1.5. Irrigation regime and water consumption norms for rice and secondary crops

There are information on 11 pilot plots from which 9 are in the Republic of Kazakhstan and 2 -in the Republic of Uzbekistan. Irrigation regime being studied on 9 pilot plots for rice, and on 2 - for rice and in parallel for alfalfa and on 1 plot for alfalfa.

1.5.1. Climatic conditions

All pilot sites of rice and secondary crops as alfalfa are located in north zone, and only "Yangiabad" dehkan farm (1.05. Uzb) in central zone. Climate over the plots is continental

Table 1.4.2.

Water balance of pilot plots with maize for grain and silos

# #	Indicators of assessment of irrigation regime and consumption norm efficiency	1.05.Tad. collective farm K.Marx				1.06.Tad. collective farm Turkmenistan gibride specic ЮЗПСК				1.06. Tad. collective farm Turkmenistan gibride specic ВИП -156ТВ			
		Control	60x60x60	70x70x70	80x80x80	Control	70x70x70x	70x80x70	80x80x70	Control	70x70x70	70x80x70	80x80x70
1.	Inflow, m^3/ha	4502	5240	5052	4926	7855	9088	9320	9420	7363	8355	8634	8673
2.	Precipitation, m^3	-	-	-	-	592	592	592	592	280	280	280	280
	%%					7.5	6,5	6,4	6,3	3,8	3,4	3,2	3,2
3.	Water supply, m^3/ha	333262	4275	4275	4290	6087	7736	8057	8338	5848	7392	7768	7948
	gross, %	72,5	81,6	84,1	87,1	77,1	85,1	86,4	88,5	79,4	88,5	89,9	91,6
4.	Soil water stock used, m^3/ha	1240	965	805	636	1176	160	671	490	1235	683	586	445
	%	27,5	18,4	15,9	12,9	14,9	8,4	7,2	5,2	16,8	8,2	6,8	5,1
1.	Water expenses, m^3	4502	5240	5052	4926	7855	9088	9320	9420	7363	8355	8634	8673
2.	Total evaporation, m^3/ha	4333	3288	4254	4536	6345	7252	7414	7546	5945	6693	6888	6935
	%	96	62,3	84,4	92,1	80,8	79,8	79,5	80,1	80,7	80,1	79,8	80,0
3.	Losses for surface releases and precipitation, m^3/ha	169	1952	798	390	1510	1836	1906	1874	1818	1662	1746	1738
	%	4/0	37,7	15,6	7,9	19,2	20,2	19,5	19,9	19,3	19,9	20,2	20,0

where average monthly temperature varies from 8°C to 12°C under maximum +26 - 29°C and minimum 11-15°C and more. Effective air temperatures sum fluctuates within 3500-4800°C. Precipitation - 100-160 mm per year. Main precipitation volume (80-85%) responds to winter-spring period; it does not play a significant role in soil water storage formation under evaporation values 1100-1600 mm/year. Water availability deficit is 1500 mm/year. Mellowing coefficient is 0,06-011. Climate of northern zone with high belt of desert and semi-desert determines development of rice crop rotation (appendix 2).

1.5.2. Geomorphological- hydrogeological and soil- reclamation peculiarities

The pilot plots are located in river deltas which territory is represented by alluvial sediments of AmuDarya and SurDarya. They covered by low thickness loam and sandy-loam with thickness from 1,5-3,0 to 10m, and underlaid by fine sands with low permeable interlayers. Aquifer thickness varies within the limits 30-20 mm and more. Deltas are weakly drained to north, and near Kzil-Orda outflow is not available.
Groundwaters were 4-5 m before irrigation development, now they fluctuate within the limits 0,5-3,0m.
Soils relate to gray and desert soils. At present time they are represented by gray-meadow and meadow- marshy species. Soils by water-physical properties relate to non-compacted and slightly compacted soils (Y=2,62,73 t/m^3); they are subjected to various degree of salinization from slight to strong. Shallow ground water is slightly mineralized - 3-5 g/l and groundwaters salinity in lower layers does not exceed 1,5-3,0 g/l. They are acceptable for irrigation (appendix 3 and 4).

