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Satbayev University

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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Zhaparkulova E.D.[1*], Amanbayeva B.Sh.[1], Dzhaisambekova R.A.[2], Mirdadayev M.S.[2], Mosiej J.[3]

[1]Kazakh national agrarian university, Almaty, Kazakhstan;
[2]Kazakh scientific research institute of water economy, Taraz, Kazakhstan;
Warsaw University of Life Sciences, Warsaw, Poland.
E-mail: ermekull@mail.ru

GEOLOGICAL STRUCTURE OF SOILS AND METHODS OF WATER RESOURCES MANAGEMENT OF THE ASA RIVER

Abstract: the article presents the results of studies of the geological structure of soils and methods of water resources management. From a geological point of view, the massif of the Asa River belongs to the complex of modern alluvial - proluvial deposits, contributes to their complex relationship in size and area, lithological differences [1]. In the valley of the Asa River, hydromorphic soils developed, influenced by shallow mineralized groundwater [2, 3]. The soil cover of desert areas consists of loose gray soil. Meadow-serozem irrigated loamy sandy soils, the parent rock is sandy loam, the bedding is sand [4].

The main source of irrigation for plants in the Asa river basin is surface water. However, during the growing season, there is an annual shortage of irrigation water; over the years of research, the water supply for 1 ha of irrigated land in the Zhambyl region was 3561 - 5988 m^3/ha. The analysis of the water balance shows that irrigation along furrows increases the loss of water, the consumption of which is 2100 m^3/ha [5]. When irrigating through the furrow, losses for consumption reduced to 600 m^3/ha, i.e. 29% higher than furrow irrigation. Water-saving technology of irrigation through the furrow will allow: to reduce the size of water intake for irrigation to 15-35%; reduce economic costs; will increase the yield of agricultural products.

Key words: geology, soil cover, surface water, water-saving technology, watering by furrow, watering through furrow, evaporation, infiltration.

Introduction. The main source of irrigation for plants in the Asa river basin is surface water. However, during the growing season, there is an annual shortage of irrigation water; over the years of research, the water supply for 1 ha of irrigated land in the Zhambyl region was 3561 - 5988 m^3/ha [6]. The study area is located in the Asa river basin on the irrigated lands of the Besagash village, located in the south of Kazakhstan in the Zhambyl district of the Zhambyl region.

In the upper hydrogeological layer of the interfluvial massif Asa, from a geological point of view, the complex of modern alluvial-proluvial deposits contributes to their complex relationship in size and area, lithological differences [1]. The geological structure of the upper layer of the hydrogeological massif at the Asa site includes complex alluvial deposits of proluvial age of the Middle Quaternary - modern age with a very complex relationship with lithological differences in size and context [2,3].

The study area belongs to the low-carbonate gray soils of the periphery of semi-deserts in the foothills of the Northern Tien Shan. The basis of the irrigated bark of agriculture made up of gray soils. [2]. In the valley of the Asa River, hydromorphic soils are developed, influenced by shallow mineralized groundwater. The soil cover of desert areas consists of loose gray soil. Soils with poor water permeability, when wet, harden, and when dry they turn into a solid mass. In the valley of the Asa river basin, sands cover 10-20% of the total land area and distributed over the territory in small areas [3].

The climate in the region is continental, the average annual amount of precipitation is low, without irrigation, agriculture is impossible. Due to the continental climate, the values of evaporation and infiltration of water resources are too high here. The existing methods of water resources management inevitably lead to large losses of irrigation water for infiltration, discharge and evaporation, the value of which reaches 60-70% of the water intake [7]. Field studies included the study of furrow irrigation techniques with water supply to each furrow and through the furrow, the study of the porosity, density, and humus of soils.

Results. To characterize the soil of the experimental production site, we used the morphological description performed by the Kazgiprozem Institute on the irrigated lands of the Zhambyl Agricultural Experimental Station at the Besagash site. Meadow-serozem irrigated loamy sandy soils. The parent rock is sandy loam, the bedding is sand.

