STUDIES CONCERNING THE POTENTIAL OF REDUCING SALT LOAD OF ALBITA-FĂLCIU ARRANGEMENT SOILS TACKING INTO ACCOUNT THE MODERNIZATION OF LAND IMPROVEMENT WORKS

STUDII PRIVIND POTENŢIALUL DE SPĂLARE A SĂRURILOR DIN SOL, ÎN CONDIŢIILE MODERNIZĂRII AMENAJĂRILOR HIDROAMELIORATIVE DIN INCINTA ALBIȚA-FĂLCIU

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Abstract. *This paper is presented some impacts of hydro complex spatial arrangements Falciu Albita performed on mineralization of groundwater in the area. It highlights the effect of irrigation and drainage systems on groundwater level differences on the three sub-areas: strip near river, meadow and preterrasic. Tacking into account to minimize the phenomenon of secondary salinization of soils, it is looking to increase efficiency by the action of integrated irrigation and drainage systems by simulating water and salt regime of soils under the action of scarified soil and leaching in conditions of drainage systems upgraded.*
Key words: land improvement works, drainage system, soil salinity

Rezumat. *In această lucrare se prezintă unele efecte ale lucrărilor hidroameliorative executate în amenajarea complexă Albiţa Fălciu asupra regimului şi mineralizării apelor freatice din zonă. Se evidenţiază efectul irigaţiei asupra nivelului freatic diferenţiat pe cele trei subzone: de grind, luncă şi preterasic. Având în vedere minimizarea fenomenului de salinizare secundară a solurilor, se analizează posibilităţile de reducere a salinităţii prin acţiunea integrată a lucrărilor de irigaţii şi desecare drenaj. S-a simulat regimul hidric şi salin al solurilor sub acţiunea lucrărilor de scarificare şi spălari în condiţiile unor sisteme de drenaj modernizate.*
Cuvinte cheie: lucrări de îmbunătăţiri funciare, sistem de drenaj, salinitate sol

INTRODUCTION

The land reclamation developments in Prut River flooding area between Albita and Falciu consist of a series of dikes on the side of the river, an 18,655 ha drainage system, and an irrigation system with open main canals and water distribution networks for sprinkler irrigation on 16,795 ha. In addition, there are 560 ha of land with subsurface horizontal drainage on saline and alkaline soils which is situated on a strip adjacent to the terrace area. The dikes, the surface drainage system, the works for control of torrential water courses originating on the terrace area and the works for soil protection on the sloped lands of the terrace were finished in the 1966-1970 period. The irrigation infrastructure was carried out in the 1977-1980 period. Beginning with 1984, modernization works for both the irrigation system (on 1,726 ha) and the drainage system were performed. Furthermore, 1995 was the year when modernization works of all main pumping plants situated near Prut River started. The main rationale of these complex measures is to minimize the salinization and water logging and to diminish the damage to agricultural crops.

Investigations into the operation performance of reclamation works confirmed that the salinization of soils in correlation with groundwater conditions (regarding the depth and the salinity of the groundwater) has intensified following the area being impounded and drawn out from natural flood of Prut River. Other factors contributing to this phenomenon are the low permeability of the soil layers, the deficiency of internal drainage, the inefficient irrigation practices and canal seepage (Cismaru et al., 2004). These features are observed on the strip situated near terrace foot and within the central strip of the floodplain, where internal natural drainage of soils is very slow. It is evident that during a 16 year period from 1974 to 1989, the use of irrigation water with a salinity of 0.4-0.5 g/l generated a low to moderate phenomenon of secondary soil salinization which attenuated in time. This dynamic has changed since 1990 when the social-economical conditions lead to a lesser utilization of the irrigation systems and the under-maintenance of the irrigation and drainage works. Finally, the salt leaching process due to surplus irrigation and the influence of surface drainage collectors were significantly diminished.

The aim of this study is to analyze the actual conditions for the operation and maintenance of the land improvement works, the contributing factors to soil salinity, and the alternatives to improve the current condition.

MATERIAL AND METHOD

The soil water balance in our investigation area is determined by rainfall rate, irrigation, evapo-transpiration, and the upflux from the shallow aquifer. The dissolved salts in the groundwater upward flow are the main contributor to soil salinity balance. Their contribution varies in time mainly due to various groundwater conditions such as depths and salt concentration. The local groundwater within the study area has an ascending character due to the supply of groundwater from higher lands. Prut River has a supply action of floodplain groundwater during high levels and a drainage action during opposite conditions.

