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A. G. Rau[1], A. Sh. Bakirova[1], K. K. Anuarbekov[1], Zh. Kadasheva[1], L. Jurik[2]

[1]Kazakh National Agrarian University, Almaty, Kazakhstan,
[2]Slovak University of Agriculture in Nitra, Nitra, Slovakia.
E-mail: alexyrau@gmail.com, bakirova0202@gmail.com,
kanat.anuarbekov@kaznau.kz,dikuwa_90@mail.ru, lubos.jurik@uniag.sk

WATER GEOCHEMISTRY ON AKDALA RICE IRRIGATION SYSTEMS

Abstract. In the rice system produced discharges of water from rice fields that rice farmers is explained by the increase of water mineralization in rice bays influencing a reduction in rice yield. Given the Geochemistry of water Akdala irrigation system. The physics of negative influence of salts in water of rice bays on development of plants of rice and its productivity is proved. The critical threshold indicators of salinity and pH of water of rice bays and the frequency of discharges, providing a decrease in the rate of water consumption and sanitation by 15 %, increasing the yield of rice by 12 %, the profitability of production by 11%.

Key words: management, water, rice irrigation systems, rice, rice bay, salinity, change of water, irrigation rate, yield.

Introduction. Rice irrigation systems of Kazakhstan are situated on terraces in basins of rivers Syrdarya, Ile, Karatal on the area 200 thousand hectares. Soils are alluvial-sierozemic, takyr, weakly, moderately and strongly saline, climate is extremely continental arid, summer is hot 30-45^{0}C. Rice is cultivated on rice bays, which area is from1,5 ha to 3,0 ha. Periodical water discharges from rice bays are performed in rice-planting cooperatives and farm, growing rice during irrigation period, which necessity is related to increase of water salinity in bays, affecting on reduction of rice yield.

Disadvantage of this method of water resources management on rice irrigation systems is that there is insufficiently studied water geochemistry rice bays, no adequate substantiation of necessity of water discharge from rice bays during irrigation period. Unnecessary water discharges from rice bays overfill drain discharge channels, decrease their drainage effect, and lead to soil water head, secondary salinization and genesis of bog soils of rice systems. About 20-30% of mineral fertilizers, herbicides is removed by discharge outflow resulting in reduction of rice yield. In the result of application of this method of rice planting, rice yield has reduced to 46 c/ha, and irrigation norm has increased to 26,800 thousand m^3/ha, anddischarge outflow is 20-30% of irrigation norm.

Usage of water resources on rice systems in terms of restricted water access requires new approaches to water management and usage on rice irrigation systems, where nowadays there are hundreds of cooperatives and farms, which are water consumers and have equal rights on irrigation water in accordance with the Water Code of the Republic of Kazakhstan [1]. But there are a lot of problems due to water supply deficit, caused by application of obsolete method of rice growing and t1chnology of regulation and usage of irrigation water in rice irrigation systems. According to literary sources [2, 3] threshold values of water quality in rice bays, affecting rice yield and necessity in periodical water discharges are salinity and pH of water layer in water consumption rate rice bays. Dynamics of salinity and pH of water level during irrigation period, its impact on rice yield, water consumption and water discharge rates, water resources the frequency of water discharges from rice bays, efficiency use on rice irrigation systems is presented in this work.

Methods. Researches were conducted in Akdala rice system of Ile river basin, on rice fields of “Birlik” Agricultural Company of Balkhash region, Almatinskaya oblast. Water resources management in

Akdala rice system and necessity in water discharge from rice bays during irrigation period due to increase of salinity and pH of water layer has been studied on 20 bays of rice field with area 155 ha (figure 1). Chemical composition of salts in soils was determined at spring prior to rice planting, salinity and pH of water layer during irrigation and their impact on growth and development of rice, yield, water consumption and water discharge rates. Lands of rice bays 10 and 11 were very salted, with salt content more 1,0%, lands on other bays were slightly saline with salt content in soils 0,3%.

