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Rice on saline soils of Russia

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Abstract. In southern regions of Russia there are large areas of saline lands. But there is possibility and usefulness of rice cultivation in this zone. There are two methods to use such soils. The first one is to use agrotechnical methods of soil amelioration. The second method is to have breeding program resulting in rice plant salt resistance at germination and flowering stages. New salt-tolerant variety Kurchanka has been produced using Russian and foreign varieties.

Introduction

Rice in Russia is cultivated to produce valuable dietary grits. Rice crop also plays an important role in reclamation of swamped and saline soils, which cannot be used for growing other crops.

In southern regions of Russia there are huge territories which demand special amelioration works to be used for farming.

Only in delta of the Kuban river there are 110,000 ha of alkaline and saline soils in Krasnodar territory. Rice growing started to develop very fast in Kuban beginning middle of the sixties. The total area of engineering systems reached 250,000 ha. Reclamation of saline soils was preceded by wide scale research, which showed the possibility and usefulness of rice cultivation in this zone. More than 30 years experience of land reclamation has shown that after 5-7 years of growing rice, soils lost excess salinity and as a result cereals, fodder crops and vegetables could be grown there.

I – Salt Resistance of Rice

Rice ability to grow on saline soils is justified by world practice. Many researchers consider rice to be a crop with medium salt resistance. But since water layer reduces salt concentration, plant growth is not inhibited.

Investigations carried out by physiologists showed that rice is most susceptible to saline soils at the stage of germination, shoots and flowering.

It was found that salt concentration increase has osmotic and toxic influence. Osmotic influence of salts mainly causes delay of water penetration into cells and dehydration of protoplasm (Tur, 1978). Toxic influence of salts is especially strong in case of excess accumulation of chlorine ions in shoots (Tulyakova, 1978). When rice is grown on saline soils at emergence plant density is high, but at the stage of 2-3 leaf it decreases due to of dying away of shoots. Salts influence seed germination and seedling growth differently: they inhibit enzymes and suppress breathing and phosphorylation process and change the content of organic phosphate, nucleic acids, protein nitrogen (Tur, 1978). That is why at germination stage it is important not to have high salinity level of subsurface soil layer and irrigation water. That is why water is normally replaced in the basins.

Two types of soil salinization—chloride and sulfate—are observed in rice growing areas of Russia. As a rule there is a mixed type of salinization with different ratio of salts. Sodium chlorides are the most toxic.

But in both cases increase of salt concentration causes decrease of dry weight of plants, nutrients uptake, NPK content and grain yield (Table 1).

Both types of salinization suppress rice growth and yield. Plants perished at 0.7% chloride and <1% sulfate soil salinization. At the same time it was found that low concentrations (up to 0.1%) of sulfate salts stimulate rice plants.

In rice growing practice of Russia irrigation water is used repeatedly. Thus the total volume of discharged water from Kuban rice fields for repeated use, is about 1 billion cubic meters. About 0.6 billion cubic meters were used for rice irrigation and 30,000 ha were irrigated additionally (Dzhulay et. al., 1980).

Table 1. Chloride and sulfate salinization of soil and productivity of rice cultivar Dubovsky 129 (N. Tur, 1978)

Salinization level (%)	**Chloride**		**Sulfate**	
	Plant height (cm)	Grain weight per plant (g)	Plant height (cm)	Grain weight per plant (g)
0	75,5	2,91	-80,6	2,90
0,1	70,0	2,03	-90,1	3,30
0,3	70.0	0,85	-82.9	2,26
0,5	62,3	0,23	-80,3	1,24
0,7	-	-	-72,3	0,93
1,0	-	-	-60,1	0,13

Rice resistance to salinization differs depending on growth stage. That is why it is very important for an agronomist to know, when mineralized water can be used for irrigation by and what salt concentrations are accepted.

In special tests begun at germination, and continued at shooting and flowering, rice was irrigated with saline water with 1.5-3.5 % salts (Table 2).