1.5.3. The pilot plots parameters

Over the pilot plots irrigation and drainage network in earthen channel was build. Drainage-release channel's depth varies within the limits 1,8-2,0 m, and group release channels -2,5 - 3m (table 1.5.1). Drainage is executed by close drainage and wells over the plots 1.04. Kaz. and 1.05. Kaz. The pilot plots size varies from 30 to 238,4 ha. Rice field size fluctuates within the limits 12-25 ha, and cheque size 3-4 ha under width 150-200m and length 600-1000m. Cheque height is 20-25 cm. Ditches discharges fluctuate from 150 to 300 l/s which provides initial cheque flood under water allowance 14-18 l/s/ha. Average water allowance for vegetation is 2,2-2,8 l/s/ha.

1.5.4. Irrigation regime and water consumption norm

Specific feature of rice is flooding regime and certain water layer keeping in check during development phase and for other crops it is the permissible pre-irrigation moisture limits in root zone keeping. Water salt balance and soil salt regime were studied. Experiments were executed in the following variants (table 1.5.2):
1- variant - permanent flooding without running water;
2-variant - permanent flooding with running water up to 50% of water supply;
3-variant- interrupt flooding (9 days of flooding with water layer 10-15 cm. and 6 days without water supply).

Table 1.5.1.

Parameters of pilot projects with rice on «Irrigation regime and crop water consumption norm»

Codes of objects	Location	Farm speci-ality	Plot area, ha	field/ check area ha	Parameters of field and check			Qк, l/s effi-ciency	Water allowance l/sec/ha			Parameters of collector-drainage network			
					Bk, m	Lk m	h, cm		q_1	q_2	q_3	D	L	h_1	h_2
The Republic of Kazakhstan															
1.01.Kz.	Kyzylkum massif, Chimkent province	rice and live-stock	35-40	12-15 3-4	150-200	800-1000	15-20	200-300 0,9	-	-	-	-	-	-	-
1.02. Kz.	Terenozek massif, KyzylOrda province	rice	-	-	-	-	-	-	-	-	-	-	-	-	-
1.03. Kz.	Terenozek massif, KyzylOrda province	rice	7,0 rice 5,8 luc.	-	-	-	-	-	-	-	-	-	-	1,5-2,0	2,5
1.04. Kz.	Kyzylkum massif, Chimkent province	rice	80	12-15 3-4	150	800-1000	up to 20	150-200 0,82				5,500-6000	100-600	1,6	2,5
1.05. Kz.	Kyzylkum massif, Chimkent province	rice	238,4	12-15 3-4	150-200	800-1000	up to 20	0,87				40-60			
1.06. Kz.	Kyzylkum	rice	33	12-15	150-	up to	up to	-	-	-	-	-	-	-	-

Codes of objects	Location	Farm speci-ality	Plot area, ha	field/ check area ha	Parameters of field and check			Qк, l/s effi-ciency	Water allowance l/sec/ha			Parameters of collector-drainage network			
					Bk, m	Lk m	h, cm		q_1	q_2	q_3	D	L	h_1	h_2
	massif, Chimkent province			3-4	200	1000	20								
1.07. Kz.	Kyzylkum massif, Chimkent province	rice	33	12-15 / 3-4	up to 200	up to 1000	up to 20	-	-	-	-	-	-	-	-
1.08. Kz.	Kazalinsk massif	rice	-	13,6-19,8 / 1,5-3,0	up to 200	up to 1000	up to 20	100-250 / 0,76	-	-	-		43-45	1,8-2,0	up to 2,5
1.09. Kz.	Kyzylkum massif, Chimkent province	rice	-	20-30 / 2-3	up to 200	up to 750-800	up to 15-20	200-300 / 0,74	18,8	4,8	2,2-2,8	-			
1.05.Uz.	Yangiabad massif, Syrdarya Province	rice	130	20-25 / 3-4	up to 200	up to 1000	15-20	200-250 / 0,85	15,5	4,0	2,5	3500-5000	50-60	2,0-2,5	-

Legend: ω_1-pilot plot area, ha; ω_2-field area, ha; ω_3 - check area, ha; **Bk** - width of field and check, m; **Lk** - check length, m; **h** - check height; $\mathbf{q_1}$ - maximum water allowance for field flood; $\mathbf{q_2}$ - maximum water allowance for check flood; $\mathbf{q_3}$ - average water allowance for vegetation; **D** - collector-drainage outflow, m^3/ha; **L** - collector-drainage network density; $\mathbf{h_1}$- field release depth, m; $\mathbf{h_2}$ - group release depth, m.

