RICE IRRIGATION TECHNOLOGY ON SALINE LANDS

ТЕХНОЛОГИЯ ОРОШЕНИЯ РИСА НА ЗАСОЛЕННЫХ ЗЕМЛЯХ

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Abstract: *Rice production on the irrigated lands of the Syr Darya river basin (the Aral Sea region) is a traditional specialization of the agricultural sector. If on the mildly saline soil rice yield reaches more than 5 t/ha, then on highly saline soil rice yield is below 2 t/ha, which makes its cultivation not profitable. Those lands degrade and eventually excluded from agricultural use. We studied the rice irrigation technology of saline lands, which enables to provide rice yield of 4 tons per hectare and above.*
KEYWORDS: RICE, RICE SYSTEM, IRRIGATION TECHNOLOGY, SALINE LAND.

1. Introduction

Rice production on the irrigated lands of the Syr Darya river basin (the Aral Sea region) is a traditional specialization of the agricultural sector and occupies more than 200 thousand hectares, of which 70% are saline, 30% are excluded from agricultural use due to strong secondary salinization [1]. If on the mildly saline soil rice yield reaches more than 5 t/ha, then on highly saline soil rice yield is below 2 t/ha, which makes its cultivation not profitable. [2] Those lands degrade and excluded from agricultural use. We studied the rice irrigation technology of saline lands, which enables to provide rice yield of 4 tons per hectare and above.

2. Means and methods for solving problems

The research activities were carried out on strongly saline lands of Karaultyubinsky Experimental and Production Farm located in the Syr Darya river basin, which were not cultivated for over 20 years because of the strong secondary salinization. After completion of the irrigation and drainage restoration works on the experimental plot of 20 hectares, the spring plowing was carried out to a depth of 22-24 cm, then disking, twofold harrowing, leveling and compaction of the topsoil. Mineral fertilizers were applied before planting rice (300 kg/ha of ammonium sulfate and 100 kg/ha of ammophos). Rice field flooding was carried out in early May. During irrigation period from the rice crops to milk-wax ripeness phase a permanent layer of water on rice field was maintained. The water layer was varying from 5 to 15 cm, depending on the phase of rice plant growing. Rice field in the period of full shoots was treated against weeds with herbicide "Gulliver", a dose of 25 g/ha. During tillering phase of rice plants top dressing with ammonium sulfate, a dose of 150 kg/ha was carried out. On the experimental site monitoring of the water and salt regime, water consumption, growth and development of rice plant yield were conducted. In the lysimeter pots of 3000 sm^2 area a study was carried out in order to determine critical salinity level thresholds for the growth and development of rice plants. Critical limits for rice field water layer mineralization were determined: 1.8 g/l at the initial phase of the growth season - germination - seedling-tillering; 2.5 g/l in the later phases of growing rice plants.

3. Results and discussion

On strongly saline lands of Karaultyubinsky Experimental and Production Farm soil is heavy texture. In the 0-50 cm depth layer of the soil the aggregation degree is reduced from 74-80% to 28-35%, humus content reduced from 1.51% to 0.81%, in the absorbed bases composition increases the exchangeable magnesium proportion from 14-30% to 39-57% of the total.

The experimental site is characterized by strongly saline level with highly toxic salts: NaCl and Na_2SO_4. The salt content reduces from the soil surface into the depth from 5.501% solid residue in the upper 0-5 cm layer to 2.277% solid residue at a depth of 120-140 cm (Table 1).

Table 1 *– Salt content at experimental site soil*

Depth of soil sampling, cm	Salts,%						
	$Ca(HCO_3)_2$	$CaSO_4$	$MgSO_4$	NaCl	Na_2SO_4	Na_2SO_4	Total of salts,%
1	2	3	4	5	6	7	8
0-5	0,0292	0,6725	0,3005	1,1147	0,0038	3,3803	5,501
5-10	0,0252	0,7718	0,4056	0,6945	-	1,8389	3,736
10-20	0,0252	0,8228	0,2253	0,6396	-	0,8981	2,611
20-40	0,0227	0,6109	0,3912	0,8461	-	0,5701	2,441
40-60	0,0252	0,6698	0,5711	0,6738	-	0,6851	2,625
60-80	0,0267	0,6752	0,6611	1,0851	-	0,7859	3,234
1	2	3	4	5	6	7	8
60-80	0,0267	0,6752	0,6611	1,0851	-	0,7859	3,234
80-100	0,0227	0,5760	0,4658	0,9175	-	0,8010	2,783
100-120	0,0252	0,5748	0,5559	0,6967	-	0,7284	2,591
120-140	0,0252	0,5617	0,5259	0,7035	-	0,4607	2,277