Table 2. Reaction of rice cultivar Krasnodarsky 424 to chloride-sulfate salinization of water at different groth stages of rice (A.P. Smetanin, L.V. Dolgikh, 1966)

Salinization level (%)	**Plant height** (cm)	**Productive shoots**	**Grain weight of the main panicle** (g)	**Spikelets sterility** (%)
		Shoots at 2-3 leaf stage		
0	82,4	2,1	2,1	9,6
1,5	74,3	1,9	1,6	9,8
3,5	60,3	1,1	0,8	26,0
		Tillering (5-6 leaf stage)		
0	74,0	1,2	1,7	12,6
1,5	67,3	1,3	1,3	16,0
3,5	55,3	1,4	0,4	52,4
		Flowering (10-11 leaf stage)		
0	76,5	1,3	1,8	8,5
1,5	72,1	1,5	1,9	30,3
3,5	58,3	1,2	0,5	86,1

Higher concentrations of soil solution according to rice growth stages resulted in negative influence on plants.

Plants suppression resulted in lower plant height, less number of productive shoots, lower grain weight per panicle and dramatic increase of spikelet sterility.

The most negative reaction of rice plants was observed when saline water was used for irrigation at flowering stage: panicle sterility increased 6 times. That is why the decision of repeated use of water for rice irrigation should be taken only after its quality is determined.

II – Increase of rice productivity on saline soils

Results of Russian scientists' research show that there are two ways to increase rice productivity on saline soils. The first one is to use agrotechnical methods of soil amelioration. It means preliminary washing of saline fields, application of ameliorants (gypsum and gypsum phosphate), high rates of organic and mineral fertilizers and change of water layer in basins during rice vegetation with fresh, non-mineralized water.

The second method is to have breeding program resulting in rice plant salt resistance at germination and flowering stages. Some success has been made in solving such problems. After construction of rice irrigation systems saline soils were reclaimed with washing at wintertime. The soil ploughing was followed by basin filling with 20-30 cm water layer. The first flooding was done during the period from October 24 to November 18; the second—November 24 to December 24. Discharge water was removed from irrigation system. As a result salt content in soil arable layer decreased 7-8 times (Tur, 1978). During rice sowing further decrease of salinization took place in the fields. To avoid secondary salinization it is recommended to permanently control salt content in soil arable layer and sow non-irrigated crops when the soil salinity is reduced to norm.

During reclamation of alkaline soils the best efficiency is reached when chemical ameliorants are applied. The widely used products are gypsum, gypsum phosphate and other calcium products. Application of gypsum phosphate 8-10 t/ha results in increase of grain weight and number of panicles per 1 square meter and grain weight per panicle. Rice grain yield increase due to gypsum phosphate application 0.39-0.54 t/ha (Kremzin, 1995). Experiments of N. Vorobyov and T. Zhurba (1995) show that soil chloride salinization (0.35% NaCl) and water mineralization at the level of 0.35 g/l inhibit rice plant photosynthetic activity, decrease foliar surface and net plant productivity, above ground matter is decreased considerably. But the value of such changes depends on salt resistance of the cultivar and mineral nutrition level. Inhibition effect of salts on salt-resistant cultivar Spalchick was lesscompared to non-resistant cultivar Kulon. Plant nutrients, nitrogen in particular, positively influence growth and development of salt-resistant cultivars under saline conditions compared to standard. Thus, high fertilizer application rates resulted in higher grain yield of cultivar Spalchik under saline soil conditions (4.2 times). Under standard conditions the increment received was only 1.7 times.

