Studying of Structure-functional Features of Halophytic Vegetation in depend on Degree of Soil Salinity (The South Part of Central Siberia, Khakasia)

Slyusar N.A.[1], Zorkina T.M.[2], Pechurkin N.S.[1]

[1]Institute of Biophysics SB RAS, Russia, Krasnoyarsk, Akademgorodok 50-50, 660036

[2]Khakas State University, Russia, Abakan, Lenina 90, 655017

Phone: +79607585094; Fax: +7(3912)433400; E-mail: nata_slyusar@mail.ru

ABSTRACT

Field investigations of yields of halophytic meadow plant communities were performed in the coastal area of Lake Kurinka in the central part of the Republic of Khakasia in 2003 – 2008 years. Salinity plant communities play important role for agricultural practice of Khakasia. Five plant communities *Festuca – Elytrigia* (PC.1.), *Artimisia – Puccinellia* (PC.2.), *Suaeda* (PC.3.), *Carex* – herbs (PC.4.), herbs – *Phragmites* (PC.5.) were investigated (2004-2008) on the north-west coast in depend on degree of salinity soil. Each plant community locates on soils of different types with different degree of salinity, resulting in changing in structure. Results of investigation can be used for distributing dynamic halophytic meadow vegetation to quality estimate its dependence on environmental factors with construction mathematical model.

Keywords: halophytes; plant communities; temperature; salinity level of the soil.

INTRODUCTION

The important factor influencing change of soil salt concentration and change of vegetation structure are weather conditions of a vegetative season. In the coast zone of salt-lake (besides air temperature and precipitation sum) a special role play change of altitude above the sea and concentration of readily soluble salts in the soil. This parameter determines species plant distribution on plant communities and influence, consequently, on their productivity.

There is very little published information on the relationships between agricultural crop yields and such soil factors as the depth of the salinity maximum and the amounts and composition of the soil salts.

Halophytic plants are capable to exist on soil with high salt concentration. Different researchers (Lee et al., 2005) observed beneficial effects of moderate salinization on life processes of halophytic plants. Particularly, increasing of ferments strength, responsible for a salt exchange, maximal growth, etc was observed. However, high concentrations of soluble salts in the soils had negatively impact on plants. Soil salinity is a major abiotic stress in plant agriculture worldwide (Zhu et al., 2001). In addition, toxic salts action depends on chemical compound of salts and depends on salt tolerance of plant. It was established, that toxic sequence of widespread in nature soluble salts are $MgSO_4$ --- Na_2SO_4 --- $MgCl_2$ --- $CaCl_2$ --- NaCl --- Na_2CO_3 --- $NaHCO_3$. Thus, toxicity increases from sulfates to chlorides and further to carbonates (Martin et al., 2006.).

MATERIALS and METHODS

The study was performed on plants of halophytic meadows in the coastal area of Lake Kurinka in central part of the Republic of Khakasia (53°26'01"N, 91°34'85"W). The common mineralization is changing from 72 to 108 g l-1 (Krivosheev, 1991). Field investigations were conducted during 2003–2008. Harvest was gathered during the time period of May to September, on the same days of every month. Three plant communities were studied: meadow fescue-couch grass (Festuca pratensis Huds., Elytrigia repens (L.) Nevski) – PC. 1, sagebrush-puccinellia (Artemisia nitrosa Web., Puccinellia tenuissima Litv. ex V. Krecz.) – PC. 2, and seablite (Suaeda linifolia Pall.) – PC. 3. Carex – herbs - PC. 4., Every plant community grew on the soil of a different level of salinity – the amount of the solid residue of the saline soil aqueous extract (Table 1). The type of salinity is sulfate-sodic. Theoretical results are compared with the field data of the first three months of active growth of plant communities (May, June, and July). The field data were processed statistically (Dospekhov, 1973).

Determination of Plant Productivity

Plant productivity was determined in the growth period in 2004 - 2007 year. Three permanent study plots (10×10 m 2) were located on soil with different degree of salinity. The occurrence of each vascular species, its coverage, density and mean height was recorded in each plot. Plant productivity calculations were based on alive aboveground biomass from samples that were harvest from a 1 × 1 m area in four replications in the center of each plot. Raw material was separated into five botanical-functional groups: gramineous plants, sedges, beans, sagebrush, herbs. All reproductive shoots were weighed, dried from air-dry state (at 80°C) and weighed again (Voronov, 1973).