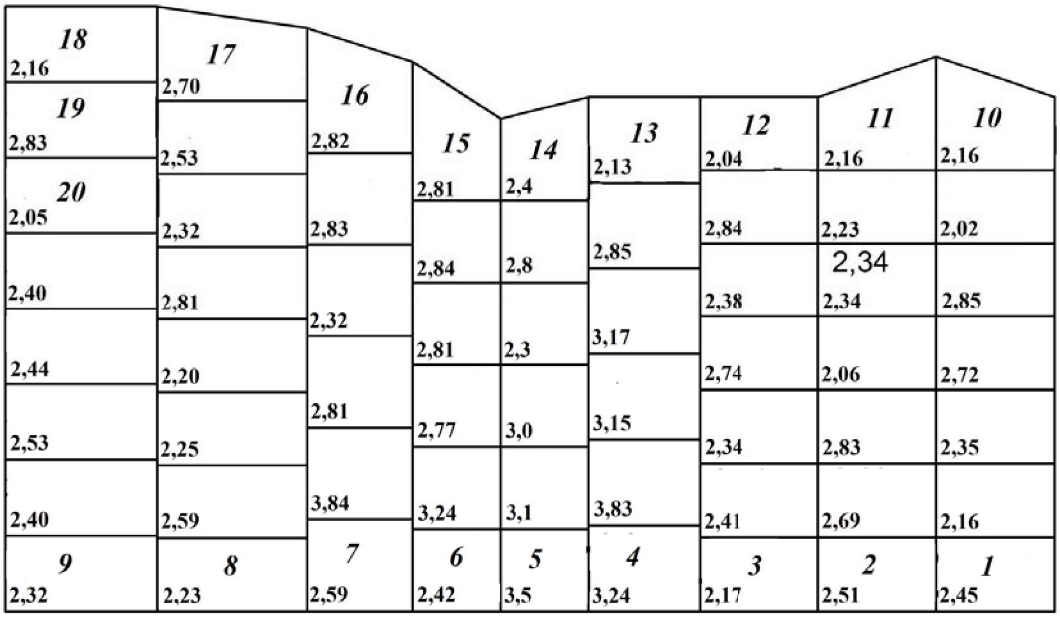

Figure 1 – Plan of rice field 155 ha of second agricultural area of "Birlik" Agricultural Company:
1-20 – rice bays, where salinity and pH of water layer were determined during irrigation period;
10 and 11 – rice bays, where water was discharged during irrigation period, 2.16 – area of rice bays hectares

Using the chemical content of water in rice bays, the irrigation coefficient SAR [4] was calculated, which was later used for assessment of water suitability for growth and development of rice plants, we were observing the condition of rice plants as well. With increase of SAR > 18 and appearance of first signs of wilting or delays in growth and development of rice plants, the water was discharged (changed) from rice bays immediately, and the "new" water was supplied from irrigation channel. Water supply into rice bays of experimental section of the fields was defined using Ivanov water release systems.

Results. Irrigated land of Akdala rice system are irrigated using water from Ile river. Since 2018, salinity of water within irrigation channels of production cooperative of "Birlik" Agricultural company was as follows: in May – 319 mg/l, in June – 339 mg/l, in July – 433 mg/l, in August – 476 mg/l, acid environment – pH – was not exceeding the level of 8.54 (table 1). In terms of chemical content, the water from Ile river is considered to be hydrocarbonate and calcium water suitable for domestic purposes and irrigation. In terms of irrigation coefficient SAR, the water is of a very good quality.

Irrigation coefficient – is the ability to rock and dust distribution within soils, which evaluated by the value of coefficient of potential sodium absorption and it is equal to 0.63 for water in Ile river.

$$SAR = Na : \sqrt{\frac{Ca+Mg}{2}} = 0.85 \sqrt{\frac{3.70}{2}} = 0.63. \qquad (1)$$

According to SAR index, the water from Ile river falls under the class with low salinity rate.