A -	0-33 cm	Gray, sandy loam, boils from the surface, weakly compacted, radicular, the transition is clear in color, lumpy-silty
B -	33-50 cm	Grayish-fawn, lumpy-silty structure, sandy loam, dry, radicular, gradual transition.
BC -	50-67 cm	Lighter, loamy (sandy), fresh, compacted, effervescent, gradual transition
C -	67-105 cm	Yellowish fawn, sandy loam, sand towards the end of the profile, moist, structureless, boils, compacted [4].

The results of studying the density of soils showed that they evenly distributed along the soil profile. The homogeneity of the experimental production site confirmed by the results of statistical processing of data on the density, density of the solid phase and porosity of the soils of the root layer (Table 1).

Table 1 – Indicators of the physical properties of the soils of the experimental production site

	Horizons, cm	Indicator values			
		minimum	medium	maximum	The coefficient of variation, %
Density, t/m^3	0-20	1,47	1,50	1,52	12,6
	20-40	1,55	1,59	1,61	10,7
	40-60	1,62	1,65	1,67	8,3
	60-80	1,64	1,68	1,71	10,1
	80-100	1,72	1,73	1,76	9,2
Solid phase density, t/m^3	0-20	2,71	2,72	2,73	6,3
	20-40	2,71	2,72	2,74	11,8
	40-60	2,72	2,73	2,74	7,4
	60-80	2,73	2,73	2,74	6,9
	80-100	2,73	2,73	2,74	6,5
Porosity, %	0-20	41,3	43,6	44,5	9,2
	20-40	40,9	41,7	42,8	9,7
	40-60	38,5	39,3	40,4	7,2
	60-80	37,7	38,1	39,2	6,8
	80-100	35,3	36,2	37,6	7,2

For example, the coefficient of variation for soil density in 0-100 cm layer varies within 8.3-12.6%. These figures are less than 20%, which indicates a low variability in soil density. Similar low indicators of the coefficient of variation also obtained for the density of the solid phase and porosity of soils [4].

The results of studying the field moisture capacity of soils show that they have an uneven distribution along the soil profile. The maximum value of the field moisture capacity noted in the 80-100 cm layer - 19.3% of the dry soil mass. Such an unevenness of the values of the field moisture capacity of soils is associated with the inhomogeneity of the mechanical composition of the root layer [8].

Chemical analysis of soils shows that the maximum value of humus occurs in the upper 0-20 cm layer. In this layer, humus reserves amounted to 1.44%. With an increase in the depth of the root-inhabited layer of soils, their size decreases and in the 40-50 cm layer it is 0.40%. Gross nitrogen and phosphorus have a similar distribution over the soil profile (Table 2).

Table 2 - Stocks of humus and gross forms of nutrients in the soils of the pilot plant

Horizons, cm	Humus		Gross forms,%		CO2 carbonates
	%	t/ha	Nitrogen	Phosphorus	
0-10	1,44	21,9	0,158	0,122	5,10
10-20	1,09	17,0	0,176	0,118	5,08
20-30	0,87	13,9	0,167	0,118	5,36
30-40	0,75	12,1	0,078	0,065	9,00
40-50	0,64	10,4	0,057	0,050	8,74
50-60	0,40	6,6	0,042	0,041	7,40
0-30	1,13	52,8	0,167	0,119	5,18
0-60	0,87	81,9	0,113	0,086	6,78

During the growing season, soil moisture in the root zone maintained in optimal condition. For example, when watering along the furrows, the cabbage was the very furrow that was watered [8]. At the same time, the moisture content in the 0-100 cm layer ranged from 18.2 to 22.4% (Table 3). The moisture content of the soil on the ridge between the irrigated and non-irrigated furrows in the upper layers has a lower moisture content than in the irrigation furrow. In the lower soil layers, moisture increases. A similar dynamics of soil moisture on the profile also took place in the non-irrigated furrow [9, 10].

