SOIL DEGRADATIONS IN RICE (BANLOC, TIMIS COUNTY)

R. BERTICI[1], D. DICU[1], L. NITA[1], Laura SMULEAC[1], Alina LATO[1], M. HERBEI[1], R.C. HERBEI[2]
[1]Banat University of Agricultural Sciences and Veterinary Medicine "Regele Mihai I al României" from Timişoara, 119 Calea Aradului, 300645 Timişoara, România
[2]University of Petrosani
Corresponding author: danieldicu@usab-tm.ro

Abstract. *Hydrotechnical arragement for rice cropping from Banloc – Topolea (Timis) worked since 1786 year. In this paper we present the environmental conditions (climate, geological, geomorphological, and hydrological and vegetation), hydro technical scheme, irrigation regime, the design of field irrigation systems and soil cover. In the irrigated plots for 120 years and 25 years and also in the field limitrophe to the rice cropping it was effectuated physical, chemical, hydrological and morphological determinations (particle –size distribution, air porosity, hydraulic conductivity, pH, $CaCO_3$, soluble salts, humus, macro and microelements content, redoxpotential). The findings and results from the soil and water analysis allow us to have some relevant information about profound impact of the long time irrigation upon soil profile and on the other environmental conditions. The alterations yielded in the internal arrangement and also in the limitrophe zone. The most evidently alterations are observed in the soil profile irrigated for 120 years while in the soil profile irrigated for 25 years the changes are difficult to be recorded. For instance, in the plot with 120 years irrigated a lot of properties are modified: the texture species became clayey, the bulk density are great even in the topsoil (1.33/1.68 $g \cdot cm^{-3}$), infiltration velocity is diminished from 38 $mm \cdot h^{-1}$ to 5 $mm \cdot h^{-1}$ at 50 cm depth, the level of carbonates lowers from 40 cm to 150 cm depth. There are proposed some measures to control land degradation and to increase the economic efficiency of the rice cropping.*

Key words*: irrigation, rice, alteration, bulk density, infiltration*

INTRODUCTION

In Banat there were a series of horizontal arrangements (Valcani, Sannicolau Mare, Sanpetru Mare, Gataia, Denta, Uivar, Rauţi, etc.) but the largest rice mill that still works today is the one in Banloc (DICU D. ET ALL, 2019). It is located in the protected area of the lower basin of the river Bârzava, namely on its right and left bank between km 6 + 100 and 10 + 390 (HERBEI, M. V., 2012, 2020).

The rice mill from Banloc is the first rice mill in the country established in 1784 in Topolea, which is located in the immediate vicinity of the village of Partoş, which currently belongs to the commune of Banloc (ONCIA, S., 2013). It was built by a family of Italians for the benefit of the landowner of those times. From then until today, more than 200 years have passed in which rice has been grown every year for the following owners (ŢĂRĂU D., ET ALL., 2019).

Before World War II, the Banloc estate was bought by Queen Elizabeth. It continued to grow rice while increasing the area from 150 ha to 300 ha.

After nationalization, between 1960 and 1989 the area of rice growing gradually increased, reaching today 639 ha.

Both the former owners and today's SCA Banloc have grown rice continuously with economic results. In recent years, however, due to financial problems and the ownership of these lands, the rice mill is practically abandoned.

In the year 2000, the cultivation of rice was resumed on an area of 25 ha, aiming to cultivate the entire surface of the landscaping in the coming years.

The objectives of the horizontal arrangements are desalination of the soils on the root layer, prevention of secondary salting of the surrounding soils, ensuring the conditions for soil improvement, timely realization of desalination and / or desalination of soil - parent material - groundwater, obtaining rice production (ŢĂRĂU, D., ET ALL, 2013, 2015).

At the Banloc rice field, due to the high operation and maintenance costs of the rice field, as well as due to the drainage system - inefficient drainage, a series of degradation phenomena appeared which gave rise to the modification of the morphological, physical and chemical properties of the soils.

MATERIAL AND METHOD

Soil samples were collected from the Banloc rice field in 1997 and compared with the analyzes from 1975, observing the changes in the physico-chemical properties of the soil during 23 years. The changes of all soil properties to a non-irrigated land, irrigated for 25 years and irrigated for 120 years, were also followed.

The equation of the balance of water and salts by physical and mathematical modeling was also used, establishing the washing curves for the different water norms (FLOREA N., ET ALL., 1987).