Chemical content of water in rise bays is not only condition by the initial chemical content of irrigation water, but by the content of water-solvable salts within the upper layer of soils, method of filling up the rice bay and the water layer. In terms of chemical content, water in rice bays transfers from being hedrocarbonate and sulphate water to natrium and magnesian water. Among acid ions present in rice bay water, sulphates are the main part of it; among positive ions, main parts compose of natrium and potassium.

During the irrigation period, salinity level of water was not exceeding 917 mg/l in 18 bays out of 20 (table 1). During May and June, salinity of water in 18 bays was 319-442 mg/l and was characterized by the sulphate-hydrocarbonate-calcium content. During July and August, salinity of water in all bays was increasing up to 657-917 mg/l, chemical content of water during this period was sulphate-hydrocarbonate-calcium-magnesium. Alkaline condition of water in rice bays was considered to be satisfactory and the pH level was not exceeding 9.24 units (table 1).

Table 1 – Salinity and pH level of water within rice bays of experimental field section

№ of bays	Salinity rate				pH rate			
	May	June	July	August	May	June	July	August
Irrigator	319	339	433	476	7.5	7,8	8,54	7,0
Rice bays without water release								
1	319	377	511	407	7.5	7.7	7.97	8.3
2	319	319	461	404	7.7	7.6	8.02	8.3
3	319	363	431	515	7.7	7.3	7.65	7.9
4	319	397	448	500	7.5	7.7	7.67	7.9
5	319	393	503	400	7.3	7.5	6.95	8.3
6	319	326	437	312	7.4	7.5	8.05	8.8
7	319	407	495	444	7.85	7.3	7.79	8.2
8	319	–	–	541	7.4	7.7	–	7.7
9	319	381	537	917	7.3	7.1	7.15	8.7
12	319	281	554	516	7.5	7.4	8.06	8.1
13	319	442	657	454	7.4	8.6	7.81	8.0
14	319	–	573	423	7.5	7.8	8.01	7.8
15	319	338	581	506	7.7	7,8	9.29	7.6
16	319	364	543	592	7.6	7.9	8.23	8.0
17	319	–	357	523	7.4	7.9	7.94	7.8
18	319	279	321	523	7.5	7.8	7.86	7.6
19	319	293	–	476	7.5	8.3	–	–
20	319	359	–	433	7.4	7.8	–	–
Rice bays with water release								
10	319	1.381	2.490	2.520	7.7	8.2	7.58	8.8
11	319	1.520	2.510	2.56	7.4	8.6	7.60	8.9

According to irrigation coefficient SAR, the water in 18 rice bays during the irrigation period was considered to be of a good quality, suitable for production of rice and other cultures. Water was not released from these bays for the whole irrigation period (figure 2). In land within these rice bays had low salinity rate with only 0.2-0.3% content of salts in 0-100 cm layer.

In two bays (10 and 11) out 20, salinity of water during the irrigation period was increasing and by the end of May was 1.381-1.520 g/l, by the end of second decade of July – 2.490-2.510 g/l (table 1). Having the water salinity rate of 2,5 g/l and above, the chemical content of water becomes sulphate-magnesium-sodium, and the coefficient calculated by the chemical content of water exceeds 18 units, which means that such water considered to be of poor quality and unsuitable of production of agriculture plants, including rice. The water in rice bays was released and then substituted with the fresh water from irrigation channel that has salinity level of 339 mg/l. Alkane water in rice bays, with salinity level of up to 2.5 g/l was considered to be satisfactory, and pH level was 8.2-9.29 units.