Table 3 - Soil moisture in the root zone during furrow irrigation of cabbage on irrigated lands in Besagash

Soil moisture, %						
Horizons, cm	The bottom of the watered furrow		Ridge		Dry furrow bottom	
	%	$м^3$/га	%	$м^3$/га	%	$м^3$/га
0-20	18,2	538	12,7	376	9,8	290
20-40	19,8	598	16,3	492	12,7	384
40-60	20,1	663	18,5	610	17,4	574
60-80	20,9	715	20,4	698	20,6	705
80-100	22,4	770	22,3	767	22,4	770
0-100	20,3	3284	18,0	2943	16,6	2723

Analysis of the water balance shows that irrigation along furrows increases the loss of water, the consumption of which is 2100 m^3/ha. When irrigating through the furrow, losses for consumption reduced to 600 m^3/ha, i.e. by 29% compared to furrow irrigation (Table 4) [11].

Table 4 - Water balance of cabbage with different irrigation technologies

Balance indicators	Watering by furrow	Watering through furrow
Initial moisture reserves, m^3/ha	1470	1470
Precipitation, m^3/ha	695	695
Irrigation rate, m^3/ha	7200	6000
Groundwater inflow, m^3/ha	4800	5600
Total	14165	13765
Infiltration losses, m^3/ha	2950	2400
Water loss for discharge, m^3/ha	2100	1500
Final moisture, m^3/ha	2350	2210
Evapotranspiration, m^3/ha	6765	7655
Total	14165	13765
Productivity (biological), t/ha	32,1	38,4
Water consumption coefficient (water consumption per ton of cabbage), m^3	211	199

With furrow irrigation, infiltration losses of cabbage were 2950 m^3/ha. The minimum amount of losses of infiltration of irrigation water obtained during irrigation through furrows, which amounted to 2400 m^3/ha. This compared to the reference case below at 550 m^3/ha. Furrow irrigation reduces the amount of infiltration losses by 30-40% [11, 12].

In the conditions of experimental production plots, during irrigation at the beginning of the growing season, it is necessary to strive to moisten the upper layer of the thickness of the root zones. This ensures a decrease in the volume of losses of irrigation water for infiltration. However, with furrow irrigation, an increase in soil moisture observed over the entire area of irrigated land [11, 12, 13]. This confirmed by the data on soil moisture obtained after irrigation (Table 5).

Table 5 - Soil moisture when changing irrigation technology

Horizons, cm	Technology of watering					
	by furrow					
	Furrow bottom		crest of furrow		average	
	% from weight of the dry soil	% from SMC (NV)	% from weight of the dry soil	% from SMC (NV)	% from weight of the dry soil	% from SMC (NV)
0-20	19,03	90,6	18,21	86,7	18,62	88,6
20-40	18,74	89,2	18,32	87,2	18,53	88,2
40-60	18,26	87,0	18,15	86,4	18,20	86,7
60-80	18,85	89,8	19,22	91,5	19,04	90,6
80-100	21,83	103,9	21,70	103,3	21,76	103,6
0-40	18,88	89,9	18,26	86,9	18,58	88,5
0-100	19,34	92,1	19,12	91,1	19,23	91,6

	through furrow							
	bottom of the watered furrow		crest of furrow		bottom of dry furrow		average	
	% from weight of the dry soil	% from SMC (NV)	% from weight of the dry soil	% from SMC	% from weight of the dry soil	% from SMC	% from weight of the dry soil	% from SMC
0-20	18,83	89,7	17,76	84,6	13,88	66,1	16,82	80,1
20-40	18,16	86,5	18,04	85,9	15,57	74,1	17,26	82,2
40-60	18,45	87,8	17,75	84,5	15,45	73,6	17,22	82,0
60-80	18,96	90,3	19,07	90,8	18,90	90,0	18,98	90,4
80-100	21,34	101,6	21,40	101,9	21,07	100,3	21,27	101,3
0-40	18,50	88,1	17,90	85,2	14,72	70,1	17,04	81,1
0-100	19,15	91,2	18,80	89,5	16,97	80,8	18,30	87,2

