

Regulation of ameliorative condition of soils in the area of Ingulets irrigation system

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Goal. To determine directions of change of chemical indicators and physical and chemical properties of dark-chestnut irrigated soil at various reclamation loads. **Methods.** Studies were conducted on experimental fields of Institute of irrigated agriculture of NAAS in the area of Ingulets irrigation system in 2016 – 2018 with the use of the field, quantitative-weight, visual, laboratory, comparative-calculation, and mathematical-statistical methods. **Results.** The observations over the chemical composition of irrigation water during the growing season provide an opportunity to establish that in 2016 the salinity of irrigation water ranged from 1.444 to 1.813 g/dm³, 2017 — from 1.130 to 1.584, in 2018 — from 1.418 to 1.891 g/dm³. At the interaction of variants of the system of differential-1 tillage and fertilizer application, they observed the following tendency: reduction of alkaline action of low mineralized irrigation water, where it was observed the highest content of absorbed calcium from the sum of the cations (69.3%) and lowest content of toxic salts in water extract of soil (0.075%). The content of magnesium and sodium were the largest in the shallow subsurface cultivation (option 3) — 32.3 and 3.9% without fertilizer, and 30.7 – 31.3 and 3.5 – 3.8% of the sum of cations — at entering fertilizers, respectively. **Conclusions.** The use of different methods of primary tillage and fertilizers is not able to reduce the process of irrigation alkalization. But at the use of shelf and differential cultivation, where for crop rotation plowing alternates with shallow shelf loosening under crops of rotation, with the application of fertilizers they fixed the highest content of absorbed calcium from the sum of the cations (69.1–69.3%). At the same time, they also fixed a slight decrease in the alkalization and increase in the ratio of calcium cations to sodium in the soil solution up to 0.61 – 0.63 units, and it helps to reduce the intensity of alkalization.

Key words: *water chemistry, doses of mineral fertilizers, main system of soil cultivation, alkalization.*

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In the south of Ukraine irrigation is the powerful factor of intensification of production which together with positive influence is able to entail transformation at first aquatic and gas modes of soil, and then to result in substantial changes in composition eaten up cations of ground-absorptive complex and among physical parameters. Intensity of transformation of soils especially grows at the use of irrigation waters limitedly suitable and useless for irrigation on the agronomical and ecological criteria of estimation [1-3].

In connection with the use of watering waters with their enhanceable mineralization practically on all irrigated arrays of south region lixiviating of calcium is marked from the meter epiphase of soil, which results in the height of maintenance of eaten up sodium in a soil-absorptive complex and development of secondary alcalination [4-6].

It is educed the agromelioration monitoring, that convertible and irreversible processes (resalinization, alcalination, flooding, destruction macro- and microstructures, bearing-out of organic and nourishing matters and others like that) pass in the irrigated soils. Conformities to law of development of soil processes depend on many factors: duration of irrigation, watering method, quality of irrigatory water, systems of basic tillage of soil [7-10].

The results of long-term researches testify in relation to the last factor, that application of the traditional system of tillage of soil with the turn of layer not always is justified. It does not provide the reliable protecting of soils from deflation and irrigational erosion, may cause soil compaction [11-14].

Study of the noted processes, and especially conformities to law of their changes, under act of anthropogenic factors enables to estimate the modern state of the irrigated earths and rationally to use him in concrete agrotechnical and reclamative terms, what determines actuality of this development.

The purpose of researches consisted in establishment of directions of changes of chemical indexes and physical and chemical properties of the dark chestnut irrigated soil at the different reclamative loading.

Materials and methods of researches. Researches were conducted on the experienced fields of Institute of the irrigated agriculture of NAAS in the area of action of Ingulets irrigation system during 2016-2018. Soil of the experienced field — dark chestnut medium loamy weakly saline, typical for South Steppe.

Experience is stopped up on the study of the systems of basic tillage of soil and doses of mineral fertilizers in the irrigated row crop rotation (table 1).

1. Chart of stationary experience on the study of the systems of basic tillage of soil in the irrigated row crop rotation

№ pitch.	System basic tillages	Tillage under the cultures of crop rotation			
		Corn on grain	Sorghum	Wheat winter	Soy
1	Moldboard soil tillage with different depth	20-22 (p)	23-25 (p)	14-16 (p)	25-27 (p)
2	Nonmouldboard soil tillage with different depth	20-22 (c)	23-25 (c)	14-16 (c)	25-27 (c)
3	Nonmouldboard soil tillage with one deep	12-14 (d)	12-14 (d)	12-14 (d)	12-14 (d)
4	Differentiated- 1	8-10 (d)	12-14 (c) + 38-40 (s)	8-10 (d)	14-16 (d)
5	Differentiated - 2	18-20 (p)	16-18 (c)	10-12 (d)	14-16 (d)

Note: p — ploughing; c-chisel loosening; d — disk till; s — subsoiling.

