2.3. MANAGEMENT OF WATER-SALT PROCESSES ON IRRIGATED LANDS THROUGH LEACHING AND LEADING REGIME OF IRRIGATION ON BACKGROUND OF DIFFERENT TYPES OF DRAINAGE

INTRODUCTION

At present time from 7.7.mln.of irrigated lands of the Central Asia, on appraisal of Giprozyems of sovereign States, more than 65 % (5.2 mln.) is related to category of salinizated lands. At the same time almost the whole area of perspective irrigation more or less is salinizated as well. The struggle with salinization of irrigated lands is always considered as an important problem of irrigated agriculture.

Now, reclamation science and practice have the developed methods of soil desalinization: land leaching on a base of strengthening of the territory drainability through drainage construction. In this connection the theoretical aspects of land leaching and drainage design were developed on a base of salt storage formation in natural conditions study and the theory of physical- chemical hydrodynamics of flow movement and relief-soil conditions, the technique and technology of soil desalinization were worked out under capital and operational leaching.

At the same time in last years in the republics of Central Asia and regions of Kazakhstan water related situation dramatically changed. Everywhere the critical deficit of water resources is observed, connected with irrigated agriculture development and revision of water limits; irrigated water quality is deteriorated in sources because of return collector - drainage water. Long-term dry season periods repeat with negative temperature regime in winter months and scarce rainfall in spring.

Change of water related situation needs other approach to the selection and implementation of desalinizing measures. First of all, there are a links establishing between the areas subjected to leaching with leaching norms; definition of operation leaching optimal terms; development of measures on the salt removal acceleration from active thickness and range of other measures. Moreover, in last years hardly-reclaimed strongly saline soils are more and more involved in agricultural turnover. To improve their fertility it is necessary to develop specific measures on land desalinization, as well as on of agricultural crops yield increase.

In the report on soil leaching based on field study results, implemented in various natural-economic conditions of the Aral Sea basin, the possibility of accelerated soil desalinization and increase of irrigated land productivity is shown for complicated water related conditions through the drainability increase, capital and operational leaching implementation, deep subsoiling with and without chemical meliorants.

Information is presented on 7 pilot plots, from which 4 - on the Republic of Uzbekistan (Hungry Steppe), 1 - on South Kazakhstan (Arys-Turkestan massif), 1 - on the Republic of Kyrgazstan (Chu valley) and 1 - on the Republic of Tadjikistan (Vakhsh valley) (Table 1.). In the process of information analysis the results of field researches were attracted on capital and operational leaching on background of different types of drainage received in various natural- economic conditions of Uzbekistan.

Table 1

List of pilot projects on direction 2
«Test-production study of irrigated land desalinization through soil leaching»

Project code	No. of plot	Symbol	Authors	Location			Topic title
				province	district	farm	
02.39	1		Yakubov Kh.I.	Syrdarya	Saykhunabad	50 years of Uzbekistan	Study and development of technology for accelerated desalinization of strongly saline gypsum bearing soils through capital leaching with and without rice sowing on plots with vertical drainage
02.3	2		Baturin G.E.	Syrdarya	Rashidov	state farm # 6 named after G.Titov	Test-production plots of land leaching with close and open horizontal drainage (duration 3 years)
02.34	3		Klimova G., Beglov F.F.	Syrdarya	Rashidov	state farm # 5 named after Yu.Gagarin	Two-stage leaching of strongly saline lands on background of subsurface drainage with provisional one
02.13	4		Khasankhanova G.M.	Syrdarya	Rashidov	Pakhtakor	Development of intensive technology of hardly reclamated lands leaching (6 options)
02.4	5		Vishpolsky F.	Chymkent	Bugun	Timiryazev	Improvement of water use and soil desalinization on background of horizontal drainage
02.5	6		Duyunov I.K.	Chu	Moscow	Besh-Terek	Leaching through flooded rice on background of horizontal drainage combined with provisional one and without it (2 options)
02.8	7		Aliev I.S.	Khotlon	Bakhtar	collective farm Safarov	Assessment of different types leaching of saline soil on background of vertical drainage

2.3.1. Salinization impact on productivity of irrigated lands

Soil salinization in arid zone is one of major factors decreasing productivity of irrigated lands. It arises at expense of re-distribution of easily-soluble salts accumulated in the thickness of quaternary deposits within geological period of their formation. Process of salt storage re-distribution and soil salinization depends on many climatic, geological and hydrogeological conditions. More dry and continental climate, more degree of salinization. Strongly-salinizated soils are more often founded in desert and semi-desert zones, and with the transition to steppe zone the salinization degree becomes slack.

V. Kovda (1968) in geography of salinizated lands formation process distinguishes several cycles of salt storage:

1. Continental, connected with movement, re-distribution and accumulation of carbonate, sulphide and chlorine salts in inter- continental provinces without outflow. Depending on nature of salt storage process (accumulation or re-distribution) the primary and second cycles of salt storage are assigned (Fergana, Hungry Steppe).

II. Seaside, connected with accumulation of sea salt.

III. Delta (deltas of AmuDarya, SyrDarya rivers, etc.).

IV. Artesian, obliged to evaporation of inter-layer ground water.

V. Anthropogenic, being result of errors in water related activity or ignorance of salt storage regularity (soil salinization under the rise of ground water, irrigation by saline water).

In the republics of Central Asian region and South Kazakhstan the process of soil salinization is mostly spread due to III and V and, partially, I and IV cycles of salt accumulation.

Salt accumulation process is closely connected with geomorphologic and hydrogeological conditions, but under irrigation development with irrigated water quality as well. In geomorphologic respect the highly elevated lands, having steep slopes and high natural drainability (foothills slopes), in most cases are not imposed to salinization.

With the transition to lowlands the sharp change of geomorphologic-lithologic-hydrogeological conditions and the deterioration of territory drainability are observed. In connection with this salinizated soils are most likely belong to low part of relief. There are flood-plains and deltas, inter-cone depressions, low river and seaside terraces. Lands, located within these geomorphologic structures, are not drained or weakly drained. On these lands under irrigation ground water balance is usually disturbed. of Infiltration increase with lack or weak natural drainability of territory causes the ground water rise. Rise velocity depends on infiltration rate and natural drainability: the more rate, and less drainability of territory, the more ground water level rise velocity. Under ground water rise concentration of mineral salts is observed at the expense of their leaching from the soils.

Soil salinization process in most cases is connected with salt storage under impact of ground water evaporation. Therefore, intensity of soil salinization depends on the and ground water depth ans salinity, as well as mechanical composition of soils determining capillary properties. The more close ground water table to the land surface and higher salinity, the more salt accumulation velocity. For loess soils of Central Asia an intensive evaporation of ground water is started from depth of 2.5 - 3.0 m and depends on mechanical composition of soils. With the ground water level approach to the land surface the evaporation intensity reaches the maximum value. So, under ground water depth of 0.5 m their discharge for evaporation, depending on soil type, varies within 700 -900 mm per year for cotton and 900 - 1200 mm for lucerne. Along with lowering of ground water table below 3 m evaporation value is, respectfully, 50-60 mm and 80- 120 mm per year.

At the same time salt accumulation intensity is determined not only by evaporation volume, but also by ground water salinity. In conditions of shallow ground water (0.5 -1.0 m) salt accumulation in root layer can be 150 -180 t/ha per year, depending on their salinity. With reduction of ground water level below 2.5 -3.0 m the sharp decrease of salt accumulation intensity is observed : 5 -10 t/ha per year (Fig. 1 b). Hence, to prevent salinization restoration it is necessary to keep ground water level below its «critical» depth and to reduce water salinity.

Other source of salt accumulation in arid zone is irrigation water containing easily-soluble salts. Salt accumulation intensity at expense of irrigation water also depends on water supply volume and salinity and can be about 15 -20 t/ha per year. In modern conditions the soil salinization at expense of irrigation water has more dangerous character because of collector -drainage outflow return to the rivers. In this connection the most dangerous zones are lands located in middle and down streams of the rivers, where a water salinity during several months reaches 1.5 -2.5 g/l.

Lands located in the low reaches of SyrDarya, AmuDarya and Zarafshan have the strongest salinization because ground waters are shallow and irrigation water has salinity higher than 1.0 g/l. In these conditions superficial salinization is formed with salt accumulation within 1 - 1.5m. In Karakalpak Republic and Bukhara province the salinizated lands occupy more than 55 -60 % from total irrigated area. Here, in fallow lands, salinity degree reaches 15 % on salt sum. However, the biggest supplies in cover sediments are concentrated in inter-mountain depressions and lake sediments of large river deltas, such as Hungry Steppe, Central Fergana, the Republic of Karakalpakstan, Kazalinsk massif in Kzyl -Orda province, etc. In these regions strong salinization covers 10-20 m of the soil thickness achieving 4-5 th. tn/ha. and forms the high salinity of drainage outflow for 10 years. Salinization, depressing plants growth and development, causes a certain damage to crop yields, for prevention of which the huge inputs and water resources are being spent.

Yield losses value as a result of salinization also depends on many other factors: soil moistening, content and chemical composition of salts, salt resistance of agricultural crops. Salt impact on plants also depends on phase of their development.

From materials of the numerous field studies and mass observation of farms located on the saline soils it is obvious that on slightly saline lands the yield is less on 8 -10 % than on non-saline lands.

On medium-saline and strongly saline lands yield losses has achieved 50 -60 %, and on salts - more than 70 -80 % (Fig. 2).

Sodium-chloride salts most dramatically effect growth and development of plants. There are soils in Uzbekistan of sulphate (Fergana valley, most part of Karshi steppe), sulphate - chloride (Djizak and Surkhan-Sherabad steppes) and chloride (the low reaches of AmuDarya river) types of salinization. Main method of soil desalinization is land leaching on the background of artificial drainage, technology of which is enlighted in the report.

2.3.2. Field researches of soil desalinization through capital leaching implementation

2.3.2.1.Conditions of capital leaching implementation

Capital leaching is implemented under desalinization of strongly saline soils and salts and is intended for extraordinary desalinization of root layer to needed limit. It is used mainly on new developed lands. On the old irrigated lands the capital leaching is used under introduction of inter-oasis fallow lands. Desalinization of these lands requires significant water volume (more than 10 th. m^3/ha).

Capital leaching implementation requires higher drainability of territory, than under operational leaching. In connection with this under capital leaching a permanent drainage designed for conditions of operational period of irrigation, should be strengthened by temporal one. Temporal drainage operates only within the period of capital leaching implementation and diverting excess water participates in desalinization of soil upper active layer. Under leaching a main demands are charged to desalinized layer depth of soils up to the limit, under which normal development of agricultural crops is provided. Therefore, capital leaching norm is defined depending on soil root layer desalinization taking into account the degree and type of salinization, water -physical soil properties, as well as irrigated land drainability. For clean tilled crops as a calculated layer 1 -1.5 m is assumed and for perennial plants - 2.0 m.

On light soils with medium and strong degree of salinization, where the permeability K_f is more than 0.5 -1.0 m/day, the desalinization is achieved by leaching norm of 6.0 -7.5 th. m^3/ha, and duration of its implementation does not exceed 1-1.5 months, capital leaching can be implemented without temporal drainage. Such soils are introduced usually in agricultural turnover along with preventive leaching in operational period of drainage. The highest effect on desalinization is achieved under intermittent leaching with water supply by in-times - 2.0 - 2.5 th. m^3/ha per one irrigation. For increase of desalinization regularity throughout area of leached field water supply is needed to be implemented, best of all, from the middle of drain spacing by flooding of every check individually from provisional ditches. Check flooding is implemented from down to up. Check sizes depend on relief conditions: the more steep slope, the more less size of check. Checks of 0.25 -0.5 ha size are optimal for capital leaching, implemented on light soils.

Under lower permeability and salt availability of soils the norms and duration of leaching are increased and necessity of the provisional drainage and reinforcement of drainability by permanent artificial drains arises (Table 2.1).

As a criterion of provisional drainage use necessity permeability coefficient, salinization degree and salt availability of soils are accepted. Provisional drainage is used under very strongly saline lands and salts with permeability less than 0.1 - 0.15 m/day and salt availability $L \leq 1.0$ -1.2. Provisional drainage capacity is designed depending on water -salt balance forecast.

Table 2.1

Classification scheme of desalinization of soil 1-m layer and preparation of lands to development

Land permeability, m/day	Soil drain-ability, th. m^3/ha per year	Leaching norm, th. m^3/ha	Leaching duration, month	Requi-rements to provisional drainage, m/ha
Normal permeability, medium and strong salinization, $K_f > 1$	3.5 - 4.0	6.0 -7.0 -7.5	1.0 -1.5	no need.
Medium permeable, medium and strong salinization, K_f =0.3 - 1.0	4.0 -4.5	10 -12	1.5 -2.0	no need.
Lower permeability, medium and strong salinization, K_f =0.1 - 0.3	4.5 -5.0	12 -15	1 -3	50 -100
Low permeable, medium and strong salinization, K_f =0.05 - 0.1	5.0 -6.5	15 -25	3 -5	150 -200
Very low permeability, medium and strong salinization, $K_f < 0.05$	6.5	25	more than 5	250 -300

On soils with medium mechanical composition the intermittent leaching is accepted. However, a necessity of intervals within the leaching process comes when salt leaching intensity and remained content are considerable reduced. For facilitation of leaching on these lands checks size could be increased up to 0.5 - 0.75 ha with borders' height 0.6 -0.7 m. Provisional drainage with length 75 -100 m/ha and depth 0.8 -1.0 m provides more regular desalinization of soil along the profile. It is worth to note, that on medium soils on the background of vertical drainage the regular soil desalinization can be achieved without provisional drainage. It could be achieved by increase of pumped water volume at the end of vegetation before leaching and within the process of its implementation. This provides free capacity within soil before leaching. Land leaching under big free soil capacity sharply increases desalinizing effect of water. On heavy soils the biggest effect of desalinization is given by the leaching with continuos flooding. In this case leaching of large checks is accepted, size of which achieves 1 ha and more. Along with it borders' height should be not less than 0.75 m; provisional ditches are rotated with provisional drains.

Multiyear field researches implemented in different soil-hydrogeological conditions show, that provisional drainage with depth to 1.0 m and length 100 -250 m/ha in combination with permanent one, allows to accelerate desalinization of soils with low permeability ($K_f < 0.10$ m/day). Example of accelerated soil desalinization is land leaching in state farms. At the same time, with decrease of soil permeability less than 0.1 m/day the irregularity of soil desalinization increases. Soils with permeability $K_f > 0.05$ m/day are considered as hardly-reclaimed. Acceleration of these lands desalinization can be achieved by use of various methods including improvement of their ability to be leached. G. Klimova (1986 - 02.34) recommends the following methods of influence:

- hydrotechnical - lateral leaching, two-tiered drains and vacuum impact ;
- physical-technical- soil desalinization acceleration by the permanent electric treatments and magnetized water are used.
- chemical - use of different chemicals - soil conditioners, particularly, polymers K-4, K-9, etc.;
- hydrobiotechnological - different pioneer crops of high salt resistance are widely used.
- agrotechnical - leaching through rice crop, deep ploughing, subsoiling with bringing in organic fertilizers, as well as soil slotting. Effectiveness of these measures is clearly shown on Fig. 2.1.

The highest effect of leaching as for root zone desalinization, so for cotton yield increase was given by deep ploughing with application of manure by volume 30 t/ha. In this variant 183.5 t/ha salt are removed from active zone, including 78.2 t. of chlorine-ion, and cotton yield was 18.3 c/ha.

From economic point of view, deep soil desalinization is most advantageously achieved by summer leaching through rice crop. In this case, the costs of capital leaching implementation are compensated by rice yields.

It is worth to note, that under capital leaching duration of aeration zone and upper layer of ground water desalinization sharply decreases depending on the permeability and soil salinization degree: from 1-3 years - for horizontal, 1 year - for vertical and to 2 years - for combined drainage.Comparative effect of capital leaching on the background of different types of drainage under identical drainability of territory (medium and strong salinization) depending on soil conditions is presented below:

Soil conditions	**Horizontal drainage**	**Vertical drainage**	**Combined drainage**
Light soils, $K_f > 0.5$ m/day			
Water expenses for removal of 1 t salt from 1ha, m^3	60 -75	40 -50	45 -55
Duration of aeration zone desalinization, years	1 -2	for year	for year
Medium soils, $K_f = 0.1$ -0.5 m/day			
Water expenses for removal of 1t salt from 1ha, m^3	100-150	75 -100	100 -150
Duration of aeration zone desalinization, years	1 -2 years	for year	1 -2 years
Heavy soils, $K_f < 0.1$ m/day			
Water expenses for removal of 1t salt from 1ha, m^3	200 -250	100 -150	150 -200
Duration of aeration zone desalinization, years	2- 3 years	for year	for 2 years

Along with increase of soil permeability the duration of aeration zone and upper layer of ground water desalinization decreases, water expenses for removal of 1t salt from active layer of soil reduce; for light soils the water expenses change under different types of drainage from 40 to 150, and for heavy one - from 100 to 250 m^3 per ton.

The least water expenses for removal of 1 ton salts and the least duration of soil of aeration zone and ground water upper layer desalinization are observed on the background of vertical drainage. That is explained by vertical drainage allowance for ground water level regulation in broad diapason (from 2 to 5 m and more), therefore, excluding salinization restoration during a year, as well as creates the best conditions of drawdown of flushing infiltrating water. Moreover, the vertical drainage provides more regular soil desalinization. Quality of land leveling influences on desalinization regularity. Under good leveling regular flooding of checks and moistening along furrows are provided under leaching during irrigations of agricultural crops.

On the most hardly-reclaimed lands with permeability 0.03 -0.075 m/day, presented by strong-saline soils and salts the soil desalinization can be achieved by two-stage leaching (G. Klimova. F. Beglov - 02.3 Uz.). Following this method during the first stage of leaching, additionally to permanent drainage, provisional one is constructed. This accelerate filtration rate between drains up to 7 -10 mm/day. During the second stage additional leaching of stripes along provisional drains is carried out.

Method of soil desalinization by capital leaching implementation has a range of shortcomings, main of which is requirement for high norms of water,

2.3.2.2. Desalinization of saline highly gypsum-bearing soils on background of vertical drainage (PP -02.39 The Republic of Uzb.)

Fields researches of low permeable soils desalinization were organized on experimental pilot plot in the state farm "50 years of Uzbekistan" of Saykhunabad rayon of SyrDarya oblast, where in 1963-1965 28 high capacity wells were constructed on area 3,0 th. ha. Wells capacity changed within 80-120 l/sec, under total abstraction volume of ground water near 2,5-3,0 m^3/sec. Similar abstraction volume created high lands drainability, where drainage modulus reached 0,28-0,36 l/sec. ha. Tests were conducted in three variants-lands desalinization by means of capital leaching, soils desalinization through rice sowing and over the separate fields.

Top fine-grained deposits are represented by flaky sediment of heavy structure composition (middle and heavy loam are alternated with interlayers of clay and sandy loam).

Average permeability of soil top deposits is 0,05 -0,07 m/day. PP soils belong to low drained variations, where top loam soil horizon is everywhere underlain with gypsum-bearing inte-layers and clay.

Before leaching ground water table was at depth of 3-3,5 m. salinity fluctuated from 6 to 25 g/l. Initial easily y soluble salt content was on average 2 % on dry residue and 0,20 % on chlorine-ion of dry soil weight. Leaching was carried out on the area of 14 ha by method of flooding over checks without release. During leaching ground water table raises much, depending on duration of flooding and water supply it was on the depth 0,3-0,5 m from land surface.

Piezometric head fluctuated within 2,5-3 m from land surface. Head gradient under descending leaching water flow was on average 0,14 and filtration rate under leaching - 0,008 m/day (V_{av}-0,0045 m/day against 0,0025-0,003 m/day under usual irrigation regimes. Under water supply by norm on average 18 th. m^3/ha (gross) soil desalinization zone was spread to the depth of 3 m. Common content of water soluble salt in 1 meter soil layer decreased from 1,89 to1,28 % on dry residue, volume of chlorine-ion and sulfur acid ion was reduced, appropriately, on 0,19 and 0,26 (pic.2.2).

Salt removal over horizons 1-2 m, 2-3 m and 3-4 m was on dry residue appropriately 0,65; 0,15 and 0,22 %, including on chlorine-ion-0,127; 0,066 and 0,013 % and on sulfur acid ion-0,30; +0,05 and + 0,01 % of their initial content.

Coefficient of season salt accumulation (SSA) after leaching over horizons 0-1 m, 0-4 m (aeration zones) and in ground water is described by curves (pic.2.3).

Curves data point not only to soil desalinization, but to ground water desalinization as well

Ground water desalinization during leaching period proceeds slower than top soil layers desalinization. In the beginning of leaching ground water salinity increased from 9 to 17 g/l is observed due to top soil layers desalinization and further, when supply increases, salinity becomes 7-3,5 g/l and ground water desalinization covers all areas of pilot plot. Ground water mine desalinization coefficient changes within 0,16-0,76.

Water-salt balance of soil 1 meter layer is formed according to type of irreversible desalinization with salt removal from 54,8 (check 21) to 114,7 t/ha (chek76) (table 2.2.). Water volume, discharged for 1 t salt removal on water desalinizating discharge (g), changed from 170 to 200 m^3 under drainage modul-0,5-0,8 l/sec.

Under common water supply from 271,6 to 331 m^3/t was discharged for 1 t salt removal (N:Δ S) (table 2.2.).

The similar situation is with soil salt removal and ground water desalinization was obtained under leaching via rice on the background of vertical drainage on area of 297,5 ha. Lands drainability, water-physical properties, and soils salinity, chosen for leaching via rice crop, are identical to above mentioned.

The main salt volume is concentrated in top 3 m thickness of soils, which content fluctuates within 1,5-2,5 % on dry residue, including chlorine-ion-from 0,10 to 0,30 % of dry soil weight. Gypsum-bearing horizons are met from the depth 40-160 cm, and its content fluctuates within 20-40 % (seldom more 50 %) of dry soil weight. Before water supply ground water was on the depth of 2,5-3,0 m and had salinity 5,6-11,4 g/l. piezometric level changed within 3-35 m, and head gradient was 0,04-0,05.

Water balance of all 3 fields of rice plots was formed in the following way:

Balance component	1 plot 1967		2 plot 1968
Area, ha	73,5	62	162
Water supply, th. m^3/ha	46,8	44,3	46,0
Surface release, th. m^3/ha	22,9	19,5	25,5
Water supply (net), th. m^3/ha	23,9	24,8	20,8
Ground outflow, th. m^3/ha (g)	11,8	11,7	13,6
Total evaporation as a balance descreancy	12,1	13,1	8,13
The same according to B. Milkis. calculations	11,03	11,03	-
The same according to Bleiny-Krydle calculations	9,15	9,15	9,43
Desalinization discharge, th. m^3/ha (g)	11,8	11,7	13,6

Table 2.2.

Water-salt balance of soil 0-1 m layer under leaching (March-November, 1966)

Indicator	Check № 21, 50 m from well № 12		Check № 76, 257 m from well № 12			Check № 70, 476 m from well № 12	
	28.03 - 23.04	for season	24.03 - 02.06	02.06 - 25.08	for season	23.03 - 21.12	for season
Water balance, m^3/ha							
Water supply	6000	15000	6450	14400	30200	10070	19620
Precipitation	525	888	522	106	958	525	953
TOTAL (N)	6525	15888	6972	14506	31153	10695	20573
Evaporation	2407	4939	1643	6483	11072	6094	10005
Desalinizating discharge	4118	10949	5329	8023	20081	4501	10568
Salt balance, t/ha							
Salt influx with water supply: salinity, g/l salts, t/ha	 1.6 9.5	 1.6 24.0	 1.6 10.3	 1.6 23.0	 1.6 48.3	 1.6 16.0	 1.6 31.3
Desalinizating discharge(g) salinity, g/l salts, t/ha	 8.2 33.8	10949 7.2 78.8	 10.5 56.0	 8.0 64.0	20081 8.2 164.7	 12.0 54.0	10568 8.8 93.3
Salt stock changes, t/ha (ΔS)	-24,3	-54.8	-45.7	-41.0	-114.7	-38.0	-62.0
Water expenses (m^3),for 1 ton salt removal (g: ΔS)	170	200	119	195.0	175	118	170
Total amount of water (m^3) for 1 ton salt removal (N: ΔS)		289			271.6		331

Under similar water supply volume and lands drainability in process of rice crop growing it was removed from 1 meter layer: on the first field -24-24-28 % on dry residue and 76-85 % on chlorine-ion, and on the second fields-49 % on dry residue and 90,2 % on chlorine-ion; in the second plot salt content in 1 meter layer of soil was reduced on dry residue on 91 %, on chlorine-ion-87,8 %.

The rest content of easily soluble salt in meter layer changed over plots from 1,28 to 1,47 % on dry residue and from 0,029 to 0,034 % on chlorine-ion.

Season salt accumulation coefficient varied over plots within 0,5-0,69 on dry residue for meter layer and within 0,83-1,05 for the second meter later SSA on chlorine-ion changed widely within 0,097-0,17 for 1 meter layer and 0,35-0,39 for the 2 meter (table 2.3.)

Under leaching via rice crop, as well as without it, sharp changes happened in water soluble salt composition: toxic salt content was much reduced. In 0-3 m layer after leaching their quantity did not exceed 0,16 % against initial one 0,39-0,47, that is significantly lower than permissible level of toxicity. At the same time quantity of calcium and gypsum after leaching increased to some extent.

Salt balance on plots of leaching through rice crop, as well as on the plots without rice, was formed in according with water balance, on type of irreversible desalinization of aeration zone soils and l top fine-grained deposits:

Indicator	1 plot		2 plot
Area, ha	73,5	62	162
Salt influx with irrigation water + water pumped from wells, t/ha:			
on dry residue	135	64,0	63,9
on chlorine-ion	27,1	16,7	10,8
Salt disposal due to release:			
on dry residue	65,6	28	82,4
on chlorine-ion	13,5	7,4	11,2
At the expense of ground outflow, t/ha:			
on dry residue	88,6	58,6	82,4
on chlorine-ion	19,2	17,9	7,6
Total:			
on dry residue	147,2	86,6	174,8
on chlorine-ion	30,7	25,2	18,8
Salt difference, t/ha:			
on dry residue	-2,6	-22,6	-100,9
on chlorine-ion	-3,6	-8,6	-7,6
Salt stock changes, in 3 m layer, t/ha:			
on dry residue	610,4	683,0	583,5
on chlorine-ion	560,2	537,4	460,9
Salt stock changes, t/ha:			
on dry residue	-50,4	-145,6	-122,6
on chlorine-ion	-36,4	-70,5	-47,7
Water expenses for 1 t salt removal, m^3:			
on dry residue	235	80	1146,8
on chlorine-ion	325	167	366,0

Table 2.3

Soil salinity changes under leaching through rice (average for sites), %

Indicator	Salt content in soil layer							
	0 - 1 m	1 - 2 m	2 - 3 m	0 - 1 m	1 - 2 m	2 - 3 m	0 - 1 m	1 - 2 m
			site 1				**site 2**	
Dry residue:								
before leaching	2.09	1.61		2.54	1.45		2.13	1.49
after leaching	1.32	1.40		1.28	1.42		1.47	1.57
Difference	-0.77	-0.21		-1.26	-0.013		-0.66	+0.08
On chlorine-ion:								
before leaching	0.196	0.154		0.351	0.140		0.238	0.152
after leaching	0.034	0.055		0.034	0.054	0.059	0.029	0.05
Difference	-0.162	-0.099		0.399	-0.086	-0.011	-0.209	-0.102
Coefficient								
CAC:								
on dry residue	0.63	0.83	1.02	0.50	0.98	1.10	0.69	1.05
on chlorine-ion	0.17	0.35	0.40	0.097	0.38	0.84	0.12	0.39

Salt removal over the first plot was within 12-22,6 t/ha on dry residue and within 3,6-8,6 t/ha on chlorine-ion and over the second plot, appropriately,-100,9 and 7,6 t/ha. Negligible salt removal from the first field of the first plots could be explained by high salinity of applied water from Shuryzyak collector (4.0 g/l.