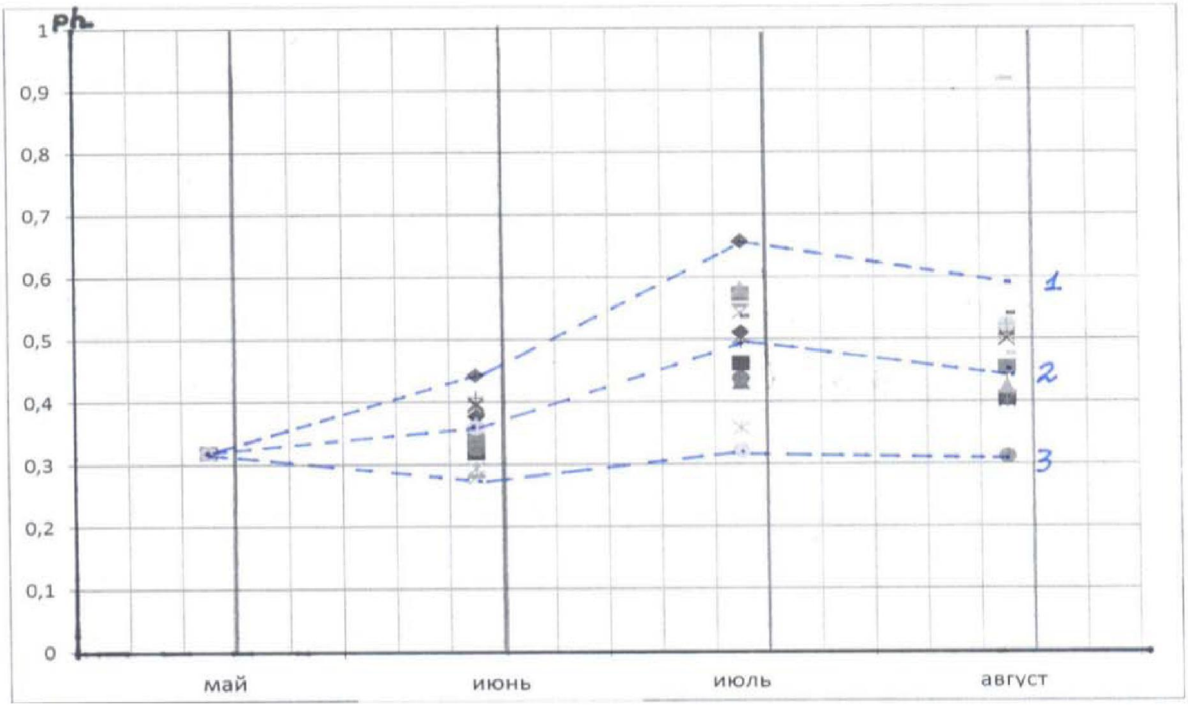

Figure 2 – Salinity of water layer on rice bays where water was not discharged during the irrigation period:
1 – maximum, 2 – average, 3 – minimum value

The second water release from two rice bays 10 and 11 was performed in first decade of August, when salinity level of water in bays was 2,520-2,560 g/l (figure 3).

