

Main results of close horizontal drainage study in Uzbekistan

Main natural indicators and designed drainage parameters	Fergana province, c/f "Bolshevik" and "Soviet" of Altyaryk district	Golodnaya steppe, s/f N 6 "Titov"		
		Southern part of farm, 1- Study pilot plot	Central part of farm	Northern part of farm
Syrdarya basin				
Gross area, ha	350	60	150	200
Surface slope gradient	Highest to NW; 0.0021-0.003 the smallest in S-W; 0.0002-0.0003	0.005	0.003	0.001
Lithology	Middle and heavy loam with shoh inter-layers on depth of 0.7-1.2 m. Beneath - heavy loam with interlayers of sandy loam, clay and sand	Light and middle loam with gipsum interlayer on depth of 0,5-1,0 m. Bed rock-clay with thickness 4-5 m on depth of 20 m	Light and middle loam with gipsum interlayer on depth of 0,8-1,0 m. Bed rock-clay with thickness 4-5 m on depth of 20 m	Light and middle loam with gipsum interlayer on depth of 1,0-1,2 m. Bed rock depth is 8-15 m
Natural drainability (ground water outflow availability)	Naturally weakly drained area	Naturally very weakly drained area	Naturally very weakly drained area	Naturally very weakly drained area
Drainage operation condition (cleavage, bedrock position)	Multi-layer media, bedrock is very deep.	Multi-layer media, bedrock depth 30-35 m	Multi-layer media, bedrock depth 20-25 m	Multi-layer media, bedrock depth 8-15 m
Drainage operation regime (head) ground water natural regime: during growing period, before leaching; during leaching; after leaching up to 1- Study irrigation, m	Low head On irrigated fields 1.2 - 1.6; 2.3-3.0; 1.0-1.2; 1.8-2.5; On non-irrigated fields 2.0-2.5; 3.0-3.5; 1.8-2.5; 2.4-2.6	Low head due to South Golodnostepsky canal influence Before and after leaching and vegetation irrigations 2.6-3.0 m, during growing period 1.5-2.5 m	Low head due to vegetation irrigations Before and after leaching and vegetation irrigations 2.8-3.0 m, during growing period 1.8-2.3 m	Low head due to vegetation irrigations Before and after leaching and vegetation irrigations 2.6-3.0 m, during growing period 1.8-2.3 m.
Soil type	Marshy and meadow-marshy	Marshy (hydromorphis and grey-meadow)	Grey-meadow	Grey-meadow
Permeability coefficient of unsaturated zone soil, m/day	0.2-2.0	0.12-0.24	0.28-0.5	0.3-0.58
Ground water salinity before drainage construction, g/l	On non-irrigated lands 15-21 On irrigated lands 4-8	20-45	25-30	25-30
Ground water salinity type	Sulfate, seldom carbonate-chloride with high content of sodium	Sulfate - sodium	Sulfate - chloride with high content of sodium	Sulfate - chloride with high content of sodium
Soil salinity degree before drainage construction	Strongly saline and salts	Strongly saline and salts	Slightly saline, medium and strongly saline	Slightly saline, medium saline