Table 1.5.2.

Options and conditions of conducting experiment on rice irrigation regime and water consumption norm

Codes of objects	Location	Options of tests			
		I - option	II- option	III - option	IV- option
KAZAKHSTAN					
1.02.Kaz.	Terenozek massif	+ control	+ water running 30%	+	+
1.03. Kaz.	Terenozek massif	+ control	water running 50 %	+	-
1.04. Kaz.	Kyzylkum massif	-	-	-	+ on background of vertical drainage
1.05. Kaz.	Kyzylkum massif	-	-	-	+ on background of open and close horizontal drainage
1.08. Kaz.	Kazalinsk massif	-	-	-	+ on background of horizontal drainage, optimal variant B=200 m
1.09. Kaz.	Terenozek district, KzylOrda province	control +	+	-	+
UZBEKISTAN					
1.03.Uz.	collective farm Oktyabr, Karakalpakstan	+ control	-	-	+ on background of open drainage with depth 1.5-1.8 m, B=250-400 m
1.05.Uz.	dekhkan farm Yangiabad, Syrdarya province	+ control	-	-	+ on background of open horizontal drainage with depth up to 1.5 m, B=150-200 m

After sowing the water layer 10-15 cm was kept in check during 4-6 days and when water supply was ceased. After sprouts appeared the water layer in check before bushing was kept at level 10-15 cm, during bushing period decreased upto 5 cm. After bushing before milk ripeness the water layer was kept at level 10-15 cm. Within milk ripeness phase water supply is ceased.

On the pilot 1.05. Uzb in shortened variant the layer with thickness 5 cm was established instead of water layer 10-15 cm.

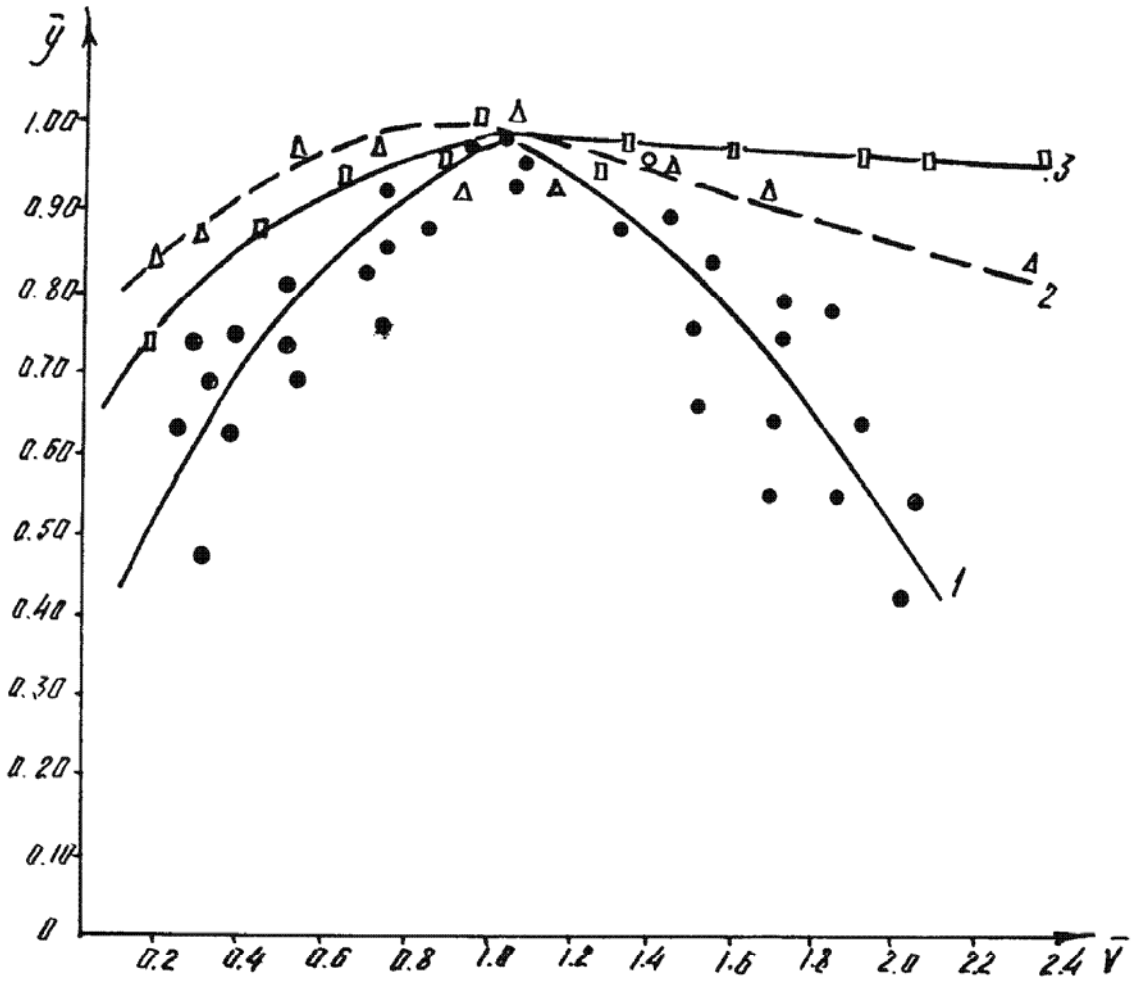
According to results of investigations over 9 pilot plots the shortened variant of water supply regime and water layer in check keeping was optimal, under which highest rice yield (about 50-60 c/ha) with minimum water supply (22-28 th. m^3/ha) was achieved (table 1.5.3.).