Plocessing of leaching results by different methods showed that in Shuruzyak massif conditions, where irrigated lands are represented by low permeable soils with low salt availability (α = 2,7-3,5), intensified removal of the most toxic chlorine-ion is found under water supply by norm to 12-13 th m^3/ha. Under these norms chlorine-ion removal was 80-85 % of initial value. Further increase of leaching norms did not desalinize 1 meter layer soils effectively, though intensification of salt removal on dry residue is found due to washing out hardly soluble ions of sulfur acid and other salts (pic.2.4).

Theoretical calculation of leaching norms, which are necessary for chlorine-ion removal from meter layer being observed in practice 66,7; 82,1 and 88 % of initial, showed that they are equal, appropriately, to 10,3; 16,5 th m^3/ha.

So, according to field researches data and theoretical calculations the conclusionwas drawn that water supply more than 12-13 th. m3/ha for leaching is not rational (pic.2.4.). Capital leaching effectiveness on acceleration of soil desalinization and irrigation water productivity increase are evident from data of table 2.4.

From this table data the best indicators of effectiveness under VDS operation are obtained in variants of leaching through rice crop and on fields with cotton crop sowing under desalinizating discharge (infiltration), appropriately, near 12853 and 7883 m^3/ha. In these options SSA coefficient was 0,5-0,7, and water expenses for 1 t salt removal from 1 meter layer changed within 775-120 m^3 (table 2.4).

During the beginning of leaching intensive washing out of salts proceeds from soil thickness, and than removal process becomes slower. After obtaining certain limit salt removal became so slow, that water supply for leaching turnrs out unprofitable. For sulphate and chloride-sulphate soil salinity type (Shuruzyak and Sardob massives lands) it is unprofitable. Limit of salinity level is 1,0-1,2 % on salt sum and 0,02-0,03 % on ion -chlorine.

While soils are being desalinized, specific water expenses for 1 t salt removal increase (pic.2.5).

At the same time insufficient technology of capital leaching on the background of VDS results in large expenses of irrigation water that is evident from results of soil desalinization under lands reclamation in Vakhsh valley (index 02.8).

Compared to previous pilot projects (02.39) which are located in old irrigation zone of Hungry steppe here experiments were conducted, on the one hand, with other technological schemes of leaching; on the other hand - in other natural-economic conditions. Were climate is subtropical with sum of positive temperatures 5500-6000^0 C, precipitation 290-400 mm per year, and evaporativity exceeds 1500-1600 mm per year. Pilot plot with diverse options of leaching is located in active salt accumulation zone, on the third alluvial terrace of Vakhsh river. Relief is kind of bowl: the northern part of plot has gradient-0001, and the western-00017. Lithology is represented by two-layer deposits: from top on depth to 10-11 m by top fine-grained deposit, and downward to 100 m by high thickness of pebbles with K_f =10-20 m/day. Permeability of loam soil of top fine-grained deposit is estimated within 0,025-1,0 m/day, that is by 2-10 times exceeds soil water permeability (02.39.), ground water table before reclamation was on depth 0,5-3,0 m, ground water salinity. In the western part reached 50 g/l, and canal zone plots-3-5 g/l. Ground water salinity changed within 4,5-10,5 g/l. About 40 % of plot areas is gypsum-bearing.

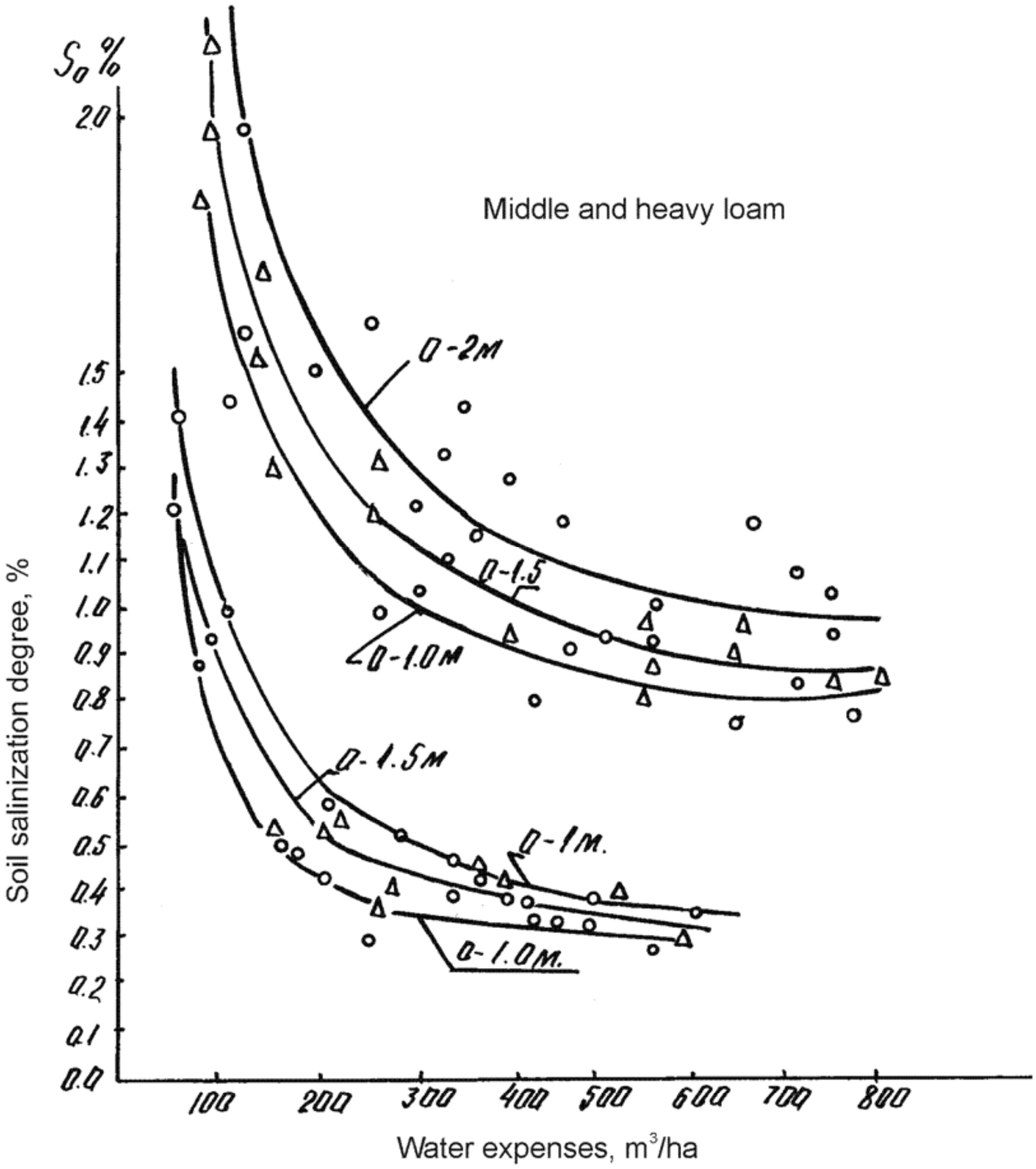


Fig. 2.5. Irrigation water expenses for 1 tn of salt removal under its different concentrations.

Table 2.4

Assessment of leaching efficiency depending on water expenses for salt removal and per yield unit

Plot index	Leaching type	Versions (or years)	Leaching norm, net, m^3/ha	Soil horizon, m	salt removal		Desalinizating discharge, m^3/ha	Leaching regime coefficient	Ground water salinity, g/l	Season salt accumulation (CAC)	Drainage modulus, l/sec/ha	Water expenses for 1 t salt removal	Agricultural crops yield, c/ha	Water expenses per yield unit, m^3/c	
					t/ha	% of initial							initial/ final	initial	final
							UZBEKISTAN								
02.39	capital	1-vers.	15000	0-1	-70.3	27	10949	3.2	9/3.5	0.35-0.84	0.350	178-256	24/53 (rice)	rice: 625-	283-
				0-2	-186	34	-	-	-	-	-	-	-	1041	471
				0-3	-100/6	36	-	-	-	-	-	-	-	-	-
	through rice	2-vers.	25000	0-1	-151.5	16	12853	1.98	9/3.5	0.5-0.7	0.570	105-119	14/28 (cotton)	-	-
				1-2	-171	43	-	-	-	-	-	-	-	cotton:	
				0-3	-162	29	-	-	-	-	-	-	-	1070-	535-
	on plots	3-vers.	18000	0-1	-148.5	22	7883	1.71	9/3.5	0.59-0.7	0.63	74-121	-	1785	892
				1-2	-174	41	-	-	-	-	-	-	-	-	-
				0-3	-243	29	-	-	-	-	-	-	-	-	-
02.3	capital	1-year	25180	0-1	-82.8	30	16547	2.82	28.6/15.4	0.62	0.38-0.55	304	24/28 (cotton)	cotton:	
				1-2	-110/6	38	-	-	-	0/58	-	228	40/53 (rice)	1049- 1377	899- 1180
				0-3	-317.4	42	-	-	-	0.56	-	79.0	-		
		2-year	33060	0-1	-129.1	44	22730	3.15	49.3/40.2	0.61	0.28-0.64	256	-	rice:	
				1-2	-46.2	39	-	-	-	0.85	-	718	-	629-	475-
				0-3	-172.2	15	-	-	-	0.81	-	192	-	826	624
		3-year	25900	0-1	-190.4	19	15732	2.51	21.9/2.9	0.30	0.21-0.37	136	-		-
				1-2	-52.1	69	-	-	-	0.75	-	498	-	-	-
				0-3	161.8	25	-	-	-	0.47	-	159			

Plot index	Leaching type	Versions (or years)	Leaching norm, net, m^3/ha	Soil horizon, m	salt removal		Desalinizing discharge, m^3/ha	Leaching regime coefficient	Ground water salinity, g/l	Season salt accumulation (CAC)	Drainage modulus, l/sec/ha	Water expenses for 1 t salt removal	Agricultural crops yield, c/ha	Water expenses per yield unit, m^3/c	
					t/ha	% of initial							initial/ final	initial	final
02.34	capital, two stage	1-vers.	19600	0-1	-226	57	19060	7.14	40-60	0.43	1.16	86	no data		
				1-2	-143	38	-	-	-	0.61	-	137			
				0-3	-399	35	-	-	-	0.65	-	49			
	control, 1 stage	2-vers.		0-1	-218	52	14760	5.64	40-60	0.47	0.89	73			
				1-2	-109	29	-	-	-	0.71	-	147			
				0-3	-293	26	-	-	-	0.74	-	55			
02.13	leaching on checks	1	2500	0-1	-10.7	16	2500	-	5-8	0.84	no data	250	7/15 (cotton)	cotton: 357.0-2857	133-1333
		2	5000	0-1	-14.9	62	5000	-	-	0.37		119	-		
		3	7500	0-1	-48.9	72	7500	-	-	0.27		143	-		
		4	10000	0-1	-58.9	88	10000	-	-	0.12		169	-		
		5	15000	0-1	-62.4	94	15000	-	-	0.07		242	-		
		6	20000	0-1	-54.9	82	20000	-	-	0.18		364	-		
							KAZAKHSTAN								
02.4	autumn-winter	1-vers.	8500	0-1	-110	39	8100	14.5	9/15.5	0.61	0.540	77	20/25 (cotton)	425-1300	340-1040
				0-3	-74	12	-	-	-	0.88	-	115	35/45 (grain)	242-742	188-578
		2-vers.	26000	0-1	-276	77	25500	37.5	8/6.5	0.23	1.74	94	55/75 (maize)	154-472	113-347
				0-3	-207	29	-	-	-	0.71	-	126	-	-	-
							KYRGYZSTAN								

Plot index	Leaching type	Versions (or years)	Leaching norm, net, m^3/ha	Soil horizon, m	salt removal		Desalinizating discharge, m^3/ha	Leaching regime coefficient	Ground water salinity, g/l	Season salt accumulation (CAC)	Drainage modulus, l/sec/ha	Water expenses for 1 t salt removal	Agricultural crops yield, c/ha initial/final	Water expenses per yield unit, m^3/c	
					t/ha	% of initial								initial	final
02.5	rice plus permanent drainage	1-year	20352	0-1	-105.8	66	10748	2.04	19/8.0	0.34	0.73	194	20/31 (rice)	1018 - 1778	656 - 1147
		2-year	21632	0-1	-5.8	11	12738	2.27	-	0.89	0.56	3730	-		
		3-year	22897	0-1	-3.3	6	13604	2.36	-	0.94	0.42	6938	-		
	rice plus permanent and provisional drainage	1-year	35572	0-1	105.9	72	26070	3.38	26/16.1	0.28	0.94	335	-		
		2-year	34835	0-1	-20.3	50	24427	3.21	-	0.50	1.82	1740	-		
							TADJIKISTAN								
02.8	capital with rice	1-vers.	11000	0-3	-99.1	26	11000	0.79	6.5/4.3	0.75	no data	110	15/18 (cotton)	733 - 5200	611 - 4330
		2-vers.	19800	0-3	-225	35	5400	1.38	17.6/20.8	0.65		88	22/40 (rice)	500 - 3540	275 - 1950
		3-vers.	29100	0-3	-78	27	14700	2.02	4.7/3.7	0.73		373	22/112 (lucerne)	500 - 3540	98-696
		4-vers.	64000	0-3	-173.3	45	49600	4.44	7.4/3.2	0.55		369	-	-	
		5-vers.	67000	0-3	-173.3	41	52600	4.65	7.9/3.4	0.58		387	-	-	
		6-vers.	78000	0-3	249.2	56	63600	5.42	5.85/2.8	0.44		313	-	-	

In these natural conditions experimental-production plot of vertical drainage system was constructed on area of 400 ha where divers types of leaching technology on 20 ha were used. Water pumped from wells had salinity 4-10 g/l, irrigation water -0,5 g/l.

Wells discharge changed within 110-136 l/sec. Tests on leaching technology were conducted in 3 variants:

1. Water supply from well, flood over small checks including half of checks without surface release. Leaching norm is 19 th. m^3/ha (gross), 15,2 th m^3/ha (net) leaching period-Dec ember-June. In result of leaching chlorine-ion content is reduced on 40 cm layer from 46 to 4,6 t/ha with 90 %, salt removal and in 1 meter layer from 76 t/ha to 11 t/ha (removal was 85 %). Irrigated land was transfered from salt category to slightly saline. Soil desalinization covers deep horizon up to 500-700 cm of thickness, where chlorine-ion content is reduced to 34 %. Further for leaching 4,0 th m^3/ha of ditch water were supplied with salinity to 0,5 g/l by means of soil desalinization was obtained and soil transfer in non-saline category were (pic.2.6.)

2. Land leaching with water filling into big checks (1,0-1,2 ha), with height of bordersto1,0 m under permanent and interrupted operation of vertical drainage system. For leaching under vertical drainage system permanent operation 10 th m^3/ha (net) was withdrawn from wells for 8 days. In the result salt content in 1,5 m layer (on sum of salts) was reduced from 520t/ha to 197 t/ha (salt removal was 38 %), and on chlorine-ion from 50 t/ha to 12 t/ha (28 %). After 10 th m^3/ha of water supply leaching was conducted by gifts with vertical drainage system stop for 10-20 days with water supply to 60 th m^3/ha of which share of surface release was 30-40 th m^3/ha. Water was supplied in 3 gifts, that allowed to obtain fast desalinization of soils to permissible limit-0,015-0,017 % on chlorine-ion (pic.2.6.11).

3. Leaching of strongly saline soils under rice crop sawing on the background of the 1 well over the area of 23 ha.

For leaching (rice crop irrigation) up to 104 th m^3/ha of water was supplied, of which 40 th m^3/ha were spent for surface releaseand 49,6 for infiltration in ground water through aeration zone. In the result of regular well operation desalinization of whole thickness of top fine grained deposit was obtained. Salt content residue in 5 m layer did not exceed 0,015 % on chlorine-ion (pic.26. III). In the first year rice crop yield was 22 c/ha, in the second-40 c/ha/ Cotton crop yield was 18 c/ha.

It worth to note that observation on soil-meliorative processes in leaching period were conducted on 6 test fields.

According to information from these test fields for leaching huge water volume from 60 100 to 115 000 m^3/ha were supplied, of which about 31-40 th m^3/ha were discharged for surface release. Leaching norms (net) changed within 11-78 th m^3/ha. The 2 variant is exception, where leaching was conducted without release and norm was 19 800 m^3/ha (table 2.4.1). In the result salt removal from 3 m layer changed within 78-249 t/ha under high water expenses for 1 t removal on pilot object 02.8 (Tadjikistan) changed from 88 m^3 (net) and 928 m^3 (gross) while over object 02.39 they are 74-150 m^3/t (net). It causes very high specific expenses of irrigation water for rice crop yield unit over Tadjikistan, reaching 611-4330 m^3/c. At the same time, test results in Uzbekistan (02.39)and in Tadjikistan show:

- possibility and expediency of high mineralized drainage water (4-6 g/l) use for salts and strongly saline lands leaching and rice crop irrigation. Soil additional leaching to permissible limit is carried out with irrigation water use by not high norm - 4-5 th. m^3/ha;
- expediency of interrupted regime of reclamation under desalinization measures that accelerates salt removal from soil;
- inefficiency of leaching by flooding big checks. Leaching over big checks creates irregularity of desalinization over area.

Table 2.4.1

Leaching efficiency for soil and groundwater desalinization

Plot index	Versions (data accounting)	Duration, days	Total water supply and expenses, m^3/ha			Leaching norm	Initial salt stock			Final stock, t/ha	Removed, t/ha	Specific water expenses for 1 ton salt removal, m^3	
			gross	surface release	evapotranspiration	net, m^3/ha	information type	soil horizons, m	stock, t/ha			gross, m^3/t	net, m^3/t
02.8	1-vers.	240	92000	81000	14400	11000	on	0-3	386.9	287.8	-99.1	928.0	111.0
	2-vers.	140	19800	-	3400	19800	dry	0-3	635.0	410.0	-225	88.0	88.0
	3-vers.	240	60100	31000	14400	29100	residue	0-3	288.0	210.0	-78	770.5	373.0
	4-vers.	240	104400	40000	14400	64000		0-3	383.3	210.0	-173.3	601.0	369.3
	5-vers.	240	99000	32000	14400	67000		0-3	417.4	244.1	-173.3	571.0	386.6
	6-vers.	240	115000	37000	14400	78000		0-3	448.0	198.8	-249.2	461.5	313.1

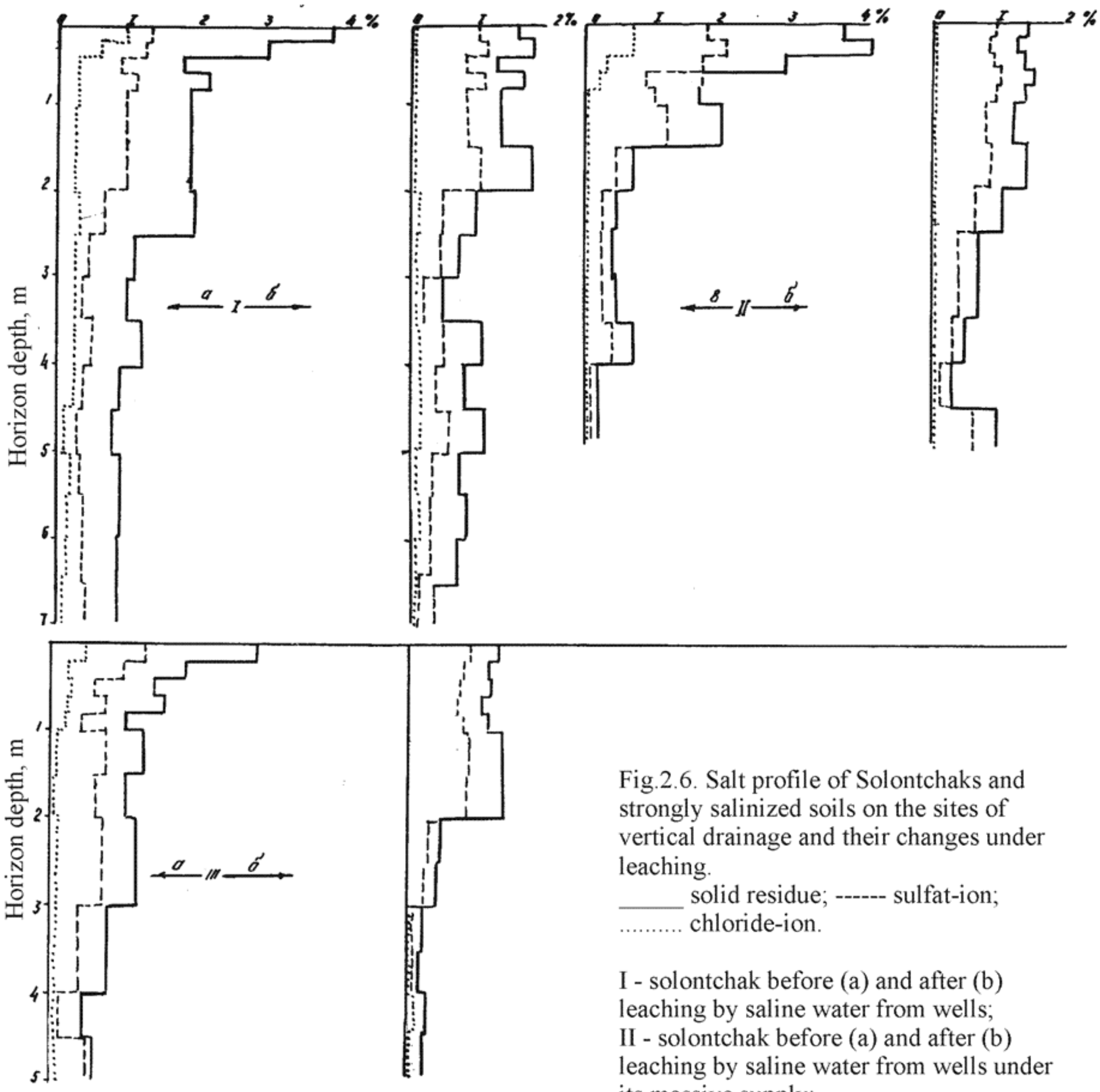


Fig.2.6. Salt profile of Solontchaks and strongly salinized soils on the sites of vertical drainage and their changes under leaching.
_____ solid residue; ------ sulfat-ion;
.... chloride-ion.

I - solontchak before (a) and after (b) leaching by saline water from wells;
II - solontchak before (a) and after (b) leaching by saline water from wells under its massive supply;
III - strongly salinized soils before (a) and after (b) leaching by irrigation water under rice.

2.3.2.3. Soil desalinization through rice crop and without it on the background of horizontal drainage

Field researches of soil desalinization through rice crop and without it were carried out in 2 farms: on area of the state farm # 6 "Titov" in new zone of Hungry steppe (02.3 Uz, G.Baturin) and collective farm Beshterek in Chu valley (02.5 Kyrg, I.Duyunov).

Pilot plots soil, which are located on area of the state farm "Titov", represented by light-gray loam with different content of crystal gypsum. Maximum gypsum accumulation in soil profile is noted in 0.2-0.5 m layer in the southern part of the state farm area and in 0.6-1.5 m layer in the central part. On the depth of 11-15 m and more low permeable clay deposits were exposed with interlayers of sandy loam and small-grained sands. Permeability of soil thickness fluctuated within 0.2-0.5 m/day. Soil salinity in test options was diverse and was 1.5-2.0 % of soil weight, increasing with depth. Salinity type is chloride-sulfate. Salinity of groundwater top layer, which by the beginning of leaching was on the depth 1.5-4.5 m, varied within 20-58 g/l. On collective farm Beshterek area lithology is mostly represented by top quaternary alluvial-proluvial deposits and made of 20 m thickness of light, middle and heavy loam, inter-laying with sand and sandy loam with thickness from 0.2 to 2.0 m. Before reclamation groundwater table was on the depth 0-3 m, in relief sinks - 0-1 m, groundwater salinity was 10-50 g/l, more seldom - 2-5 g/l. Salinity type is sulfate. Top soil is characterized by gray-meadow and meadow soils. Soils are salinized to the depth of 13-14 m. On degree of salinity of 0-1 m layer soils belong to strongly saline salts. Salt content over horizons was on sum of toxic salts as follow: 0-1 m - 1.0 %; 1-2 m - 1.05 %; 2-3 m - 0.68 %. Salinity type is sulfate-calcium-sodium, sulfate-sodium-calcium and carbonate-calcium-sodium.

Soil desalinization efficiency through rice crop was studied in the state farm "Titov" under deep close drain spacing 180 m (I-st variant), 260 m (II-nd variant) and 310 m (III-rd variant), in Beshterek (02.5 Kyr) with drain spacing 220 m (I-st variant) and 180 m (II-nd variant). Depth of drains - 1.8-3.5 m on plots of Titov and 3.0-3.5 m on Beshterek plots. So far as permanent horizontal drainage has no reserve capacity, as it has place in vertical drainage system, for soil desalinization acceleration and irrigation water efficiency increase in both farms temporary drainage was constructed additionally. Length of temporary drainage in the state farm "Titov" over variants changed within 25, 30 and 35 m/ha and depth 0.85-1.0 m. On Beshterek plots temporary drains depth was 1.5 m and they were laid each 50 m.

It worth to note that soil desalinization intensity on the background of well operating drainage depends on leaching norms and water disposal and water desalinizating discharge, i. e. water exchange between aeration zone and groundwater. On plots of the state farm "Titov" for rice vegetation period 29.2 th cu m/ha (I-st variant, 1966), 46.8 th cu m/ha (II-nd variant, 1967) and 36.7 th cu m/ha of water gross (III-rd variant, 1968) (table 2.5) and on experimental-production plots, which are located on area of collective farm Beshterek (Kyrgyzstan) 42.0 th and 39.5 th cu m/ha (table 2.6) were supplied. Water balance was formed according to type of groundwater intensive outflow. Drainage outflow on plots of Titov farm varied within 51 % (1966) to 25 % (1967 and 1968) and was, appropriately, on years 15000, 11700 and 9700 cu m/ha. Of these drainage outflow volumes 9250 (1966), 5200 (1967) and 6400 (1968) cu m/ha was disposed by temporary drains. On Beshterek plots drainage outflow was 42-50 % of total water disposal volume and changed within 18.4-20.5 th cu m/ha, of which 13.3 and 15.4 th cu m/ha was disposed by temporary drains. Such big volume of water disposal on temporary drains in Beshterek plot comparing to the state farm "Titov" is explained by deeper drains (h = 1.5 m against 0.8-1.0 m in the state farm "Titov"). Total evaporation over plots changed within 9100-11038 cu m/ha (tables 2.5 and 2.6).