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Salinity type	Sulfate, chloride-sulfate	Chloride-sulfate, sulfate-chloride	Chloride-sulfate	Chloride-sulfate
Drain depth, m	2.8-3.2	2.5-3.0	2.6-3.5	2.8-4.0
Drain spacing, m	238-380	90-100	100-120	160-180
Drain length, m	1.663-1.713 (всего 8.395)	0.8-1.0	1.0-1.2	1.2-1.3
Specific extent, m/ha	Total extent 36.5, including close 24.2	102	75	42-45
Tube material and diameter mm	Asbesto-cement, 141-189, length 3-4 m	Polyethilen tubes 100-150 length 6-8 m. Asbesto-cement 100-150 m, length 3-4 m.	Polyethilen, tile and ceramic 100-200. Length of ceramic tubes 0.33-0.6-1.0 m	Tile and ceramic tubes 100-150 mm, Length 0.33-1.0 m
Perforation type, slot width (orifice diameter) mm	Round d=8 mm 26-30 orifices per 1 m; total orifice surface - 0.254-0.34 %	Slofled 100 x 3, step 300 mm, openness 0.3-0.5 %	Longitudinal slots, orifices 5 mm, openness	Openness 0.3 %
Screen material and thickness, sm	Gravel-sand mix, 15-20 sm	Sand-gravel mix, 10-15 sm	Sand-gravel mix, 10-15 sm	Sand-gravel mix, 10-20 sm
Average drainage modulus l/s/ha	0.22	0.12	0.17	0.16
Irrigation depth, m ³ /ha	1500-1800	980-2195	525-3040	886-3477
Number of irrigation	3-4.5	3-4	2-3.5	2-5
Leaching norm, th.m/ha	2.5-3.0, реже 4.5-6.15	Operation norm 3, seldom 5	2.5-3.0	3.0-3.5
Ground water regime between drains in spring and autumn, mm	Leaching period (I-III) 0.8-1.2; growing (VI-IX) 1.2-1.6; after vegetation before leaching (X-XII) 2.4-2.8; after leaching before vegetation (IV-VI) 1.8-2.3	During capital leaching 0.1-0.2; during operations leaching (I-III) 1.8-2.0; during vegetation (VI-IX) 2.4-2.5; After vegetation before operational leaching (X-XII) 2.5-3.0. After capital and operation leaching (XI-IV) 2.0-2.4	During operational leaching (I-III) 1.8-2.2; during vegetation (VI-IX) 2.4-2.6; after vegetation before operational leaching (X-XII) 3.0-3.5; After operational leaching before vegetation (I-IV) 2.2-2.4	During operational leaching (I-III) 1.6-2.0; vegetation. (VI-IX) 2.2-2.4; After vegetation before leaching (X-XII) 3.2-3.8 after leaching before vegetation (I-IV) 2.0-2.4
Ground water level recommended depth for growing period, m	Critical 2.0-2.2, recommended 1.5-2.0	Critical 2.4-2.5, recommended 2.5-2.8	Critical 2.4-2.5, recommended 2.5-2.6	Critical 2.4-2.5, recommended 2.45-2.5
Working head, m	1.0-1.5	0.8-1.0	0.4-0.5	0.2-0.4
Ground and drainage water mineralization changes, g/l	During 10 years ground water salinity decreased from 9.03 to 4.85, on chlorine from 0,245 to 0,075, drainage water from 6,11	During 9 years ground water salinity decreased from 20-45 to 15-19, drainage water from 44.8 to 16.1	During 9 years ground water salinity decreased from 25-30 to 11-11,2, drainage water from 26 to 9,1	During 8 years ground water salinity decreased from 25-30 to 12-16, drainage water from 19.8 to 12.1

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					Southern part of farm, 1- Study pilot plot	Central part of farm	Northern part of farm	
	to 4,017, and on chlorine from 0.167 to 0.07							
Ground and drainage water salinity type	Carbonate-sulfate				Sulfate-sodium	Sulfate-sodium	Sulfate-sodium	
Ground water lowering rate, cm/day	1.5-3.5; lowering duration 40-60 day				4.0-6.2; lowering duration 40-50 day	5-9; lowering duration 35-45 day	3-6; lowering duration 50-65 day	
Ground water depletion rate after irrigation and leaching, cm/day	4-5				12-16	8-13	6-12	
soil salinity degree	slight and medium				slight and medium	slight, medium	slight, medium	
Volume of salt influx per year, th/ha	36.6				46.6	14.2	17.0	
Water expenses for the salt removal, m ³	150				105-140	122-144	135-160	
Recommended drainage modules, l/sec/ha (for vegetation, during leaching)	0.25 0.35				Mean 0.35 Mean 0.6-0.7	Mean 0.26 Mean 0.4-0.6	Mean 0.26 Mean 0.4-0.6	
Recommended irrigation depth, m ³ /ha	№ 1-1500, № 2-1800, № 3-1500, №4 – 1200, totally 6000				For operation period			
					№ 01 operation – 3500, № 1-900, № 2 – 1000, № 3 – 900, total 6300	№ 01 operation. - 3000, № 1 – 800, № 2 – 2000, № 3 – 900, total 5700	№ 01 operation. – 3000, № 1 – 800, № 2 – 1000, № 3 – 900, total 5700	
Recommended leaching norm, m ³ /ra (slightly saline, strongly saline and salts)	Light loam 1.5 2.5 4.0 6.0	middle loam soil 2.0 4.0 8.0 12.0	Heavy loam 3.0 6.0 16.0 24.0	slightly saline – 10300 medium saline – 17200 strongly saline – 38600 salts – 44000			slightly saline – 5660 medium saline – 13400 strongly saline – 29300 salts – 32000	slightly saline – 4570 medium saline – 11200 strongly saline – 26000 salts – 28000
Drain depth th/m	3.0-3.5				2.8-3.5	3.0-3.5	3.0-3.5	
Permeability coefficient, m/day	K< 1.0 (low permeability) K=2.0 (medium permeability)) K> 2.0 (high permeability)				K=0.1-0.24	K= 0.5-0.6	K= 0.5-0.6	
Drain spacing, mm	150-174, 200-250, 250-300				90-100	100-120	160-180	
Drain diameter, mm	Upper (500m length)				100-200 (depending on drain	100-200 (depending on drain	100-150 (depending on drain	