The samples collected were analyzed at OSPA Timişoara according to the methodology of ICPA Bucharest and the STAS in force. Granulometry, DA, D, hygroscopicity coefficient, permeability were determined. A series of indices were calculated such as: PT, PA, CO, CC, CU, CT, GT (BERTICI, R., ET ALL. 2012).

The surface of the rice field falls within the plain of the Barzava river. The important source for irrigation in the area is the Barzava River from which water is captured by gravity or by pumping (POPESCU, C. A., ET ALL. 2020).

For the gravitational capture of water, in the middle of the last century, the gravitational intake was made on the river Barzava, from Great Rovinita, consisting of a concrete dam and a dam with two openings on the intake and supply channel (Italian Canal) (ROGOBETE GH., ET ALL, 2015).

The Italian canal has a length of approx. 12 km starting from the place of Great Rovinita and goes parallel to the course of Barzava and then of Birdeanca, and at km 7 + 200 it crosses through a siphon the river Barzava on the left bank, after which it enters the fishery and rice paddy and evacuates again in Barzava at km 6 + 100 dam on the left bank (NIŢĂ L., ET ALL 2018, 2019).

The Italian canal was built in the last century and demolished at the initial quota in 1951 when it was provided with a transport capacity of at least 2 m3 / sec. Along it are currently arranged in an area of 352 ha, field crops and vegetables, as well as a fishing arrangement of 124 ha and rice fields in an area of approx. 600 ha.

The rice field was divided into distinct watering sectors, in order to give the possibility to fill the plots with water, by rotation, by adjusting the closing and opening of the dams in the network of supply channels.

Supply network

This was analyzed in terms of transport capacity and control quotas to ensure the difference between the water level in the canal and the level of plots served by 25-35 cm.

The sizing of the sector supply channels was done with the hydromode increased 2-4 times (7.14-14.28 l / s) in order to shorten the flood duration of the plots.

The distance between the supply channels is on average 350 - 400 m.

The total length of the supply network is 5030 m and with a volume of 61225 m3.

Dams are installed on the supply network to direct the water as well as to raise the level on the canal.

At the intersection between the two pairs of plots, vents for installing water from the canal to the plot are installed.

Exhaust network

The drainage network ensures the emptying of the plots and the water management in the nearest discharge emissary (Barzava) as well as the isolation of the rice field surface from the rest of the land (through belt canals) in order to prevent the contamination of the neighboring surfaces.

The discharge of the collected waters is done gravitationally through the existing drainage network (Roiga system), or by pumping, through the existing pumping station - Topolea.

The depth of the canals is between 1.5-2.5 m, thus ensuring the drainage of the soils after harvesting. The distance between the evacuation channels is 250-420 m. The total length of the evacuation network is 14170 m.

Operating roads

The rice field is crossed by the communal road 184 (Partoş - Denta) from which the right and left entrance to the rice field is made, on the exploitation roads that serve the rice surface.

The exploitation roads are arranged on both sides of the escape channels and are planned to be executed in the embankment, taking the place of dikes at the plots. Their road width was provided by 3 m, the platform height of 0.6 m and the slope of the slopes 1: 1.

At the intersection of the road with the plot boundary, a water drain valve from each plot was provided.

Also, two permanent exploitation roads were provided, with two traffic wires, with a width of 5.5 m, a height of 0.75 cm, slopes 1: 1, namely the access road to the pumping station and the road on the right bank of the main collector for draining water from the rice field.

The total length of the roads is 9060 m, with a volume of embankments of 23483 m3.

Landscaping

The shape adopted for the plots is rectangular, on average 100x200m = 20000m2 representing the average gross area of a plot.

The plots are fed into a corner on the short side and the outlet is designed in the opposite diagonal corner to achieve a uniform water flow in the plot.

To accelerate the supply and evacuation of water from the plots, they are provided with contour gutters with a depth of approx. 0.5 m. These ditches are important in the case of plots with a larger area (4 - 6 ha) and for the achievement of a good drainage of the plot in the periods after the water evacuation from the plot.

It was also planned to execute some subdivision dikes with a crown of 0.3 m, slopes 1: 3, height of 0.4 m for breaking the shawls during periods when the rice is not well rooted (April-May).

RESULTS AND DISCUSSION

The influence of irrigation on ground water

In the non-irrigated area, the groundwater level varies between 2-3 m. In the plot used as rice paddy from the beginning of the 19th century, the groundwater was identified at 1.5 m, and in the plot used as rice paddy since 1932, at 1 , 7 m.