Table 2.5

Water balance of pilot plots in state farm «Titov»

Test versions	Positive balance components	m^3/ha	Negative balance components	m^3/ha
1966	Supplied for leaching (gross)	29180	Withdrawn by collector-drainage network: deep	5750
	Precipitation	467	shallow	9250
	Water stock within thickness 0-3 m	7230	Evaporation and transpiration	9100
			Water stock within thickness 0-3 m	9012
			Surface release	4000
	TOTAL	**36877**	**TOTAL**	**37112**
1967	Supplied for leaching (gross)	46800	Withdrawn by collector-drainage network: deep	6500
	Precipitation	277	shallow	5200
	Water stock within thickness 0-3 m	7900	Evaporation and transpiration	10600
			Water stock within thickness 0-3 m	14900
			Surface release	13740
	TOTAL	**54977**	**TOTAL**	**50940**
	Supplied for leaching (gross)	38460	Withdrawn by collector-drainage network: deep	3300
	Precipitation	232	shallow	6400
	Water stock within thickness 0-3 m	8553	Evaporation and transpiration	10400
			Water stock within thickness 0-3 m	13450
			Surface release	12560
	TOTAL	**47245**	**TOTAL**	**46110**

Table 2.6

Water balance of the site with leaching through rice on background of permanent horizontal drainage with provisional one on field 4 of IV rotation in state farm «Besh-Terek», Moscow district for 1976-1977, m^3/ha/%

Balance component	Balance period	
	1976	1977
	4.05 - 14.10 164 days	25.04 - 26.09 155 days
Irrigation water inflow, Â	41980 96.6	39566 98.5
Precipitation, Î$_{\text{ñ}}$	1456 3.4	630 1.5
Inflow, total	43436 100	40196 100
Surface release, Ï$_{\text{ñáð.}}$	6408 14.8	4731 11.8
Drainage outflow through permanent drains, Ä$_{\text{îñò.}}$	5121 11.8	4698 11.7
Drainage outflow through provisional drains, Ä$_{\text{âðåì.}}$	13355 30.7	15450 38.4
Total water consumption and evaporation, È+Ò$_{\text{ð}}$	10958 25.2	11038 27.5
Soil saturation up to depth of 3.65 -3.30 ì, $\Delta W_{\text{íàñ.}}$	7827 18.0	2484 6.2
Balance discrepancy	-233 -0.5	1795 4.4
Discharge, total	43436 100	40196 100
Soil saturation within the horizon 0-1 m, $\Delta W_{\text{íàñ}}^{0-1}$	1528	1528
Amount of water percolating through soil layer 0-1 m	24542	22899

In correspondence with water balance results over all plots negative salt balance was formed according to type of soil intensive desalinization.

On plots of the state farm "Titov" from 3-m thickness of soil 177.8 (1966), 298.3 (1967) and 104.2 t/ha (1968) were removed. With regard to results of salt survey from 3-m layer of soils 317.1, 172.2 and 403.2 t/ha was removed, appropriately. Salt removal volume from 1-meter layer is some what less and changes from 82 (1966) to 190.4 t/ha (1968) (table 2.7).

Table 2.7

Salt balance of experimental sites with leaching (t/ha)
in state farm «Titov»

Salt balance elements	Year of leaching		
	1966	1967	1968
Positive balance elements, including:	30.6	66.0	54.3
Salt inflow with irrigation water	30.6	66.0	54.3
Negative balance elements, including:	208.4	364.3	158.5
Salt removal by drainage, including:	202.2	325.3	139.6
by close horizontal	104.9	174.1	54.1
by provisional	97.3	151.2	85.5
Salt removal by surface release	6.2	20.9	18.9
Salt stock changes	-177.8	-298.3	-104.2
Salt removal according to salt survey data	-317.1	-172.2	-403.2

On Beshterek plots according to balance salt removal is 234.3 and 145.2 t/ha and according to salt survey it changes within 278.1-68.1 t/ha. Specific water expenses per 1 t salt removal over pilot plot (02.3 Uz) Titov were as follow: from 1-m layer - 304 (1st year); 256 (2nd year) and 136 m^3 (3rd year); from 3-m layer - 79 (1st year) and 160 m^3 (3rd year). Over plot (02.5 Kyr) from 1-m layer 194 (1st year) and 335 m^3 (2nd year) (table 2.8). It worth to note that in the result of leaching through rice crop on the background of horizontal and temporary drainage soil desalinization to toxicity limit of not only 1-m layer of aeration zone, but groundwater top layer desalinization was obtained. So, the following common regularities were defined:

- in the beginning of leaching some increase of groundwater and drainage outflow salinity proceeds, which gradually changes into its gradual lowering.

Table 2.8

Salt balance of the site of leaching through rice on background of permanent horizontal drainage with usage of provisional one on field 4 of IV rotation in state farm «Besh-Terek», Moscow district for 1976-1977, t/ha/%

Balance element	Balance layer 3,5 m			
	1976		1977	
	dry residue	toxic salts	dry residue	toxic salts
Salt stock in soil by the beginning of leaching	688.7 / 96.2	493.0 / 96.9	432.6 / 95.3	226.5 / 93.3
Salt stock in groundwater by the beginning of leaching	2.8 / 0.4	2.5 / 0.5	2.5 / 0.5	2.3 / 1.0
Salt influx with irrigation water	24.2 / 3.4	13.3 / 2.6	19.0 / 4.2	13.9 / 5.7
Inflow, total	715.7 / 100	508.8 / 100	454.1 / 100	242.8 / 100
Salt stock in soil by the end of leaching	410.6 / 57.4	227.9 / 44.8	363.7 / 80.1	164.4 / 67.7
Salt stock in groundwater by the end of leaching	8.6 / 1.2	7.9 / 1.6	9.5 / 2.1	8.6 / 3.5
Salt removal by permanent drains	76.9 / 10.7	71.3 / 14.0	52.1 / 11.5	50.4 / 20.8
Salt removal by provisional drains	157.4 / 22.0	142.4 / 28.0	109.2 / 24.0	94.8 / 39.0
Salt removal by surface release	8.9 / 1.2	6.4 / 1.2	4.9 / 1.1	3.3 / 1.4
Balance discrepancy	54.2 / 7.5	52.9 / 10.4	-85.3 / -18.8	-78.7 / -32.4
Discharge, total	715.7 / 100	508.8 / 100	454.1 / 100	242.8 / 100

Intensity of growth and decrease of groundwater and drainage outflow salinity depends on easily soluble salt content in aeration zone, desalinizating discharge value and head of aquifers beneath. Desalinization value of groundwater salinity on experimental-production plot of the state farm "Titov" over years was: - 3.2 (1966), - 9.1 (1967) and - 2.9 g/l (1968) and drainage outflow, appropriately; permanent drainage: - 16.5; - 27.5 and - 14.8 g/l; temporary drainage: -24.5; - 34.2 and - 12.6 g/l (table 2.9). On plots of collective farm Beshterek (Kyrgyzstan) groundwater salinity varied: on 1st plot - from 29.5 to 16.6 g/l (on 12.9 g/l); on 2nd plot - from 26.5 to 16.1 g/l (11.4 g/l);

- drainage outflow of temporary drains, mainly, is formed in central part between drain of deep horizontal drainage. On temporary drains in zone of refraction of depression curve (on distance of 30-40 m from permanent drainage) drainage outflow is absent or its volume is negligible. Intensity of leaching water infiltration and desalinization between deep drain is different: in central part by 3-5 times less than near drains. So in stripe near deep drains active desalinization of soil proceeds. In temporary drains outflow formation their depth is very important. The deeper drains, the higher outflow and salt removal volume. These regularities should be taken into account under temporary drains position planning and their depth selection;

- under vertical drainage system operation in formation of outflow, its salinity and salt removal over drains not only water exchange between aeration zone and groundwater participates, but the deeper aquifers too. With regard to data of piezometric observations over plots of the state farm "Titov" active water and salt exchange zone is 16 m and on Beshterek - 10 m. So, over pilot plots of the state farm "Titov" salinity of groundwater, obtained on piezometers from different depth (7, 10, 12 and 16 m) before and after leaching in between drain of close drainage, is reduced from 28-45 to 20-26 g/l and near drains increased from 30-42 to 45-53 g/l;

- influence of leaching or rice fields on adjacent areas is absent, where groundwater was in initial position on the depth of 2.5-3.0 m.

The basic result of researches of capital leaching through flooded rice crop on the background of horizontal permanent drainage in combination with temporary one or without is that saline lands leaching through flooded rice crops have positive, as well as negative factors: positive is high leaching effect and already in the 1st year from leached plot rice crop yield and income are obtained; negative is that leaching method is wasteful concerning land, water and other inputs, promotes toxic salt removal through drainage outflow to the surface and surface water salinity increase, influences negatively ecology of downstream areas.

In conditions of proluvial-alluvial plains of Chu valley soil desalinization and groundwater salt removal under rice crop cultivation (as method of leaching and lands desalinization) is some what more intensive, than similar one for proluvial-alluvial plains of Hungry steppe. In connection with that in such difficult natural-economic conditions as Hungry steppe southern part, represented by hardly reclaimed low permeable and strongly saline soils, it is necessary while introducing leaching technology to evaluate, relevant of soil types the most convenient for collector-drainage water use.

Foreign and local specialists determined that on light and sandy loam soils there is a possibility of saline water use for irrigation without danger of salinization.

Measures on collector-drainage water use for irrigation should be dependent on availability of areas and soil types with light structure in each region in connection with volumes of available drainage water with proper quality accelerating the soil desalinization. Two-stage land leaching relates to these measures of soil desalinization, the essence and results of test are described below.

Table 2.9

Salt content in soils (t/ha), ground and drainage water (g/l) changes over test sites of leaching

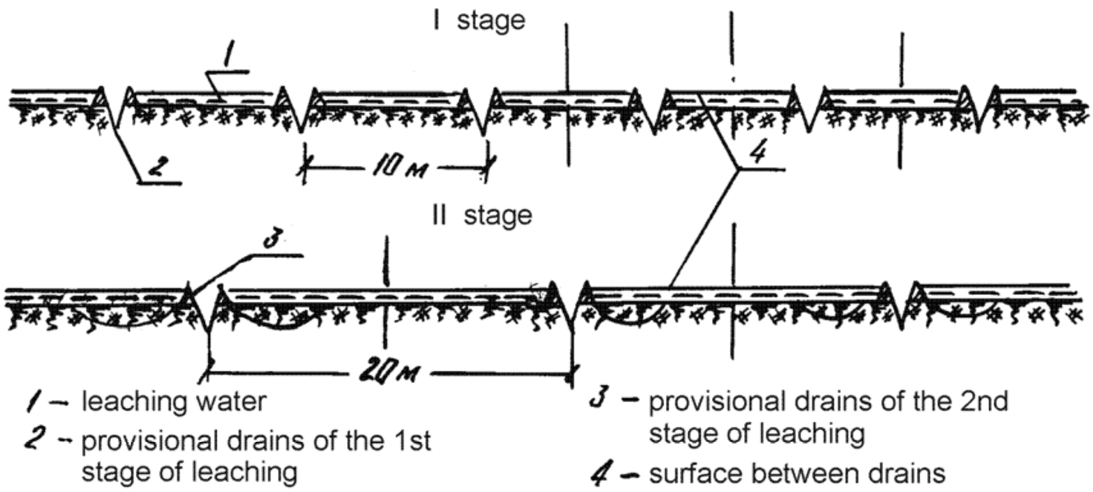
Indicator	Years of leaching								
	1966			1967			1968		
	before leaching	after leaching	difference	before leaching	after leaching	difference	before leaching	after leaching	difference
Soil salinization within layer, t/ha 0...100 cm	220.0/11.5	137.2/1.5	-82.8/10.0	333.5/59.6	204.4/3.7	-129.1/-55.9	273.0/24.2	82.6/3.1	-190.4/-21.1
10...200 cm	261.8/22.8	151.2/2.4	-110.6/-20.4	310.5/49.8	264.3/7.9	-46.2/-42.1	207.5/21.3	155.4/3.3	-52.1/-18.0
200...300 cm	249.2/25.6	117.6/5.6	-131.6/-20.6	252.0/47.6	267.6/13.3	+15.6/-34.3	279.4/13.7	117.6/4.9	-161.8/-8.8
0...300 cm	722.4/59.3	405.3/9.5	-317.1/-49.8	898.8/157.5	726.6/25.9	-172.2/-131.6	760.2/59.2	357.0/11.3	-403.2/-47.9
Groundwater salinity, g/l	28.6	15.4	-13.2	49.3	40.2	-9.1	21.9	19.0	-2.9
Drainage water salinity, g/l: close drains	22.3	5.7	-16.6	47.3	19.8	-27.5	24.2	9.4	-14.8
open drains	28.6	4.1	-24.5	56.7	22.5	-34.2	19.7	7.1	-12.6

Note: numerator - total salt content, denominator - chlorine-ion content.

2.3.2.4. Effectiveness of two-stage leaching of hardly-reclaimed strong-salinizated soils `

In Central Asia a large area of irrigated lands is presented by hurdly-reclaimed strongly-salinizated soils of heavy mechanical composition and low permeability. Soils with such characteristics are hardly subjected to desalinization under ordinary leaching, the acceleration of desalinization process of strongly-salinizated hardly-reclaimed lands and reduction of irrigation water costs are impossible without special measures, promoting increase of water filtration and reinforcement of salt drainage water diversion from leached area. As researches have shown, implemented by SANIIRI, SoyuzNIHI and Sredazgiprovodkhlopok, the best conditions for leaching of gypsum bearing hardly -reclaimed soils are achieved under leaching by temporal drainage construction additionally to close horizontal drainage, length of which can be defined depending on water -physical characteristic of soils. One of such methods, called as two-stage leaching, was proposed by VNIIGIM in 1977 for desalinization of heavy strongly-salinizated soils. It was supposed, that the effectiveness of these lands can be increased by the dense temporal drainage and, therefore, by increase of filtration head gradient and velocity.

In proposed method after desalinization of upper 1-m thickness up to optimal limits (1 stage) and plot leveling the temporal drains are dug anew in the middle between the first stage drains (Fig. 2.7). Distance between temporal drains for second stage of leaching are made twice as much, then for the first stage.



Dr.2.7. Method of two-stage leaching

This method of leaching was tested by G. Klimova (1977) on pilot plot, disposed in the state farm № 5 (code 02.34 - Sh. Rashidov district, SyrDarya province). Soils of pilot plot are grey - meadow and salts with toxic salt content in upper horizons up to 1.2 %. Along the profile salinization gradually increases, that is typical for present zone. Type of salinization is chloride-sulphate. Soils of pilot plot are characterized by very low permeability (less than 0.1

m/day). Volumetric mass of soil varies within 1.36 -1.73 g/cm^3, and porosity 36 - 49.6 % , that means heterogeneity of soil composition within aeration zone.
Ground water with salinity 40 -60 g/l on dry residue before leaching was discovered at depth 3.6 m.

In experience the variants of temporal small drains allocation with depth 0.9 -1.0 m and 10 m between them (1 stage of leaching) and 20 m (II stage) were tested on the background of close horizontal drainage with depth 3 - 3.5 and B =125m. As a control leaching was studied under distance between small drains 20 m.

In the first stage of leaching during 110 days 14.4 th.m^3/ha of water was supplied (water supply module is 1.55 l/s/ha), and average daily filtration was 130 m^3/ha. In the second stage within 40 days it was supplied 5.2 th. m^3/ha (water supply module-1.07 l/s/ha), and average daily filtration decreased to 92 m^3/ha. Thus, the fastening of temporal drainage allowed to intensify considerably water exchange process in leached thickness of soils. Water-salt balance of plot was negative with progressive soil and ground water desalinization (Tables 2.10 and 2.11).

Table 2.10

Water balance for leaching period according to its options, th. m^3/ha

Water balance elements	Option			
	two-stage leaching			control
	first stage	second stage	total for two stages	
Positive balance components:				
Water supply	14.40	5.20	19.60	16.0
Precipitation	1.94	0.62	2.56	1.94
TOTAL	16.34	5.82	22.16	17.94
Negative balance components:				
Evaporation from water surface	2.08	1.02	3.10	3.18
Withdrawn by horizontal drainage:				
- permanent deep	2.30	0.92	3.22	3.15
- provisional shallow	9.60	2.20	11.80	8.50
Groundwater supply recharge	1.80	1.30	3.10	2.10
TOTAL	15.78	5.44	21.22	16.93
Discrepancy	0.56	0.38	0.94	1.01

NOTE: discrepancy between positive and negative components does not exceed 5 % because of measurement error and may be due to availability of ground outflow infiltration and groundwater outside leached site.

Table 2.11

Salt balance for leaching period according to its options, t/ha

Water balance elements	Option			
	two-stage leaching			control
	first stage	second stage	total for two stages	
Positive balance components:				
Salt inflow with irrigation water	29.0	11.0	40.0	32.0
Negative balance components:				
Salt removal by drainage, including:	288.4	96.6	388.0	232.0
- permanent deep	155.0	62.0	217.0	148.0
- provisional shallow	129.4	36.6	166.0	84.0
Salt stock total change	-255.4	-87.6	-343.0	-200.0

NOTE: salt removed under two-stage leaching is 1.7 times more compared with control plot leaching.

Discrepancy between salt removal, determined by salt survey, for different versions does not exceed 8...9.6 %.

Favorable negative salt balance has been built within the test plot as a result of leaching.

Under above mentioned intensity of water exchange in soil thickness during the first stage of leaching by temporal drains 9.6 th. m^3/ha of water was diverted. Average module of drainage flow was 1.22 l/s/ha. 129.4 t/ha of salts were removed by drainage outflow. During the second stage of leaching 2.2 th. m^3/ha 36.6 t/ha of salt were removed by provisional drains; 3.32 th.m^3/ha of water and 217 t/ha salts, correspondingly, were diverted by deep drains.

In the control version for the same leaching period (150 days) 16.0 th.m^3/ha were supplied. Average daily filtration for all period is 88 m^3/ha under water supply module 1.02 l/s/ha. 8.5 th.m^3/ha water were diverted by temporal drains under average module of drainage flow 0.67 l/s/ha. During leaching period 84.0 t/ha of soluble salts were removed by temporal drains. At the same period 3.15 th.m^3/ha of water and 148 t/ha salts were removed by deep drains. Totally for the leaching period 343 tn/ha of salts were removed from aeration zone and 200 t/ha - in the control variant. In accordance with that on the plot of 2-stage leaching the best indicators of soil desalination effectiveness were achieved:

- salt removal from 1m layer is 226, and from 3m is 349 t/ha, against control 218 and 293 t/ha, respectively, under desalinizing discharge 19600 and 14760 m^3/ha;

- coefficient of seasonal salt accumulation in the plot of 2-stage leaching in 1m- and 3 m-layers are 0.43 and 0.65 against control variant 0.47 and 0.74;

- water expenses for removal of 1 ton of salts from 3 m-layer in the plot of 2-stage leaching and in control version are 49 and 55 m^3/tn, correspondingly (table 2.4).

It follows from mentioned above, that construction of dense temporal drainage promotes, under other equal conditions, acceleration of water filtration through the soil thickness and intensive salt removal from soils deeper than temporal drainage depth. This assumption is proved by data on changes of soil salinization. Under rotation of temporal small drainage disposal (stage leaching) the regular soil desalinization on depth to 1.8 -2.0 m was found. Content of toxic chlorine -ion in this thickness during leaching period was decreased to 0.02 %, and sum of harmful salts were up to 0.4 % from soil weight (table 2.12). In the control, although water supply norm was a little less, on average satisfactory desalinization during leaching period as on chlorine-ion, so on sum of harmful salts, occurred on depth 0.8 -1.0 m. At the same time, in several parts between drains residual high content of salt was registered, especially in upper layer of soil.

Thus, two-stage leaching of low permeable salinizated soils based on consecutive transfer of temporal drains during leaching period, similarly to described above, allows to achieve the regular soil desalinization along the area of plot on depth 1.5 m up to 90 %, against control 7-75 %, to increase depth of soil desalinization up to 3 m and significantly accelerate the rate of introduction of these lands in agricultural turnover. Main advantage of this technology of desalinization is water saving for leaching. In the plot of two-stage leaching under soil desalinization on depth 3 m 5.0 th.m^3/ha savings of irrigated water were achieved under decrease of irrigations duration on 15 -20 %. However, 2-stage leaching of hardly-reclaimed strongly salinizated soils is expensive and requires high-cost measures for leveling and construction of temporal drains of large extent. The most effective method of desalinization acceleration is use of chemical meliorants under leaching. In connection with that the section «Impact of chemical meliorants on rate of soil desalinization» was brought into the summary.

Table 2.12

Soil desalinization under leaching on the background of shallow drainage, %

Version	Salts	Layer, cm					
		0-40	40-100	100-150	150-200	200-250	250-300
Two-stage leaching	chlorine -ion	$\frac{0.219}{0.010}$	$\frac{0.333}{0.013}$	$\frac{0.282}{0.012}$	$\frac{0.178}{0.021}$	$\frac{0.199}{0.095}$	$\frac{0.127}{0.126}$
	sum of harmful salts	$\frac{0.833}{0.173}$	$\frac{1.777}{0.203}$	$\frac{1.429}{0.256}$	$\frac{1.167}{0.390}$	$\frac{1.594}{0.899}$	$\frac{1.271}{0.927}$
Control	chlorine-ion	$\frac{0.256}{0.014}$	$\frac{0.272}{0.026}$	$\frac{0.301}{0.055}$	$\frac{0.217}{0.063}$	$\frac{0.199}{0.140}$	$\frac{0.165}{0.172}$
	sum of harmful salts	$\frac{0.903}{0.217}$	$\frac{1.687}{0.339}$	$\frac{1.423}{0.777}$	$\frac{1.173}{0.745}$	$\frac{1.365}{1.607}$	$\frac{1.488}{1.081}$

Note: numerator - salt amount before leaching;
denominator - the same after leaching.

2.3.2.5. Impact of chemical meliorants and deep loosening on soil desalinization rate

One of the ways of the hardly-reclaimed lands desalinization acceleration, development of which is complicated by solid high-carbonate shoh pans, sharply reducing soil permeability, is use a manure and lignin.

Role of manure as a meliorant of biological and chemical influence and its effectiveness in development and increase of land productivity is well known**.** Wide researches of leaching of desalinizated lands under manure application were implemented in Khorezm, Bukhara, Fedchenkov and Central (Hungry Steppe) experimental-meliorative stations and high efficiency of manure application before leaching was demonstrated.
During last years lignin attracted an attention of researchers as a product similar to manure by its properties , replacing it as a fertilizer. Total output of lignin from three enterprises operating in cotton zone of Uzbekistan - Jyangiyul biochemical plant, Fergana plant of furan compounds and Andijan hydrolyze plant is 300 -400 th. t. a year.

Lignin is the predecessor of soil humus and consists of a range of macro- and micro-nutritious elements: nitrogen (0.17 - 0.19 %), phosphorus (0.20 - 0.26 %), potassium (≈ 0.02 %), iron (more than 3 %), manganese, copper, zinc, vanadium, etc. All these elements in lignin are situated in movable form. Depending on production technology lignin consists of 0.4 to 3 % of acid, which being applicated interacts with soil carbonates. With application of manure and lignin under leaching the process of coagulation of soil particles and their aggregation is going. However, in spite of available positive experience of lignin use as a humus predecessor in irrigated zone, it is not yet broadly used. This is connected with need of a scientific background optimal dose of application taking into account soil water -physical and other properties.

In connection with that in Central Fergana (state farm «Pakhtakor»), SANIIRI special researches were implemented with purpose to вуеукьшту the effectiveness of lignin under development and leaching. Soils of pilot plot are characterized by hard mechanical structure (middle and heavy loam), great cleavage, considerable diversity of colors. Typical peculiarity in the soil structure are availability on profile of low permeable shoh pans that significantly reduce leaching efficiency. Capital leaching of these soils is implemented in following versions:

I version (control) - deep ploughing (40 cm), leaching - norm 9.5 th. m^3/ha;

II version - application of 20 t/ha manure, deep ploughing, leaching -norm 4.75 th. m^3/ha;

III version - application of 40 t/ha lignin, deep ploughing, leaching -N = 7.75 th. m^3/ha

Experiment versions are located perpendicularly to open drain with depth 3 m. Three-fold repetition was made. Total area of plot is 4.8 ha.

Leaching was implemented in winter period by checks flooding with small gifts of 1.5 - 3.0 th. m^3/ha up to achieving desalinization degree of 0.15% on toxic salts. Totally for leaching 4.75 -9.5 th. m^3/ha water were supplied depending on initial salinization.

Chlorine content in 1m-layer of soil before leaching beginning was 0.11 -0.56 %, and toxic salts were 0.311 -1.10 % of soil mass. Application of manure and lignin under leaching promoted intensive desalinization of 1-m soil thickness. The biggest intensity of desalinization was observed during the primary stage of leaching. Salt removal by first water portions in the versions with manure and lignin was advantageously differed from control. So, if under almost equal norms of water supply in control version after the first tact of leaching content of toxic salts decreased on 27 -37 % from initial, then in II version this indicator was 45 -61 %, and in III and IV were, accordingly, 52 -62 % and 46 -49 % (Table 2.13).

In subsequent phases of leaching the biggest intensity of flushed thickness desalinization was observed in IV version. Here intensive salt removal occurred during all leaching, in the same time as in III and, particularly, in control version the transition to extensive salt availability took place between 1-st and 2-nd tact. High effectiveness of chemical meliorants is clearly demonstrated by the data of soil desalinization. So, at the end of leaching period in IV version with application of 40 tn/ha lignin under leaching norm of 7750 m^3/ha 0.686% of toxic salts and 0.176 % of chlorine-ion were removed, whereas in control version removal was 0.48 % on toxic salts and 0.152 % on chlorine -ion under norm of 9.5 th. m^3/ha (Table 2.13).

Table 2.13

Dynamics of desalinization of soil 1-m layer under impact of chemical meliorants

Version	Leaching tact	Water supply, th. m^3/ha	Content, %		Salt removal, tn/ha	
			chlorine-ion	toxic salts sum	chlorine-ion	toxic salts
I	-	-	0.166	0.631		
	1	2.5	0.108	0.398		
	2	2.0	0.082	0.257		
	3	2.0	0.041	0.219		
	4	1.0	0.038	0.187		
	5	2.0	0.014	0.152		
Removal		9.5	0.152/91	0.479/76	20.5	64.7
II	-	-	0.284	0.714		
	1	2.5	-	0.347		
	2		0.191	0.549		
	3		0.031	0.152		
	4	2.25	0.017	0.119		
Removal		4.75	0.267/94	0.462/64	36.0	62.4
III			0.217	0.683		
	1	2.5	0.090	0.322		
	2	2.5	0.044	0.208		
	3	2.0	0.027	0.156		
	4	1.5	0.019	0.132		
Removal		8.5	0.198/91.2	0.551/81	26.7	74.4
IV			0.204	0.809		
	1	2.75	0.098	0.418		
	2	2.0	0.049	0.267		
	3	1.5	0.038	0.178		

	4	1.5	0.028	0.123		
Removal		7.75	0.176/86	0.686/84	23.7	92.6

From all of these versions the biggest desalinization effect was achieved in II version, where 20 tn/ha of manure were applied. In this version under leaching norm 4.75 th. m^3/ha the salt removal on chlorine -ion was 0.267 % from dry soil mass (94 % from whole chlorine content in soil) and 0.462 % from toxic salts sum (64 %), i.e. the same results, as in control version under half as much leaching norm (Table 2.13).