In the process of rice cultivation while surface water is discharged and water on rice fields is filtered flushing of saline soils occurs. While the initial salinity was 3.0% of salt in the 0-100 cm layer of soil, after one year of rice cultivation the salt content was reduced to 1.273%, after two years down to 0.728%, after three years down to 0.431%. (Table 2) After three years of rice cultivation the soil from the category of strongly saline moved to slightly and medium saline. Rice yield in the first year of rice cultivation is 3.27 t / ha, in the second year 3.97 t / ha, and in the third year 4.58 t / ha. (Table 2)

Table 2- *Salt regime of soils and rice yield.*

№	Indicators	Years of rice crop		
		1	2	3
1	The salts content in the spring before planting rice in the 0-100 cm layer of soil, %	3.000	1.470	0.840
2	The salts content in the autumn after harvesting rice in the 0-100 cm layer of soil, %	1.273	0.7416	0.409
3	Removal of salts from 0-100 cm layer of soil after rice cultivation, %	1.728	0.728	0.431
4	Yields of Togusken rice variety, t / ha	3.27	3.97	4.58

In the first year of rice cultivation filtration flow from rice field is 3700 m^3/ha, in the second year - 3490 m^3/ha, in the third year - 3080 m^3/ha.

On strongly saline and poorly drained lands of Karaultyubinsky Experimental and Production Farm due to convective diffusion of salts from the soil and groundwater the salinity of rice field increases. When the critical salinity level during the initial phase of vegetation, 1.8 g/l and in the subsequent phase 2.5 g/l, the water from the rice field completely discharged and the field is flooded with fresh water from the irrigation network. The number of water discharges on the rice field during the rice-growing season constituted: in the first year of rice cultivation - 5 times, with a total volume of 4624 m^3/ha; in the second year of rice cultivation - 3 times, with volume - 3110 m^3/ha; in the third year of rice cultivation -1 time, with volume - 1260 m^3/ha.

With constant flooding of saline lands irrigation norm constitutes 24.35 thousand m^3/ha. Constituent elements of the irrigation norm: evapotranspiration - 10367 m^3/ha, saturation of ground soil - 4460 m^3/ha, leachate and surface discharge into the drainage network in the first year of rice cultivation - 8324 m^3/ha, in the second year of rice cultivation - 6810 m^3/ha, in the third year of rice cultivation - 5550 m^3/ha.

Irrigation modulus of original flooded rice field is 5.1-6.16 l/from ha, during the water layer maintenance - 2.0-2.4 l/from ha.

The water layer on rice field plays a multi-factor role, it has a great influence on the water infiltration and washing salts from the rice field soil, plays an environmental factor that determines if all other things being equal, the formation and productivity of rice plants. [3,4,5] With the water layer salinity change on the rice field irrigation rate changes, the yield of rice and water consumption per tonne of harvest.

We found a correlation (r = 0.983) of rice yield (Y) from the mineralization of water (C) of the rice fields during irrigation period:

$$У = (2.5 + 4.9c^1) - 0.5C,\ 2.5 > C > 1.0\ g/l \quad (1)$$

While C - 1 g/l У = 6.4 t/ha, C > 2.5 g/l У = 2.75 t/ha.

Studies have shown that the rice field's water mineralization depends on the degree of soil salinity, the salts concentration in irrigation water, the intensity of total water use on the rice field, water layer and drainage, i.e. the effectiveness of the drainage system.

The intensity of salts accumulation in the water of the rice field and the need to change the water can be determined by calculation of the balance equations describing the dynamics of changes in water volume and intensity of salt accumulation in the water during the time dt.

$$V\frac{dC_ч}{dt} = C_ч(V_n - V_{nt} + V_{гр}) = V_n C_n + V_{гр} C_{гр} \quad (2)$$

where V - volume of water in the rice bay at time t, m^3/ha; V_0 - initial volume of water in the rice bay, m^3/ha; $V_п$, $V_{гр}$ - the average daily amount of water coming in the rice bay in time $t_1, t_2, t_3 \dots t_n$ by the overflow from the soil solutions and ground water, m^3/ha; $V_е$, $V_{чт}$, $V_ф$ - the average daily volumes of water consumed at the rice bay in time $t_1, t_2, t_3 \dots t_n$, respectively, to discharge, evaporation and transpiration, infiltration, m^3/ha; C_0, $C_п$, $C_{гр}$, $C_ч$ - respectively the initial water salinity in rice bay, salinity of irrigation, groundwater and water in the rice bay in time t, g/l.