The irrigation system is provided with drainage channels that collect quickly and lead the infiltration waters to the Barzava river, thus determining the maintenance of the groundwater level at a constant depth. Because of this, wilting processes do not take place.

At some distance from the rice field, groundwater was identified at the same depths (1.6 - 1.7 m) due to the hydrostatic pressure excited by the water layer in the rice field.

Changes in the morphological features of soil profiles

Submerged irrigation applied for a long time (100 years) produced important changes in soil profile. The soil took on a blackish color, bearing the imprint of the pseudogleization and glaze processes, manifested with intensity. Calcium carbonate has been deep leached, the horizon of hydroaccumulation has been prolonged and horizon 3 is marked by reduction processes. Horizon C dropped from 94 cm to 150 cm.

In the irrigated area for 25 years, the reduction processes are lower, the level of leaching of calcium carbonate is lower from 40 to 100 cm, the horizon B has lengthened by approx. 30 cm, and the level of $CaCO_3$ concretion formation ranged from 100 to 140 cm.

Changes of the physical properties of soils

a) Particle size composition

The processes of alteration of the mineral matter, intensified under the prolonged influence of the water in the soil mass, determined the crushing of the mineral fragments and of the finer texture.

In the irrigated profile for 120 years the proportion of sandy fraction decreased by 8.8 - 7.4% to 120 cm depth, the clay fraction (less than 0.002 mm) by 8.5 - 19.9%.

The biggest differences between the clay proportions are registered based on the soil profiles leading to the modification of the soil species from clayey to clayey.

In the irrigated soil for 25 years the differences from the control are much smaller, but still noticeable. There are differences of clay from the control of 0.7 - 5.0% by a light leaching without highlighting accumulations in the B horizon.

Here the index of textural differentiation exceeds 1.4 compared to 1.25 as achieved in the control, which indicates an obvious evolution, quite fast of the pedogenetic processes in stopping.

In both cases we consider that the granulometric composition of the soils in the area is very suitable for submerged rice cultivation, as the higher clay content, constant below the depth of 50 cm, ensures the maintenance of water at the soil surface.

Table 1

Granulometric analysis of non-irigated soil from Banloc rice field

Depths (cm)	20	39	50	88	100	143	220
Coarse sand (2,0 – 0,2 mm) %	3,9	3,1	3,2	1,1	1,2	1,0	0,4
Soft sand (0,2 – 0,02 mm) %	35,2	34,0	25,5	26,6	23,8	21,1	36,3
Dust (0,02 – 0,002 mm) %	26,3	24,2	29,4	26,8	25,3	27,7	26,0
Clay 2 (under 0,002 mm) %	34,6	38,7	41,9	45,5	49,7	50,2	38,3
Physical clay (under 0,01 mm) %	47,7	50,7	57,4	59,7	62,4	65,9	51,3

Table 2

Granulometric analysis of irigated soil for 25 years from Banloc rice field

Depths (cm)	20	40	80	110	140	200
Coarse sand (2,0 – 0,2 mm) %	4,0	5,0	5,2	2,0	0,8	1,4
Soft sand (0,2 – 0,02 mm) %	35,0	34,5	30,1	22,2	23,8	33,2
Dust (0,02 – 0,002 mm) %	27,1	25,9	23,9	24,6	25,8	29,3
Clay 2 (under 0,002 mm) %	33,9	34,6	40,8	51,8	49,6	36,1
Physical clay (under 0,01 mm) %	48,7	48,6	53,7	65,0	65,1	49,8

Table 3

Granulometric analysis of irigated soil for 120 years from Banloc rice field

Depths (cm)	20	40	60	80	100	120	150
Coarse sand (2,0 – 0,2 mm) %	1,7	1,6	1,5	1,2	1,3	4,2	6,3
Soft sand (0,2 – 0,02 mm) %	21,3	24,5	27,3	29,3	21,1	27,8	31,7
Dust (0,02 – 0,002 mm) %	31,6	27,3	24,4	22,4	28,1	16,7	5,5
Clay 2 (under 0,002 mm) %	45,4	46,6	46,8	47,1	49,5	51,3	56,5
Physical clay (under 0,01 mm) %	49,5	51,3	57,1	58,9	61,0	63,8	64,5

b) Water stability of structural components

It is generally good, resulting from the favorable interaction between clay and humus, calcium, found in the soil in balanced proportions.

Soil irrigated by submersion for 120 years is characterized by a very good degree of structuring, especially at a depth of 0-40 cm. The same thing was observed in the irrigated plots for 25 years, but in a smaller proportion here the structural aggregates being more fragmented.