The background of fertilizer presented for a wheat winter: without fertilizers, N₉₀P₆₀, N₁₂₀P₆₀; soy: without fertilizers, N₃₀P₆₀, N₆₀P₆₀; corn on grain: without fertilizers, N₁₂₀, N₁₈₀; sorghum: without fertilizers, N₉₀P₆₀, N₁₂₀P₆₀. On the average it was brought in croprotation: without fertilizers, N_{82,5}P₆₀, N₁₂₀P₆₀. Irrigation was carried out by the sprinkler aggregate ДДА-100 МА. An agrotechnics in experience confessedly for the terms of irrigation of south of Ukraine except for the ingredients of technology, which was studied. For the book-mark of experience used instruments: ПЛН — 5-35, ПЧ — 2,5, АКШ — 3,6, БДВ — 6,3.

During an experiment used the field, in-gravimetric, visual, laboratory, calculation-comparative, mathematically-statistical methods with the use of confessedly in Ukraine methods and methodical recommendations [15, 16]. The analysis of ion-salt composition of aquatic extraction of soil was determined on the method of DSTU 7945:2015, exchange sodium — in extraction of 1% vinegar-sour to the ammonium, flamingly photometrically DSTU 7912:2015, exchange calcium and magnesium — on DSTU 7604:2014.

Results of researches. When conducting research during the growing season of plants during irrigation conducted watching chemical composition of water. Mineralization of the irrigated water for 2016 on the average presented a 1,596 g/dm³, for 2017 — 1,432, in 2018 — a 1,6932 g/dm³. On chemical composition water belonged on anionic composition to the chloride-sulfate, and on cationic composition to magnesium-sodium.

A table of contents of toxic salts is in the equivalents of chlorine, which characterizes quality of water on the threat of resalinization of soil, presents on the average after 2016, - 15,46 meq/dm³, in 2017 — 11,48, in 2018 — 13,36 meq/dm³ and belongs to II to the class (limitedly suitable for irrigation).

On the danger of alkalization of soil, salinization and toxic influence on plants watering water also behaves to the same class of quality. The size of pH water changed scope from 7,2 to 8,7. In separate summer periods of sampling of standards of water at presence of CO₃ — and high pH 8,5 water in a pool belonged at alkalization and toxic influence on plants to the III class (table 2).

2. Irrigational estimation of irrigatory water in 2016-2018

Date of research	Mineralization g/dm ³	H ₂ O	A concentration of toxic ions is in the equivalents of Cl ⁻ , meq/dm ³	100 Na ⁺ Ca ²⁺ + Mg ²⁺ + Na ⁺	$\frac{g}{2+} \frac{M}{C}$	$\frac{a}{2+} \frac{c}{Z}$	Table of contents of ions meq/dm ³			Class of water on a danger (DSTU- 2730-94)			
							CO ₃ -	HCO ₃ -	Cl -	salinization	alcalination	alkalization	toxic influence on plants
2016													
19.05.	1,510	8,3	10,50	51,1	1,4	0,40	0,00	3,36	8,16	II	II	II	II
14.06.	1,444	8,7	20,95	49,7	3,8	0,20	0,80	2,64	10,96	II	II	III	III