Determination of the Solid Residue of the Saline Soil Aqueous Extract

It was measured 30 g of soil samples and scooped of soil into a 300-ml conic flasks. Then, in conical vessel was added 150 ml of distilled water. The soil samples and water was stirred in during 3 min and was leave the solution to settle for at least 5 min. After that an extract filter, using double folded filters, and place in porcelain cup. Previously, porcelain cup was dried up and weighed with a margin error no more 0,001g. After that porcelain cup was put up on a water-bath for evaporation of a filtrate. Then a cup was weighed again (with a margin error no more than 0,001g). The mass fraction of solid residue of the saline soil aqueous extract (total dissolved solid (TDS) was calculated under the formula:

$$TDS = (A - B)*1000 / V$$

where:

A = weight of dried residue + dish, mg, and

B = weight of dish, mg.

V= sample volume, ml (Schukin, 1985).

RESULTS and DISCUSSION

The purpose of this work is to study of structure-functional features of halophytic vegetation in depend on degree of soil salinity (the south part of Central Siberia, Khakasia). Five plant communities Festuca – Elytrigia (PC. 1.), Artimisia – Puccinellia (PC.2.), Suaeda (PC. 3.), Carex – herbs (PC. 4.), herbs – Phragmites (PC. 5.) were investigated (2003 - 2008) on the north-west coast in depend on degree of salinity soil (table 1).

Table 1.Structure of plant communities and soil salinity level

Plant community	Plant community structure	Soil salinity, %
PC.1	Elytrigia repens Elymus junceus	0.1
PC.2	Puccinellia tenuissima Artemisia nitrosa	1.84
PC.3	Puccinellia tenuissima Suaeda linifolia	3.58
PC.4.	Carex enervis Halerpestes salsuginosa	1,29
PC.5.	Phragmites australis Juncus gerardii Triglochin maritimum	0,6

These plant communities include 36 species, which belong to 15 families. Most of them from family Chenopodiaceae (19.4 % from all species). Each plant community locates on soils of different types with different degree of salinity, resulting in changing in structure (table 2).

Table 2. The characteristics of soil nearest coastal zone Lake Kurinka

№	Plant community	Soil type	pH
1	PC.1	medium loam meadow soil	7,7-8,9
2	PC.2	meadow sandy loam saline soil	8,5-8,4
3	PC.3	medium meadow loam saline soil	9,2-8,3
4	PC.4.	heavy loam meadow-swamp saline soil	8,2-8,7
5	PC.5.	heavy loam meadow-swamp saline soil	7,8-8,2

PC. 1. growth on medium loam meadow soil with low salinity level of 0.25%, pH varies from 7.7 to 8.9 along profile soil. Vertical stratification of this plant community have three layers. The first layer has height 85 – 90 cm and occupies by dominant species Elytrigia repens and subdominant

Festuca pratensis. The second layer is presented by Artemisia nitrosa and rarely Potentilla inclinata, Limonium gmelinii. The third layer is occupied by Suaeda linifolia (the coverage lower then 2%).

Artimisia – Puccinelia plant community locates also on meadow sandy loam saline soil with degree salinity changing from 0.6 to 1.8%. The increase of sulfate-ions up to 0.24% and appearance chloride (the pH values changing from 8.3 to 8.5 along profile soil). Plant community structure also varies. PC. 2. has three layers such as PC. 1., but first layer is presented by dominant Puccinellia tenuissima. Subdominant Artemisia nitrosa occupies the second layer. It is registered logical increasing size of Suaeda and Salicornia – spot.

PC.3. has boundary status. It has specific second-layers structure due to enhance degree salinity up to 3.58%. Soil type is medium meadow loam. The value of pH has maximum in near-surface zone (0 – 5 cm) and composes 9.2%. The first layer has height 25 cm and is presented by dominant species Suaeda linifolia and subdominant Suaeda corniculata. Salicornia europaeae does not grows here, as it associate with chloride land.