Equation (2) allows to determine the salinity of water in the rice field at any time t, and the need for changing the water when it reaches critical value (3)

$$C_ч = \frac{в}{\alpha} + (C_0 - \frac{в}{\alpha})e^{-\alpha t}, \quad (3)$$

where $в$ – accumulation of salt in rice bay over time $t_1, t_2, t_3 \dots t_n$;

$$в = \frac{1}{V}\sum_{t=1}^{n}(V_n C_n + V_{гр} C_{гр}),$$

- change in water supply volume to the rice bay over time $t_1, t_2, t_3 \dots t_n$

$$\alpha = \frac{1}{V}\sum_{t=1}^{n}(V_n + V_{гр} - V_{nt})$$

From Equation 3 follows that an increase in water supply (V_n) decreases salinity level on the field, and conversely, a decrease in the water supply through the discharge V_n and increased supply from groundwater $V_{гр}$ leads to increase of water salinity on the field. The concentration of salts in the water on the rice field may change at the magnitude

$$\frac{\alpha}{в} = \frac{\sum_{t=1}^{n}(V_n C_n + V_{гр} C_{гр})}{\sum_{t=1}^{n}(V_n + V_{гр} - V_{nt})} \; при \;\; V_n \longrightarrow 0 \;\; и \;\; V_ф + V_c \longrightarrow 0$$

Up to $C_п$ while $V_{гр} \longrightarrow 0$ and $V_ф + V_с \longrightarrow V_п$

The dependence of changes in rice filed water salinity level on the irrigation water mineralization and the ratio $V_ф$ and $V_{гр}$ for saline loamy soils is shown on the Figure.

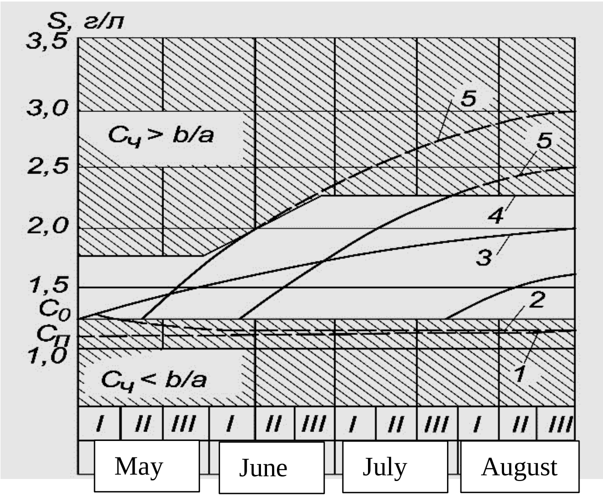

Figure. Dynamic of the rice field's water salinity in irrigation period

Where: *1* — irrigation water salinity; *2*, *3*, *5* — rice field water salinity while $Q_ф + Q_ч = Q_Г$ and $C_ч < b/a$, while $Q_ф > 0$ and $C_ч < b/a$, while $Q_{гр} \geq 0$ and $C_ч > b/a$; 4 – the maximum permitted salinity level of water on the rice field.

From the data it follows, that the higher the water infiltration on rice field and lower the ground water salinity, the lower the salt level in rice field's water accumulated. With reduction of infiltration and increasing pressure of groundwater the rice field's water salinity increases and in order to reduce salinity level it is necessary change the water.

To reduce the water salinity on the rice field and prevent loss of rice crop, it is necessary on a strongly saline lands to periodically discharge the water from the rice fields and fill with fresh water. But the water discharges shall not become spontaneous as excessively frequent discharges cause increase in water intake from an irrigation source, relief network overflow and pollution. Water discharges from rice field shall be carried out in the cases where the water salinity on rice field exceeds the maximum permissible value, the curve 4, drawing. In a production environment salinity water on the rice field can be determined by salinometer. Daily take measurements and determine the salt content of the water in the rice fields.

4. Conclusion

Adoption of the developed technology on saline lands of rice irrigation systems, i.e. the constant flooding with the replacement of water on the rice fields when the salinity level reaches of 1.8 g/l in the period of germination, seedling and tillering, while 2.5 g/l in the next phase of rice crop development, this will allow to avoid chaotic discharges and ensures the rice production profitability on saline lands up to 35% and additional raw rice yield in the Aral Sea region more than 100 thousand tons. It will reduce the burden on the water drainage network by 25-30%, reduce the amount of waste runoff from rice fields by 35-40%, and bring into agricultural production lands, which were abandoned due to secondary salinization.

5. References

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