The data on specific water expenses for salt removal also indicates increase of desalinization efficiency with application of manure and lignin. So, application of 20 t/ha manure under leaching allows to decrease the expenses of water for removal of 1ton toxic salts from 1-m soil thickness on 24 % (76.1 m^3), bringing in 20 t/ha of lignin, on 14 % (114.2 m^3) and 40 t/ha of lignin -on 49 % (81 m^3) in comparison with control, where specific water expenses were 146.8 m^3.

It is worth to note, that specific water expenses for removal of 1 ton salts, achieved under experimental leaching with application of chemical meliorants, are by 2.5 - 3.0 times less than with temporal drains use (section 2.3 and 2.4). Coefficient of water flushing action in this case increases on 31, 21 and 100 %, respectfully.

Results of experiment have proved that the application of manure and lignin under leaching reduces water expenses for leaching on 22 -29 % in comparison with usual leaching, that in respect to real conditions of experiment would be 1300 -3600 m^3/ha depending on initial salinization, kind and dose of meliorants application. It is necessary to emphasize the similar impact on water saving in versions with application of 20 t/ha of manure and 40 t/ha of lignin (Tables 2.13, 2.14).

Manure and lignin significantly influence on soil salt regime after leaching period. In control version just to the end of first year after leaching the some salt restoration is demonstrated throughout a whole 1-m thickness. Lands from non-saline category moved to slightly saline. For their desalinization up to toxicological threshold under initial salinity 0.032% on chlorine -ion and 0.215 % on toxic salts sum and indicator of salt availability 1.418, water supply for leaching in volume 3.02 and 2.32 th. m^3/ha will be needed. Rainfalls of autumn -winter period (156 mm) and a spring reserve irrigation by depth 2 th. m^3/ha have provided the soil desalinization up to permissible limits by vegetation start. In II version to the end of first year chlorine-ion amount in 1-m soil layer has not changed; toxic salts content rather increased - 0.146 % against 0.113 % at the beginning of vegetation (Table 2.14). Nevertheless, to the end of first year the content of toxic salts remained below toxicological threshold. Salt restoration process has affected mainly the lower layers of profile. In the second year after leaching already whole 1-m layer of soil was covered by this process. Rate of toxic salts accumulation in this version are significantly slower than in control one.

In III and IV versions observed changes in soil salinity are similar. Only difference is an application of lignin by double norm, which promotes deeper desalinization effect in comparison with single norm of lignin (0.045 -0.00115 % of toxic salt sum against 0.094 - 0.199 %) (Table 2.14). Due to this fact as well as improvement of soil water -physical properties the salinity in IV version to the end of first and second years after leaching remains below toxicological threshold and is 0.008 -0.010 % on ion -chlorine and 0.100 -

0.147 % on toxic salts. Indicators of III version is rather higher: 0.017 - 0.029 % and 0.137 - 0.235 % respectfully (Table 2.14).

Table 2.14

Soil salinity change after leaching period on background of chemical meliorants incertion

Versions	Layer, cm	In soil concentration, %								
		chlorine-ion			sulfate-ion, toxic			sum of toxic salts		
		after leaching	by the end of 1st year	by the end of 2nd year	after leaching	by the end of 1st year	by the end of 2nd year	after leaching	by the end of 1st year	by the end of 2nd year
1	0-25	0.007	0.032	0.022	0.072	0.102	0.081	0.110	0.190	0.162
	25-50	0.018	0.032	0.038	0.134	0.111	0.133	0.212	0.202	0.242
	50-75	0.018	0.032	0.039	0.080	0.133	0.148	0.137	0.233	0.264
	75-100	0.018	0.034	0.034	0.084	0.132	0.147	0.142	0.234	0.238
	0-100	0.015	0.032	0.033	0.092	0.120	0.127	0.150	0.215	0.226
II	0-25	0.010	0.013	0.016	0.063	0.074	0.090	0.101	0.122	0.173
	25-50	0.012	0.009	0.033	0.064	0.065	0.104	0.106	0.102	0.200
	50-75	0.017	0.015	0.051	0.068	0.101	0.076	0.120	0.162	0.166
	75-100	0.018	0.019	0.041	0.072	0.123	0.069	0.126	0.198	0.142
	0-100	0.014	0.014	0.035	0.067	0.091	0.085	0.113	0.146	0.170
III	0-25	0.007	0.022	0.017	0.061	0.089	0.077	0.094	0.156	0.131
	25-50	0.019	0.019	0.021	0.086	0.079	0.102	0.147	0.137	0.173
	50-75	0.021	0.018	0.018	0.121	0.115	0.129	0.199	0.186	0.209
	75-100	0.012	0.020	0.029	0.094	0.100	0.138	0.147	0.169	0.235
	0-100	0.015	0.020	0.021	0.090	0.096	0.112	0.147	0.162	0.187
IV	0-25	0.004	0.009	0.009	0.029	0.076	0.081	0.045	0.122	0.125
	25-50	0.006	0.010	0.010	0.034	0.078	0.089	0.054	0.127	0.147
	50-75	0.008	0.008	0.008	0.044	0.074	0.077	0.072	0.118	0.113
	75-100	0.011	0.010	0.010	0.100	0.060	0.092	0.155	0.100	0.139
	0-100	0.007	0.009	0.009	0.052	0.072	0.085	0.082	0.117	0.131

Analysis of results allowed to receive the following empirical formula (A Ramazanov., B. Ostrobrod, 1986) for definition of optimal, economically profitable norm of lignin application under leaching of shoh saline soils:

$$\mathbf{A = 0.63\,HC + 2.5,}$$

where **A** - norm of lignin application, t/ha;
H - thickness of shoh horizon, m;
C- total content of calcium and magnesium carbonates in shoh horizon, % to dry soil weight.

Lignin application norm depending on total content of carbonates, estimated in this formula for small thickness soil (< 0.4 m) are 10 -18 t/ha, for middle-thickness soils (0.4 - 1.0 m) are 12 -40 t/ha, for big thickness (>1.0 m) are 28 -40 t/ha.

Application of chemical meliorants as lignin and manure provides not only improvement of soil desalinizing ability, but also increase of irrigated land productivity, that is evident from table 2.15.

Table 2.15

Position of trials and soil characteristics	Type of Measure	Yield	Yield supplement	
			c/ha	% to control
Central Fergana, Niyazov state farm	1.Loosening on h=60cm (control, N=6000 m^3/ha)	18.96		
Grey-meadow soils, medium -saline	2. The same with application of super-phosphate -350 kg and 60 tn/ha of lignin	22.0	2.94	15.5
N =6000-6500 m^3/ha	3. The same, with application of manure 40 tn/ha	24.4	5.44	28.7
	4. The same with application of manure 60 tn/ha	28.3	9.34	49.3

The most effective was manure application, under which yield supplement was 5.4 -9.3c/ha.

From above mentioned is clear that for modern phase of irrigation-reclamation design, where a role of drainage is universally recognized as a main method of water-salt regime regulation, capital leaching of strongly saline lands and salts are needed to be implemented under availability of normally operating collector-drainage network. On lands with poor water - physical properties the capital leaching needs to be implemented with chemical meliorants application in combination with mechanical soil tillage (deep ploughing, deep loosening).

One of these methods of intensification of hardly reclaimed land desalinization was studied by Sredazgiprovodkhlopok Institute in state farm «Pakhtakor» of Mekhnatabad district of SyrDarya province. Information about results of researches is available in IPTRID register

«Development of intensive technology of hardly reclating land leaching. Index 02.13. Author G. Khasankhanova ». Total area of pilot project is 160 ha.

In geomorphological respect this is the alluvial - proluvial plain, formed by cones of removal. Lithology is inter-laying loam, sands, sandy loam and clays. Ground water level 3-5 m, salinity type is sulphate-chloride.

Soils are meadow -grey, strongly saline with high content of gypsum along the profile (from 20 to 60 %). Mechanical soil composition varies light-loam, sand to loam and heavy loam.

Tests were conducted on small fields, checks and on plot of 160 ha on the background of horizontal closed drainage with depth 3.0 -3.2 m, after implementation of deep (0.8 - 1.2 m) loosening. Leaching was carried out on deep short furrows (50 -100 m) with inter-rows 45 and 90 cm. Water to the furrow was supplied by flexible irrigation pipes (KP -160), that provided regularity of irrigation flow distribution.

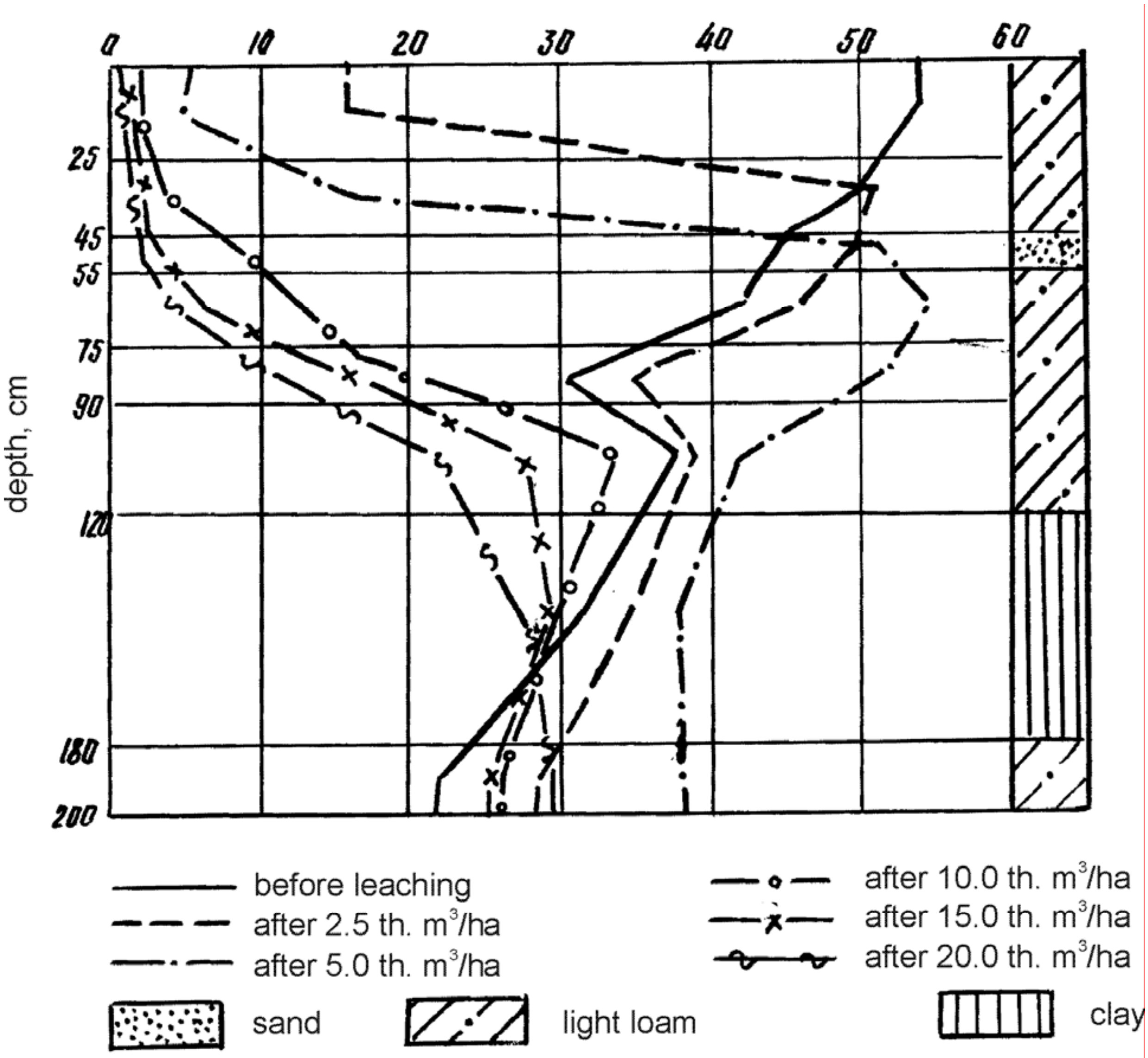
In experiments on plots the following irrigation norms were tested: 2500,5000, 7500,10000, 15000 and 20000 m^3/ha.

Experiments on small plots showed that under leaching by norm 2.5 th.m^3/ha the soil desalinization under furrow bottom and noticeable salt accumulation on ridges is resulted. After 6.0-10 th. m^3/ha application the further salt removal under furrow bottom is registered with desalinization of soil profile up to toxicological threshold on depth to 1.0 m and on plots under ridges. The most optimal salt removal and the smallest their accumulation in ridges is 45 cm spacing between rows. In this case «intensive» sedimentation of soluble salts from upper horizons to lower ones is observed and the desalinization of upper 1-m layer is achieved.(Fig. 2.8).

Under irrigation on maximum filled furrows with spacing between rows 90 cm the similar effect is obtained. Final result of leaching efficiency on background of deep loosening as well as other types of soil desalinization technology is salt removal from 1-m thickness on ion-chlorine.

	Leaching norms, m^3/ha	Salt removal, tn/ha on «CI»
1	2500	10.7
2	5000	41.9
3	7500	48.9
4	10000	58.9
5	15000	62.4
6	20000	54.9

From this is evident that the leaching efficiency on ion-chlorine is revealed under increase of leaching norm up to 10000 m^3/ha and further increase of water supply practically did not affect desalinization process, that was reflected by the indicator of specific water expenses for removal of 1ton salts. Specific water expenses for salt removal changed from 119 m^3/t (5000 m^3/t) to 364 m^3 /t (20000 m^3/ha; table 2.4). Specific expenses for removal of 1 ton salts are close to received under leaching with temporal drainage use (indexes- 02.3; 02.5). Rather low effect of leaching on furrows is proved by yield of cotton sowed after leaching, which was 7 -15 c/ha. Water expenses per yield unit under leaching were 357 -2857 m^3/c, and after leaching carrying out were 133 -1333 m^3/c.



Dr. 2.8. Graph of salt leaching

Presented figures indicate very high specific expenses of irrigation water per yield unit in comparison with the data of other plots with leaching, where maximum 300 -400 m^3 water were spent per 1c of yield. However, high water expenses per yield unit, probably, are connected with the violation of intensive agro-technique of optimal production receipt from irrigated hectare, as the high efficiency of loosening in improvement of all indicators of water-physical properties is well known and proved. In connection with that the deep loosening as a measure on improvement of hardly-reclaimed soils water -physical properties and ability to be leached, is widely used under operational leaching.

2.3.2.6. Water use and soil desalinization improvement on the background of horizontal drainage (index 02.4 - object P. Kazakhstan; author F. Vishpolsky)

In the Republic of Kazakhstan under development and reclamation of saline lands the methods of soil desalinization through leaching are not practiced, except is farms, located in northern-west part of Hungry Steppe -Pakhtaaral, Djetysay and Kirov districts, where the annual winter-spring operational leaching is carried out. In other massifs of Chimkent and Kzylorda provinces the soil desalinization is achieved through rice sowing. Even in cotton districts, such as Bugun, Turtkul and Turkestan, lands of which are presented by saline soils, the irrigations are carried out instead of leaching. Leaching tests implemented in cotton state farms “Timiryazev”, “Iskhanov”, of Bugun district show certain interest as for water use improvement, so for rise of soil and irrigation water productivity.

In geomorphological respect the farm territories, where pilot plots were selected, are located on proluvial -alluvial plain, which has slope 0.002 -0.006. Lithologically the pilot plots are made of loess loam of heavy mechanical composition, which transits to middle and light loam from depth 3 -5 m. Top fine-grained deposit thickness is 10 -17 m. Permeability of heavy loam is 0.3 - 0.6 m/day, of middle one- 0.5 1.2 m/day. Gravel-pebbles sediments underlay top fine-grained deposits and has sandy loam-loamy filling. Before drainage construction ground water level was 1.5 -2.0 m, and after it declined on 2.5 -3.0 m. Soils are strongly saline, type of salinization is chloride-sulphate. Salt content in upper 1-m layer varied from 0.8 to 2.0 %, and in 2-m one is 0.6 -1.8 % .

Experiments were carried out in two plots with total area 135 ha, from which the first turn was 60 ha, the second one-75 ha. Specific extent of close drainage was 40 m/ha. Drain spacing was 100, 200 and 300 m. Depth at the beginning was 2.5, in the end -3.0 m. Plots were bordered from one side by continuously operating canal P-3, from other side - by periodically operating canal P-3-11. The collector K-1 and drain-collector passed along opposite side, their specific length is 20 m/ha. For soil desalinization autumn-winter leaching was used by norm 8.5 th. ha or rice sowing with irrigation norm up to 26.0 th. m^3/ha. Leaching was implemented by tact 4.5 th. m^3/ha, 8.5 th. m^3/ha, 14 th. m^3/ha and 26 th. m^3/ha. After implementation of measures on desalinization the plots were sowed by cotton. Close horizontal drainage construction allowed to:

- create the high drainability during leaching and use of leaching irrigation regime. Drainage outflow was 25 -36 % from water supply, and taking into account the overflow of ground water of top fine-grained deposits to gravel-pebbles sediments and their seepage to drainage structures on bordered territories, increased up to 70 % from water supply;

- provide increasing velocity of ground water level reduction after leaching and vegetation irrigations, which varied within 8 -10 cm/day. Before drainage construction it did not exceed 4 cm/day;

- support ground water level below critical depth (for conditions of Bugun-Chayan watershed deeper than 2.5 m) and to guarantee their fast drawdown after conducting of water recharge and vegetation irrigations;

- use the availability of well hydraulic relations between different aquifers of quaternary deposits for the reinforcement of salt removal from aeration zone and superficial layers of ground water under leaching, recharge and vegetation irrigations;

- establish the depth of aeration zone desalinization and regularity of salt mass dislocation under leaching by use of following sizes of leaching norm: 4.5 th. m^3/ha (50 % from calculated norm on formula of V. Volobuyev); 8.5 th.m^3/ha (calculated norm); 14 th. m^3/ha (on 50 % higher than calculated one); 26 th/ m^3/ha (2.5 times higher than calculated norm). In first cause the soil desalinization to permissible limits (0.3 % on harmful salts) has happened on depth 0.5 m, in second case - 1.0 m, in third case - 1.5 m, in forth case-2.5 m. Salt mass content in reclaimed thickness changed as follow:

a) under leaching by norm 4.5 th. m^3/ha the salt stock (harmful) is reduced on 99 t/ha in 1m layer, and increased on 17 t/ha in layer 1 -2 m, on 26 t/ha in layer 2 -3 m. Chlorine stock is reduced on 26 t/ha in layer 1.0 m, on 1 t/ha in layer 1 -2 m, salt stock increased on 5 .6 t/ha in layer 2 -3 m.;

b) under leaching by norm 8.5 th. m^3/ha salt stock is reduced on 107 t/ha in layer 1.0 m, on 17 t/ha in layer 1 -2 m, on 14 t/ha in layer 2 -3m. Chlorine stock is decreased on 29 t/ha in layer 1.0 m, and increased on 1 t/ha in layer 2 -3 m;

c) under leaching by norm 14 th. m^3/ha the salt stock is reduced on 170 t/ha in layer 1.0 m, on 47 t/ha in layer 1 -2 m, and increased on 15 t/ha in layer 2 -3 m. Chlorine stock is reduced on 50 t/ha in layer 1.0 m, on 19.5 t/ha in layer 1 -2 m, and increased on 3 t/ha in layer 2 -3 m.;

d) under leaching by norm 26 th. m^3/ha the salt stock is reduced on 175 t/ha in layer 1.0 m, on 79 t/ha in layer 1 -2 m, on 21.5 t/ha in layer 2 -3 m, on 5 t/ha in layer 3 -5 m. Chlorine stock is reduced on 51 t/ha in layer 1.0 m, on 21 t/ha in layer 1 -2 m, on 7.4 t/ha in layer 2 -3 m, on 4.5 t/ha in layer 3 -5 m (aquifer). Reduction of salt stock lower than 3 m showed desalinization of ground water, i.e. the main object of reclamation is desalinized. Specific water discharge for removal of 1 ton of salts from 1-m layer was 45 m^3, 76 m^3, 147 m^3 appropriately, and from 3 m-layer 82 m^3; 76 m^3; 84 m^3 (table 2.4). Ground water salinity in the first case increased from 8.5 to 13 g/l; in second - from 9 to 15.5 g/l; in third from 8 to 10.5 g/l; in forth - reduced from 8 to 6.5 g/l.

At the same time study results show, that at the initial stage of leaching process the accelerated rate of soil desalinization is observed, which slows down with time. Within the final stage salt removal practically stopped (Figure 2.9).Figure shows that for conditions of Arys-Turkestan massif with sulphate-chloride type of salinity the optimal leaching norm is 12 -13 th. m^3/ha, under which 1 m -layer of soil is desalinizated up to toxicological threshold as for ion-chlorine, so for salt sum. However, for desalinization of ground water upper layer the fixed norm is not sufficient, although this process principally is very long.

Water balance of pilot plots is formed as a type of accelerated surface inflow at the expense of water supply, respectfully, over versions 10.2 th.m^3/ha and 28.0 th.m^3/ha and ground outflow and drainage flow. Drainage flow in first version (10.2 th.m^3/ha) is 2.8 th.m^3/ha, in second -9.0 th.m^3/ha; and ground outflow is, accordingly, 5 and 14.5 th.m^3/ha under common moisture income 54.6 and 75.15 m^3/ha (Table 2.16). Rainfall and evaporation play insignificant role in balance formation. Salt balance, in accordance with water balance, was formed negatively in type of irreversible soil desalinization.

Table 2.16

Water balance under leaching by norm $\frac{8.5}{26.0}$, th.m^3/ha

Positive balance components	th.m^3/ha	Negative balance componenets	th.m^3/ha
Unsaturated zone			
1. Initial stocks	$\frac{8.5}{8.4}$	1. Final stocks	$\frac{9.8}{9.9}$
2. Water supply	$\frac{10.2}{28.0}$	2. Evaporation	$\frac{0.6}{0.75}$
3. Precipitation	$\frac{0.2}{0.25}$	3. Filtration	$\frac{8.5}{26.0}$
TOTAL	$\frac{18.9}{36.65}$	TOTAL	$\frac{18.9}{36.65}$
Groundwater			
1. Initial stocks	$\frac{35.7}{38.5}$	1. Final stocks	$\frac{37.5}{39.5}$
2. Filtration	$\frac{8.5}{26.0}$	2. Evaporation	$\frac{2.8}{9.0}$
		3. Underground flow	$\frac{5.0}{14.5}$
TOTAL	$\frac{44.2}{64.5}$	TOTAL	$\frac{45.3}{63.0}$
Common			
1. Initial stocks	$\frac{44.2}{46.9}$	1. Final stocks	$\frac{47.3}{49.4}$
2. Water supply	$\frac{10.2}{28.0}$	2. Evaporation	$\frac{0.6}{0.75}$
3. Precipitation	$\frac{0.2}{0.25}$	3. Drainage outflow	$\frac{2.8}{9.0}$
TOTAL	$\frac{54.6}{75.15}$	4. Underground flow	$\frac{5.0}{14.5}$
		TOTAL	$\frac{55.7}{73.65}$

NOTE: Calculation have been made for top fine-grained deposits.

Under leaching by norm 8.5 th.m^3/ha the salt balance was formed as follow: salt stock in aeration zone reduced on 110 t/ha, in aquifer it increased on 36 t/ha, and totally reduced on 74 t/ha (Table 2.17).

Table 2.17

Salt balance under leaching by norm $\frac{8.5}{26.0}$, t/ha

Positive balance elements	t/ha	Negative balance elements	t/ha
Unsaturated zone			
1. Initial salt stock	$\frac{283}{358}$	1. Final salt stock	$\frac{173}{82}$
2. Salt influx with irrigation water and precipitation	$\frac{4.0}{10.0}$	2. Salt removal with irrigation water and precipitation	$\frac{114}{335}$
TOTAL	$\frac{287.0}{368}$	TOTAL	$\frac{287}{417}$
Groundwater			
1. Initial salt stock	$\frac{320}{356}$	1. Final salt stock	$\frac{356}{425}$
2. Salt influx with irrigation water and precipitation	$\frac{114}{335}$	2. Salt removal with drainage outflow	$\frac{18}{105}$
		3. Salt removal with underground flow	$\frac{65}{150}$
TOTAL	$\frac{434}{691}$	TOTAL	$\frac{439}{680}$
Common			
1. Initial salt stock	$\frac{603}{714}$	1. Final salt stock	$\frac{529}{507}$
2. Salt influx with irrigation water and precipitation	$\frac{4.0}{10.0}$	2. Salt removal with drainage outflow	$\frac{18}{105}$
		3. Salt removal with underground flow	$\frac{65}{150}$
TOTAL	$\frac{607}{724}$	TOTAL	$\frac{612}{762}$

Under leaching by norm 26 th.m^3/ha the salt stock in aeration zone reduced on 276 t/ha, in aquifer - increased on 69 t/ha, and as a whole decreased on 207 t/ha. In the first case the water balance of aeration zone is formed as follow: positive components - water supply 10.2 th.m^3/ha, rainfall 200 m^3/ha; negative components- evaporation 600 m^3/ha, saturation (to full field capacity - FFC) 1.3 th.m^3/ha, filtration 8.5 th.m^3/ha. In the second case: positive components - water supply 28 th.m^3/ha, rainfall 250 m^3/ha; negative components - evaporation 750 m^3/ha, saturation 1.5 th.m^3/ha, filtration 26 th.m^3/ha. Under leaching by norms 8.5 and 26 th.m^3/ha the salt removal from aeration zone and aquifer in quaternary deposits by drainage outflow was 18 and 105 t/ha, and by ground outflow, which came out to drainage structures of bordering territories - 65 and 150 t/ha (Table 2.17). In multi-layer conditions the indicators of meliorative efficiency of horizontal drainage within farm (5 -6 th. ha) increased by 2 and more times compared to pilot plots.

R E S U M E

Analysis of presented information on 7 pilot plots of capital leaching shows that:

1. This type of leaching, used under development of strongly saline soils and salts as well as under bringing in agricultural turnover the internal fallow lands, is a high-effective method of land desalinization. Intensity of soils and ground water desalinization depends on drainage workability, norm and technology of capital leaching implementation. In all pilot plots the capital leaching with rice sowing and without it was carried out on the background of well operating drainage system, that allowed to receive high desalinizing effect:

- during one season (60 -150 days) not only root soil layer was desalinized to toxicological threshold, but aeration zone and ground water upper layer as well. Intensity of salt removal depending on salinity degree, leaching norm and territory drainability, changed within 150 -160 to 250 tn/ha in plots of vertical drainage system (VDS), 74 -207 on background of horizontal drainage and 110-399 tn/ha in plots of close horizontal drainage (CHD) in combination with temporal drainage (Table 2.P);
- in all plots ground water desalination is observed. Strong desalination of ground water was achieved in plot of VDS - from 9 and 20 g/l to 3.5 -4.0 g/l. In plots of CHD and OHD (open horizontal drainage) the mineralization of ground water reduced from 28 - 49.8 g/l to 15 -16 g/l and below;
- water -salt balance in all plots of capital leaching formed on type of irreversible soil desalinization for big depth - to 3 -4.5 m on the background of horizontal drainage and for all thickness of top fine-grained deposit under operation of VDS. Under that soil and ground water desalinization, mainly, at the expense of salt removal. Salt removal volume on plots of horizontal drainage system changed within 104 - 383 t/ha (index 02.3 and 02.34) to 105 -238 tn/ha (index 02.4 and 02.5), from which part of temporal drainage had 60 (index 02.3) - 80 % (02.34 and 02.5) (table 2.P);
- on all plots in the process of capital leaching certain regularity of drainage flow salinity changes is registered, as for permanent, so for temporal drains; at first the rise on 5 - 10 g/l and to the end of leaching - salinity decrease on 10 -30 g/l (Table 2.P.);
- negative impact on meliorative situation of adjacent lands, that is confirmed by observation data over all 8 pilot plots.