Highest crop yield under irrigation norm 20-24 th.$m^{3/}$ha (gross) was received on the plots 1.04. Kaz and 1.05. Kaz. On other plots crop yield under optimal variants fluctuated within the limits 43,3-48,2 c/ha. In the control variants yield was 18,8-32,3 c/ha under permanent flooding and water supply from 20-30 th.m^3/ha (gross) to 31,6 th.m^3/ha.

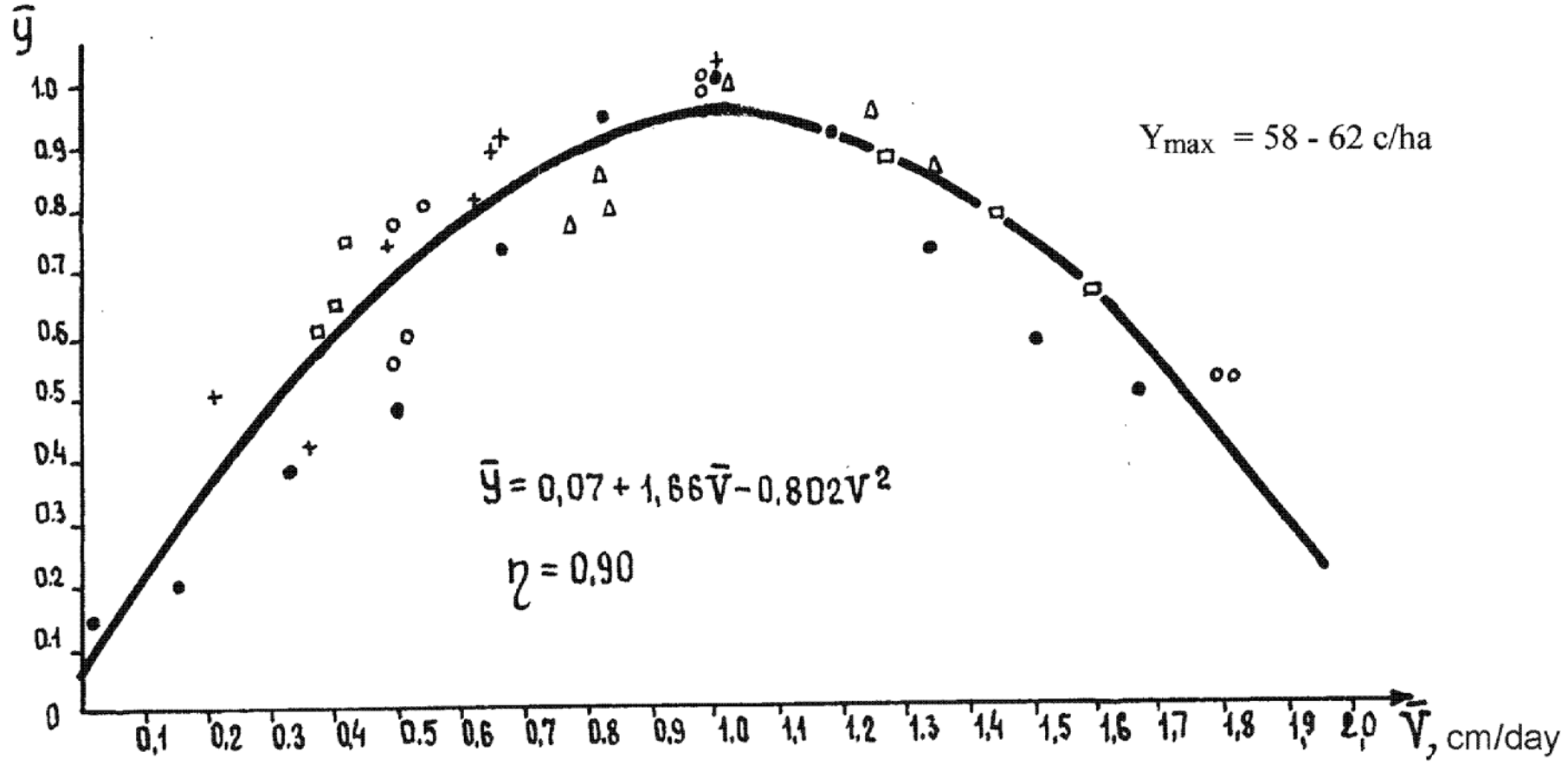
Rice yield increase from 7 to 12 c/ha was obtained under optimal variants of flood regime and interrupted water layer in check, water saving on separate plots is 2160-13400 m^3/ha. Specific water expenses for yield unit corresponded to water supply and rice yield. Lowest water expenses corresponded to shortened flood, and highest ones to permanent flooding. Specific water expenses under shortened flood fluctuate from 631 to 500 m^3/c, and under permanent one-555-1223,4 m^3/c (table 1.5.3). On the plots, where vertical and horizontal close drainage were constructed, the best indices of rice cultivation efficiency were obtained. Under vertical and horizontal close drainage on the plots 1.04 Kaz and(1.05 Kaz) rice yield, during 5 years of investigations, fluctuated within the limits 50-60 c/ha with water supply 20-24,5 th.m^3/ha (gross). Specific expenses for yield unit under perfect type of drainage were 361-400 m^3/c against 412-432 m^3/c under open drainage. On the base of perfect drainage type the above mentioned rice growing efficiency indices were obtained because of water-salt and nutrition regimes optimal management through vertical filtration rate regulation on rice checks. Highest rice yield was obtained within the plots where perfect type of drainage caused water filtration in checks with rate 6-9 mm/day (picture 2.22). Rice growth yield conformity with vertical rate value was received by other investigations in Krasnodar region, Toguzken massif and Japan (picture 2.21).

1.5.5. Rice field water balance

Within the pilot plots, study of irrigation regime and water consumption norms for rice revealed the negative water balance with groundwater certain volume withdrawal and surface release.
The basic element of the positive part of balance is water supply to field varied within the limits 25-28,5 th.m^3/ha (gross) which is 80,6-99,5% of the positive part of balance. Precipitation share is 0,05-19,5% (table 1.5.4). In the negative part of balance the share of total evaporation prevails and fluctuates from 8970% m^3/ha to 17750 m^3/ha over the plots. Drainage outflow together with surface release constitute from 8570 (1.02. Kaz) to 11710th.m^3/ha (1.04. Kaz) or 33 and 38,6% in the negative part of balance. Vertical filtration value in balance reachs 6500-8500 m^3/ha per year. Along with transition from development to operation the tendency of all elements values decrease in positive and negative parts of water balance is occurred.