12.07.	1,81 3	8, 6	20,02	49,6	2,0	0,33	0,6 4	2,5 6	11,0 4	II	II	III	III
09.08.	1,55 1	7, 5	12,28	50,8	1,9	0,34	0,0 0	3,2 0	10,0 0	II	II	I	II
23.09.	1,66 3	7, 8	13,44	51,9	1,5	0,37	0,0 0	3,2 0	11,2 0	II	II	II	II
Amon g.	1,59 6	8, 2	15,46	51,2	1,9	0,33	0,2 9	2,9 9	10,2 7	II	II	II	II
2017													
31.05.	1,58 4	8, 0	12,86	49,8	1,9	0,35	0,0 0	3,0 4	10,6 4	II	II	II	II
29.06.	1,72 3	8, 5	15,86	48,3	1,8	0,38	0,2 4	3,0 4	11,0 4	II	II	III	III
25.07.	1,55 2	7, 8	12,98	50,5	2,1	0,32	0,0 0	3,0 4	10,8 0	II	II	II	II
29.08.	1,18 7	7, 7	9,78	48,9	1,8	0,37	0,0 0	2,5 6	8,24	II	II	II	II
25.09.	1,13 0	7, 2	8,34	50,8	1,5	0,38	0,0 0	3,0 4	6,64	II	II	II	II
Amon g.	1,43 2	7, 8	11,48	49,6	1,8	0,36	0,0 03	2,9 4	9,47	II	II	II	II
2018													
07.05 .18	1, 528	8, .1	11, 40	45, 8	1, 6	0, 45		3 ,20	9, 20	I	I	I	I
28.05 .18	1, 769	7, .6	13, 50	50, 6	1, 3	0, 43		4 ,16	10 ,96	I	I	I	I
21.06 .18	1, 724	8, .1	14, 23	50, 0	2, 2	0, 31		4 ,08	11 ,52	I	I	I	I
19.07 .18	1, 664	8, .0	13, 62	51, 9	1, 5	0, 37		3 ,44	11 ,36	I	I	I	I
16.08 .18	1, 891	8, .4	15, 64	47, 4	1, 8	0, 39	0 ,32	3 ,76	13 ,10	I	I	II	II
20.09 .18	1, 418	7, .2	11, 73	51, 4	1, 9	0, 32		2 ,88	9, 76				
AV	1, 661	7, .9	13, 36	49, 6	1, 7	0, 38		3 ,59	10 ,98	I	I	I	I

Note: I class — suitable for irrigation; II class — limitedly suitable for irrigation; III class — useless for irrigation.

The important criterion of irrigational estimation of water is attitude of maintenance of calcium toward sodium. In irrigatory water which was used in our experiments, this relation presented 0,36, that specifies on activity of cations of sodium.

Consequently, on an operating standard irrigatory water belongs to II of class and limited to suitable for irrigation from the threat of resalinization, salinization, alkalization and toxic influence on plants.

Analysis of content of exchange cations in the layer of soil a 0-40 cm testifies at the end of vegetation, that least the process of alcalination takes place for ploughings in the system of the protracted application different depth dump tillages of soil and in the system differentiated tillages of crop rotation (table 3).

3. Contents of exchange cations in dark chestnut soil at the different reclamative loading (end of vegetation of cultures) 2016-2018

variant	System basic tillages of soil	Sum of exchange cations, meq/ 100 g of soil	% from the sum of cations		
			Ca ²⁺	Mg ²⁺	Na ⁺
Without fertilizers					
1	Moldboard soil tillage with different depth	20,3	67,2	29,5	3,2
2	Nonmouldboard soil tillage with different depth	20,2	65,8	30,7	3,6
3	Nonmouldboard soil tillage with one deep	20,2	63,8	32,3	3,9

4	Differentiated- 1	20,3	67,4	29,4	3,2
5	Differentiated - 2	20,2	66,5	30,1	3,4
$N_{82,5}P_{60}$					
1	Moldboard soil tillage with different depth	20,5	68,4	28,7	2,9
2	Nonmouldboard soil tillage with different depth	20,1	66,9	29,8	3,2
3	Nonmouldboard soil tillage with one deep	20,2	64,9	31,3	3,8
4	Differentiated- 1	20,4	68,8	28,2	3,0
5	Differentiated - 2	20,3	67,2	29,6	3,2
$N_{120}P_{60}$					
1	Moldboard soil tillage with different depth	20,5	69,1	28,1	2,8
2	Nonmouldboard soil tillage with different depth	20,4	67,2	29,7	3,1
3	Nonmouldboard soil tillage with one deep	20,2	65,7	30,7	3,5
4	Differentiated- 1	20,4	69,3	27,9	2,8
5	Differentiated - 2	20,4	67,9	29,1	3,0

LSD₀₅, meq/ 100 g of soil:

A=0,3 A=0,2 A=0,05

B=0,4 B=0,3 B=0,07

Amount of exchange sodium in the layer of soil a 0-40 cm grew due to eaten up a calcium maintenance of which diminished in relation to a variant 1 at the without dump methods of tillage on 1,9-3,4%, and at ploughing in the system of the differentiated tillage of soil in a crop rotation (variant 5) — on 0,7-1,3 % depending on the dose of fertilizers. At tillage of soil in the system of the differentiated tillage of crop rotation (variant 4) maintenance of Ca^{2+} was at level with ploughing (variant 1) and hesitated within the limits of 67,4-69,3% from the sum of cations. Top-dressing the doses of $N_{82,5}P_{60}$ and $N_{120}P_{60}$ increased maintenance of Ca^{2+} on 1,4-1,9% from the sum of cations.