2. On lands with poor water -physical properties if soils (high salinity degree - 2 -3.5 % on dry residue, low permeability $K_f \leq 0.1$ -0.3 m/day and salt availability $\alpha \leq 0.9$ -1.2) it is expedient to carry out leaching using temporal drains, chemical meliorants like a manure and lignin and other soil structure developers, and on gypsum bearing soils is expedient to carry out additionally deep loosening 0.8 -1.2 m. Temporal drains in accordance with their parameters gave possibility to decrease the load on permanent drainage to 60 -80 % on water

Table 2.P

Land capital leaching efficiency on background of different types of drainage

Objects parameters and indicators of capital leaching efficiency	Pilot plot index							
	02.39	02.3	02.34	02.13	02.4	02.5	02.8	chemical meliorant
Total area of leaching, ha	310.5 297.5 (rice)	104	78	160(16)	135 га	101	20	4.5
Drainage type	VD	CHD+ PD	CHD+PD	CHD	CHD	HD+PD	VD	HD
Character of salt distribution in soil profile	superficial up to 2 m	regularly to big depth	regularly to big depth	superficial up to 2 m	regularly to big depth	reg. to depth of 13-17 m	superficial up to 2.5 m	superficial up to 2 m
Salinity degree	strong	strong	strong	strong	strong	very strong	strong	middle and strong
on sum of salts	2-30 %	2-3.8	2.2-3.9	1.6- 0.7	up to 2.5	0.6- 1.1	up to 5.5	up to 1.2- 1.8
CL	0.25-0.3	0.20-0.35	0.14-0.4	0.53-0.6	0.14-0.18	0.23-0.35	0.7-1.0	0.14-0.18
Permeability, m/day	0.05-0.07	0.15-0.25	0.03-0.06	0.1-0.3	0.3-0.6	0.1-0.3	0.025-0.3	0.3
Salt availability coefficient	0.9-1.2	1.2-1.4	1.0-1.3	-	-	1.3-1.4	1.4	1.2-1.4
Leaching norm: N (gross), th.m^3/ha	41-45	29-38	22.0 (18 control)	5.0-2.0	4.5-26	39.5-42	19-115	4.5-9.5
N (net), th.m^3/ha	18-25	25-33	19.6 (16 control)	-	-	20-35	11-78	4.5-9.5
Desalinizating discharge “g”, th.m^3/ha	7.8-12.8	15.7-22.7	19.6 (14 control)	5-20	4.0-20	10-26	5-63	4-8.5

Objects parameters and indicators of capital leaching efficiency	Pilot plot index							
	02.39	02.3	02.34	02.13	02.4	02.5	02.8	chemical meliorant
Drainage outflow (DO), th.m^3/ha	11-13.8	9.7-15.0	15.2 (11.6 control)	3-10	2.8-9.0	18.5-20.1	5-10	3
including provisional, th.m^3/ha	-	6.4-9.5	11.8 (8.5 control)	-	-	13.3-15.4	-	-
Groundwater salinity, g/l								
at the beginning	9.0	2.8-49.3	40-60	5-8	8-9	19-26	6.5-20.8	-
at the end	3.5	15.4-40.2	-	-	6.5	8-16	2.8-4.3	-
Drainage water salinity, g/l								
at the beginning	1.5-2.0	22-42	-	-	15-16	21-23	6.1-12	-
at the end	1.5-2.0	5-17	-	-	4.5-5	12-17	2-4	-
Provisional drains outflow salinity								
at the beginning	-	28-55	-	-	-	24	-	-
at the end	-	4-24	-	-	-	8.0	-	-
Salt removal, t/ha								
0-1 m	70-150	82-193.4	226 (218 control)	15-62.4	110-276	105-106	-	62.4-92.6 (64 control)
0-3 m	100-160	110-317.4	399 (293 control)	-	74-207	-	78-249.2	-

Objects parameters and indicators of capital leaching efficiency	Pilot plot index							
	02.39	02.3	02.34	02.13	02.4	02.5	02.8	chemical meliorant
Salt removal with drainage outflow, t	-	104-298.3	383 (232 control)	-	105	161.3-238.3	-	-
including provisional drains, t	-	65-164.2	166 (84 control)	-	-	109.2-157.4	-	-
Specific water expenses for 1 ton salt removal, m^3/t	105-256	79-159	86 (137 control)	119-364	77-115	194-335	110-387	76-114 148 (control)
Rice yield, c/ha	53	40-53	-	-	-	-	22-40	-
Cotton yield, c/ha	28		-	7-15	20-25		15-18	-
Specific water expenses, m^3/c								
on rice	283	475-624	-	-			500-275	-
on cotton	535			1330-1333	425-340		650-4330	-
Economic effectiveness, rouble/ha (1983-1984)	450-600	-	202	200-600	250-300	-	300	-
Depth of desalinization, m	25-30	3.5-4.0	4.0-4.5	-	3.5-4.0	10	10-15	-
including up to threshold of Toxicity	2.0	1.5-2.0	1.5	-	2.0	1.5-2.0	5.0	1.5
Zone of active water and salt Exchange	50-60	16	-	-	7-8	10	50-60	

Note: VD - vertical drainage; CHD - close horizontal drainage; PD - provisional drainage; HD - horizontal drainage.

diversion as well as on salt removal. In this connection, objects of vertical drainage system present exception because they have drainage capacity reserve due to interaction of wells. On the other hand, VDS has possibility to manage ground water table within wide diapason from 1.5 to 4.5 -5.0 m from land surface, creating big free volume for receipt of infiltration water. Results of capital leaching through rice crop or without it , received on pilot plots of VDS 02.39 and 02.8, where irrigated lands are presented by strongly saline soils and salts with low permeability K < 0.1 -0.3 m/day and salt availability < 0.9 -1.2 (Table 2.P.) proved this thesis. On very hardly-reclaimed lands good results of soil desalinization are achieved under 2-stage leaching.

3. Under well operating drainage (VDS and HD) capital leaching needs to be carried out with rice use, which simultaneously with soil desalinization allows to receive production from irrigated lands. In conditions of satisfactory operation of drainage the leaching through rice as well as leaching with weighty norm, exceeding 25 -30 th. m^3/ha, is sufficiently effective.

4. On all pilot plots, with exception of experiments with chemical meliorants use and 2-stage leaching, the water supply norms were not strictly based and were by 1.5 -2.0 times higher. Analysis of capital leaching on pilot plots shows, that for soil desalinization up to toxicological threshold even for 1.5 -2.0 m layer the norm 12 -15 th. m^3/ha and, taking into account running flow of rice irrigations, - 20 -22 th. m^3/ha against 35 -45 th. m^3/ used under leaching, was sufficient (Fig.2.2 and 2.6.1). These results need to be accounted under capital leaching organization on internal fallow lands providing their optimal drainability.

5. Capital leaching with weighty norms under well drainage operation involves in water -salt exchange the big thickness of soils. On vertical drainage plots all thickness of top fine-grained deposit (from 15 to 30 m) participates in water -salt exchange. Therefore, because of insufficient intensity of water-salt overflow from top fine-grained deposit in comparison with volume of ground water abstraction, the rapid increase of abstracted water salinity is not observed. On plots of horizontal drainage (according to materials of capital leaching experiments) from 10 (index 02.4) to 16 -20 m (indexes 02.3 and 02.5) of thickness participates in water-salt exchange. That is a reason for slow decrease of drainage outflow salinity under strong and regular salt content to big depth.

6. Capital leaching realization needs big expenses of water, labor, as well as inputs. In connection with this in modern conditions under scarce water and input resources the capital leaching as wide-scale effective method of soil desalinization can not be recommended.

Specific water expenses for removal of 1ton of salts from aeration zone changed depending on salt availability coefficient, content of easily soluble salts from 79 -159 (index 02.3) to 194 -335 m^3/tn (index 02.5) on plots of CHD in combination with temporal drains and from 105 to 387 m^3/tn on pilot plots with VDS. The lowest specific water expenses for removal of 1ton of salts are formed on plots of 2 -stage leaching technology (86 m^3/t, against 137 m^3/t in control) and chemical meliorants use - 76 -114 m^3/tn against 148 m^3/tn on control plot. Efficiency of horizontal drainage system within farms (5 -6 th.ha) increased by 2 and more times.

Main result of study is establishing aeration zone rational depth of desalinization by means of leaching, water use improvement at the expense of water use norm reduction within the period of development of leached lands and use of unregulated flow of surface water during non-growing period for leaching, acceleration of soil desalinization rate and receiving of cotton yield within 20 -25 c/ha, grain 35 -45 c/ha, maize 55 -70 c/ha. On the background of calculated irrigation regime the minimum values of yield are received under leaching by norm 8.5 th. m^3/ha, maximum - under leaching by norm 26 th. m^3/ha.

Results of tests on Bugun plot also show a high desalinizing effect of capital leaching in conditions of heavy loamy soils under good operation of close drainage.

2.3.3. Operational leaching of saline soils

Operational or so called preventive leaching, conducted annually in autumn-winter and early spring periods, is mostly for desalinization of slightly and medium saline soils which are in agricultural rotation. Operational leaching is also supposed in order to prevent soil salinization. Sustainable desalinization of root-zone layer and aeration zone is obtained under this method for some years on the background of intensively operating permanent drainage. Operational leaching norms are established depending on degree, type of salinity and water-physical quality of soils. On slightly and medium saline soils with middle and high permeability leaching norms 2.5-3.5 th cu. m/ha and on strongly saline to 5.0-6.5 th cu. m/ha are sufficient.

On heavy soils leaching norms are 15-20 % more than on light and middle soils. In vegetation period leaching irrigation regimes are appointed. Obligatory condition of meliorative period leaching regime is keeping of condition $W \leq (1.15\text{-}1.2) : (И+T)$, where W – total water supply to irrigated fields; И+T – total evaporation.

Specific features of operational leaching are gradual desalinization of aeration zone soils and groundwater top layer for 3-5 years without drainage application. Operational leaching norms should be related to meteorological conditions and water resources of year considered, on which water supply limits are established in oblasts and rayons (table 3.1). In dry years because of water resources lack leaching norms are to some reduced extent. So in order to increase desalinizating effect (especially in dry years) of leaching, prevention of soils salinity restoration by the beginning of sowing it is necessary to keep strictly technology of desalinizating measures conduction and agrotechnical methods, conducted after leaching completion (leveling of checks, sub-soiling and harrowing, etc.). Deep ploughing and loosening with application of organic fertilizers (manure, lignin) abruptly increase desalinizating effect of leaching.

Table 3.1

Operational leaching approximate norm on irrigated lands of Uzbekistan subjected to salinization (on background of drainage)

Unsaturated zone soil mechanical composition and texture	Initial chlorine content within layer 0-100 cm, %	Common leaching norm, th. m^3/ha	Leaching repetition
Golodnaya steppe			
Middle and light loam,	0.01 - 0.04	3.0 - 3.5	1
homogeneous	0.04 - 0.10	3.5 - 5.0	2
Flaky, heterogeneous	0.01 - 0.04	4.0 - 5.0	2
	0.04 - 0.10	5.0 - 6.5	3
Fergana valley			
Light, flaky	0.01 - 0.04	2.0 - 2.5	1
	0.04 - 0.10	2.5 - 4.0	2
Middle loam, flaky,	0.01 - 0.04	3.0 - 3.5	1
heterogeneous	0.04 - 0.10	3.5 - 5.0	2
Clayey, heavy loam, homogeneous, flaky	0.04 - 0.10	5.0 - 6.5	3
Bukhara province			
Light	0.01 - 0.04	2.0 - 2.5	1
	0.04 - 0.10	2.5 - 4.0	2
Middle loam, flaky,	0.01 - 0.04	3.0 - 3.5	1
heterogeneous	0.04 - 0.10	3.5 - 5.0	2
Clayey, heavy loam, homogeneous,	0.01 - 0.04	4.0 - 5.0	2
flaky	0.04 - 0.10	5.0 - 6.5	3
Karakalpakstan and Khorezm province			
Light, flaky	0.01 - 0.04	3.0 - 3.5	2
	0.04 - 0.10	3.5 - 5.0	3
Middle loam, flaky,	0.01 - 0.04	4.0 - 5.0	3
heterogeneous	0.04 - 0.10	6.0 - 7.5	5
Karshi and Sherabad steppes			
Light, flaky	0.01 - 0.04	3.0 - 3.5	2
	0.04 - 0.10	3.5 - 5.0	2 - 3
Middle loam, flaky,	0.01 - 0.04	4.0 - 5.0	3
heterogeneous	0.04 - 0.10	5.0 - 6.5	4
Clayey and heavy loam	0.01 - 0.04	5.0 - 6.0	3

Unsaturated zone soil mechanical composition and texture	Initial chlorine content within layer 0-100 cm, %	Common leaching norm, th. m^3/ha	Leaching repetition
	0.04 - 0.10	6.0 - 7.5	

Operational leaching as well as the capital one gives maximum effect on background of vertical drainage, which creates big free volume within soil through strong abstraction before leaching (Table 3.2).

Table 3.2

Operational leaching comparative effect on background of different types of drainage under equal area drainability (medium and strong salinity)

Leaching conditions	Type of drainage		
	horizontal	vertical	combined
Light soils, $K_{ф} > 0.5$ m/day Water expenses for 1 ton salt removal, m^3/ha	70-75	up to 60	up to 60
Unsaturated zone desalinization duration, year	3-5	1	2-3
Middle soils, $K_{ф} = 0.1$-0.5 m/day Water expenses for 1 ton salt removal, m^3/ha	160-150	70-100	85-125
Unsaturated zone desalinization duration, year	5-8	2-3	3-5
Heavy soils, $K_{ф} < 0.1$ m/day Water expenses for 1 ton salt removal, m^3/ha	200-250	150-200	175-250
Unsaturated zone desalinization duration, year	5-7	2-3	3-5

In the same time quick release of leaching water can be obtained by means of groundwater withdrawal intensification and regulate groundwater table in optimal ranges, preventing soil salinity restoration.

2.3.3.1. Terms and conditions of operational leaching and water recharge irrigation conduction

Water recharge irrigation, conducted in spring usually on non-saline and slightly saline soils with increased norm of water supply to 2.0 th cu. m/ha, can be considered as type of operational leaching. It is conducted in the regions with low precipitation – less than 200 mm per year.

Water recharge irrigation is the most effective on automorphous soils with deep groundwater (more than 3 m). Here it allows obtaining sprouting without irrigation before sprouting, to reduce vegetation irrigation number and decrease irrigation norm value.

On hydromorphous soils with different degree of salinity additional waterings, conducted in early spring period, are called winter irrigation. In some regions (on light and low thick soils) additional irrigation is conducted before sowing called irrigation before sowing. Its technique is the same as vegetation irrigation. Water recharge irrigation norm fluctuates from 1.0-1.8 th cu. m/ha on low thick soils, underlain with sands and pebbles (depth 0.5-1.0 m), to 2.0 th cu. m/ha – on thick automorphous soils. Under low gradients water recharge watering can be carried out like leaching, applying lower borders (25-30 cm). Under low fields gradients mellowing can be applied on shallow flooded furrows. On fields with middle and high gradients water recharge watering should be conducted over furrows, however their length should be by 1.5-2 times less than usually under vegetation watering, furrow should be obtuse and irrigation should be conducted without release.

In the Republic of Uzbekistan annually on area of 1.5 mln ha of lands operational leaching and water recharge irrigation are conducted. On area of 1.1-1.2 mln ha, represented by slightly saline soils, leaching is combined with water recharge irrigation. For autumn-winter leaching and water recharge watering from 11.5 to 13.0 cu km of water are discharged in Uzbekistan and in total on Central Asia more 20 cu km. Autumn-winter desalinizating measures efficiency mostly depends on proper organization of leaching, in the first turn, lands preparation and their fulfillment terms.

When autumn-winter operational leaching and water recharge irrigation terms are planned, main indicator is drainability, which is characterized by infiltration water depletion; groundwater table, defining free volume and water volume, being contained in aeration zone in one irrigation; types and degree of soil salinity, as well as water resources and weather conditions for non-growing period. Under high land drainability quick depletion of infiltration water (>5 cm/day) and in soils with high water conductivity (light loam and sandy loam) leaching time can be fixed freely. In these conditions leaching terms are established depending on degree and type of soil salinity which defines water supply norms: the stronger soils are saline, the bigger water supply volume and leaching duration. For hardly reclaimed lands, characterized by low water and salt availability, leaching duration is longer.

Results of multi-year tests of water-related organizations and field researches show that operational leaching optimal term is time when groundwater table is the deepest. In this time on reclaimed lands conditions are created for infiltration water necessary volume supply through leaching thickness. For majority of irrigated regions optimal terms are winter and autumn.

Numerous tests, carried out in different soil-climatic and engineering-geological zones, show that in conditions of insufficient drainability of area the best leaching terms are as follow:

Hungry steppe – the end of November-December-January;

Fergana valley – December-January;
Karakalpakstan – December (2/3 of leaching norms);
Khorezm oblast – February-April (1/3 of leaching norms);
Bukhara, SyrDarya and
Kashkadarya oblasts – the end of January-February-March.

Exact terms of leaching irrigation should be established by specialists (agronomist, engineer-hydrotechnician) with respect to weather and climatic conditions and spring field works start. Usually in warm periods of year under positive temperatures easy soluble salts are fastly removed from soil layer by leaching water. However, evaporation is much higher than in winter. In principle, leaching terms should be planned in order to provide optimal water storage and soil solution concentration in root-zone layer by the beginning of sowing to obtain normal sprouting of agricultural crops and at the same time by means of groundwater depletion to prevent soil salinity restoration. Therefore in humid years leaching should be started by the end of November and December and in dry years –later.

Up to present days in many farms opinion is kept of necessity to conduct leaching irrigation only in autumn-winter period – November-December, when groundwater table is the deepest. This opinion is formed from experience when leaching was carried out without drains or their capacity was insufficient for fast groundwater table regulation and lowering. In these conditions easy soluble salts are forced out into lower soil layers and groundwater and in growing period lands are salinized again. On the other hand, leaching organization and conduction in autumn-winter period was caused by non-regulated water resources. At present water reservoirs allow to conduct leaching in any season. Simultaneously, in main regions of Central Asian irrigation zone collector-drainage system was constructed and operated providing water-salt processes management under their usual operation.

It worth to note that on-farm drainage network because of insufficient repair-reconstruction works is rather unsatisfactory that could be resulted in abrupt decrease of leaching effect. If farms do not pay special attention to collector-drainage network repair and cleaning, so leaching irrigation effect will be not evident.

On massifs where vertical drainage is constructed, during autumn-winter desalinizing measures period system must be operated without stop, creating free volume for infiltration water acceptance. Open and closed collector-drainage network must be operated without stop too, disposing groundwater outside of irrigated massifs, which should be cleaned from sediments and overgrowing.

While terms of leaching and water recharge irrigation are planned, agro-climatic factor also should be taken into consideration. Specific features of dry years are not only limited water resources, but temperatures which sharply differ from average multi-year ones, as well as rainfall distribution over seasons. Usually in these years quantity of autumn-winter days with positive temperatures is more and precipitation in spring months – rather less than average multi-years value. So, according to weather stations, located in Hungry steppe, in winter-spring period of 1986 air temperature veried from +3.9 ^{0}C to +15.4 ^{0}C. For 5 winter-spring (January-May) months precipitation did not exceed 98 mm and evaporation from soil layer was 318 mm. If under those relation between rainfalls and total evaporation which is formed this year, leaching is conducted in the first ten days of January by norm 3.0 th cu. m/ha, so by March 15-20, soil moisture in root-zone will reach 0.7 of FFC and by beginning of sowing (April 5-10) will be 0.55-0.6 of FFC. Similar situation creates conditions for formation of unfavorable salt regime of soils – inevitable restoration of their salinity, that is proved by field researches data (dr. 3.1).

In dry years agrotechnical measures, planned by farms, should be directed not only on soil layer desalinization, but on prevention of lands salinity restoration, provision of optimal moisture and permissible concentration of soil solution in soil for obtaining of normal sprouting and plants development. Therefore, in dry years the best terms of desalinizating measures are last winter months and early spring period which should be connected with agricultural crops sowing, soil moisture discharge duration to their optimal value (0.75-0.8 of FFC) and to permissible soil concentration of solution.

So leaching terms should be chosen in the following way: time period from the beginning of its conduction to the beginning of sowing should correspond to time which is necessary for water supply to the field, its suction into soil, water necessary volume disposal by drainage and soil top layer drying to degree under which soil, moisture and soil solution concentration would be within required limits. It is known that period from the beginning of leaching to soil readiness to be sown depends on leaching norm, ground water depth, drainage capacity, soil texture and weather conditions.

Soil moisture expense duration to soil readiness to be sown, that is to optimal moisture before sowing 0.75-0.8 of FFC with respect to precipitation, groundwater inflow can be established using dr.3.2; 3.3; 3.4, 3.5 and table 3.3 (agricultural crops sowing term).

Tests of SANIIRI, NPO Soyuzkhlopok, advanced farms, conducted in different rayons of the republic, show that under normal operation of collector-drainage network annual operational leaching can be carried out as in autumn-winter, so in early spring periods. But postponing of leaching will provide necessary moisture storage before sowing. Taking into account this fact and water resources shortage in dry years on medium and slightly saline lands, area of which is more than 2.02 millions hectares, leaching irrigation should be combined with water recharge irrigation and they should be conducted in period before sowing. In the same time organization and conducting of water recharge irrigation should be related with on-farm irrigation network capacity. It is necessary for successful irrigation completion and fields preparation for sowing.

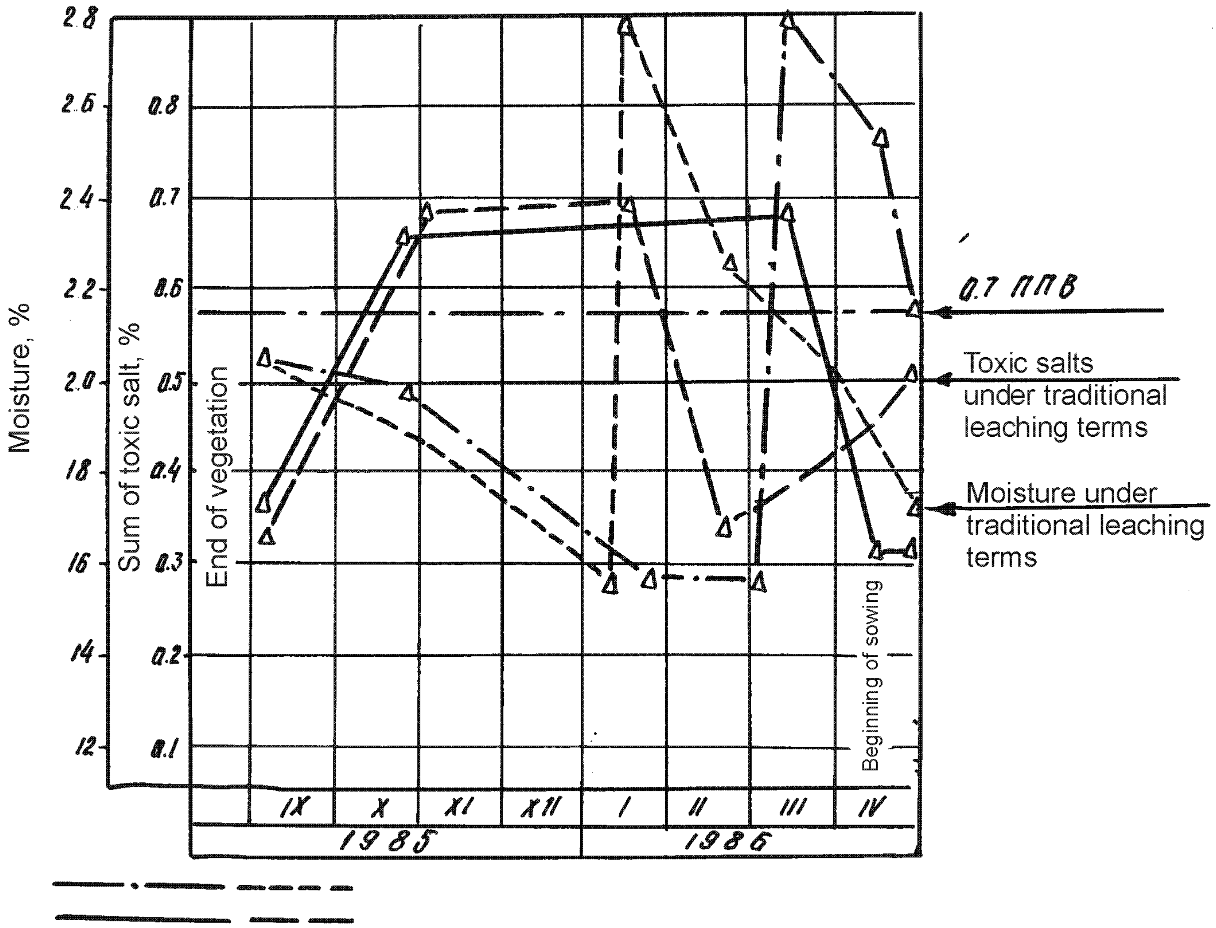
Table 3.3

Recommended terms of sowing

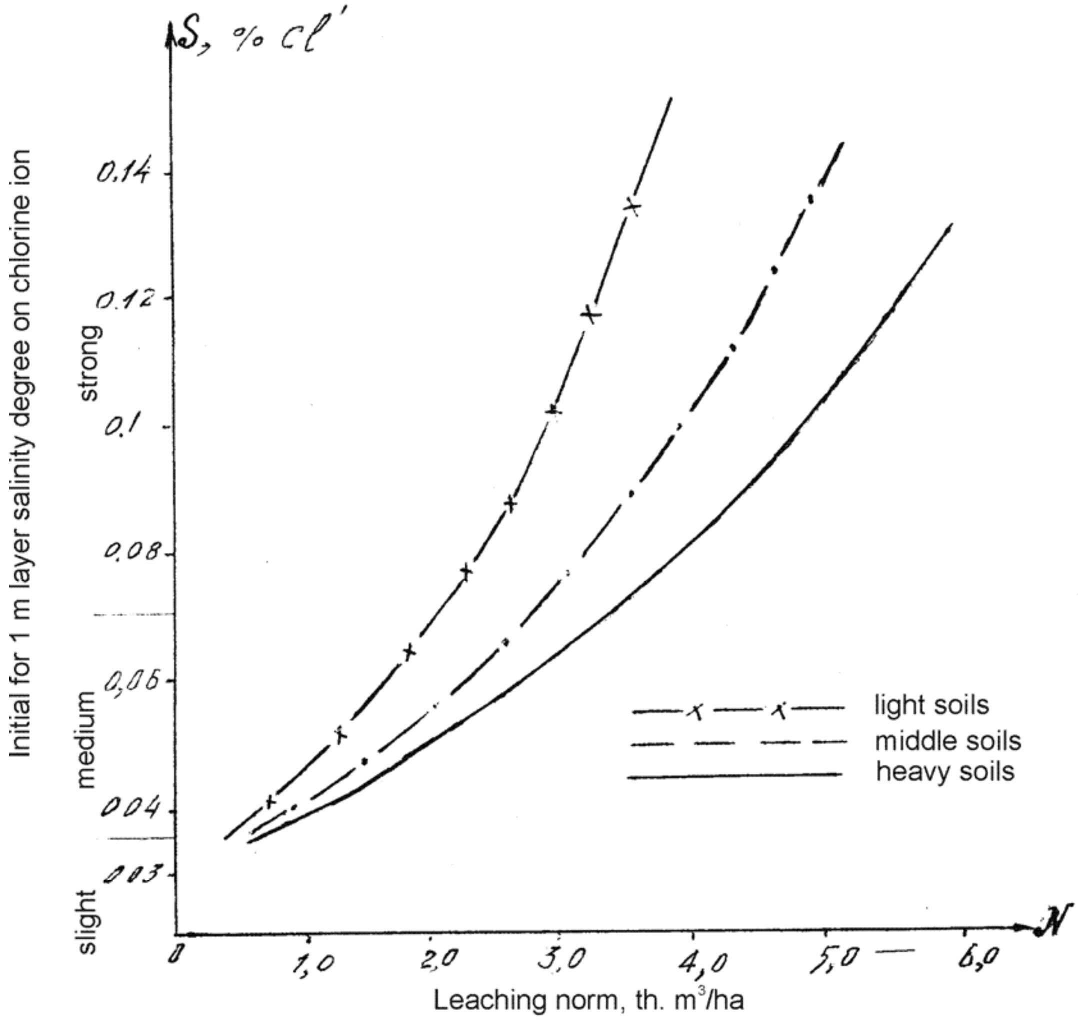
Province	Cotton	Grain (winter) after cotton[x]	Maize (for grain)[xx]
Tashkent	5-15 April	10-18 October	10-20 April
Syrdarya	1-15 April	10-18 October	10-20 April
Djizak	1-15 April	10-18 October	10-20 April
Fergana	5-15 April	15-25 October	10-20 April
Namangan	1-15 April	15-25 October	5-15 April
Andijan	1-15 April	15-25 October	5-15 April
Samarkand	5-20 April	20-30 October	10-25 April
Navoi	1-15 April	20-30 October	5-15 April
Bukhara	1-15 April	20-30 October	5-15 April
Kashkadarya	25 марта - 10 April	5-10 November	1-15 April
Surkhandarya	25 марта - 10 April	5-10 November	1-15 April
Khorezm	10-25 April	5-10 November	15-30 April
Karakalpakstan	10-30 April	5-10 November	15-30 April