Carex – herbs (PC. 4.) and herbs – Phragmites (PC. 5.) plant communities locate nearest to coast and have great species diversity including mesohalophyte, halomesophyte and also swamp species. It has significant degree of similarity (up to 95% in 2005 year). However, PC. 4. has second-layers vertical stratification and associate with heavy loam meadow-swamp saline soil with degree of salinity 1.29%, pH values increases with depth from 8.2 to 8.7. The first layer of plant community is significantly saturated and includes subdominant Carex enervis and also prevailing herbs: Triglochin maritimum, Tripolium vulgare, Iris biglumis. The second layer is presented by salt marsh species Halerpestes salsuginosa, Glaux maritime and others. The structure of PC. 5. has third-layers due to appearance of dominant Phragmites australis.

In addition, our research display, that plant community productivity change correlate with increasing of degree salinity soil (Fig.1. and Fig.2.).

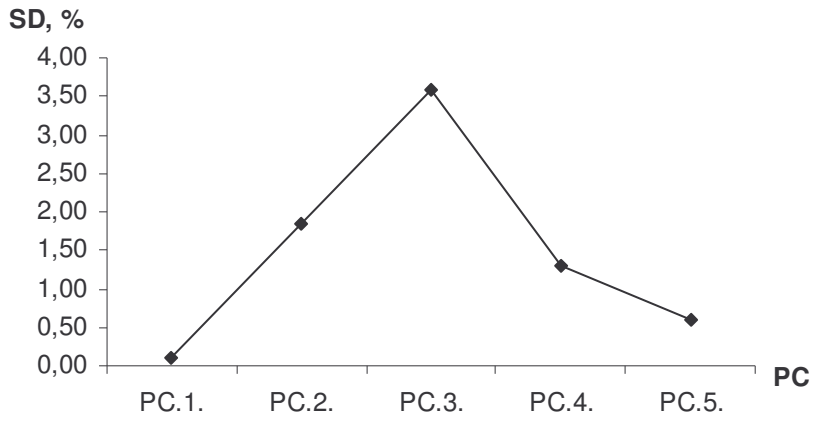

Fig.1. The sum salt concentration of plant community (SD – salinity degree, %)

In accordance with the diagram are changes productivity of the presented communities. All communities locates at one height concerning a coastal line, therefore change of a soil salinity degree is a primary factor which defines plant productivity halophytic meadows. As a whole, plant communities productivity is high enough, as climatic features of Khakassia allow to pass all physiological cycle.

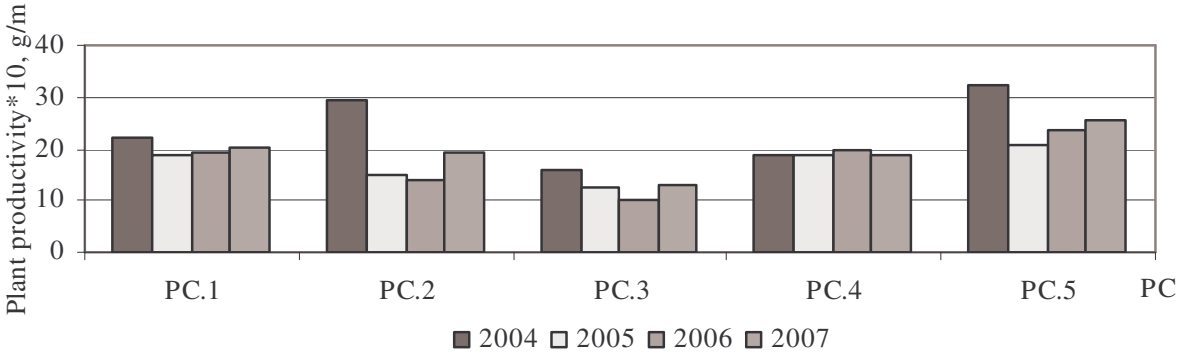

Fig.2. Plant productivity (dry mass) of halophytic meadows for 2004-2007 years

The similar analysis allows to estimate features of functioning of plant communities (in our case – halophytic vegetation) in depend on climatic conditions of a vegetative season and change of a degree soil salinity. The quantitative estimation of stability plant community will help to reveal mechanisms due to which stability plant community to constantly varying conditions of environment is formed.

Results of research can be used for the description of dynamics of productivity of vegetation halophytic meadows with the purpose of a quantitative estimation of its dependence on environmental factors of with construction of mathematical model.