For example, in the upper layer of 0-20 cm, the average soil moisture is 18.62% or 88.6% SMC, and when irrigated through the furrow - 16.82% or 80.1% of the SMC. In the second variant of the experimental plot, where the furrows were not irrigated, the average soil moisture was somewhat lower (by 2-4% of the dry soil mass) than when irrigated in each furrow. As a result, optimal soil moisture limits constantly maintained in the root zone layer, ensuring the normal growth and development of crops.

Soil moisture increases in the layer of the root zone from 16.6% to 20.3%, which is about 900-1000 m^3/ha, and the total water consumption of vegetable crops is 10951 m^3/ha. At the same time, the maximum daily water consumption of vegetable crops changed from 83.9 to 98.7 m^3/day [14, 15]. Thus, the moisture content and the depth of soil wetting, almost the same distribution of water regardless of the path. For example, the moisture content of the upper 40 cm of the soil layer in the variant with water supply to each furrow was 18.62% or 88.6% of the SMC, and in the 0-100 cm layer - 19.23% or 91.1% of the SMC, with In the variant, when irrigation was carried out through the furrow, half of the irrigated land has the same moisture as in the case of irrigation along the furrows. In the future, the volumes of water consumption specified for irrigation along the furrows and through the furrow for the growing season (Table 6)

.

Table 6-Use of irrigating water when watering by furrow and through furrow for the vegetative period

Variants	Irrigation norm gross, m^3/hectare	Expenses of water (m^3/hectare) on		
		Moistening of soils	Filtration	Discharge
Watering by furrow	1500 1100	805 630	285 190	260 180
Watering though furrow	800 600	496 409	152 100	112 60

In the context of an increased shortage of water resources on the irrigated lands of Kazakhstan, the main criterion for methods of economic assessment of surface waters is the rational use of water resources. However, the problem of rational use of water and land in the current conditions requires a solution through the development of water-saving methods of using irrigation water in irrigation systems. Consequently, in market conditions, the development and implementation of technologies for managing soil resources and ecological processes in irrigated ecosystems should help reduce the cost of obtaining the planned harvest and predetermine the growth of profit per unit area of irrigated land (Table 7).

Table 7 - Definition of profit on water saving up technology of watering on furrows and through a furrow

Indicators	Variants	
	watering by furrow	watering through furrow
Preparation of irrigated lands for crops, cabbage landing, tg/hectare	48000	48000
Care of sprouts of cabbage and cabbage during the vegetative period (cultivation, cutting of furrows, temporary sprinklers, introduction of herbicides and pesticides), tg/hectare	32000	32000
Costs of cabbage watering, tg/hectare	15800	12000
Costs of cleaning and cabbage transportation, tg/hectare	65000	72000
Total expenses, tg/hectare	198800	202000
Productivity of cabbage, tons	32,1	38,4
Realization price of 1 ton of cabbage, tenge	25000	25000
Cost of cabbage tg/hectare	802500	960000
Expenses, tg/hectare	198800	202000
Net profit, tg/hectare	603700	758000
Additional profit, tg/hectare	-	154300

Analysis of the above materials shows that increasing the yield of cabbage when irrigated through the furrow gives the greatest profit from 1 hectare of irrigated land. Under this option, the profit from 1 hectare of irrigated land amounted to 758,000.00 tenge. In the control variant, where irrigation was carried out along furrows, the profit is minimal and amounted to 603,700.00 tenge/ha. Comparative analysis of the presented data shows that the maximum profit obtained for the option, where cabbage watered through the furrow, predetermined the maximum additional profit. Under this option, the amount of additional profit amounted to 154,000.00 tenge/ha compared to the control option.