[x] Optimal terms of sowing after another crops 10-25 September

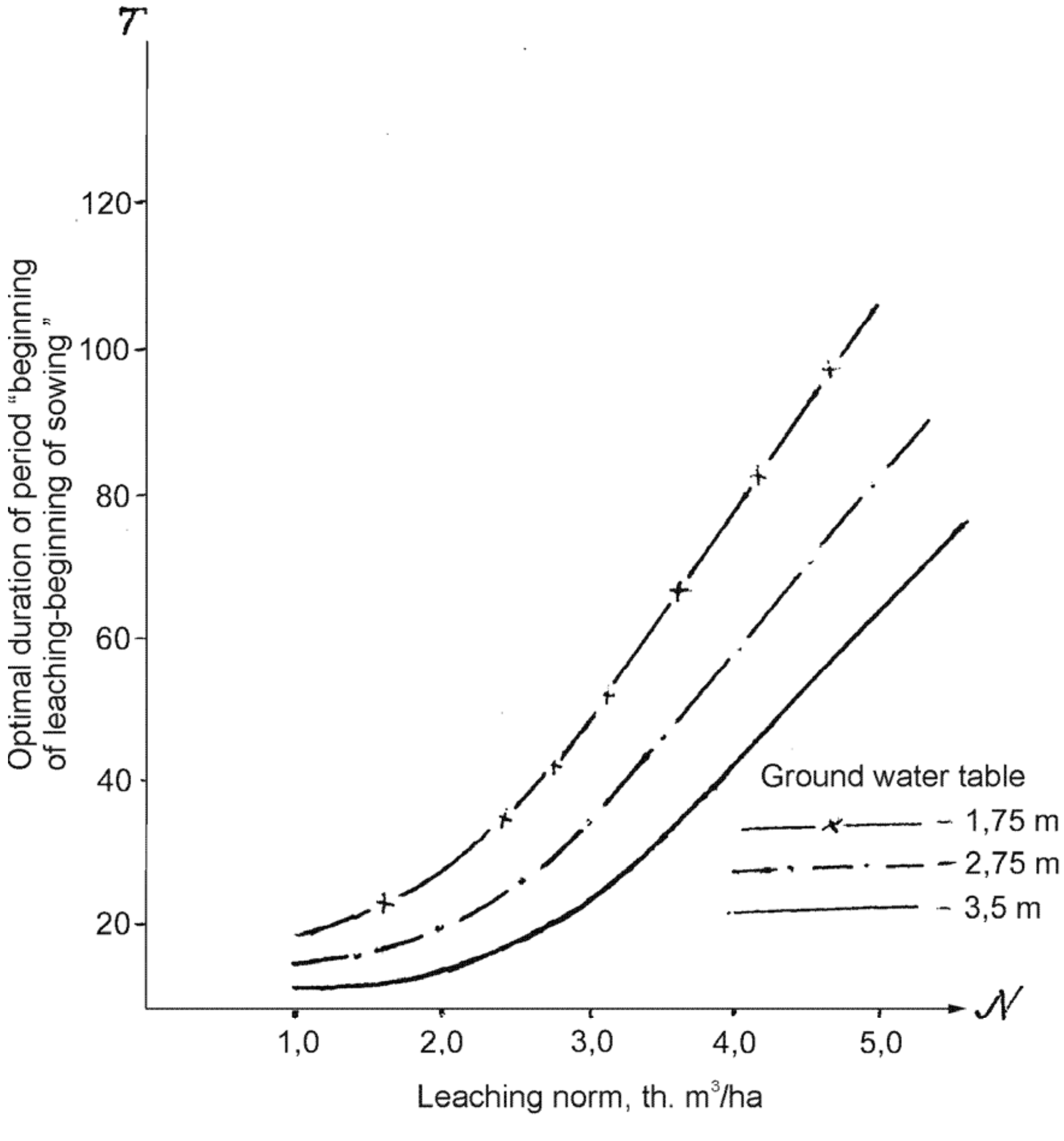
[xx] Under traditional practice maize sowing is completed 5-7 days before cotton sowing start



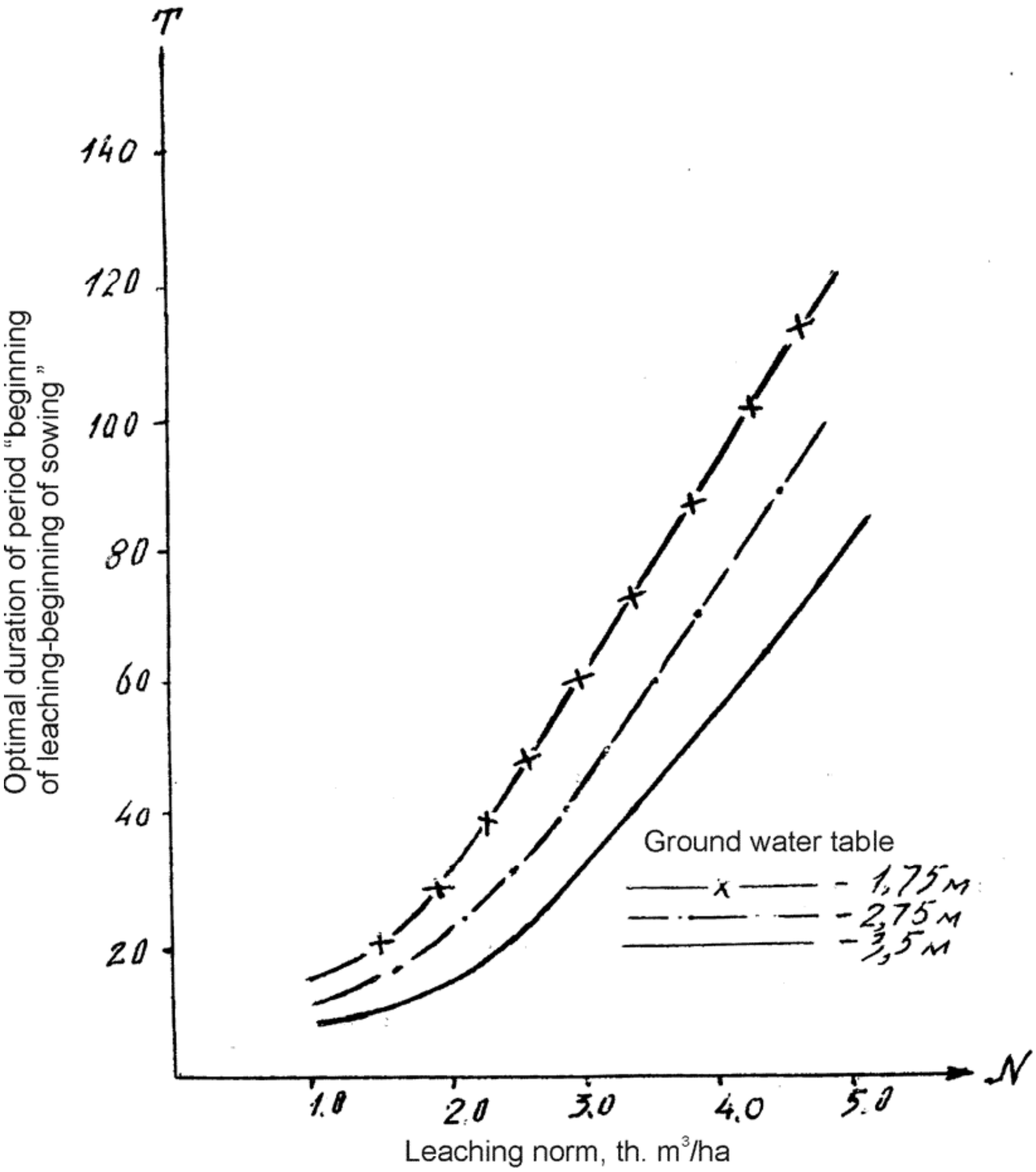
Dr. 3.1. Leaching terms influence on soil moisture and salinity (leaching norm is 4.5 th. m^3/ha).



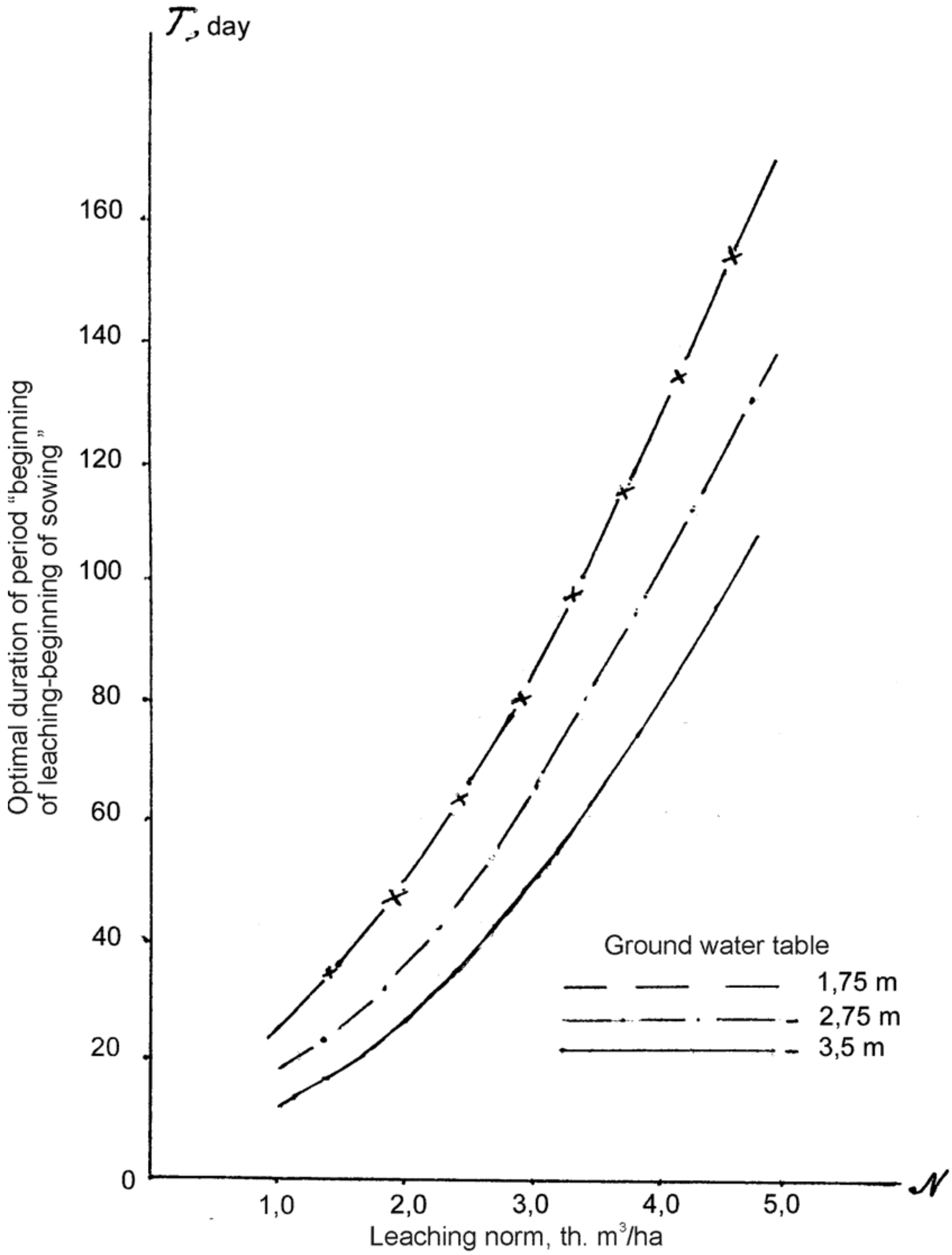
Dr. 3.2. Optimal norm of operational leaching depending on soil 1 m layer salinity degree for different types of soil mechanical composition.



Dr. 3.3. Optimal duration of period "beginning of leaching - beginning of sowing" versus leaching norms for soil of light mechanical composition under different ground water table.



Dr. 3.4. Optimal duration of period "beginning of leaching - beginning of sowing" versus leaching norms for soil of middle mechanical composition under different ground water table.



Dr. 3.5. Optimal duration of period "beginning of leaching - beginning of sowing" versus leaching norms for soil of havy mechanical composition under different ground water table.

There are general regulations on lands' preparation and leaching order. Under lands preparation for leaching cleaning of irrigation network and drains from siltation and vegetation should be fulfilled in the first turn. After cotton harvesting tillage on depth 30-35 cm, harrowing and current leveling by long-based grader are carried out in two directions with difference of marks ±5 cm. Field division in checks is carried out by irrigator and meliorator of farm. Axis of borders and ditches are marked with poles with height 0.8-1.0 m Checks dimension depends on slope and field leveling quality:

Surface slope	**Width, m**	**Length, m**	**Area of one check, ha**
0.002	50	50	0.25
0.002-0.004	50	33	0.165
0.004-0.006	50	25	0.125
0.006-0.01	50	17	0.085

Borders cutting with height of 40-50 cm is carried out by means of border-makers КЗУ-0.3; ВД-61. Firstly lateral borders are made, then – longitudinal. Under such consequence of cutting hand works on borders joints' blocking up are excluded.

In conditions of production it is difficult to keep pointed dimensions. However it is necessary to obtain checks maximum size which does not exceed 0.5 ha. When leaching over checks' size of which exceed 0.4-0.5 ha is conducted, uniform water horizon on all area is not kept and, as a result, uniform soil desalinization does not proceed. Besides that, because of micro-lowering after leaching soil gets ready unevenly within checks that prolongs terms of spring works before sowing.

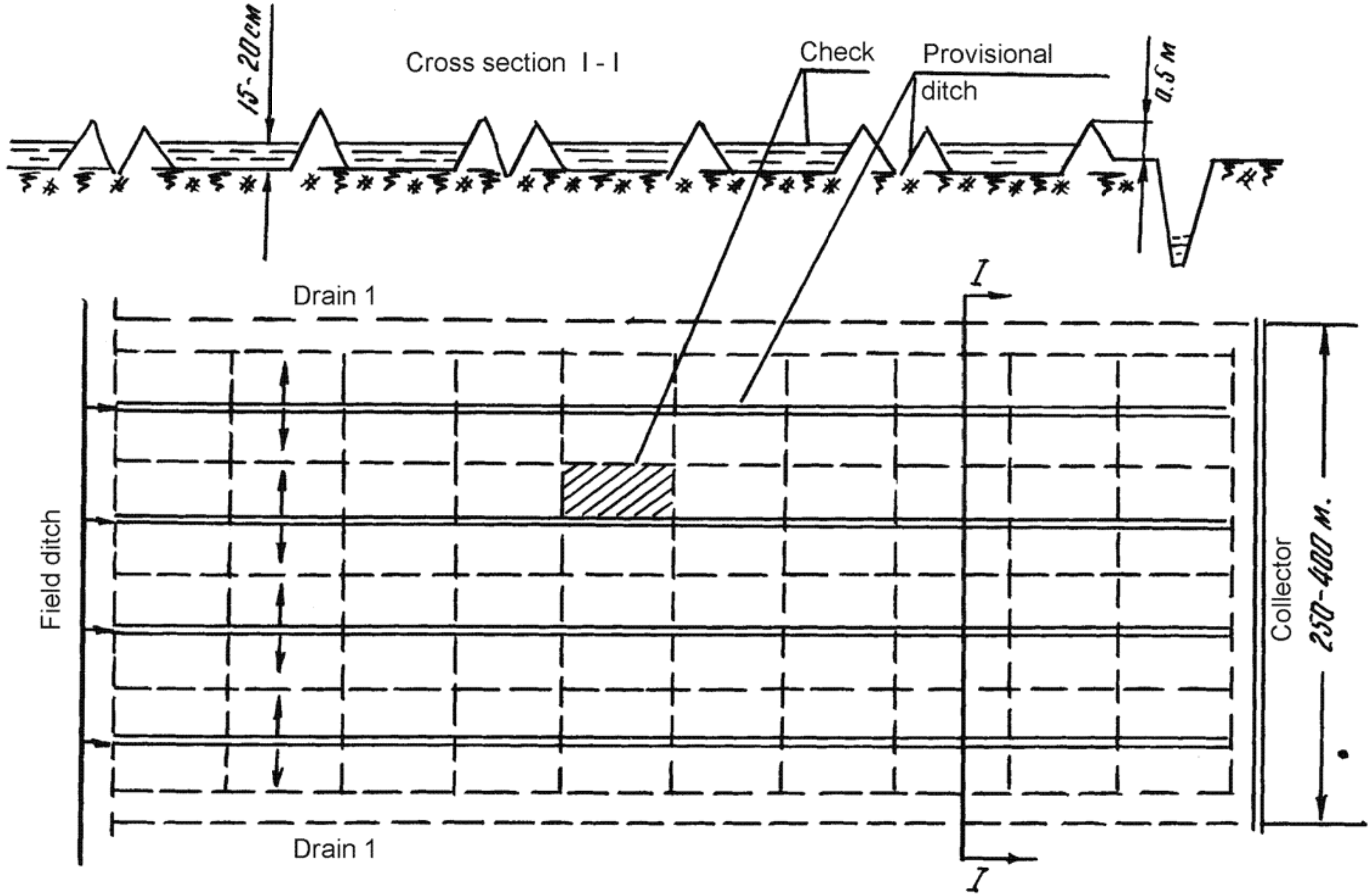
It worth to take into account that under leaching over big checks, slope damage, borders washing away, water break from fields into drains and their siltation frequently occur under hydrostatic heads pressure. Leaching over big checks also resulted in sufficient lowering of water use coefficient comparing to leaching over small checks. Similar leaching is irrational from point of view of works organization. Because of water resources lack and their limitation, as production tests in Hungry steppe and AmuDarya river lower reaches show, operational leaching is not managed to be conducted on all area, which should be desalinized, in autumn-winter period.

Leaching is conducted all day and night and shift work of irrigators is needed to be organized. Checks are filled with water up to creation of layer 10-20 cm thick. In order to prevent breaks and unproductive releases all works on water distribution over checks are fulfilled in day time by means of concentrated flow and in night examination and additional water distribution by means of non-concentrated flow are fulfilled. For prevention in nighttime direct water releases from drain in the end of plot it is necessary to remain fields with area 1-1.5 ha, surrounded with borders which height is to 1.0 m (dr. 3.6).

Leaching should be started from the middle between drains and move to drains. Total leaching norm must be supplied differentially: on slightly saline – by one time; on medium and strongly saline, with interval 3-6 days. Water supply must be carried out in such a way that checks filling and water table formation will take as short as possible time.

Leaching experience in Hungry steppe and Fergana valley shows that water must be supplied into checks through temporary ditches with discharge at least 30-40 l/s.

As whole checks' area is flooded and certain water horizon is formed, each check is closed separately. After calculated leaching norms supply water flow to field is stopped and while soil is drying, salt survey after leaching is conducted. On base of data comparison on salt test (survey), conducted before and after leaching, its efficiency is estimated.



Dr.3.6. Leaching over small checks.

If area of lands leached incompletely is in total 10-15 %, so in vegetation period of such crops as alfalfa, Sudan-grass, jougara, etc. additional leaching is conducted by means of irrigation with exceeded norms. When area of lands incompletely leached does not exceed 25 %, soil root-zone layer desalinization is obtained by means of increased irrigation depths (5-10 % higher on moisture lack) that is by means of irrigation leaching regime in vegetation period.

While lands are desalinized, leaching is stopped. As soil is drying borders, temporary ditches and fields are leveled by long-based grader and preparation works are carried out for main crops sowing.

Results of field researches of operational leaching efficiency, which are obtained on pilot projects on the background of different types of drainage, are given below.

2.3.3.2. Field investigations of soil water-salt regime management under operational leaching on background of vertical drainage

2.3.3.2.1. Water-salt regime of hardly reclaimed soils under leaching irrigation regime on background of vertical drainage

Investigation were carried out in farm "50 years of Uzbekistan", Saihunabad rayon, SyrDarya oblast. The pilot plot size is 17 ha. Vertical drainage parameters are mentioned in chapter1, section 1.3.

Soils are strongly salinizated with salt content in 1m layer 2,03% on dry residue, 0,16% on chlorine- ion, and 1,3% on sulfuric acid-ion. Down wards profile in 1-2 m horizons salt quantity decreases to 1,28 and 0,11; 0,66% ,respectively.

Site development started from spring leaching by norm 10,2 th.m^3/ha. Water abstracted from well # 5 was used whit salinity 1,3-1,4 g/l; including 0,3-0,4 g/l chlorine-ion. Cotton was sowed on irrigated site after leaching. Easy soluble soils content in 1m decreased after leaching as compared with autumn of precedent year (from 2,10 to 1,65% on dry residue and from 0,16 to 0,083% on chlorine-ion). However, in spite of irrigations by norm 5,7 th.m^3/ha, some salt restoration (15%) by autumn was observed against spring, which is explained by shallow ground water (table 3.2.1). Cotton yield was 5 c/ha. (Table 3.2.1).

On the second year of development, during vegetation period total water supply was 5,78 th.m^3/ha, that caused easily soluble salt content decrease. Since autumn of this year, operational leaching by norm 2,8-3,6 were conducted on site, and during vegetation period waterings under irrigation depth 4,8-6,5 th.m/ha was carried out. Total water supply (gross), taking into account precipitation, fluctuated from 11,0 to 12,5 th.m/ha under total evaporation 7,8-8,5 th.m/ha (table 3.2.2) with leaching irrigation regime:

$$\frac{\text{В+О}}{\text{И+Т}} \geq 1{,}25 - 1.3$$

Table 3.2.1

Easy soluvable salts content changes under influence of leaching irrigation regime
on background of vertical drainage, % of dry mass

Indicator	Year of observation												Change from initial	
	spring-autumn of precedent year		spring-autumn of 1-st year		spring-autumn of 2-nd year		spring-autumn of 3-rd year		spring-autumn of 4-th year		spring-autumn of 5-th year		spring-autumn	
Layer thickness, m 0 - 1	2.03[x] / 0.16	2.10 / 0.16	1.65 / 0.083	1.80 / 0.15	1.5 / 0.046	1.5 / 0.036	1.7 / 0.045	1.3 / 0.04	1.5 / 0.09	1.29 / 0.037	1.46 / 0.027	1.21 / 0.027	-0.57 / -0.123	-0.89 / -0.133
1- 2	1.29 / 0.11	1.5 / 0.11	1.57 / 0.086	1.15 / 0.07	1.2 / 0.022	1.15 / 0.024	1.4 / 0.075	1.33 / 0.057	1.36 / 0.037	1.24 / 0.028	1.34 / 0.047	+1.1 / 0.027	+0.06 / -0.123	-0.4 / -0.133
0 - 2	1.65 / 0.13	1.8 / 0.13	1.61 / 0.85	1.47 / 0.11	1.35 / 0.034	1.32 / 0.03	1.55 / 0.06	1.31 / 0.045	1.43 / 0.043	1.27 / 0.029	1.4 / 0.042	1.16 / 0.027	-0.25 / -0.108	-0.64 / -0.103
Groundwater table, m	1.95	1.75	0.8	1.4	2.0	1.6	2.0	2.5	2.3	2.6	2.4	2.75		
Piezometric head, m	1.9	1.65	2.2	2.4	2.5	2.6	2.2	3.4	2.7	3.0	3.1	3.35		
Groundwater salinity, g/l	16-17	15.0	6...9	7...8	6...8	6...7	5...6	6...8	6...7	5...6	6...7	4...5		
Water supply, th. m^3/ha	-	-	15.9			5.75		6.99		8.1		8.5		
Cotton yield, c/ha			5			9.0		20		25		28		

Note: [x] numerator - dry residue; denominator - chlorine-ion.