The system of the protracted application of different depth dump tillage of soil (variant 1) and system of differentiated — 1 tillage in a crop rotation (variant 4) positively influenced to the amount of exchange cations of soil which was most and hesitated in a layer a 0-40 cm in the range of 20,3-20,5 meq/100 g of soil

On co-operation of variants of the systems of the protracted application of different depth dump tillage of soil in a crop rotation (variant 1) and system of differentiated-1 tillage of soil there was a tendency of diminishing of salinization of poorly mineralization watering waters in a crop rotation (variant 4) and top-dressing, where the increase of maintenance of eaten up a calcium was marked from the sum of cations of 67,2-69,3% While maintenance of magnesium and sodium was most at shallow without dump tillage (variant 3) — 32,3 and 3,9 % without top-dressing, and 30,7-31,3 and 3,5-3,8 % from the sum of cations at top-dressing accordingly of doses of fertilizers, that testifies to the insignificant increase of secondary alcalination in variants without dump tillage of soil the not unfertilized background.

Thus irrigation waters of enhanceable mineralization with unfavorable correlation of one- and bivalent cations results in changes in high-quality composition of soil-absorbing complex at the end of vegetation of cultures, where lixiviating of calcium is from soil, that was accompanied by the height of part of exchange sodium and resulted in development of processes of irrigational alcalination of soil.

The analysis of aquatic extraction of livery soil testifies on the variants of experience, that irrigation water with unfavorable correlation one and bivalent cations causes the change of her ion-salt composition.

After harvesting maintenance of water soluble salts in the layer of soil a 0-40 cm increases in all variants of experience and arrives at 0,103-0,153 %. Increases of maintenance of salts mainly took place due to the increase of ions of SO_4^{2-} and Cl^- — among anions and Na^+ among cations (table 4).

4. Salt composition of soil solution at the different reclamative loading (end of vegetation of cultures) of layer of soil a 0-40 cm

Variant	System of basic tillage of soil, cm	2016-2018		
		table of contents of salts, %		$\frac{Ca^{2+}}{Na^{+}}$
		in all	toxic	
Without fertilizers				
1	Moldboard soil tillage with different depth	0,143	0,106	0,51
2	Nonmouldboard soil tillage with different depth	0,129	0,098	0,43
3	Nonmouldboard soil tillage with one deep	0,152	0,119	0,38
4	Differentiated- 1	0,128	0,093	0,54
5	Differentiated - 2	0,137	0,105	0,44
$N_{82,5}P_{60}$				
6	Moldboard soil tillage with different depth	0,130	0,097	0,54
7	Nonmouldboard soil tillage with different depth	0,129	0,098	0,43
8	Nonmouldboard soil tillage with one deep	0,140	0,106	0,40
9	Differentiated- 1	0,136	0,099	0,57
10	Differentiated - 2	0,153	0,116	0,45
$N_{120}P_{60}$				
11	Moldboard soil tillage with different depth	0,134	0,098	0,61
12	Nonmouldboard soil tillage with different depth	0,133	0,099	0,52
13	Nonmouldboard soil tillage with one deep	0,147	0,111	0,44
14	Differentiated- 1	0,103	0,075	0,63
15	Differentiated - 2	0,124	0,093	0,48

Table of contents of toxic salts in the layer of soil a 0-40 cm on the variants of experience hesitates within the limits of 0,075-0,119. At the same time their least maintenance registers in the system of the differentiated tillage of soil of crop rotation (variant 4) on a background bringing of $N_{82,5}P_{60}$ — 0,075 in the layer of soil 0-40 cm. Attitude of cations of calcium toward sodium in soil solution hesitates scope from 0,38 to 0,63 units, that specifies on development of active process of secondary alcalination. His most high correlation - 0,64 determined in variants with top-dressing on a background the system of the protracted application of different depth dump (variant 1) and differentiated tillage of soil in a crop rotation (variant 4).

Realization of cross-correlation-regressive analysis is mark dependence of relation of water soluble $Ca^{2+}: Na^{+}$ of soil solution and Ca^{2+} in soil-absorbing complex of soil.

It is well-proven on results a statistical estimation, that between the relation of water soluble $Ca^{2+}: Na^{+}$ of soil solution and Ca^{2+} there is close positive cross-correlation connection ($r = 0,911$) in soil-absorbing complex of soil.