ACKNOWLEDGEMENTS

This study was supported by Krasnoyarsk Scientific Fund – Russian Fund of Fundamental Research Grant (No. 07–05-96807). Автор выражает благодарность Ecological Fund after named V.I. Vernadsky.

REFERENCES

Aikman D.P., Scaife A., 1993. Modelling Plant Growth Under Varying Environmental Conditions in a Uniform Canopy. Annals of Botany 72, 485 - 492.

Bui, E. N., Henderson, B.L., 2003. Vegetation indicators of salinity in northern Queensland. Austral Ecology 28, 539 – 552.

Chu, Y., He, W.-M., Liu H.-D., Liu. J., Zhu X.-W., Dong, M., 2006. Phytomass and plant functional diversity in early restoration of degraded, semi-arid grasslands in northern China. Journal of Arid Environments 67, 678 – 687.

Dospekhov B.A., 1973. Metodika polevogo opyta (Methods of field experiments). Moscow: Kolos, 351 p. (in Russian).

Gao Q., Yu M. and Yang X., 2000 An Analysis of Sensitivity of Terrestrial Ecosystems in China to Climatic Change Using Spatial Simulation. Climatic Change 47, 373 - 400.

Gent Martin P.N., Enoch Herbert Z., 1983. Temperature Dependence of Vegetative Growth and Dark Respiration: A Mathematical Model. Plant Physiol. 71, 562-567.

Krivosheev A.S., 1991. Treatment and rest on lakes of Krasnoyarsk territory. Krasnoyarec, Krasnoyarsk, Russia, 93 pp. (in Russian).

Krivtsov V., 2004. Investigations of indirect relationships in ecology and environmental sciences: a review and the implications for comparative theoretical ecosystem analysis. Ecological modeling 174, 37 – 54.

Lee G., Carrow R.N. and Duncan R.R., 2005. Criteria for Assessing Salinity Tolerance of the Halophytic Turfgrass Seashore Paspalum. Crop Science 45, 251 – 258.

Martin, C. San, Subiabre, M., Ramirez C., 2006. A floristic and vegetational study of a latitudinal gradient of salt marshes in South-Central Chile. Cien. Inv. Agr. 33 (1), 33 – 40.

Mulder, C. P. H., Bazeley-White, E., Dimitrakopoulus, P.G., Hector, A., Scherer-Lorenzen, M., Schmid, B., 2004. Species evenness and productivity in experimental plant communities. OIKOS 107, 50 – 63.

Ni, J., Wang, G. H., Bai, Y.F., Li, X.Z., 2007. Scale-depend relationships between plant diversity and above-ground biomass in temperate grasslands, south-eastern Mongolia. Journal of Arid Environments 68, 132 – 142.

Pisman T.I., Slyusar N.A., 2007. Model of seasonal growth of halophytic plant community with account of temperature factors. Modeling of non-equilibrium systems-2007. Proceedings of the 10th all-Russia workshop. Krasnoyarsk. 113-115 (in Russian).

Sanchez, J.M., Izco, J., Medrano, M., 1996. Relationships between vegetation zonation and altitude in a salt-marsh system in northwest Spain J. Vege. Sci. 7, 695 – 702.

Sanderson, E.W., Ustin, S.L., Foin, T.C., 2000. The influence of tidal channels on salt marsh vegetation. Plant Ecol. 146, 29 – 41.

Schukin N.M., 1985. Methods of soil analisis. Izdatelstvo standartov, Moscow, Russia, 40 pp. (in Russian).

Svendsen, H., Hansen, S., Jensen, H.E., 1995. Simulation of crop production, water and nitrogen balances in 2 German agroecosystems using the daisy model. Ecological Modelling 81, 197 – 212.

Yan W. and Hunt L.A., 1999a. An Equation for Modelling the Temperature Response of Plants using only the Cardinal Temperatures. Annals of Botany 84. 607 - 614.

Yan W. and Hunt L.A., 1999b. Reanalysis of Vernalization Data of Wheat and Carrot. Annals of Botany 84, 615 - 619.

Zhu J.-K., 2001. Plant salt tolerance. TRENDS in Plant Science 6, № 2, 66 – 71.