Table 3.2.2

Water-salt balance of top soil loam under vertical drainage in state farm «Pakhtaaral»

Drainability conditions	Year	Inflow, m^3/ha			Outflow, m^3/ha			Moisture stock change, m^3/ha			Deep under ground water inflow and outflow, m^3/ha	Salt accumul. (+), salt removal (-), t/ha	
		Precipitation	water supply and filtration losses	total	evaporation and transpiration	outflow with horizontal drainage	total	in ground water	in soil unsaturated zone	total		dry residue	chlorine-ion
Before vertical drainage system completion	1961	2535	5540	8075	8118	137	8991	288	90	378	596	+6.6	1.2
	1962	2481	6568	9049	9920	151	9071	576	-150	426	510	+7.0	1.2
	1963	2595	6986	9681	9578	189	9768	128	180	308	496	+7.0	1.2
	1964	3707	6163	9870	9785	210	9995	-48	60	12	137	+4.1	0.6
Under vertical drainage system operation	1965	2113	8122	10235	8486	98	8584	-72	-80	-152	-1803	-6.8	-1.3
	1966	2540	7645	10185	7046	124	7170	-256	-210	-466	-3481	-18.7	-3.9
	1969	5652	7253	12905	8394	765	9159	-88	-235	-323	-3423	-20.0	-3.6
	1971	2515	10872	13387	7505	1001	8506	-144	-271	-415	-5291	-15.35	-3.2
	1973	2127	10308	12435	7551	962	8513	-	-668	-668	-4590	-21.55	-4.0
	1975	1799	7570	9370	8083	-	8245	-	-152	-152	-1430	-5.3	-0.9
	1984	2955	8142	11097	8170	1466	11200	-103	-	-103	-1561	+1.83	+0.18
	1987	3346	6210	9556	8118	91	8209	+55	+85	+140	1347	+1.68	+0.14

During 5 years under such regime operational leaching and irrigation strongly salinizated lands were transformed in to slightly salinizated lands. According to autumn survey salts content in 1m layer by the 5th year was 1,21% on dry residue against initial 2,10%. Chlorine-ion quantity decreased to 0,027% against initial content 0,16% (table 3.2.1.).

Total easy soluble salt removal from 2 m thickness during 6 years of investigations was 158,6 t/ha (29%) on dry residue and 43,3 t/ha (77%) no chlorine-ion. Ground waters were desalinized simultaneously with soil desalinization to 4-5 against initial 16-17 g/l which was facilitated by descending overflow due to vertical drainage from top soil to aquifer in amount of 3,2-4,5 th.m^3/year.

Soil desalinization rate during vegetation period depended on depth of irrigation and irrigation interval duration, i.e. on volume of desalinating water expenses which are determined as difference $\pm$ g=Δ W + m - (È+Ò). Easy soluble salts content after each watering decreased, and within irrigation interval depending on its duration and water depth norm partially restoration or soil desalinization were observed.
Desalinization of 1 m layer and lower occurred to the end of vegetation period. Seasonal salts accumulation coefficient is linked with initial soil salinization and irrigation norms. For 1m layer it varied within the limits 0,84-0,92 under irrigation norms (gross) 5,5-6,5 th.m^3/ha.

Under salinizated soil development process and leaching irrigation regime influence significant changes in soil salt content were observed on site. 49,6% toxic salts; 80,5% chlorine- ion; 22,5% $MgSO_4$ + $NaSO_4$ were removed from 1 m layer. During this time in 1 m layer $CaSO_4$ content decreased. In 3,5 m layer above mentioned salts content were decreased on 46,66 and 38,5% respectfully, against initial stock with water soluble gypsum accumulation in lower layers.

Residual content for 1 layer was 0,04% on chlorine-sodium; 0,143% on sulfate- magnesium and sodium and harmful salt sum 0,18 % of dry soil mass.
In thickness 0-3,5 m residual salt content was 0,045; 0,152 and 0,319% respectfully of dry soil mass (table 3.2.1).

2.3.3.2.2. Soil water-salt regimes under operational leaching on lands of spotted salinization

Field investigations of soil desalinization acceleration on lands of spotted salinization lands were conducted in farm "Pakhtaaral", which territory is presented by two and multi-layers deposits with top loam thickness 20-30 m ($K_ф$= 0,11-0,15 m/day) which is underlain by highly permeable aquifers with conductivity $K_2 m_2$ up to 1500 m^2/day.

Lands on desalinization complexity related to middle category, where top fine grained deposits is presented by homogeneous light and middle loam, and resistance coefficient Φ=150-250 day. Highly permeable layer had relatively high hydraulic link with ground water. Ground water overflow into captured layer intensity was W= 0,020-0,03 m/day, and overflow coefficient B=200-250 m^2. Soils are gray-marshy, light and middle loam. Water-physical properties of 1m layer were characterized by the following data: volumetric mass - 1,5 g/cm^3; density - 2,63-2,7 g/cm^3; porosity - 40-45% of dry soil mass; water availability μ = 0,065-0,09; salt availability α = 0,75-1,32; $K_ф$=0,3-0,5 m/day

Ground water depth was 9,6 m before irrigation, then under development process water table rise occurred which caused soil spot salinization.

Vertical drainage system of 74 wells was constructed in 1966-1968 for lands reclamation. In 1967-1973 it is operated with average workability coefficient 0,65-0,73 under design value 0,75. Total volume of pumped ground waters was 73-85 against designed 130,4 mln.m^3/year. Total volume of pumping does not exceed 3,2 in 1967 and 5,4 m^3/s in 1973. Before vertical drainage development on lands of neighbouring farms ground water overflow share from top loam into captured layer was 55-60 %. Residual share of total volume of pumped water was formed at expense of ground inflow from outside. Starting from wells operation in other farms, ground water inflow share from top fine-grained deposits increased up to 85% of total pumping volume. Reduction of ground waters external inflow provides top fine-grained deposits drainability increase and gave the possibility for ground water table regulation in wide range. As a result ground water table and artezian water head reduction occurred over all farms' territory.

During vegetation period ground water depth was 2,3-3 m; before leaching it was 3,5-4,5 against 1,8-2,1 and 2,5-2,8m before pumping. Actual average annual difference between water table and ground water head was (for 1965-1973) 0,15-0,35m, fluctuating in certain year periods from 0,1 to 0,65m. Under head gradient influence ground water descending flows from top loam were formed everywhere, which average velocity was 2,5-3,5 cm/day.

Before drainage putting into operation lands on 30-35% of total area were medium and strongly salinizated and for their desalinization leaching was necessary. Taking into account experience of leaching in Hungry Steppe, for 1,5-2,0 m thickness desalinization 15,0-25,0 th.m^3/ha water will be necessary, and in order to supply such norms it is necessary to exclude lands from agricultural rotation, increase sites drainability and irrigation network capacity. Under such conditions economically profitable variant of soil desalinization is desalinization by means of autumn-winter leaching during several years and prevention of seasonal salt restoration.

In order to determine optimal norm of autumn-winter leaching irrigations two sites with medium and strongly salinizated lands and area 214 and 93 ha were selected. Over these sites five variants of land desalinization under various leaching norms were studied. Results showed, that the main condition for high leaching effectiveness is normal drainability creation during and after leaching. For example, leaching by the same norm 5,6 and 6,0 th.m^3/ha gave different results depending on drainability and ground water table depletion after leaching.

In the first case, good results on desalinization were obtained under module 0,21 l/sec/ha during leaching (October-November) and 0,14 l/sec/ha during ground water table depletion. Salt content in arable and sub-arable layers was decreased up to 0,45% on dry residue and to 0,025% on chlorine ion under initial content 0,941 and 0,086%, respectfully. Depth of soil desalinization on some observation wells was 1,0-1,2 m.

In the second case, under drainage module values, respectfully, for the same leaching period 0,09 and 0,04 l/sec.ha. good results on desalinization were not obtained. Salt content decreased only on 15% or 0,854% on dry residue and up to 0,062% on chorine- ion under initial content 0,899 and 0,078%, respectfully.

Highest soil desalinization was obtained on the second site under leaching by norm 7,6 th.m/ha (gross) and drainage module 0,35 and 0,21 l/sec.ha during October -December and January -April. Salt stock in 1,5 m layer decreased to 0,460 and 0,030% under its initial content 0,801% on dry residue and 0,076% on chlorine. Water expenses for 1t salt removal from 1,5m layer under normal drainability were from 80-100 m^3 under initial salts content 1,2-1,5% to 150-200 m under salt content 0,6-0,8% .

Medium and strongly saline soils leaching by norm 2800-3000 m^3/ha does not give good results. Arable layer residual salinization exceeded limits of crops salt resistance.

Autumn-winter leaching by norm 4,5-6,0 th.m^3/ha and cotton crop vegetation irrigations by depth 3,0-3,2 th.m^3/ha were conducted in the following 3 years over the site (214 ha). In 1969 area of non- saline lands was 180,9 ha, against initial 50,5 ha. Strongly saline lands and salts (97,6 ha) were eliminated (table 3.2.2.1)

Similar results were obtained on the second site where area of non- saline and slightly saline lands was decreased from 31,4 to 83,6%. Soil desalinization process was proved by high crop yield. On the first site it was on average 28,8 c/ha, on the second- 30,8 c/ha against 14 and 18,0 before vertical drainage wells construction.

Optimal leaching norms for medium and strongly saline lands, which are presented by light and middle loams allowing to obtain high crop yield since the first year after leaching, as well as salt restoration preventing are water supply norms 5,0-6,0 th.m^3/ha. For slightly saline lands leaching norms 2,5-3,0 th.m^3/ha will be sufficient. Under similar norms easy soluble salts are removed from aeration zone in to ground water and vice versa. Therefore, taking into account big height capillary rise, it is very important to prevent salt restoration during vegetation period.

Table. 3.2.2.1

Dynamics of areas with different soil salinization in farm “Pakhtaaral”

Salinity degree	Year					
	1964	1965	1966	1967	1968	1969
Non and slightly saline	50.5 / 23.5	71.0 / 33.0	139.9 / 65.4	155.3 / 72.5	174.5 / 81.5	180.9 / 84.5
Medium	65.9 / 30.7	73.0 / 32.0	51.1 / 23.9	58.7 / 27.5	39.5 / 18.5	33.1 / 16.5
Strongly	76.7 / 36.8	71.0 / 33.0	23.0 / 10.7			
Salts	18.9 / 9					

Note: numerator- hectares; denominator -%

Experiments show, that cotton irrigation depth 1,9-2,4 th.m^3/ha (usually three irrigations by sprinkling) under ground water depth 1,5-2,0 m can not prevent salinization; it could be realized only under irrigation depth 3,2-3,5 th.m^3/ha and ground water depth maintenance within the limits 2,5-3,0 m. This principle is the basic one for lands reclamation in this region.

After good results over the pilot plots were obtained all area of farm under cotton and other spring crops was subjected to autumn-winter leaching. Fields for perennial grass were leached up as well. Leaching norms for areas under cotton were differentiated depending on salinity degree: on strongly saline sites water supply was 4,5-6,0, on slightly and medium saline - 2,5-3,5 th.m^3/ha. During vegetation period three cotton irrigations were conducted: the first by depth up to 1,5 th.m^3/ha on furrows, another two by depth 900-1100 m^3/ha by sprinkling. On strongly saline sites all waterings were conducted on furrows by depth 4 th.m^3/ha (gross). Other crops were irrigated by depth up to 5,5 th.m^3/ha. As a result total water-salt balance of top loam on a background of vertical drainage was found as negative. Average annual ground water outflow from top fine-grained deposits fluctuated within the limits 1,8-5,4 th.m/ha, against ground water inflow 500-600 m^3/ha before drainage introduction. 75% of positive water-balance sum for top loam thickness corresponded to water supply share and 25% to precipitation share. After drainage introduction water supply was increased on 1,0-3,5 th.m^3/ha, at expense of water supplied for autumn-winter leaching.

In negative part of water-balance total evaporation by 1973 was 6,8-8,9 th.m/ha or 55%, against 82% in 1965, and collector drainage outflow was equal to 7 and 0,95%, respectfully (table 3.2.2).

Soil salt balance by 1984 was formed by type of irreversible soil desalinization with salt removal of 15-22 t/ha/year (including 2,5-4,0 t/ha chlorine). Total salt removal from aeration zone, under ground water infiltration volume 3,5-4,0 th.m/ha, fluctuated within the limits 25-37 t/ha depending on irrigation regime and leaching norms. By 1968-1969 under similar desalinization rate land spotted salinization was eliminated completely and meliorative background over farm was established. As a result during 2-3 years 2m thickness was desalinized, and on separate up to ground water table.

Under operational leaching ground water salinity gradual decrease was observed, in first turn on medium and strongly saline lands. It decreased from 10-15 to 3-5 g/l and stabilized on this level. Due to fact that total evaporation value during vegetation period exceeds irrigation norm, on other sites salt restoration was observed by autumn. However, within a year irreversible soil desalinization process took place caused by water supply exceedance over total evaporation on 20-30%.

Salt survey was conducted over irrigated territory of farm in autumn 1972, for superficial and deep salinity definition. Obtained results were compared with salt survey, which was conducted over similar points by Soil Science Institute of Kazakhstan in 1959-1960 and Uzgiprozem in 1966-1986.

Analysis of soils salt regime dynamics for 1969-1972 on average data (106 wells) shows that under agromeliorative measures (mainly operational leaching) on background of vertical drainage stable soil desalinization was achieved. In soil layer 0-1 and 1-2 m total salt content decreased, respectfully, from 0,502 to 0,243 and from 0,426 to 0,273% including chlorine-ion from 0,40 to 0,018 and from 0,034 to 0,019% of dry soil mass. From 2m thickness was removed 39,1% of dry residue and 46,6% of chlorine-ion of initial content. As a result area of non-saline lands increased from 5838 (in 1959) to 10760ha (in 1972)., area of slightly saline lands decreased on 1106ha, medium saline lands on 302 ha, strongly saline lands in 1972 were not available. In 4 departments where vertical drainage was operated from 1966 land spotted salinization was not found, and area of non- salinizated and weakly salinizated lands was increased on 2 th.ha during this time.

Irrigated lands meliorative conditions improvement caused sharp cotton yield increase, since before vertical drains introduction agrothechnics of agricultural crops cultivation was high. Vertical drainage promoted not only soil salt regime, but water-air and thermal soils regime as well. Therefore, average annual cotton yield growth on lands in farm "Pakhtaaral" after vertical drains introduction was 2,9 c/ha. Cotton yields 37-40 c/ha were achieved by 1971-1974.
However, since 1980 water management situation in farm has changed: irrigation water supply was decreased on 10-15% due to leaching norm decrease; top fine-grained deposit drainability was decreased by 2-3 times. Top fine-grained deposits drainability created by means of vertical drainage fluctuated within the limits 1,4-1,85 th.m^3/ha (1978-1986) against 4,5-5,0 th.m^3/ha (1972-1974) which was caused by low network workability, which constituted 0,24-0,3 (on designed project 0,7-0,8) for 12 years. Besides, supplied water salinity was increased in 1,5-1,7 times (1,4-1,6 g/l against 0,7-0,9g/l in 1966-1974). Since 1983-1984 salt balance of irrigated lands was build on type of gradual salts accumulation in top thickness even under negative water balance (table 3.2.2).

For the last ten-years period area of non-saline and slightly saline lands decreased, medium and strongly saline lands - increased (table 3.2.3). Therefore, starting since 1980 cotton and other agricultural crops yield decreased on 9-10 c/ha.

Table 3.2.3

Change of areas with different soil salinization in farm "Pakhtaaral", % (w= 11,5 th.ha)

Salinity degree	Year				
	1966	1972	1977	1985	1968
Non-saline	25.4	93.7	73.1	63.0	61.6
Slightly	59.4	2.2	19.8	19.4	17.1
Medium	6.3	4.1	7.1	15.3	18.5
Strongly	8.2	-	-	-	-
Salts	-	-	-	-	-
TOTAL	**100**	**100**	**100**	**100**	**100**

It should be mentioned, that salt restoration and crops yield decrease occurred under ground water depth corresponding to the optimal meliorative regimes. Ground water tables fluctuated over year periods in wide limits: during leaching period and high precipitations (January-middle of March) within the limits from 0,5-1,0 to 2,0 m; during vegetation period (May-August)- 2,5-3,2 m, Autumn (before leaching- September, first half of December) - 3,2-4,0m. Such ground water table position shows that soil salt restoration links with high irrigation water salinity and irrigation norms shortage under which requirements for leaching irrigation regime are not kept ($\frac{\text{B+O}}{\text{e И+T}} > 1,15-1,2$)

Analysis of water supply on field and total evaporation changes shows that during 1980-1986 non-leaching irrigation regime was formed during vegetation period and within a year.

Relation $(\text{B+O}/\Sigma \text{И+T}) \le 0.9-1.05$.

Hence, to keep sustainability of desalinization it is necessary to increase autumn-winter operational leaching norms up to 3.0-3.5 th cu m/ha.

2.3.3.2.3. Soil desalinization in conditions of non-artesian groundwater recharge on the background of vertical drainage

One of prospective regions of vertical drainage development are Zarafshan river lower reaches, where on the January 1, 1983 more than 350 wells were constructed and operated, which reclaimed about 30 th. ha of lands. In prospective here on area of 150-160 th. ha vertical drainage will be constructed. Vertical drainage desalinizating effect under non-artesian groundwater recharge was tested in state farms "Kagan", "Bukhara" and collective farm "Kommunism" (Kagan rayon, Bukhara oblast) since 1968 till 1971. Objects of researches on lands desalinization complexity belong to simple category. They are located on the second flooded plain terrace of Zarafshan river. Experimental plots soil is composed of quaternary deposits and is made interlayering loam, sandy loam and sands, in lower horizons top fine-grained deposit thickness changes within 8-12 m; loamy deposits permeability is 0.2-0.5 and sandy loam and sands - 0.5-4.0 m/day. Soil resistance coefficient (Ф) of top deposits does not exceed 20 days.

Top fine-grained deposits are underlain by gravel-pebble deposits with thickness 5-12 m with permeability 35-40 m/day (Kh.Kadyrov, R.Gerasimov, 1974-1975).

Groundwater has high hydraulic link with shallow water, overflow intensity exceeds 0.05-0.75 m/day. Experimental plots soil belongs to highly drained types, where top loamy soil is underlain by sandy loam, loam and sands. Soil top layer is presented by meadow-gray and meadow soils variety with high water and salt availability (u = 0.08-0.1; a = 1.5-1.75).

Soil salinity type is chloride-sulfate and salinity degree varies from slightly to strongly saline. Main salt content is concentrated in top 1-meter layer of soil. Salinity is superficial, that corresponds to areas with shallow groundwater table (1.5-2.4 m) with weakly drained top deposits, formed due to insufficient regional groundwater outflow.

Salt content on the most part of area changes within 0.5-1.0 %. It worth to note season dynamics salt regime demanding operational leaching conduction on 70-80 % of irrigated lands.

Groundwater in fine-grained deposit has salinity 3-5, 5-10, more seldom, to 25-40 g/l and in captured aquifers they are brakish - 0.5-2.0 g/l.

Till 1960 meliorative state of these lands was rather unsatisfactory, that is caused by:

- weak natural and artificial drainability of top deposits. The latter did not exceed 0.012 l/s under collector-drainage system length of 5 m/ha;
- stable saline shallow groundwater table, that was reason of permanent restoration of soil salinity under sharp predomination of evaporation comparing to groundwater outflow. Total evaporation in negative part of water balance reached 78-80 %of water supply to area;
- insufficient water availability of irrigated lands in dry years and over-moistening in humid years.

In these conditions for lands meliorative state improvement in Kagan rayon in 1960-1971 96 wells of vertical drainage was constructed and introduced in operation.

Analysis of researches for 1960-1962 and 1969-1971 found improvement of soil fertility expressed in formation of irreversible salt balance of irrigated lands.

So, when Amu-Bukhara canal started to be operated, water supply to farms area increased almost twice under simultaneous reduction of losses for infiltration from 3495 to 1590 cu m/ha. Water losses reduction was obtained due to irrigation network reconstruction.

In the result of vertical drainage wells construction lands drainability abruptly grew under negligible change of collector-drainage system length, which was just 7 m/ha in 1971. Due to vertical drainage system construction drainability was 6085 and 5237 cu m/ha for 1969-1970 and 1970-1971 hydrological years. During these years drainage outflow removed appropriately 18.08 and 14.55 t/ha of salts, of them just 5 t/ha corresponded to open collector-drainage system. With respect to ground flow salt removal was 23.1 and 19.6 t/ha (table 3.2.3.1).

Table 3.2.3.1

Water-salt balance of water exchange active thickness
(state farm "Bukhara")

Balance components	Water, m^3/ha		Salts, t/ha	
	1969 - 1970	1970 - 1971	1969 - 1970	1970 - 1971
Positive part: precipitation	1.226	1.328	-	-
filtration from canals	1.588	1.665	7.368	6.292
water supply	9.366	8.295		
ground inflow	2.561	3.307	6.397	5.711
TOTAL	**14.714**	**14.595**	**13.765**	**12.003**
Negative part: total evaporation	7.637	8.049	-	-
outflow over vertical and horizontal drainage	6.085	5.237	18.082	14.544
ground outflow	2.604	1.421	4.984	5.081
TOTAL	**16.326**	**14.779**	**23.066**	**19.635**
Difference	-1.612	-184	-9.301	-7.632

Intensive pumping of groundwater under vertical drainage system workability coefficient 0.55-0.6 allowed to create everywhere descending filtration flows of groundwater from top fine-grained deposits into captured aquifer with velocity up to 0.1-0.15 m/day; to regulate groundwater table in wide ranges - in spring within 1.5-2.0 m; in vegetation period - 2.5-2.8 m; and in autumn before leaching lower than 3.5 m. Salinity restoration can be prevented as in vegetation period, so during the year by means of groundwater expense for evaporation decrease; operational leaching can be conducted differentially depending on soil salinity degree: on medium saline - by norm 3-4 th cu m/ha, on strongly saline - 4-6.5 and on salts - 6.5-7.5 th cu m/ha. Average leaching norm on farms area was 2.5-3.0 th. cu m/ha allowed to conduct agricultural crops irrigation operatively. In vegetation four irrigations by depth from 1.1 to 1.5 th cu m/ha were supplied. Irrigation norm varied within 6.2-6.8 th cu m/ha.

So, soil desalinization on old irrigated lands and development of strongly saline fallow lands inside oasis in Kagan rayon were also based on irrigation leaching regime under relations:

ΣВ/(ΣИ+Т)=1.2-1.35

Field researches of salt content change in soils and groundwater showed that in 0-0.2 m layer salt content in initial state exceeded permissible norm and varied within 8-40 t/ha (on average 22.6 t/ha) and in layer 0-1.0 m - from 30.5 to 89.4 t/ha (on average 69.7 t/ha). Later after operational leaching it fluctuated within 8-15.7 t/ha in 0-0.2 m layer and within 28.6-47.7 t/ha in 0-1 m layer. In general for 4 years in 0-3 m layer salt stocks were reduced by 3 times - from 191.7 to 67.2 t/ha (table 3.2.3.2).

1. On irrigated lands salt shifting process became more dynamic than on non-irrigated lands, in the latter common salt content was by 2-5 times higher. Groundwater salinity on intensively irrigated lands was 1.2-3 g/l, on lands subjected to salinization – 3.5-7 g/l, on salts – 5-10 g/l and more. Groundwater salinity in pebbles fluctuated from 0.8-1.2 to 2.5-3.0 g/l and more, seldom from 3 to 5 g/l. Pumped water salinity increased by 2.4 times. On saline lands after wells starting operation pumped water salinity was 0.8-3.6 g/l, it was reduced by 1.3-1.8 times on lands, were in the first moment highly saline water was pumped (7-10 g/l and more).
2. Area of non-saline and slightly saline lands increased constantly. So, by 1971 area of these soils increased by 3 times under simultaneous decrease of medium saline lands by 10 times in comparison with 1960, when there were no wells of vertical drainage.
3. All this promoted land quality improvement and agricultural crops yield capacity growth.

4. Table 3.2.3.2

5.

6. Dynamics of salt stocks on the experimental plot
7. of the state farm “Bukhara”

8.

Year	Month	Salt stocks over horizons, t/ha				
		0-0.2 m	0-1 m	1-2 m	2-3 m	0-3 m
1968	X	22.6	69.7	70.5	51.7	191.7
1969	У	10.8	39.8	39.8	33.7	125.7
	X	13.9	45.1	35.7	27.8	108.6
1970	X	14.6	36.4	23.9	32.2	92.5
1971	1	11.5	55.6	53.3	24.0	132.9
	II	8.6	28.6	22.6	54.4	105.6
	III	9.5	40.1	22.2	17.3	79.6
	1У	15.7	77.7	48.7	43.6	140.0
	У1	11.2	44.7	43.4	39.9	128.0
	У11	12.4	32.6	27.8	11.1	71.5
	1X	16.3	46.1	40.0	15.8	101.9
	X	8.0	29.0	22.0	15.8	67.2

9.

10. In 1969-1975 cotton crop yield capacity in Bukhara oasis, in particular Kagan rayon, grew on 1.9-2.7 c/ha, but on lands, where vertical drainage was constructed and operated, increase was much higher. So, if average cotton crop yield capacity in the state farm “Kagan” for 1959-1965 was 12.9 c/ha, so in 1966-1971 it raised to 18.5 c/ha, crop yield capacity increment reached 5.6 c/ha. In the collective farm “Kommunism”, where agrotechnique was more perfect, crop yield capacity was for the same years, appropriately, 13.7 and 21.1 c/ha. In some rayons, such as Vabkent and Kagan, where vertical drainage wells are operated, average crop yield capacity for 1968-1978 reached 27.4-32.1 c/ha.

11. By means of autumn-winter-spring leaching and irrigation regime, providing irrigation leaching regime (1.1-1.2) annually on the background of vertical drainage system, in 1970-1985 soil desalinization and agricultural crops yield capacity growth was obtained on large irrigation massifs such as: old zone of Hungry steppe on the area of about 350 th ha, of them 150 th ha of Kazakh part, Central Fergana (104 th ha) and Kagan, Bukhara, Vabkent rayons of Bukhara oblast.

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2.3.3.3. Operational leaching efficiency on the background of horizontal drainage

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2.3.3.3.1. Operational leaching efficiency in AmuDarya lower reaches

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17. Study of operational leaching efficiency on the background of horizontal drainage was carried out on area of Chimbay rayon of Karakalpakstan (A.Ramazanov, A.Kalimbetov, 1975). Experimental plots with area of 1.6-2.0 ha are located in zone of collector-drainage network influence on meadow old-irrigated middle loam soils. In initial state experimental plots soil belonged to slightly- and medium-saline with chlorine-ion content in top 1-meter thickness 0.04-0.07 % of soil mass. Volumetric mass of soil varies within 1.3-1.48 g/cu cm, specific mass – 2.59-2.70 g/cu cm.

18. Terms and leaching norms influence on soil desalinization intensity was studied. Leaching was conducted by means of check flooding, common leaching norm was supplied in two-three gifts. Before leaching tillage was carried out to depth of 27-30 cm without top layer rotation. Experiment was repeated three times.

19. Under all tested norms and terms soil 1-meter thickness desalinization up to toxicity threshold, adopted equal to 0.02 % on chlorine-ion (table 3.3.1).

20. While water supply norms for leaching increase, tendency directed to salts washing out is observed. So, under leaching norms 3.5-3.9 th cu m/ha from 1-meter layer of soil 0.157-0.240 % of water soluble salt of soil mass is removed, while norms 4.9-5.1 th cu m/ha washed out 0.42-0.46 %.

21. Observations did not define leaching terms influence on desalinization. In all variants of test it was approximately uniform and sufficiently high.

22. Operational leaching conduction (indepently of terms) promotes abrupt groundwater table rising on 80-100 cm comparing to initial state. However, by the beginning of vegetation irrigations groundwater table lowers to the depth of 1.8-2.2 m. As usual, groundwater top horizon salinity after leaching increases that is caused by their salinization with water soluble salts, washed out under leaching from aeration zone soils.

23.

24.

25.

26. Table 3.3.1

27. Dynamics of soil 1-meter thickness desalinization under operational leaching on the background of horizontal drainage

28.