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		Southern part of farm, 1- Study pilot plot	Central part of farm	Northern part of farm
	150 200 250 (according to design)	length)	length)	length)
Recommended filling and its thickness, cm	Gravel-sand mix with content of fraction 5-20 mm to 10 %, 0.25-5 mm 30-85 %, 0.25 mm not more 7%	sand- gravel mix $D_{10} - 0.15-0.3$ mm $D_{50} - 1.0-2.0$ mm $D_{60} - 1.4-2.5$ mm irregularity coefficient 7-10, glass mates	sand- gravel mix $D_{10} - 0.15-0.3$ mm $D_{50} - 1.0-2.0$ mm $D_{60} - 1.4-2.5$ mm irregularity coefficient 7-10, glass mates	sand- gravel mix $D_{10} - 0.15-0.3$ mm $D_{50} - 1.0-2.0$ mm $D_{60} - 1.4-2.5$ mm irregularity coefficient 7-10, glass mates
Recommended year of above drain stripes development, year	On 3-5	each 1-2	each 1-2	each 2-3
Duration of reclamation period, year	6-7	8-10	6-8	6-8
Term return, year	5-6	6-8	5-6	5-6
Annual economic benefit from close drainage introduction, rouble/ha	580		409-669	

Main natural indicators and established designed drainage parameters	Khorezm province, Yangiaryk district, collective farm "Pravda"	Bukhara province, Alat district, collective farm "F.Khodjaev"
Amudarya basin		
Gross area, ha	303.7	250
Site surface gradient	-0.0002	0.0002...0.0003
Lithology	from surface - loam, 1.5-2.0 m, grey sand, 10 m; red fine - grained sands, 40-50 m	interlaying sandy loam, loam, clay, permeability coefficient 0.1-0.4 m/day
Natural drainability (groundwater outflow availability)	naturally low drained zone	naturally low drained zone
Drainage operation conditions (cleavage, bedrock position)	multi-layer media, bedrock depth 60-70 m	multi-layer media, bedrock depth 10 m
Drainage operation regime (head)	low head	low head
Groundwater natural regime: during vegetation; before leaching; during leaching; after leaching before 1 st irrigation, m	during leaching 0.0-1.3 m; during vegetation 1.5-2.0 m; during non-vegetation period 2.0-2.6 m	on irrigated fields average for vegetation, 1.67-2.08 m
Soil type	meadow	meadow-desert
Unsaturated zone permeability, m/day	upper loam layer 0.15-0.40; grey sand 19.0; red sand 1-3 m	1 st sub-site 0.5-0.3 m/day; 2 nd sub-site 0.5-0.3 m/day
Groundwater salinity before drainage construction, g/l	8.8	1 st sub-site - 4-60; 2 nd sub-site- 2-15
Groundwater salinity type	sulfate	sulfate