The salt balance components of the root soil zone were analyzed for the 1995-2007 time period. Monthly precipitation data is obtained from Vaslui meteorological stations. The water level regime of Prut River was analyzed based on the recordings of the Prut River Water Administration at Dranceni and Falciu hydrostations. These stations are located immediately upstream and downstream from study area, respectively. The dynamics of apparent depth of water table (which was measured by observation wells) and groundwater salinity concentration were provided by the hydrological Service of Water Administration Prut, referring to observation wells situated on four alignments: Risesti, Lunca Banului, Vetrisoaia, and Falciu.

The simulation of soil salinization process was carried out using UPFLOW-v.2.2 model of Catholic University Leuven-Belgium (Raes, De Proost, 2003), where the main output is upflux from groundwater. Several input elements were considered, such as the stratigraphy and hydro-physical properties of soil profile (the depth of soil root zone is 0,5 m), monthly real depth of water table (this is an apparent depth, modified by the coefficient developed by dr. ing. Tomita O. (Tomita O., 1999). the salt concentration of groundwater, the evapotranspiration rate (calculated with Penman-Monteith formula), and the soil water content for a well irrigated soil.

The significance of the input factors shows a net difference in transversal direction upon the Prut River direction depending on the soil profile and its physical properties, the water pressure of groundwater, and the real depth of water table. In the floodplain land strip situated near high terrace, there are aluvial soils with very low permeability and slow drainage porosity (2,5-6,2 %), from the land surface down to 4-5 m depth. The real depth of groundwater table varied from about 2 m over wet periods up to about 5 m over dry periods, while the salt concentration of groundwater in observation wells varied between 2 and 3 g/l (Atanasie, 2008).

In the floodplain's central zone, stratigraphy is about the same as in near foot terrace zone. The drainage porosity has medium values of 0-1 m depth, but downward it fast diminishes and stabilizes at about 3% (from 1,4 m depth to water table). Real depth of water table ranged from 2,5m to 4m and the salt concentration of groundwater in observation wells varied between 1g/l and 2,5 g/l.

In the strip zone near Prut River, there is a great influence of river water level variations on the groundwater table depths. Real depths of groundwater are in the range of 3-5 m. Salt concentration of groundwater is in range of 1-2 g/l in observation wells, but overpasses 2,5 g/l in dry years. The soil stratigraphy from surface to groundwater is composed mainly by loam, sandy clay, clay, sand, and clay loam layers, all of which generally have a good permeability, with the exception of the clay layer which is about 1m in depth.

RESULTS AND DISCUSSIONS

Salt amount rising from groundwater in soil root zone

Simulations of salt build-up were carried out using the previously demonstrated model for each of the three zones of floodplain between Albita and Falciu. An observation well was chosen as the representative data point for conditions influencing the salt move-up.

On average, annual salt inflow to the active soil layer supplied from groundwater are different between near foot terrace zone, central part of floodplain and in the zone near Prut River, respectively. These differences are due to various amounts of upward flow and salt concentration of groundwater. The largest salt amount builds into the soil root zone during the dry years, with water deficit during cool season, especially when we observe a gradual increase of groundwater salinity.

Soil salt evolution and leaching efficiency with increased rainfall rates

During the study period we observed reduced salt leaching by natural rains which occurred only during cool periods of the year while the soil water regime is in excess and only in the proximity of the drainage canals. In other circumstances, the salinization process is intensified. In the conditions of successive years with limited precipitation and the cool period of the year, it is possible to reach elevated values of soil salt concentration that can generate low yielding crops.

To ensure a leaching process of soil salts, it is necessary to rehabilitate the subsurface drainage system by promoting reduced drain spacing and to extend the area provided with horizontal subsurface drainage on the central and the near foot terrace strip of the floodplain.

The soil water balance simulation was carried out for the condition of a horizontal drainage system with drains 12.5 m apart and 1.2 m depth and with a filtering layer situated above the drains with a 50 cm height. The simulations reported on two alternatives: scarified and non-scarified soils. It was considered that the subsurface drainage system helps evacuate 30% of exceeding water in non-scarified soils and 70% in the scarified soils conditions (research of dr. ing. O. Tomita - Tomita O., 1999). Salt leaching efficiency was measured during experiments for condition of predominant soil texture in study area, silty clay respectively, and for 0,5 m depth of soil (table 1).