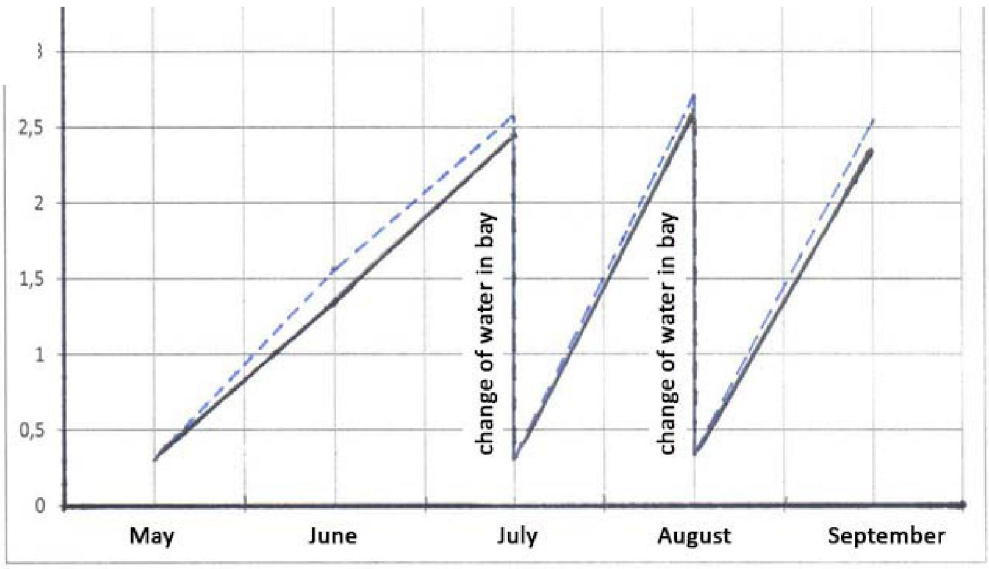

Figure 3 – Salinity of water on rice bays with water release during the irrigation period:
- - - - - – rice bay №10, ______ – rice bay № 11

Irrigation norm during the mineralization of water in rice bays is 0.7-0.9 g/l and without water release during the irrigation period is 21396 m^3/ha, in case of water salinity in rice bays of 2.5 g/l and above with water being released in July and August – 23448 m^3/ha (tables 2, 3). Hydromodule of filling up the rice bays is equal to 6.4-7.8 l/s.ha, during the period of maintaining the water level – 1.9-4.6 l/s.ha (table 2, 3).

Table 2 – Water supply to rice bays without water release systems during the irrigation period

Month	Decade	Water layer on the bay, cm	Water layer in water release system, mm	Water consumption, l/sec	Specific water consumption, l/sec ha	Water supply. m^3/ha
May	2	12.2	476	200.0	78.0	6723
	3	12.4	83	22.8	8.9	766
	Total per month					7489
June	1	4.9	125	42.0	16.3	1412
	2	3.3	37	6.1	2.4	205
	3	2.7	30	5.0	1.9	168
	Total per month					1785
July	1	2.5	137	47.9	18.6	1610
	2	9.8	126	42.3	16.5	1422
	3	14.0	126	42.4	16.5	1425
	Total per month					4457
August	1	11.0	79	21.0	8.2	706
	2	10.2	212	89.0	34.6	2992
	3	9.4	280	118.0	46.0	3967
	Total per month					7665
Water supply during the irrigation period						21396

Table 3 – Water supply to rice bays with water release systems during the irrigation period

Month	Decade	Water layer on the bay, cm	Water layer in water release system, mm	Water consumption, l/sec	Specific water consumption, l/sec ha	Water supply. m^3/ha
May	2	12.2	367	152.5	64	5525
	3	8.6	111	33.3	14.0	1209
	Total per month					6734
June	1	14.9	157	57.6	24.2	2091
	2	8.95	109	34.6	14.5	1256
	3	4.75	51	18.4	7.7	668
	Total per month					4015
July	1	2.33	45	9.0	3.8	327
	2	10.7	241	101.6	42.7	3688
	3	9.6	140	50.4	21.2	1830
	Total per month					5845
August	1	8.5	169	60.6	25.5	2200
	2	12.0	160	63.3	26.6	2298
	3	12.0	170	66.0	28.0	2396
	Total per month					6894
Water supply during the irrigation period						23488

Yield rate of rice in tested 18 bays, where water salinity level during the irrigation period was 0.339-0.917 g/l and water discharges were not performed, is 52.4 metric center/ha, and in two rice bays (10 and 11), where two water discharges were performed – 47.2 c/ha. Rice yield is 46.0 c/ha, irrigation norm is 26800 m3/ha in rice planting cooperative, where researches were performed, at unrationed water discharge from rice bays with area 100 ha. Along with discharged water, there are minerals being washed out from fields as well, which had a certain effect on growth and development of rice plants and their yield rate, in other words, yield rate in bays with discharged water was 5,2 metric centners lower in comparison with rice bays with no water discharges performed and 6,4 c/ha as compared to data of rice-planting cooperative, where unreasonable water discharges are performed (table 4).