Conclusions. Geological structure the massif of the Asa River belongs to the complex of modern alluvial - proluvial deposits, contributes to their complex relationship in size and area, lithological differences. The results of studying the density of soils showed that they evenly distributed along the soil profile. The coefficient of variation for the density of soils in the 0-100 cm layer varies in the range of 8.3-12.6%. These figures are less than 20%, which indicates a low variability in soil density.

The climate in the region is continental, the average annual precipitation is low, without irrigation, agriculture is impossible. Due to the continental climate, the values of evaporation and infiltration of water resources are too high here [11].

The maximum value of humus occurs in the upper 0-20 cm soil layer. In this layer, humus reserves amounted to 1.44%. With an increase in the depth of the root-inhabited soil layer, their size decreases and in the 40-50 cm layer it is 0.40%. 5. During furrow irrigation, water losses increase, the consumption of which is 2100 m^3 / ha. When irrigating through the furrow, losses for consumption reduced to 600 m^3/ha, i.e. 29% higher than furrow irrigation. During furrow irrigation, water losses increase, the consumption of which is 2100 m^3/ha. When irrigating through the furrow, losses for consumption reduced to 600 m^3/ha, i.e. 29% higher than furrow irrigation.

From the given materials shows that increasing the yield of cabbage when irrigated through the furrow gives the greatest profit from 1 hectare of irrigated land. According to the option, where the cabbage irrigated through the furrow, the additional profit was 154,000.00 tenge/ha compared to the control option. The developed water-saving technology of using the surface waters of the Asa river basin: ensures the passage of tillage equipment along dry furrows (row spacing); reduces the size of the irrigation rate up to 30%; reduces the cost of water for a unit of production by 15-20%.

Жапаркулова Е.Д.[1*], Аманбаева Б.Ш. [1], Джайсамбекова Р.А.[2], Мирдадаев М.С. [2], Моисей Й.[3]

[1]Қазақ ұлттық аграрлық университеті, Алматы, Қазақстан;
[2]Қазақ су шаруашылығы ғылыми-зерттеу институты, Тараз, Қазақстан;
[3] Варшава жаратылыстану ғылымдары университеті, Варшава, Польша.
E-mail: ermekull@mail.ru

АСА ӨЗЕНІНІҢ СУ РЕСУРСТАРЫН БАСҚАРУ ӘДІСТЕРІ ЖӘНЕ ТОПЫРАҚТАРЫНЫҢ ГЕОЛОГИЯЛЫҚ ҚҰРЫЛЫМЫ

Аннотация: мақалада топырақтың геологиялық құрылымын және су ресурстарын басқару әдістерін зерттеу нәтижелері келтірілген. Геологиялық тұрғыдан Аса өзені қазіргі аллювийлік-пролювиалды шөгінділер кешеніне жатады, олардың көлемі мен аумағы, литологиялық айырмашылықтары бойынша күрделі байланыстарына ықпал етеді. Аса өзенінің аңғарында таяз минералданған жер асты суларының әсерінен гидроморфты топырақ дамыған. Шөлді аймақтардың топырақ жамылғысы борпылдақ сұр топырақтан тұрады. Шалғынды-сероземді суармалы саздақ құмды топырақтар. Топырақ түзуші – құмды саз, астыңғы қабаты – құм.

Аса өзенінің бассейніндегі өсімдіктерді суландырудың негізгі көзі – жер үсті сулары. Алайда, вегетациялық кезеңде суармалы судың жыл сайынғы жетіспеушілігі байқалады; зерттеулер жүргізілген жылдар ішінде Жамбыл облысында 1 га суармалы жерді сумен қамтамасыз ету 3561-5988 $м^3$/га құрады. Су балансын талдау көрсеткендей, жүйектеп суару судың шығынын арттырады, оның шығыны 2100 $м^3$/га. Жүйекара суару кезінде шығын мөлшері 600 $м^3$/га дейін азаяды, яғни жүйектеп суарудан 29 % жоғары. Жүйекара суарудың суды үнемдеу технологиясы: суару үшін су алу мөлшерін 15-35% дейін азайтуға мүмкіндік береді; экономикалық шығындарды азайтады; ауылшаруашылық өнімдерінің шығымын арттырады.