The Cross-correlation-regressive analysis of experimental data allowed to get equalization ($y=0,0063x^2-0,7969x+25,571R^2=0,8817$) which represents close dependence between these indexes, and testify that influencing on Ca^{2+} in soil-absorbing complex it is possible to increase the relation of $Ca^{2+}: Na^{+}$ of soil solution (index of intensity of saline process) (fig. 1).

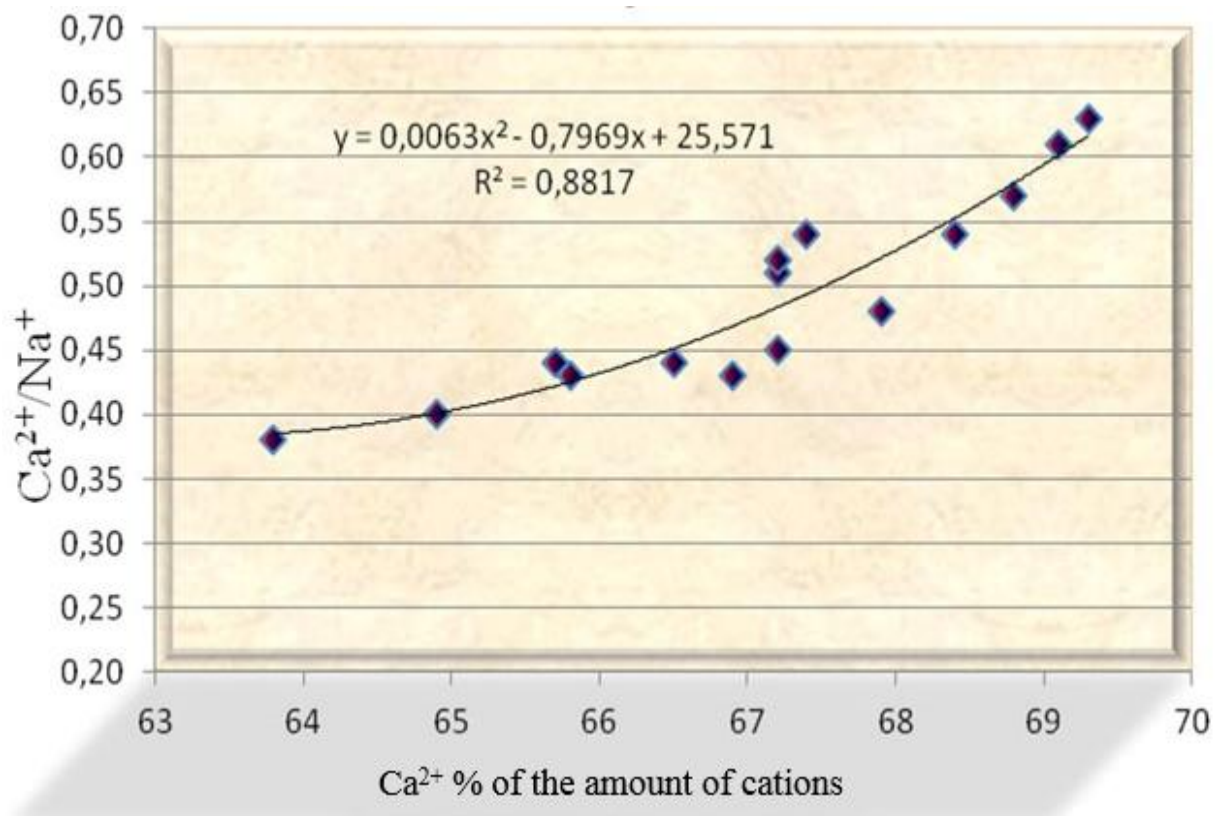


Fig. 1. Model of intercommunication of correlation of водорастворимых ions of calcium to sodium ($Ca^{2+}: Na^+$) of soil solution and Ca^{2+} in soil-absorbing complex of soil in the years of realization of researches

Under act of irrigation transformation of ionic composition of aquatic extraction caused the change of salinity chemistry from a chloride-sulfate sodium-calcium on chloride-sulfate calcium-sodium in all variants, regardless of factors which was investigated.

Conclusions

Realization of different methods of basic tillage of soil and application of mineral fertilizers is not able to remove the process of irrigational salinization, and at a dump and differentiated, where during the rotary press of crop rotation ploughing alternates with the shallow without dump loosening under the cultures of crop rotation, tillage with the use of fertilizers where the greatest maintenance of eaten up a calcium is marked from the sum of cations 69,1-69,3% his insignificant decline is marked and most correlation of cations of calcium is got to sodium in the ground solution 0,61-0,63 units that allowed to reduce the rate of salinization.

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