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Water-salt regime in the meliorated soils of the Shirvan Plain and their influence on agricultural plants productivity (Ujar Support Station)

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Abstract: The article provides detailed information about the studies conducted on saline and alkaline soils of the Shirvan Steppe. It is revealed that the soils of the studied territory are saline and solonetz in a weak and medium degree.

Keywords: salinity soils, groundwater, humus, water regime, crop-producing

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Introduction

The rational use of available soils and the obtainment of high and sustainable production are real-world problems that need to be considered carefully. The study of the current state of soils indicates that fertility parameters are falling and this results in a drop of 10-15% productivity and as much as 20-25% in some places because of incorrect practices relating to soils. It is known that the soils in the Shirvan plain are heavy granulometric and water permeability is very weak. As a result, the object of this study is complex. At present, exploitation of the majority of collector-drainage and irrigation systems in the region is like other similar regions. Lately, weak performance and lack of repair-establishment works has resulted in subsoil waters with high mineralization, above the permissible depth etc. Processes have caused salinization and solonetzification of the same soils. In light of this, identification and prognostication of the influence of the water-salt regime in the Shirvan plain soils on agricultural plant productivity, soil fertility increase, along with the preparation of complex agromeliorative measures is necessary and assumes scientific-practical importance.

1. Research object and method

The Ujar Support Station soils in the Shirvan plain have been chosen as the research object. Specific areas of research have been selected using the available soil map and 2.0-metre soil sections have been taken during the study. The soil and water samples were taken from the same sections and the chemical analyses were determined in accordance with generally accepted methods (Arinushkina, 1970). We used S.F. Averyanov's (Averyanov, 1965) formulas in the determination of the water-salt elements. The initial results of the research indicate that the soils in the research area are unsalinized, weak, strongly salinized and weakly solonetzificated. Analysis of the soils' granulometric composition indicates that the soils are composed of clay, heavy loam and loam soils.

2. Analysis and discussions

The Shirvan plain is situated on the Kur-Araz lowland, its area is 859,7000 hectares, it is situated on the left bank of the Kur river and occupies the Mingachevir water canal from the west, Langabiz in the east, a zone close to the foot of the Great and little Haramy mountains. According to A.M. Shikhlinsky's classification of climate, the area is a mild-hot semidesert and arid field climate. The average annual temperature varies between 14-15 degrees, but the rainfall amount varies between 254-510 mm. It mostly rains in spring and autumn. One of the main parameters in the salinization of the soil is an alteration of their location, depth, and mineralization. The study indicates that the Shirvan plain is rich in subsoil water and possesses a relatively pressure-free surface. The soil is nourished by rainfalls, river waters and permeated waters from irrigation. Underground water flow in the Shirvan plain is weak and is mainly in the direction of general inclination. Generally, the subsoil waters mineralization in the Shirvan plain varies from 0.4 g/L to 30-50 g/L, and as much as 100 g/L in some places. The research indicates that the underground waters in the Shirvan plain are composed of hydrocalcite, sulphate, and chloride. The hydrocalcitic waters spread into the foothill plains, debris cones, along the Kur and large canals and their mineralization changes 5-10 g/L.

The sulphate waters expand once they leave the foothills, their mineralization varies 10-20 g/L and up to 20-40 g/L in some places. The chloric waters are found in the eastern part of the plain and in the areas near the Caspian Sea. Their mineralization is 20-50 g/L and 100 g/L or higher in some places (Azizov, 2006; Mustafaev, 2014; Volobuyev, 1965).

The last study indicates that bright-chestnut and grey-brown soils lie at the foothills of the Shirvan plain. Bright-meadow and grey-brown soils in the river's debris cone, alluvial-meadow and Tugay forest soil on the Kur bank and grey, grey-meadow, solonetzificated and salinized soils in the eastern part of the plain and surrounding areas of the debris cones (Abduev, 1977; Azizov, 2006; Babaev, 1984; Mammadov, 2007; Mustafaev, 2011; Volobuyev, 1965).