Түйін сөздер: геология, топырақ жамылғысы, жерүсті сулары, су үнемдеу технологиясы, жүйектеп суару, жүйекара суару, булану, сүзілу.

Жапаркулова Е.Д.[1*], Аманбаева Б.Ш. [1], Джайсамбекова Р.А.[2], Мирдадаев М.С. [2], Моисей Й.[3]

[1]Казахский национальный аграрный университет, Алматы, Казахстан;
[2]Казахский научно-исследовательский институт водного хозяйства, Тараз, Казахстан;
[3]Варшавский университет естественных наук, Варшава, Польша.
E-mail: ermekull@mail.ru

ГЕОЛОГИЧЕСКАЯ СТРУКТУРА ПОЧВОГРУНТОВ И МЕТОДЫ УПРАВЛЕНИЯ ВОДНЫМИ РЕСУРСАМИ РЕКИ АСА

Аннотация: в статье приведены результаты исследований геологической структуры почвогрунтов и методы управления водными ресурсами. С геологической точки зрения массив реки Аса относится к комплексу современных аллювиально – пролювиальных отложений, способствует их сложной взаимосвязи по размерам и площади, литологическим различиям. В долине реки Аса развиты гидроморфные почвы, подверженные влиянию неглубоких минерализованных грунтовых вод. Почвенный покров пустынных территорий состоит из рыхлой серой почвы. Лугово-сероземные орошаемые суглинистые опесчаненные почвы. Почвообразующая порода – супесь, подстилание – песок.

Основным источником орошения растений в бассейне реки Аса являются поверхностные воды. Однако в вегетационный период наблюдается ежегодный дефицит поливной воды, за годы исследований водообеспеченность 1 га орошаемых земель в Жамбылской области составила 3561 - 5988 $м^3$/га. Анализ водного баланса показывает, что при поливе по бороздам возрастают потери воды, расход которой составляет 2100 $м^3$/га. При поливе через борозду снижаются потери на расход до 600 $м^3$/га, т.е. на 29% по сравнению с поливом по бороздам. Водосберегающая технология полива через борозду позволит: снизить размеры водозабора на орошение до 15-35%; снизить экономические затраты; повысить урожай сельскохозяйственной продукции.

Ключевые слова: геология, почвенный покров, поверхностные воды, водосберегающая технология, полив по бороздам, полив через борозду, испарение, инфильтрация.

Information about authors:

Zhaparkulova Ermekkul Dukenovna – Candidate of Agricultural Sciences, Professor of the Department of “Water Resources and Land Reclamation”, Kazakh National Agrarian University, Almaty, Kazakhstan; ermekull@mail.ru, https://orcid.org/0000-0002-5593-0016*;*

Amanbaeva Balzhan Shakirovna – doctoral student in the specialty "Water resources and water use", Kazakh National Agrarian University, Almaty, Kazakhstan; amanbaeva88@mail.ru*;* https://orcid.org/0000-0001-5000-2555*;*

Dzhaisambekova Raushan Amanbekovna – Candidate of Technical Sciences, Leading Researcher of the Department "Melioration, Ecology and Water Supply", Taraz, Kazakhstan; dzhaisanbekova.1967@mail.ru, https://orcid.org/0000-0002-0431-124X;

Mirdadaev Mirobit Salimovich – Candidate of Technical Sciences, Head of the Department "Melioration, Ecology and Water Supply", Taraz, Kazakhstan; mirdadaev@mail.ru, https://orcid.org/0000-0002-7371-5846;

Moisej Josef – Doctor of Agricultural Sciences, Professor, Head of the Department of Environmental Engineering and Environmental Remediation, Warsaw University of Life Sciences, Warsaw, Poland; jozef_mosiej@sggw.pl, https://orcid.org/0000-0002-8040-7032.

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