Dr. 2.21. Rice yield versus vertical filtration rate:
1.- Central Asia and the Republic Kazakhstan;
2. -Yapan;



Dr. 2.22. Rice yield versus filtration rate after Soyuzgiproris, KazNIIVN, SANIIRI on background of subsurface horizontal and vertical drainage.

$$\bar{y} = \frac{y_i}{y_{max.}}; \quad V = \frac{V_i}{V_{opt.}}.$$

Table 1.5.3

Irrigation water expenses estimation per agricultural production unit on the base of data of the tests «rice irrigation regime and water consumption»

Plot index	Soil-climatic zone	Genesis of soil profile's groundwater level, m	Water allowance rayon	Compaction degree	Salinity degree	Information type	Efficiency, %	Irrigation norm, m^3/ha		Achieved reduction of irrigation water use, m^3/ha (%)	Yield	Yield increment, c/ha (%)	water expenses per production unit, m^3/c	
								net	gross				net	gross
1.02. Kaz.	C-II-A	half-hydromorph. 1-2,5 m	VI	H	slightly saline	IV type open	-	17430 18430	26000 28160	-2160 (7,6)	45,6 45,6	0	382 404	570 617,5
1.03. Kaz.	C-II-A	half-hydromorph 1-2,5 m	VI	H	slightly saline	IV type open	-	20500 18300	2500 2300	+2000 (8)	27,5 18,8	8,7 (27,5)	745,4 973,4	990 1223,4
1.04. Kaz.	Ц-I-A	half-hy-	IV	H	medium	open	-		24596,5	+2991,5	62	12 (19,3)	-	396,7

Plot index	Soil-climatic zone	Genesis of soil profile's groundwater level, m	Water allowance rayon	Compaction degree	Salinity degree	Information type	Efficiency, %	Irrigation norm, m^3/ha		Achieved reduction of irrigation water use, m^3/ha (%)	Yield	Yield increment, c/ha (%)	water expenses per production unit, m^3/c	
								net	gross				net	gross
		dromorph 1-2,5 m			saline				20605	(12,2)	50			432,1
1.05. Kaz.	Ц-I-А	half-hydromorph 1-2,5 m	IV	H	medium saline	close open	-		21672,5 20605	+ 1067,5 (4,9)	60 50	10 (20)	-	362,1 412,1
1.08. Kaz.	С-I-А	half-hydromorph 1-3 m	VII	H	medium saline	IV type open	-	-	20620 23820	3200 (15,5)	48,2 42,9	5,3 (11,8)	-	427,8 555,2
1.05. Uz.	Ц-II-Б	hydromorph 0,5-	VI	H light loam	slightly and medium	IV type open	0,73 0,82	15900 25200	21700 30900	- 9200 (42,4)	47,4 40,0	74 (15,6)	335,4 531,6	457,8 772,5

Plot index	Soil-climatic zone	Genesis of soil profile's groundwater level, m	Water allowance rayon	Compaction degree	Salinity degree	Information type	Efficiency, %	Irrigation norm, m^3/ha		Achieved reduction of irrigation water use, m^3/ha (%)	Yield	Yield increment, c/ha (%)	water expenses per production unit, m^3/c	
								net	gross				net	gross
		2 m			saline									
1.05. Uz.	Ц-II-Б	hydromorph 0,5-2 m	VI	medium loam	slightly and medium saline	IV type open	0,79 0,86	14862 25400	188862 29700	-8832 48,4)	48,8 37,4	11,4 (23,4)	304,5 679,1	386,5 794,1
1.05. Uz.	Ц-II-Б	hydromorph 0,5-2 m	VI	heavy loam	medium saline	IV type open	0,78 0,87	14331 27650	18261 31650	-13389 (73,3)	43,3 32,3	11,0 (25,4)	331,0 856,0	421,7 979,9

Table 1.5.4

Water balance of rice field on the pilot plots of irrigation regime and water consumption norm