Grey, grey-brown, and bright-chestnut soils develop on proluvial-deluvial and deluvial deposits. Thorough information on the plant cover of the Shirvan plain can be found in (Mammadov, 2007; Mustafaev, 2014; Volobuyev, 1965). According to the research, white grass, grain, wormwood, grain-like and different grasses, wild pomegranate, thorn, loja, boggy and saline plants, tamariks, and other plant groups develop in the Shirvan plain.

The research shows that the soils have a granulometric structure, weak water permeability and are solonetzificated to various degrees by varying till saline in the same zone. The reason for the soils being in such a state in the Shirvan plain is the incorrect utilization and the unsatisfactory state of the collector-drainage and irrigation systems. The areas salinized to a different degree in the Ujar Supporting Station were selected and a salt study was performed by adding secondary soil sections to solve these problems. The result of the analysis indicates that the salt amount varies along the profile in the experimental area, between 0.272-1.268% (Tables 1 and 2).

Table 1. Variation of salt quantity in the experimental area soils (*own study*)

Number of the section	Depth [cm]	CO_3		HCO_3		SO_4		Cl		Dry residue [%]
		[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	
K-7	0-25	"	"	1.10	0.067	3.08	0.148	0.87	0.031	0.350
	25-50	"	"	1.00	0.061	3.24	0.156	0.75	0.027	0.343
	50-75	"	"	0.90	0.055	2.54	0.121	0.62	0.022	0.285
	75-100	"	"	0.95	0.058	2.39	0.115	0.87	0.031	0.298
	100-150	"	"	0.90	0.055	5.16	0.248	0.75	0.027	0.490
	150-200			0.85	0.051	5.51	0.265	1.00	0.035	0.525
K-9	0-25	"	"	0.60	0.018	4.00	0.043	1.00	0.035	0.300
	25-50	"	"	0.60	0.018	4.75	0.144	0.80	0.028	0.330
	50-75	"	"	0.60	0.018	6.99	0.336	0.60	0.021	0.553
	75-100	"	"	0.50	0.015	9.99	0.480	0.40	0.014	0.605
	100-150	"	"	0.50	0.015	5.99	0.288	0.40	0.014	0.605
	150-200			0,40	0,012	8,49	0.408	0,60	0,021	0,530
K-11	0-25	"	"	0.60	0.018	4.00	0.043	1.00	0.035	0.300
	25-50	"	"	0.60	0.018	4.75	0.144	0.80	0.028	0.330
	50-75	"	"	0.60	0.018	6.99	0.336	0.60	0.021	0.553
	75-100	"	"	0.50	0.015	9.99	0.480	0.40	0.014	0.605
	100-150	"	"	0.50	0.015	5.99	0.280	0.40	0.014	0.615
	150-200			0.60	0.018	7.49	0,360	0.60	0.021	0.621

Table 2. Variation in salt content in the experimental area soils (*own study*)