Table 4 – Efficiency of rice plants and their yield capacity on experimental-production field of "Birlik" Agriculture company

№ of bays	Amount of rice plants before harvest	Amount of effective rice straws, pcs/m^2	Tillering coefficient	Yield capacity, metric centner/ha
Rice bays without water release				
1	142	195	1.37	50.30
2	152	206	1.45	53.30
3	142	197	1.39	50.15
4	142	196	1.41	50.0
5	155	197	1.36	55.65
6	157	193	1.31	54.30
7	150	197	1.44	51.90
8	146	189	1.39	54.0
9	148	185	1.30	49.54
12	149	194	1.40	53.80
13	153	185	1.39	48.90
14	149	188	1.35	51.11
15	158	194	1.31	53.50
16	152	194	1.36	54.20
17	148	191	1.37	52.0
18	149	197	1.38	52.76
19	151	201	1.41	53.94
20	148	194	1.41	53.85
Area 48,2 ha	149	194	1.40	52.4
Rice bays with water discharge				
10	141	183	1.34	48.1
11	137	178	1.31	46.3
Area 6,8 ha	139	180	1.32	47.2
Rice-planting cooperative, 100 ha	136	129	1.30	46.0

Rather close relation of yield rate (Y) (r=0.983) to water salinity within rice bays was defined

$$У = (2.6+4.8C) – 0.5C. \quad (2)$$

In case of $C \leq 2.5$ g/l during the irrigation period.

Discussion. Physics of negative influence of salts on development of rice plants lays in the fact that mineral salts increase osmotic pressure of soil solvents, decrease transpiration rates, inhibit ionization of mineral fertilizers, part from which remains in unionized condition and thus is not available for plants, cells receive less water and mineral elements dissolved in this water. Chemical elements that are not required for process of biomass formation, such as natrium, chlorine, magnesium and others, settle down in vacuoles, which, in their turn, grow and cause the decrease of cytoplasm volume [2-4]. Besides, all valuable agricultural properties of soil degrade – structural condition, water retention ability, aeration porosity, alkalinity, mobility of organic compounds. Excess of natrium causes the swilling of soil colloids, degradation of coagulation and other negative effects.

The influence of water salinity in rice bays on the development of rice plants may be described by the following analytical dependence:

$$C = \frac{\chi_A}{1 + У_A} . \quad (3)$$

Such equation describes development of rice plant: changes in environmental conditions (concentration of salts in water of rice bays (χ) and leads to the fact that relation of work modes, vegetation organs (A), cone of increase ($У_A$) and environmental conditions becomes uneven (C). Rice plants try to restore the lost balance, therefore change the physiological and biochemical mode of their regulation center of increase cone, which causes that very change of physiological and biochemical mode of vegetative organs that we may observe on rice bays in case of water salinity increase up to 2.5 g/l, rice plants have delay in growth, thus, in order to improve development conditions for rice plants, it is necessary to improve the environment – decrease the salinity level in water of rice bays, and in order to do so, it is necessary to perform water release and change of water.

Conclusions. Saline soil in Akdala rice system is 15 % of irrigating area, but rice on rice is grown with water discharge from rice bays, charges are performed when salinity of water layer is 2.5 g/l, irrigation norm on these lands is 23480 m^3/ha, rice yield – 47.2 c/ha. Rice is cultivated without water discharge on slightly saline lands, which are 85% of irrigated area, salinity of water layer in bays during irrigation period is 1.0 g/l, irrigation norm is 21396 m^3/ha, rice yield – 52.4 c/ha. In rice-planting cooperatives water is discharged in all rice bays resulting in increase of irrigation norm of rice by 3945 m^3/ha and decrease of rice yield on 5.4c/ha. Introducing this method of water use on Akdala rice system, saving of irrigation water will be 39.450 thousand m^3, additional harvesting of rice – 5.2 thousand ton.