Main natural indicators and established designed drainage parameters	Khorezm province, Yangiaryk district, collective farm "Pravda"	Bukhara province, Alat district, collective farm "F.Khodjaev"
Soil salinity degree before drainage construction	strongly saline and salts	1 st sub-site - medium and strongly saline; 2 nd sub-site - slightly and non-saline
Salinity type	sulfate	sulfate, more seldom chloride-sulfate
Drain depth, m	2-3	1st sub-site - 2.4-2.95 2nd sub-site - 2.2-2.6
drain spacing, m	150-300	1st sub-site 80-150 m 2nd sub-site - 300-400 m
Drain length, m	0.26-0.9 (total 9.136)	1st sub-site 400-650 m 2nd sub-site 350-450 m
Specific extent, m/ha	total 41, including close \approx 39	1st sub-site 65-125 m/ra 2nd sub-site 25-35 m/ra
Tube material and diameter, mm	asbestos-cement 141-189, length 3-4 m. sand-concrete – 150, length 0.8-1.0 m. sand-concrete on clay cement– 150, length – 0.8 m. ceramics – 289, length 1.0 m	plastic corrugated
Perforation type, slot width (orifice diameter), mm	round d = 5-8 mm, openness 0.2 – 0.5 %	
Screen material and thickness, cm	1) gravel-sand mix, 15-20 cm; 2) two-layer filter, 30-40 cm; 3) one-layer filter made of coarse sand, 5-10 cm; 4) crashed stone filter in basement of drainage tube 10-20 cm	protection winding with gravel-sand filling
Average drainage modulus, l/sec/ha	0.49	0.05-0.08 (2437 – 1623 m ³ /ha)
Irrigation depth, m ³ /ha	700-2500	cotton – 2.8 – 2.0 th.m ³ /ha maize – 1.2 – 1.6 th. m ³ /ha wheat – 1.8 – 2.2 th.m ³ /ha
Number of irrigation	3-4	cotton – 3-4 maize 5-6 wheat – 4-5
Leaching norm, th. m ³ /ha	3-6	2.5-3, seldom 3-4
Groundwater regime between drains in spring and autumn, m	leaching period (III) 0-1.3, vegetation (VI-IX) 1.5-2.0; after vegetation before leaching 2.0-2.6 m	
Recommended groundwater depth for vegetation, m	critical 2.0-2.8, recommended 1.8-2.0	critical 2.0-2.2, recommended 1.6-1.75
Working head, m	0.5-1.0	0.3-0.8
Ground- and drainage water salinity changes, g/l	during 3.5 years of drainage operation groundwater salinity decreased from 8.8 to 3.5	during 3 years drainage effluent salinity on strongly saline soils decreased from 20-52 to 9-35 g/l; on less saline soils - from 9.4-8.5 to 2.5-4.0 g/l
Ground- and drainage water salinity type	sulfate	sulfate
Groundwater lowering rate, cm/day	10-20; depletion duration 5-10 day	
Groundwater depletion rate during irrigation and leaching, cm/day	10-20	0.08-1.13 m/day

Main natural indicators and established designed drainage parameters	Khorezm province, Yangiaryk district, collective farm "Pravda"	Bukhara province, Alat district, collective farm "F.Khodjaev"
Soil salinity degree	non-saline and slightly saline, somewhere medium saline	areas with medium and strongly saline soils reduced by 3-5 times, salts disappeared
Annual salt removal, t/ha	46.0	salt removal during 4 years 274 t/ha (1st sub-site), 27.7 t/ha (2nd sub-site)
Water expenses for 1 t salt removal, m ³	260	
Recommended drainage modulus l/sec/ha (during vegetation, leaching)	0.4-0.5 1.2	
Recommended irrigation depth, m ³ /ha	№ 1-1500, № 2-1500, № 3-1500, №4 - 1200, total 6000	
Recommended leaching norm, th. m ³ /ha (slightly, strongly saline and salts)	slightly saline - 3000 medium saline - 5000 strongly saline - 6300 salts - 7500	
Drain depth, m	2.5-3.0	on light soils 1.9-2.3 m, on heavy soils 2.0-2.4
Permeability coefficient, m/day		
Drain spacing, m	200-300	80-150 m
Drain diameter, mm	upper (200 m length) 150 (according to design)	according to design
Recommended filter filling and its thickness, cm	gravel-sand filling, thickness 10-15 cm; gravel fraction diameter 0.5-2.0 mm	
Recommended year of above drain stripes development, year	on 2	on 3-5
Reclamation period duration, year	3-4	4-5
Return term, year	3-4	
Annual economic benefit from close drainage introduction, rouble/ha	482-515	