Term of Leaching	Leaching norm, th.m^3/ha	Soil salinization			
		before leaching	after leaching	before vegetation period	in the end of vegetation period
March	3.9	0.059 0.550	0.020 0.314	0.028 0.444	0.040 0.510
March	4.2	0.053 0.512	0.018 0.230	0.032 0.352	0.028 0.280
April	3.7 - 4.0	0.035 0.397	0.016 0.236	0.024 0.385	0.022 0.377
April	4.6	0.069 0.399	0.020 0.283	0.026 0.307	0.020 0.264
April	4.8 - 5.0	0.069 0.804	0.022 0.381	0.040 0.644	0.036 0.527
April	5.1	0.066 0.738	0.020 0.277	0.336 0.426	0.030 0348
November	3.5	0.056 0.380	0.017 0.223	0.022 0.246	0.019 0.242
November-March	4.3	0.045 0.324	0.020 0.262	0.024 0.273	0.020 0.240

29. After leaching on all experimental plots cotton C-4727 was cultivated. Sowing was conducted in the first-second ten days of May. During vegetation period three-four irrigations under common irrigation norm 2.6-3.35 th cu m/ha were conducted. Four cultivations and two weedings were carried out. Mineral fertilizers were applied two-three times according to cultivation: 120 kg/ha of nitrogen and 70 kg/ha of phosphorus. Under such irrigation regime and agrotechnique system salts restoration was not observed. Chlorine-ion content by the end of vegetation period in 0-100 cm layer was 0.02-0.04 % of soil mass. Simultaneously, some lowering of groundwater table and groundwater salinity was noted.

30. Satisfactory desalinization of soils under operational leaching (soils salinization with chlorine-ion before the first vegetation irrigation did not exceed 0.022-0.040 % of soil mass) promoted obtaining of sufficiently high cotton raw crop yield: 22.7-29.0 c/ha. In the same time it worth to note, especially, that increase of chlorine-ion content in root zone from 0.022-0.024 % (crop yield 26.0-29.0 c/ha) to 0.04 % causes obligatory lowering of cotton productivity on 3.3-6.3 c/ha.

31. In comparison with usual leaching manure application according to calculation (10 t/ha) though did not influences essentially intensity of soil thickness desalinization, but is positively reflected on cotton crop growth, development and crop yield capacity.

32. Cotton raw crop yield increase under variants with manure under equal irrigation norms and irrigation number was 2.5-3.4 c/ha comparing to control, that is explained by soil-biological processes activation and soil nutrient regime improvement, proceeding during organic substance application, which smoothes out negative effect of negligible concentration of chlorine-ion.

2.3.3.3.2. Hardly reclaimed soils desalinization rate acceleration under operational leaching

33.

34. Positive influence of chemical meliorants and soil tillage on hardly reclaimed soil desalinization rate is found under operational leaching too. Tests were conducted in the state farm A.Niyazov of Akhunbabayev rayon, Fergana oblast (A.Ramazanov, S.Egamberdiyev, 1975). Experimental plots soils are old-irrigated, gray-saz, represented by inter-laying light and middle loam along profile. Strongly compacted shoh horizon with carbonate high content is located on depth 60-120 cm, which causes low filtration ability of soil and, as a result, low salt availability under leaching. Operational leaching was conducted on the following variants: the I-st variant (control) – ploughing with turning of furrow slice on depth 30-35 cm (background) and leaching; the II-nd variant – background, 20 t/ha manure application and leaching; the III-rd variant – background, 20 t/ha lignin application and leaching.

35. Test options were located perpendicularly to closed drain with depth of 3 m. Test repeatedness – 3 times (method of systematic repetition in one circle). Leaching norm similar for all options and equal to 5.4 th cu m/ha was given in two gifts.

36. Before leaching soils of experimental plot on chlorine-ion content in 1-meter layer belonged to category of slightly saline, close to medium saline (0.024-0.036 %) and on toxic salts content – to medium saline, bordering with strongly saline (0.485-0.584 %). In ploughed and under-ploughed layers toxic salts quantity reached 0.604, including 0.04 % of chlorine-ion.

37. Main salt mass is represented by sulfur-acid salts of calcium, magnesium, sodium, of which two latter are the most harmful for plants. Sufficient stocks of toxic sulfate in soil profile (about 70 % of sum of toxic salt) indicate this fact. Salts, calculated according to hypothesis, in order of concentration decrease are arranged in the following row:

38.

$$\mathbf{CaSO_4 > Na_2SO_4 > MgSO_4 > NaCI > Ca(HCO_3)_2}$$

39.

40. Leaching irrigations lowered chlorine-ion content up to permissible limits (0.01-0.02 %) in all test variants. In the same time on sum of toxic salts toxicity threshold (0.15 %), adopted for these conditions, was not obtained. It worth to note that in the II-nd and III-rd variants toxic salts removal from soil 1-meter layer exceeded this indicator under control approximately by 1.5 times (table 3.3.2).

Table 3.3.2

Heavy reclamated soils salinity changes under operational leaching

Version	Layer, cm	Salinity, %		
		CI^-	SO^{2-}_4	sum of toxic salts
1	0-25	0.036	0.365	0.580
		0.015	0.213	0.322
	25-50	0.020	0.310	0.477
		0.012	0.174	0.265
	50-100	0.019	0.284	0.441
		0.015	0.195	0.300
	0-100	0.024	0.311	0.485
		0.014	0.194	0.297

Version	Layer, cm	Salinity, %		
		Cl^-	SO_4^{2-}	sum of toxic salts
II	0-25	0.038	0.381	0.604
		0.008	0.129	0.194
	25-50	0.040	0.374	0.602
		0.010	0.141	0.211
	50-100	0.015	0.285	0.433
		0.010	0.125	0.189
	0-100	0.027	0.331	5.518
		0.010	0.130	0.196
III	0-25	0.039	0.375	0.600
		0.009	0.121	0.181
	25-50	0.035	0.359	0.570
		0.010	0.137	0.205
	50-100	0.036	0.368	0.584
		0.013	0.144	0.221
	0-100	0.036	0.363	5.584
		0.011	0.136	0.207

Note: numerator - before leaching; denominator - after leaching .

41.

42. Both sulfur-acid and chloride sodium are subjected to the highest washing out under leaching. Their content in control by the end of leaching lowered, appropriately, on 48 and 37 % of initial. Quantity of sulfur acid magnesium in leached soils did not change practically, that is connected with secondary salts formation due to soil-sorption complex of soil.

43. Manure and lignin application in the II-nd and III-rd variants sufficiently increases water soluble salt removal: chloride sodium is appropriately 64 and 70 % of initial content, sodium sulfate – 71 and 74 %, magnesium sulfate – 23 and 21 %, calcium bicarbonate – 46 and 54 % (table 3.3.3).

Table 3.3.3

Change of salt composition in heavy reclamated soils under operational leaching

Version	Layer, cm	Salt content, %					Sum of salt, %
		$Ca(HCO_3)_2$	$CaSO_4$	$MgSO_4$	Na_2SO_4	NaCI	
				Before leaching			
1	0-25	0.033	0.461	0.104	0.417	0.059	1.074
	25-50	0.029	0.553	0.081	0.363	0.033	1.059
	50-100	0.023	0.547	0.052	0.359	0.031	1.034
	0-100	0.027	0.527	0.072	0.374	0.038	1.038
				After leaching			
	0-25	0.028	0.507	0.100	0.197	0.025	0.857

Version	Layer, cm	Salt content, %					Sum of salt, %
		$Ca(HCO_3)_2$	$CaSO_4$	$MgSO_4$	Na_2SO_4	NaCI	
	25-50	0.023	0.414	0.067	0.179	0.020	0.703
	50-100	0.013	0.407	0.071	0.205	0.025	0.721
	0-100	0.019	0.434	0.077	0.196	0.024	0.750
			Before leaching				
II	0-25	0.027	0.466	0.120	0.422	0.063	1.098
	25-50	0.023	0.420	0.092	0.445	0.066	1.046
	50-100	0.023	0.517	0.071	0.338	0.025	0.974
	0-100	0.024	0.480	0.088	0.386	0.045	1.023
			After leaching				
	0-25	0.009	0.179	0.064	0.115	0.015	0.382
	25-50	0.013	0.305	0.072	0.123	0.016	0.529
	50-100	0.015	0.496	0.069	0.104	0.016	0.700
	0-100	0.013	0.369	0.068	0.111	0.016	0.577
			Before leaching				
III	0-25	0.029	0.475	0.104	0.432	0.064	1.104
	25-50	0.023	0.554	0.100	0.412	0.058	1.147
	50-100	0.031	0.726	0.107	0.419	0.059	1.342
	0-100	0.028	0.620	0.104	0.420	0.060	1.232
			After leaching				
	0-25	0.012	0.464	0.067	0.099	0.015	0.657
	25-50	0.015	0.501	0.079	0.109	0.016	0.727
	50-100	0.013	0.538	0.091	0.117	0.021	0.780
	0-100	0.013	0.510	0.082	0.110	0.018	0.733

44.

45.

46. Before leaching under application of manure and lignin process of soil particles coagulation and their aggregation proceeds. Humic substances, highly dispersed particles and their organic-mineral complex combinations, being obtained in big quantity as in manure, so in lignin play part of sticking agent. In the result of polymerizing processes original cementing framework is formed, which strengthens aggregates appeared. In the result physical and filtration qualities of soil are improved and leaching efficiency increases significantly. So, coefficient of water leaching effect on chlorine-ion in the II-nd and III-rd variants is appropriately by 1.8 and 2.6 times higher than in control.

47. So, manure and lignin equally effect on process of desalinization of leached soil thickness comparing to control.

48.

49.

50.

2.3.3.3.3. Development and operational leaching of gray-meadow and sodificated soils of Djizak steppe

51.

52. One of the prospective regions of further development of cotton-growing is Djizak steppe. At the present moment works on complex development of this zone are carried out in wide scale.

Djizak steppe area as well as Hungry steppe area is characterized by exclusive variety of soil-meliorative conditions that, in the first turn, causes differentiated approach to the selection of capacity and content of meliorative measures. Lands of Djizak steppe are saline in different degree - from non-saline to strongly saline and salts. Salts are mostly met on border part of flat proluvial plain of merging removal cones, in the middle and lower part of Zaamin removal cone as well as in stripe adjacent to the South Hungry steppe canal route.

Experimental plot was located in border part of alluvial-proluvial zone of removal cone of Zaaminsu river in 1.5 km from the South Hungry steppe canal on lands of prospective state farm # 4 and represented by gray-meadow strongly saline soils with salts. Common salt stocks in 3-m thickness of soils were 600-800 t/ha. Salt distribution along profile is irregular. Salts maximum is concentrated in top meter with gradual decrease downward along profile. Soils salinity is aggravated by high gypsum-bearing. Gypsum content in horizons of maximum accumulation reaches 30-50 %. Structure of soil is flaky with loam and sandy loam prevailing.

Character features of experimental plot soil are high density and low values of porosity and water permeability. Volumetric weight fluctuates within: 1.44-1.49 g/cm^3 for layer 0-100 cm; 1.61-1.63 for layer 100-200 and 1.66-1.68 g/cm^3 for layer 200-300 cm. Porosity varies within 43-44 %, 38-39 % and 38 % appropriately.

Free porosity under natural moisture and groundwater table about 3-m in layer 0-100 cm does not exceed 22-24% and abruptly decreases with depth. In horizon 100-200 cm it fluctuates within 6-8 %, and in horizon 200-300 cm it lowers to 2-4 %. Under field capacity free porosity is expressed in values 5.4 % for layer 0-100 cm and 1.6 % for layer 100-200 cm and is on average 3.5 % on 2 meters thickness (of volume). Water permeability from surface was 0.2 m/day.

Plot is drained by means of three open drains with depth of 3 m, joined by drain-collector, which disposes drainage and waste-water outside. Drain spacing - 200 m. After drainage network construction, plot leveling and ploughing on depth of 25 cm are conducted with following harrowing and tillage.

Three variants of leaching are tested: leaching by means of flooding on stripes, leaching on furrows and leaching by checks flooding (two fields with different norm). Stripes were cut in 5 m width and 115 m length during leaching on stripes; during leaching on furrows - furrows of 200 m length with space between them 0.9 m. In the third variant checks with area of 0.05 ha were constructed. Actual leaching norms were: the I-st field - 6.8; the II-nd field - 6.5; the III-rd field - 7.2, including surface release 2.7; the IV-st field - 4.5 th m^3/ha.

Analysis of salt regime observations (table 3.3.4) shows that high initial variety of salinity and lithology causes variety of leaching as well (as on depth, so on desalinization degree). In these conditions sufficient desalinization of top meter layer is observed with salt shifting into the second meter or all aeration zone desalinization with salt removal outside it.

53. Comparison of desalinizating effect of different variants of leaching showed equal efficiency of leaching as during irrigations by flooding on stripes, so during irrigations by checks flooding. Leaching on furrows turned out low effective (table 3.3.4). Comparatively deep furrows (18-20 cm) and their sparse disposition (in 0.9 m) led to the fact

that flooded during irrigations area was 50 % and the rest part was presented by evaporating surface.

54.

55. Table 3.3.4.

56. Soil desalinization under different variants of leaching on chlorine-ion, %

57.

Layer, cm	The I-st field: leaching on stripes	The II-nd field: leaching on checks	The III-rd field: leaching on furrows	The IV-st field: leaching on checks
0 - 25	0.231 / 0.067	0.223 / 0.050	0.229 / 0.286	0.153 / 0.028
0 - 50	0.275 / 0.073	0.266 / 0.074	0.263 / 0.216	0.208 / 0.047
0 - 100	0.262 / 0.263	0.264 / 0.134	0.264 / 0.227	0.238 / 0.078
0 - 200	0.231 / 0.189	0.252 / 0.212	0.244 / 0.261	0.234 / 0.137

58.

59. Note: numerator – before leaching, denominator – after leaching.

60.

61.

62.

63. In accordance with that soil salt regime was formed. Under furrows desalinization occurred similar to stripe and check variant of leaching. Under ridge desalinization intensity (along all profile) is much lower. In surface horizon of ridge (0-25 cm) salinity increased that is typical for furrow method of leaching. In order to increase efficiency of leaching on furrows G.Reshetov, 1986 proposes to supply water on short (100 m) and frequently cut (in 45 cm) blind furrows.

64. Concerning saline lands leaching groundwater regime of leached fields is very important, as it defines leaching efficiency.

65. Groundwater depth on the plot before leaching was about 3 m. Observations showed that under water supply free volume, which in aeration zone is about 2500 cu m/ha, is filled rather quickly after that groundwater rises to surface. Since this moment leaching slower down much as under low filtration abilities of soil of experimental plot main volume of water is spent for evaporation from open water surface.

66. Groundwater salinity increase after leaching proceeds due to salts washing out from above thickness of soils and their concentration in groundwater top horizon. It is known that desalinization does not occur immediately, but gradually. The best conditions of desalinization under leaching are obtained under checks flooding, when the most part of water corresponds not to evaporation, but directly to filtration through leached thickness. So, salts washing out intensity increases due to growth of saturation with salts of the first portions of water. Therefore, following portions of infiltrated water will be less saline. With water supply cessation slow groundwater table decrease proceeds with average rate 5-7 cm/day.

67. Analysis of observation results shows that for considered conditions optimal leaching regime is water supply by separate gifts. One norm fluctuates from 2.5 th cu m/ha, subsequent are supplied when groundwater table lowers down to 1.0-1.5 m under field surface. Under such regime leaching should be better carried out under cover of crops-developers, used as green-manure.

68. Experience of leaching and sodificated soils development matter of interest in Djizak steppe. In Uzbekistan sodificated soils have no similar wide extension as in the Siberia, Kazakhstan, Volga river zone and on North Caucasus. Relatively low level of study of their geographical extension, genesis and reclamation methods are explained by above-mentioned fact in the first turn. Complexity of sodificated soil development is aggravated by that fact that reclamation method of sodificated soils, developed for moderate climatic regions of country are not acceptable for dry gray soil zone of Central Asia.

69. Soil Institute of Uzbekistan investigated and established that sodificated soils are comparatively widely extended in region of Zaamin-Khavast depression of Obruchev sink of Djizak steppe. According to data of Sredazgiprovodkhlopok Institute top soil of Obruchev sink is presented by salts, strongly sodificated and slightly sodificated half-hydromorphous soils.

70. Meadow-gray sodificated soils are formed on leveled and lowered plots under grass-salts associations. Their surface is broken by cracks with width of 1-3 cm, to the depth of 1 m. These soils differ with availability of very compacted with coarse-grained horizon in top part of soil profile. Chemical analysis data show high salinity of top 1-meter thickness with salt content maximum within 50-200 cm. Beneath salt content decreases and on the depth of 3-4 m does not exceed 0.5-0.1 %. In cations sodium and magnesium ions prevail and in absorbed base - sodium (>60 %) under very low content of calcium. Analysis showed alkali availability along all soils profile. Gypsum in top part of profile is practically absent (<0.5%), downward profile its content increases up to 20 %.

71. Practice of soil reclamation of soda complex in USSR and other countries (Italy, Romania, Spain, Hungary, etc.) shows that reclamating measures are very diverse and demand strict differentiation with respect to chemical, physical, biological and lithological-geomorphological peculiarities.

72. As meadow-gray alkaline soils of Obruchev sink contain big quantity of toxic salts (to 1.0-2.4 % of soil mass), the beginning link of reclamation system was leaching with usage of chemical meliorants (SANIIRI with participation of Sredazgiproveodkhlopok Institute experts). Before leaching meliorants were applied according to the following variants:

73. I. conrol (without application of meliorants);

74. II. lignin 4 t/ha and biological silt 2 t/ha;

75. III. gypsum 8 t/ha and manure 50 t/ha;

76. IV. mulching by sand with 5 cm layer over ploughed soil;

77. V. mulching by sand with 5 cm layer over virgin land;

78. VI. gypsum 12 t/ha;

79. VII. manure 50 t/ha.

80. It worth to note that water supply volume of 5.0 th cu m/ha for leaching in autumn-winter period in two gifts with interval 5-8 days, turned out insufficient for desalinization 0-50 cm of thickness to toxicity threshold. After repeated water supply by norm of 5.0 th cu m/ha top 1-meter thickness desalinization was obtained, of which 95.5-98.7 % of water soluble salts was removed comparing to initial content (table 3.3.5).

81. In all variants with meliorants application soil desalinization proceeds more intensively, than in control. The best example is water supply of the first 5 th cu m/ha for leaching. So, in the control after leaching in 1-meter layer 42.0 and 56.3 % of chlorine and

sodium remained versus initial content, while in other variants these values are much lower (7.2-34.1 and 11.4-45.2 %, appropriately).

82.

Table 3.3.5

Dynamics of salt washing out under leaching of salt soil (mg-ekv/100 g of soil)

Version	Layer, cm см	Initial salinity		Salinity after 5 th.m^3/ha		Salinity after 10 th.m^3/ha	
		Cl^-	Na^+	Cl^-	Na^+	Cl^-	Na^+
1	0-50	2.57	11.19	0.78	4.44	0.21	1.68
				30.4	39.7	8.2	15.0
	1-100	5.14	16.08	2.16	9.05	0.23	2.21
				42.0	56.3	4.5	13.7
II	0-50	2.42	10.31	0.48	3.59	0.22	1.91
				19.8	34.8	9.1	18.5
	0-100	4.87	16.99	0.91	7.68	1.19	2.56
				18.7	45.2	3.9	15.1
III	0-50	5.50	19.16	1.42	6.42	0.11	0.79
				25.8	33.5	2.0	4.1
	0-100	7.91	22.17	2.70	9.85	0.10	1.23
				34.1	44.4	1.3	5.5
1У	0-50	2.40	9.25	0.45	2.18	0.11	0.36
				18.8	23.6	4.6	3.9
	0-100	4.23	14.58	0.98	5.23	0.11	0.50
				23.2	35.9	2.6	3.4
У	0-50	5.42	17.51	0.32	3.39	0.19	1.28
				5.9	19.4	3.5	7.3
	0-100	9.17	21.71	0.66	6.11	0.27	2.43
				7.2	28.1	2.9	11.2
У1	0-50	3.29	16.60	0.36	2.67	0.19	2.40
				10.9	16.1	5.8	14.5
	0-100	6.60	22.8	0.66	5.52	0.25	3.94
				10.0	24.2	3.8	17.3
УII	0-50	5.34	14.69	1.28	1.67	0.24	1.77
				23.9	11.4	13.8	12.0
	0-100	5.38	22.45	0.93	9.29	0.24	2.91
				17.0	41.4	4.4	13.0

Note: numerator - before salinity, mg-ekv/100 g of soil; denominator - versus initial content, %.

83.

84. After leaching on experimental plot, alfalfa and barley, as crop-developers, were grown (combined sowing) and cotton crop of specie Tashkent-1 with appropriate agrotechnique. Under leaching norm 1.3-2.0 th cu m/ha irrigation norm of cotton crop under 6 irrigations was 7.5-9.9 th cu m/ha and alfalfa - 6.8-8.1 th cu m/ha. Under above mentioned irrigation regime salt regime of top 1-meter thickness of soil has relatively sustainable character. It is found that for two years of growing alfalfa roots shouted alkaline layer and reached 1.5-2.0 m into depth. It was found that where alfalfa or cotton roots shouted (except of control variant), as a rule, vertical crack was formed and root soil was structured and enriched with humus. Due to chemical meliorants effect and applied agrotechnique of alfalfa and cotton cultivation physical-chemical quality of sodificated soils were sufficiently improved.

85. Chemical meliorants and crop-developers effect was the most obvious on the second year after leaching in variants II (lignin and biological silt), III (gypsum and manure) and IV (gypsum). The most residue content of absorbed sodium was noted in control and in variants with mulch application (over virgin and ploughed soil) absorbed sodium quantity decreases only in top horizons.

86. Reduction of absorbed sodium content is accompanied with alkali decrease. Under its initial value in alkaline layer (30-90 cm) about 8.6-8.9 after two years of reclamation environment became neutral or slightly alkaline, that is typical for majority of gray soils of Central Asia.

87. It worth to note that rate of humus content lowering under sodificated soils cultivation with application of manure, gypsum, lignin and biological silt are much slower than in other variants. It has big positive meaning as humus, possessing high variance, hydro and mobility plays role of factor, which promotes improvement of qualitative composition and physical-chemical properties of alkaline soils in general. Application of organic-mineral combinations during reclamation of meadow-gray alkaline soils improves to certain degree meliorated soils nutrient regime as well.

88. Under influence of applied meliorative measures (application of organics, chemical meliorants and cultivation of crop-developers) indicators of water-physical properties of sodificated soils were sharply improved. Variant with alfalfa growing reflected more obviously improvement of these properties of alkaline soils.

89. So, for successful reclamation of meadow-gray soils of alkaline-salt complex staged system of reclamation is the most rational, including leaching by norm, calculated for desalinization of 1-meter thickness, meliorants application, alfalfa cultivation during two-three years. From the meliorative point of view, combined application of gypsum (8-10 t/ha) and organics (manure 50 t/ha), wastes of hydrolysis industry: lignin (4-5 t/ha) and biological silt (2 t/ha), as well as gypsum (10-12 t/ha) is the most effective. Implementation of this reclamation system allows already in two-three years to obtain sufficiently high and stable crop yields of main crops (table 3.3.6).

90. Analysis of results of multi-year researches and experience of advanced farms shows that operational leaching is main method of salt regime regulation in root zone and formation of favorable conditions for basic crops cultivation. Norms and terms of its conduction in each zone must be determined with respect to climatic water-related conditions and soil salinity degree. Soil desalinization with application of methods of lands operational leaching is widely practiced in farms of Uzbekistan, Tadjikistan and Turkmenistan.

Table 3.3.6

Crop yield capacity of crop-developers according to years of reclamation of alkaline soils

Variant	1976				1977			
	Cotton		Alfalfa		Cotton		Alfalfa	
	c/ha	% versus control	c/ha	% versus control	c/ha	% versus control	c/ha	% versus control
1 (control)	18.8	-	108	-	18.3	-	122.0	-
2	23.0	122.3	118	109.3	23.8	130.1	161.3	132.2
3	22.8	121.3	160.6	148.7	26.5	144.8	176.7	144.8
4	23.5	125.0	182.6	169.1	23.7	129.5	171.6	140.4
5	19.0	101.0	151.3	140.1	20.6	112.6	154.7	126.8
6	20.7	110.1	121.3	112.3	22.6	123.5	157.3	128.9
7	24.2	128.7	147.3	136.4	26.0	142.1	159.3	130.6

CONCLUSION

1. An arid zone soil salinization, arising under irrigation development, is one of important factors of lands productivity reduction. At the present time of total irrigated area of Cehtal Asia and South Kazakhstan about 7,7 mln 35-40 % is subjected to salinization in different degree. Therefore conducting of irrigation farming in the republics of Central Asia is tightly connected with measures, which promote soil desalinization up to level of salt toxicity threshold for main agricultural crops.

Leaching irrigation on the background of drainage are basic method of desalinization of soil and ground water top horizon. By now in CA rich experimental material and theoretical development based on laws of physical-mechanical hydrodynamics, are collected. This fact allows to ground norms and terms of conduction of as operational so and capital leaching with respect to soil-meliorative, hydrogeological and agrometeorological conditions with sufficient accuracy.

2. Results of field researches on methods of desalinization of soil and top horizon of ground water, accumulated in CA, show that capital leaching is the most effective measure for salt removal from aeration zone and ground water desalinization.

Under capital leaching accelerated desalinization of not only soil layer, but aeration zone and ground water is obtained even within hardly reclaimed strongly saline lands. However soil desalinization with application of capital leaching methods is costly measure, demanding big capital expenses and what is the most important, huge water and other inputs. Therefore of capital leaching should be taken as prospective under water resources shortage except desalinization methods through rice crop. In prospective of it is necessary to introduce strongly saline in-contour fallow land into agricultural rotation soil leaching can be carried out through rice crop under well operating drainage system.

3. In modern conditions under lack of material-technical and, especially, water resources on large massives and administrative rayons of Central Asia the most effective method of soil and ground water desalinization is operational leaching in combination with growing period irrigation by means of which seasonal irrigation leaching regime is kept.

Operational leaching is calculated for gradual desalinization of soil and ground water that provides the least ecological influence on irrigated areas and environment. Obligatory condition of operational leaching efficiency increase is providing with high workability of drainage system on irrigated lands while following technology of their conduction on small checks.

Norms and terms of operational leaching conduction are established by water - physical parameters of soil, drainage system workability, agroclimatic conditions of year with respect to water resources, supplied for administrative rayons and certain farms. In humid year terms of operational leaching are not limited by season, that is possible to choose any season autumn-winter or early spring. But soil should be ready by the beginning of sawing. In dry years term of leaching conduction should be chosen in the following way: by the beginning of sowing optimal moisture and concentration of soil solution should be formed in rool-zone on irrigated lands. The best of all operational leaching should be conducted depending on salinity limiting water supply norms in February-March.

5. Desalinizating effectiveness of operational leaching mostly depends on irrigation regime of vegetation period waterings. Irrigation depth and irrigation norms of agricultural crops determined due to plants biological requirement for water must prevent soil salinity restoration. In other words, annual water supply to fields taking into account must satisfy demand of irrigation leaching regime and exceed total evaporation on 10-15 %.

6.On-hardly reclamed strongly saline lands, demanding increased leaching norm, leaching should be conducted with application of chemical meliorants, deep ploughing, deep harrowing, promoting improvement of soil water-physical qualities, their ability to be washed and finally, irrigation water saving.