3,1-5,8 tons per hectare (12,0- 40,2%).

References

1. Elovskaya L.G., Konorovskiy A.K. Zonation and melioration of permafrost soils in Yakutia/ Siberian branch- Novosibirsk: Science, 1978. – 173p.
2. Gypsum treatment of mid-saline soils in Central Yakutia during irrigation: practical recommendations / Russian Academy of Agricultural Sciennce, Yakut Scientific Research Institute of Agriculture,- Yakutsk, 2008.- 12p.
3. Methods in gypsum treatment of permafrost saline soil of Yakutia.- Yakutsk, 1979.- p.8
4. Ivanova L.S. Adaptive-zonal systems of agriculture in Lena-Amga interfluve: project / Russian Academy of Agriculture, Siberia branch, Yakut Scientific Research Institute of Agriculture.- Novosibirsk, 2004.- p.25
5. Dospekhov B.A. Methods in field experiments.- M.: Kolos, 1978. P.88-90
6. Methodological guidance on agro-energetical and economical evaluation of technologies and systems of food production.- M., 1995. P.36-58
7. Zonal system of arable farming of Yakut ASSR: recommendation/ VASKhNIL Siberia branch, Yakut Scientific Research Institute of Agriculture.- Novosibirsk, 1981.- 284p.