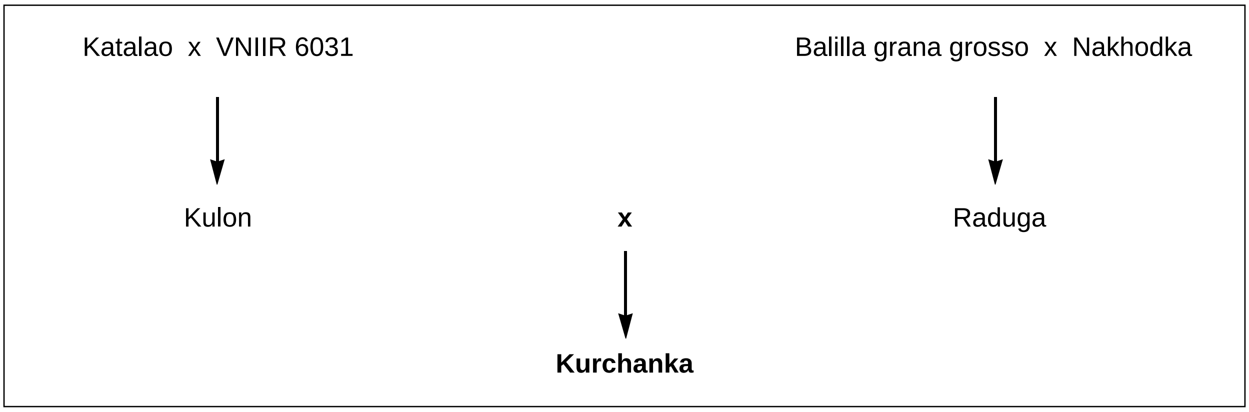
Russian plant breeders have always paid much attention to production of salt tolerant cultivars. Special breeding programs have been carried out since 1975. A big amount of rice samples combining salt-resistance with other valuable characteristics were chosen from rice collection. Early maturing, dwarfish forms are of interest, with salt-resistance below 7 grades (Table 3). They were widely used in breeding programs.

Hybridization process involved not only cultivars of Russian origin, also foreign ones as sources of particular valuable characteristics. Russian plant breeders are interested in Mediterranean rice cultivars. New rice cultivar Kurchanka can serve as a vivid example of such donor usage (Fig. 1). It has been included into State Cultivar Register in 1997. It is a cultivar with medium ripening period, with short stems, resistant to logging and falling off, possessing high salt resistance at shooting and flowering stages. It makes this cultivar different from other similar cultivars including Spalchik that has been used as salt tolerance standard in plant breeding and physiological trials.

Table 3. Early maturity collection samples as sources of salt resistance

Catalogue n°NIIR	Days from flooding to maturity	Plant height, cm	Salt resistance evalution, grade
0812	103	73.5	7
02231	109	82.7	7
02432	96	69.0	7
02611	103	106.0	7
02625	102	69.9	7
02712	93	70.7	7
02734	106	75.8	7
02865	106	79.7	7
03064	94	91.5	7
03230	101	85.3	7
01318-standard	113	85.0	7

Figure 1. Genealogy of salt-resistant rice variety Kurchanka



Now the new cultivar Kurchanka has substituted Spalchik. This variety inherited the best characteristics of parent forms. From cultivar Kulon it borrowed plant phenotype, high logging resistance, ability to emerge through water layer rapidly and elongated kernel producing good quality rice grits (Table 4). From cultivar Raduga it derived not only color of glumes (*Var Zeravschanica*) and high stability of grain yield formation in different years but resistance to rice leaf nematode and to soil salinization. Raduga, in its turn, inherited high salt-resistance from Italian variety Hallila grand grosso, which appeared in Russia in the middle of 60`s and was included into hybridization as donor of low height and salt resistance.

It is necessary to emphasize that in special trials when soil solution salinity was 3.5 g/l the yield of cultivar Kurchanka did not decrease.

Under field conditions on saline soils yields of cultivar Kurchanka are 0.5-0.6 t/ha higher compared to other cultivated cultivars; it has not been observed under non-saline soils conditions.

Table 4. Characteristics of variety Kurchanka (field trials, 1994-1995)

Index	Kurchanka	Spalchik - standard
Yield (t/ha)		
Saline soil	4,88	4,24
Non-saline soil	5,82	5,80
Vegetation period (days)	120	118
Plant height (cm)	85	80
Grain shape (l/b)	2,4	1,4
Glassiness (%)	98	64
Milled rice (%)		
Total	**70**	**69**
Head rice yield	97	60

That is why cultivar Kurchanka is recommended for cultivation on saline soils in the South of Russia, according to ecologically safe technology without pesticide application.

It helps not only to increase the efficiency of rice growing in the given area but also to decrease chemical pollution of arable lands and to improve a ecological situation.

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