Number of the section	Depth [cm]	CO_3		HCO_3		Cl		SO_4		Ca		Mg		Na+K		Salt	Dry residue
		[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	[mg-ekv]	[%]	[%]	
K-8	0-25	"	"	0.40	0.024	10.13	0.355	9.60	0.461	9.23	0.185	2.02	0.024	8.87	0.204	1.253	1.268
	25-50	"	"	0.60	0.037	8.38	0.293	8.99	0.432	8.55	0.171	2.93	0.035	6.49	0.149	1.117	1.125
	50-75	"	"	0.40	0.024	10.75	0.376	5.99	0.288	4.50	0.090	1.12	0.013	11.52	0.265	1.056	1.072
	75-100	"	"	0.70	0.043	5.13	0.179	7.99	0.384	4.50	0.090	2.25	0.027	7.07	0.163	0.886	0.897
	100-150	"	"	0.60	0.037	1.25	0.044	7.58	0.364	4.50	0.090	3.60	0.043	1.34	0.031	0.609	0.620
	150-200			0.80	0.049	1.75	0.061	8.20	0.394	5.40	0.108	3.15	0.038	2.20	0.051	0.701	0.718
K-10	0-25	"	"	1.10	0.067	1.25	0.044	7.20	0.346	4.95	0.099	3.60	0.043	0.89	0.020	0.619	0.626
	25-50	"	"	0.70	0.043	1.25	0.044	6.18	0.297	4.50	0.090	2.03	0.024	1.61	0.037	0.535	0.544
	50-75	"	"	0.60	0.037	1.25	0.044	9.39	0.451	2.25	0.045	2.45	0.029	6.73	0.155	0.761	0.773
	75-100	"	"	0.70	0.043	1.50	0.052	1.00	0.048	1.13	0.023	1.33	0.016	0.73	0.017	0.199	0.226
	100-150	"	"	0.60	0.037	1.25	0.044	7.39	0.355	1.80	0.036	1.30	0.016	5.64	0.130	0.618	0.627
	150-200			0.50	0.031	1.25	0.044	5.60	0.269	1.58	0.032	2.47	0.030	3.84	0.088	0.494	0.498
K-12	0-25	"	"	1.10	0.067	0.87	0.031	3.08	0.148	2.87	0.057	1.76	0.022	0.42	0.010	0.335	0.350
	25-50	"	"	1.00	0.061	0.75	0.027	3.24	0.156	2.50	0.050	1.75	0.021	0.74	0.017	0.332	0.343
	50-75	"	"	0.90	0.055	0.62	0.022	2.54	0.121	2.12	0.042	1.00	0.011	0.91	0.020	0.272	0.285
	75-100	"	"	0.95	0.058	0.87	0.031	2.39	0.115	1.75	0.035	0.87	0.013	1.59	0.036	0.286	0.298
	100-150	"	"	0.90	0.055	0.75	0.027	5.16	0.248	2.25	0.045	1.12	0.013	3.44	0.079	0.467	0.490
	150-200			0.85	0.051	1.00	0.035	5.51	0.265	1.87	0.037	1.13	0.013	4.36	0.100	0.501	0.525

As seen in the Table, the soils vary from unsalinized to strongly-salinized. The granulometric parameters of the soils must be fixed in the same zone to determine the water-physical characteristics of the soils. The granulometric composition was fixed by using the Kachinsky method on the soil samples taken (Table 3).

Research indicates that the reason for the increase in salinization and other processes related to the quantity of the salt in the soil is the presence of mineral--rich subsoil waters near the surface of the zone. The subsoil waters in the Shirvan plain is mainly near the surface (0.5-1.5 m). Mineralization is sometimes higher than the permissible level. That is why the study of mineralization variation in the subsoil and drainage waters is considered an important issue. Water samples were taken from the cuts in the USS soils along with samples of the subsoil waters and their chemical compositions have been determined.

Table 3. Variation of the granulometric structure of soils in the experimental area (*own study*)

Depth [cm]	Fractions quantity on diameter (mm), [%]						
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001	< 0.01
Section No 8							
0-25	0.68	21.56	25.12	15.64	16.48	20.52	52.64
25-50	0.60	16.24	28.46	14.60	18.36	21.74	54.70
50-75	0.56	16.00	26.78	13.52	19.66	23.48	56.66
75-100	0.66	21.34	24.56	15.26	17.08	21.10	53.44
100-150	0.74	27.70	21.28	14.88	16.76	18.64	50.28
Section No 10							
0-25	0.50	15.66	27.12	14.28	20.06	22.38	56.72
25-50	0.66	21.48	25.76	10.26	19.30	22.54	52.10
50-75	0.60	15.46	28.14	11.38	20.24	24.18	55.80
75-100	0.62	17.58	26.94	12.46	20.12	22.28	54.86
100-150	0.58	21.02	24.88	14.72	18.36	20.44	53.52
Section No 12							
0-25	0.57	6.99	29.80	15.72	20.24	26.68	62.64
25-50	0.42	40.60	30.16	20.56	19.08	25.72	65.36
50-75	0.45	9.59	28.88	15.44	19.04	26.60	61.08
75-100	0.63	11.73	28.48	16.76	18.36	24.04	59.16
100-150	0.45	18.17	22.98	15.92	19.76	22.72	58.40