Balance elements	Codes of pilot plots													
	1.02.K		1.03.K		1.04.K		1.05.K		1.08.K		1.09.K		1.05.Uz.	
	max	min	max	min	max	min	max	min	max	min	max	min	max	min
	(gross)		(gross)		(gross)		(gross)		(gross)		(gross)		(gross)	
B, m^3/ha	26000	-	25000	-	28550	22410	25070	19000	23820	19520	26910	23595	20671	19774
%	99,5		100		88,3	80,6	94,6	89,9	99,9	99,9	100	100	95	95
Oc, m^3/ha	150	-	-	-	1740	2560	1440	2140	20	15	-	-	1100	1100
%	0,05				5,4	9,2	5/4	10,4	0,1	0,1			5	5
П, m^3/ha	-	-	-	-	2030	2850	-	-	-	-	-	-	-	-
%					6,3	10,2								
∑ пр, m^3/ha	26150	-	25000	-	32320	27820	26510	21140	23840	19535	26910	23295	21771	20874
%	100		100		100	100	100	100	100	100	100	100	100	100
Wк, m^3/ha	3780	-	4020	-	-	-	-	-	1780	2140	3780	3600	-	-
%	14,5		16,1						7,8	11,6	15	16,1		
H, m^3/ha	4620	-	8970	-	13760	13340	17750	13760	4620	4350	5320	5707	12900	12200
%	17,8		35,9		45,3	50,8	46,8	66,9	24	23,7	20,8	25,6	60	60
T, m^3/ha	2630	-	8970	-	13760	13340	17750	13760	4790	4280	3040	2440	12900	12200
%	10,1		35,9		45,3	50,8	46,8	66,9	21,2	23,0	12,1	10,9	60	60
Фв, m^3/ha	6400	-	7500	-	-	-	-	-	3090	2280	7270	6093	8439	8081
%	24,6		30						13,6	12,4	28,8	27,3	40	40
От, m^3/ha	-	-	-	-	4880	2990	7300	13,40	-					
%					16,1	11,4	29,1	6,5						
Дс, m^3/ha	8570	-		-	11710	9930	6060	5480	2710	2370	-	-	-	-
%	33,0				38,6-	37,8	24,1	26,6	11,9	13,0				
Пс, m^3/ha	8570	-	4510	-	-	-	-	-	5670	2980	5850	4419		
%	33,0		18						25,1	16,3	23,3	20,1		
eP, m^3/ha	26000	-	25000	-	30350	26720	25110	20580	22660	18400	25150	22264	21358	20281

Balance elements	Codes of pilot plots													
	1.02.K		1.03.K		1.04.K		1.05.K		1.08.K		1.09.K		1.05.Uz.	
	max	min	max	min	max	min	max	min	max	min	max	min	max	min
	(gross)		(gross)		(gross)		(gross)		(gross)		(gross)		(gross)	
%	99,95		100		100	100	100	100	100	100	100	100	100	100
Saldo	150	-	-	-	+1950	+1560	+1400	+560	1180	1135	-	-	-	-
%	0,05				6,5	5,6	5,3	2,6	4,9	5,8				

Note: **В** - water supply; **Ос** - precipitation, m^3/ha; **П** - underground inflow, m^3/ha; **∑ пр** -sum of inflows; **Wк** - moisture stock in unsaturated zone, m^3/ha; **Фв** - vertical filtration, m^3/ha; **От** - underground outflow, m^3/ha; **Дс** - drainage outflow, m^3/ha; **Пс** - surface outflow, m^3/ha; **∑Р** - sum of outflows, m^3/ha;

Over the plots 1.03.,1.04.,1.05. and 1.08. Kaz drainage outflow decreased on 20-35%, soil moisture stock recharge in unsaturated zone-on 15-20% , share of vertical filtration and evapotranspiration is 15-25%. Within the plots of rice crop rotation the negative salt balance with salt removal from 16,5-24,4 th/ha (1.09.Kaz) to 100-150 th/ha (1.03.Kaz) is occurred i.e. salt removal from unsaturated zone was 47-80% on sum of salts and 80-96% on chorine ion. Soils desalinization intensity depends on drainage parameters: desalinization high rate was achieved under depth of drain 2,4-2,5 m and on horizontal and vertical drainage systems with high drainability. However, in the period of secondary crops sowing without leaching irrigation regime the salt restoration was occurred.

Thus the shortened flood regime and water layer from 5 (Uzbek variant) to 10-15 cm. (Kazakh variant) with short (4-5 days) interrupted water supply during sprouts growing and milk ripeness is optimal irrigation regime for rice cultivation. Under optimal irrigation regime rice yield increase from 7,4 to 12 c/ha within the sites was achieved where specific water expenses fluctuated within 369-570 m^3/c, in control variants and under production conditions - 617,5-1223,4 m^3/c.