Table 1

Salt leaching efficiency

Depth of applied water (mm)	**250**	**125**	**62,5**	**30**	**15**
Leaching efficiency (remaining salinity/ initial salinity)	0,55	0,7	0,85	0,92	0,97
Salinity reduction (%)	45	30	15	8	3

The simulations of salt leaching process under the action of soil water surplus, especially in the cool period of the year were carried out with monthly values within the 1996 – 2007 year period. In tables 2 and 3 there are presented the simulations results for the land strip of floodplain situated near high terrace zone.

It is evident that the best results of leaching soil salts were obtained for the scarified soil alternative during the years with water surplus in the cool season. However, if this water surplus is low, as was the case during the last years, the soil salinity will increase or remain at the same level. In the case of non-scarified soils, the drainage efficiency is lower. For these reasons, the reduction of soil salinity is more probable during the years with significant water surplus during the cool period; during other years, soil salinity is stationary or it may rise during dry years. These features reveal the importance of taking actions of scarifying the soil with a repetition every 2-3 years, for a successive period of dry years. However, for a period of years with water surplus in cool season, the operation of scarifying soil is sufficient if repeated at intervals of 3-5 years. With these measures, soil salinity can be favorably influenced and maintained at reduced levels for a longer period. During irrigation season, it is necessary to use a water regime that can maintain the soil solution concentration at a level demanded by agricultural crops in order to obtain the planned yields. The soil salinity management could be done by leaching irrigation with water from the Prut River. Nevertheless, this alternative demands the use of an actual sprinkler irrigation system, which in turn requires higher costs for water pumping and distribution on the fields.

Table 2

Soil saline balance under natural salt leaching in following situation: subsurface horizontal drainage and scarified soil

Year	Water surplus in the cool year period	Percent of leached salt	Salt input from groundwater		Initial soil salinity	Final soil salinity
			(mg/100g of soil)	t/ha.year	(mg/100g of soil)	(mg/100g of soil)
1995			5,95	0,387	734	577,42
1996	92,26	22,14	5,72	0,372	577,42	473,04
1997	79,45	19,06	6,25	0,407	473,04	364,53
1998	101,08	24,25	11,2	0,731	364,53	300,89
1999	85,54	20,52	19,2	1,25	300,89	293,01
2000	34,65	9,01	22,3	1,45	293,01	293,44
2001	27,51	7,46	8,4	0,54	293,44	296,78
2002	8,61	1,72	10,1	0,66	296,78	249,69
2003	80,29	19,26	8,2	0,53	249,69	234,36
2004	36,61	9,42	0,74	0,05	234,36	195,97
2005	69,58	16,69	2,27	0,15	195,97	166,93
2006	66,57	15,97	2,5	0,17	166,93	163,26
2007	17,08	3,69	8,13	0,53	163,26	171,39

Table 3

Soil saline balance under natural salt leaching for subsurface horizontal drainage and non-scarified soil (same area)

Year	Water surplus in the cool year period	Percent of leached salt	Salt input from groundwater		Initial soil salinity	Final soil salinity
			(mg/100g of soil)	t/ha. year	(mg/100g of soil)	(mg/100g of soil)
1996	39,54	10,05	5,72	0,372	666,15	612,76
1997	34,05	8,87	6,25	0,407	612,76	552,41
1998	43,32	10,86	11,2	0,731	552,41	511,49
1999	36,66	9,43	19,2	1,25	511,49	515,61
2000	14,85	2,95	22,3	1,45	515,61	525,75
2001	11,79	2,35	8,4	0,54	525,75	530,27
2002	3,69	0,73	10,1	0,66	530,27	492,91
2003	34,41	8,94	8,2	0,53	492,91	485,19
2004	15,69	3,23	0,74	0,05	485,19	447,30
2005	29,82	7,96	2,27	0,15	447,30	415,20
2006	28,53	7,68	2,5	0,17	415,20	411,62
2007	7,32	1,46	8,13	0,53	411,62	419,75

CONCLUSIONS

1. The soil salinization process of the Prut River floodplain from Albita at Falciu is more severe in land strips near the high terrace and in the central zone. This is justified mainly by lythological and hydrological conditions.

2. The prevention of increasing soil salinity in actual conditions requires the rehabilitation of the surface drainage system, especially by reducing drain spacing and extending the area with subsurface horizontal drainage (the latter is in correlation with soil salinity evolution and the degree of irrigation usage).

3. Wherever these undertakings are successful, they could achieve a proper management of the soil salinity. Soil desalinization efficiency using water surplus in the cool season depends on the drainage system efficiency as well as the salt leaching efficiency, both being very strongly influenced by the soil scarifying activity.

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