The experiments indicated that the subsoil waters' mineralization in the research zone varies by 2.815-3.418 g/L. CO_3 ions were not observed in the anion content of the water samples taken from the same zone. The amount of HCO_3 ions was 0.265-0.385 g/L. Cl ion amounts were 0.272-1.101 g/L. SO_4 ion quantity varied by 0.789-1.128%. It was known from the research that the subsoil waters' mineralization reduced in comparison with the previous years because of the utilization of salt-tolerant grain plants for the 2nd year (3.85-4.05 g/L in 2014). During the research, samples were taken from the irrigation waters in the experimental area and chemical analyses were fulfilled to investigate the salt quantity variation. CO_3 ions were not observed in water samples taken from the experimental area, HCO_3 ion - 0.185-0.215 g/L, Cl ion - 0.086-0.135 g/L, SO_4 - 0.461 g/L (Table 4).

Table 4. Mineralization of the subsoil waters in the soil of the experimental area (*own study*)

Numer of the section	CO_3		HCO_3		SO_4		Cl		Minera-lization [g/L]
	[mg-ekv]	[g/L]	[mg-ekv]	[g/L]	[mg-ekv]	[g/L]	[mg-ekv]	[g/L]	
K-8	–	–	4.34	0.265	16.43	0.789	7.77	0.272	2.815
K-10	–	–	5.93	0.362	20.51	0.985	27.77	0.972	3.162
K-12	–	–	6.31	0.385	23.48	1.128	31.46	1.101	3.418

As shown above, the irrigative waters mineralization varies 0.585-0.682 g/L. If we consider that these parameters are lower than 1.00 g/L i.e. permissible for irrigation, they can be widely used to irrigate plants in the same zone. The study shows that the main parameters; salt supply, irrigative waters and salt amounts entering the area, atmospheric precipitation, evaporation, draining expenditure and quantity of salts removed from the same zone must be fixed and their influence on plants productivity should be determined while studying a water-salt regime. From this point of view some water-salt elements were pre-scribed in the research zone and a comparison with the parameters of the results in 2015 was given.

During the study, the average value of the irrigation water mineralization was 0.503 g/L. As shown, 1.61 t/ha of soil entered the experimental area transported by irrigation waters. For an investigation of these problems, the waters' mineralization in the drainage of the experimental area, their expenditure should be fixed. During the study, the average value of the drainage flow and mineralization have been used. The consequences show that the drainage flow values vary between 1935.5-1920.5 m^3/h and their mineralization - 5.45-6.35 g/L. As a result, the quantity of the salt removed by drainage was 10.22 t/h. As it is shown that the quantity of the salt removed by drainage is sometimes more than the quantity of the salt entering from the irrigation waters. During the study, the salt supply in the soil was also calculated and it was determined that the salt supply was 65.72 t/h in 2015, but it was 71.60 t/h in 2017. The salt supply's relative increase indicates a salt quantity increase in the soil of some places (at the end of the area, in the part not used under tillage).

Conclusions

According to the research, the salt quantity in the soil is 0.226-1.268% along profile; the subsoil waters mineralization is 2.815-3.125 g/L; their location level -

2.75-2.90 m, drainage waters mineralization - 5.45-6.36 g/L; mineralization of irrigation water 0.585-0.682 g/L; humus - 2.44-0.56% and pH - 7.9-8.7. The quantity of soil entering with the irrigation waters and being removed by drainage, along with salt supply is 1.70-1.61 t/h; 11.30-10.22 t/ha and 65.72-71.60 t/ha in 2015--2017 respectively. A reason for the difference between the parameters is connected with the reduced variation in the salt quantities, irrigation and drainage mineralization and their expenditures in comparison with the previous years.

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Warunki wodno-solne w meliorowanych glebach równiny Shirvan i ich wpływ na wydajność produkcji roślin (Stacja Nawadniania Ujar)

Streszczenie: Artykuł zawiera szczegółowe informacje o badaniach przeprowadzonych na glebach solnych i alkalicznych stepu Shirvan. Na podstawie badań stwierdzono, że gleby badanego terytorium są solankowe, a ich zasolenie występuje w słabym i średnim stopniu.

Słowa kluczowe: gleby zasolone, wody gruntowe, czarnoziem, warunki wodne, produkcja roślin