А. Г. Рау[1], А. Ш. Бәкірова[1], Қ. Ануарбеков[1], Ж. Кадашева[1], Л. Юрик[2]

[1]Қазақ ұлттық аграрлық университеті, Алматы, Қазақстан,
[2]Нитра Ауылшаруашылығы Словак Университеті, Нитра, Словакия

АҚДАЛА КҮРІШ СУҒАРУ ЖҮЙЕСІНДЕ СУДЫҢ ГЕОХИМИЯСЫ

Аннотация. Күріш суғару жүйесінде күріш атыздарынан су тасталулар жүргізіледі, мұны күріішшілер күріш атыздарындағы судың жоғары минерализация және осыған орай күріш өнімділігі азаюымен байланыстырады. Ақдала суару жүйесі суының геохимиясы берілген. Күріш атыздарындағы су тұздарының күріш өсімдіктерінің дамуына және оның өнімділігіне теріс әсер ету физикасы негізделген. Су тұтыну және су бұру нормаларын 15%-ға төмендетуді, күріштің өнімділігін 12%-ға арттыруды, өндірістің рентабельділігін 11%-ға арттыруды қамтамасыз ететін күріш атыздарының минерализациясы мен pH суының шектік көрсеткіштері мен төгінділердің мерзімділігі анықталды.

Түйін сөздер: басқару, су, күріш суару жүйелері, күріш, күріш атыздары, судың минерализациясы, суару нормасы, өнімділік.

А. Г. Рау[1], А. Ш. Бакирова[1], К. К. Ануарбеков[1], Ж. Кадашева[1], Л. Юрик[2]

[1]Казахский национальный аграрный университет, Алматы, Казахстан,
[2]Словацкий сельскохозяйственный университет в Нитре, Нитра, Словакия

ГЕОХИМИЯ ВОДЫ НА АКДАЛИНСКОЙ РИСОВОЙ ОРОСИТЕЛЬНОЙ СИСТЕМЕ

Аннотация. На рисовых системах производятся сбросы воды из рисовых чеков, необходимость которых рисоводы объясняют повышением минерализации воды в рисовых чеках, влияющей на снижение урожайности риса. Дана геохимия воды Акдалинской оросительной системы. Обоснована физика негативного влияния солей в воде рисовых чеков на развитие растений риса и его урожайность. Определены критические пороговые показатели минерализации и pH воды рисовых чеков и периодичность сбросов, обеспечивающие

снижение нормы водопотребление и водоотведение на 15%, повышение урожайность риса на 12%, рентабельность производства на 11%.

Ключевые слова: управление, вода, рисовые оросительные системы, рис, рисовые чеки, минерализация воды, оросительная норма, урожайность.

Information about authors:

Rau Aleksei, Doctor technical science, Professor of the Department of "Water resources and melioration", Kazakh National Agrarian University, Almaty, Kazakhstan; alexyrau@gmail.com; https://orcid.org/0000-0001-5209-1424

Bakirova Aigerym, Magistr agricultural science, Assistent of the Department of "Water resources and melioration", Kazakh National Agrarian University, Almaty, Kazakhstan; bakirova0202@gmail.com; https://orcid.org/0000-0002-1827-0872

Anuarbekov Kanat, PhD doctor, senior lecturer of the Department of "Water resources and melioration", Kazakh National Agrarian University, Almaty, Kazakhstan; kanat.anuarbekov@kaznau.kz; https://orcid.org/0000-0003-0832-6980

Kadasheva Zhanar, doctoral student of the Kazakh National Agrarian University, Almaty, Kazakhstan; dikuwa_90@mail.ru; https://orcid.org/0000-0002-7633-5566

Jurik Lubos, PhD doctor, Slovak University of Agriculture in Nitra, Slovakia; lubos.jurik@uniag.sk; https://orcid.org/0000-0002-4855-7540

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