In both cases, the structure of the irrigated soils deteriorates in depth compared to the control where they remain constant.

It is assumed that the good structure is due to the fragmented roots of grass plants grown here exclusively, the good quality of irrigation water, but especially the influence of iron colloids. These present in large quantities act in complex with clay and humus, giving the structural elements an increased stability following dehydration during dry periods of emergence.

The phenomenon can also be attributed to the well-represented clay-humic complex, calcium mullus humus or ulminic acids, resulting from anaerobic processes under the action of heterotrophic bacteria that related to di or trivalent elements (Fe) ensure the stability of structural aggregates.

The structural aggregates of irrigated soils have specific shapes compared to non-irrigated ones, with flat faces, sharp edges and corners that favor a more inclined soil placement with repressions on other physical or hydrochemical properties.

In future research, it is expected to study micromorphological details that will surely lead to edifying conclusions on the rhythm and type of migration of components in different stages of evolution of the researched soils.

c) Apparent density, total porosity and aeration porosity

Apparent density, total porosity and aeration are normal for all three soils considered (control, irrigated 120 years and irrigated 25 years) in the layer 0-20 cm.

Under this layer the above mentioned properties deteriorate rapidly. In the interval 30-100 cm, in both profiles from irrigated soils, very high apparent densities were identified 1.53 - 1.60 g / cm3 indicating an accentuated settlement that diminished the total porosity to 43-39%, the increase of the settlement degree of the soil is largely due to the lacquering process, with repercussions on the structure, in terms of size, shape and placement of aggregates.

The degree of compaction of the soil irrigated by submersion for 120 years is higher starting right from the surface, the values of the apparent densities vary between 1.33 g / cm3 (0-10 cm) and 1.68 g / cm3 (40- 50 cm). The fine texture, the irrigation water and the groundwater as well as the heavy agricultural machines that, in wet autumns, trample the land during harvesting and plowing, causing excessive settlements (table: 4,5,6; fig. 1) also contribute to this situation.).

The high values of the apparent densities correspond to small values of the total porosity. The latter varies between 50 - 46% in the plowed layer of irrigated soil (120 years) and then up to 37% in depth (table: 4,5,6; fig. 2).

The aeration porosity is medium to low in the first 20 cm (14.8 - 5.7%) for the soil irrigated by submersion 120 years and good for the non-irrigated soil (27.5%). Below 20 cm the aeration porosity is zero from 20 cm down to the soil irrigated by submersion for 120 years becoming zero only at 70 cm (table: 4,5,6; fig. 3).

The low degree of aeration of these soils explains the intense reduction processes that take place in its mass.

Thus, the need arises to loosen at various depths at intervals of at least three years.

Table 4

The variation of Apparent density, Total porosity, Aeration porosity on non-irigated soil from Banloc rice field

Depths (cm)	20	39	50	80	100
Apparent density - DA (g/cm^3)	1,18	1,55	1,48	1,48	1,55
Total porosity - PT (%)	53	38	40	45	38
Aeration porosity - PA (%)	23,2	3,7	7,5	7,6	4,0

Table 5

The variation of Apparent density, Total porosity, Aeration porosity irigated soil for 25 years from Banloc rice field

Depths (cm)	20	40	80	110	140
Densitate aparentă - DA (g/cm^3)	1,39	1,48	1,54	1,57	1,60
Porozitate totală - PT (%)	46	41	39	38	38
Porozitatea de aerație - PA (%)	13,0	8,1	5,1	3,0	1,5

Table 6

The variation of Apparent density, Total porosity, Aeration porosity irigated soil for 120 years from Banloc rice field

Depths (cm)	20	40	60	80	100
Densitate aparentă - DA (g/cm^3)	1,42	1,66	1,68	1,67	1,66
Porozitate totală - PT (%)	44,1	34,9	34,1	33,5	33,6
Porozitatea de aerație - PA (%)	9,9	1,8	0,2	0	0

c) Water permeability

As a natural consequence of the increase in soil compaction and the narrowing of pore volume, the permeability of soils in irrigated plots has gradually decreased since the surface:

In non-irrigated soil it is good, and in irrigated soil it is moderate for 25 years and 120 years. Deep permeability worsens over the entire profile.

Expressing the permeability through the final speed of water infiltration in the mentioned layers, it results that, between 0-20 cm, it decreases in the irrigated soil from 38 to

26 mm / h, in the irrigated soil for 25 years, from 38 to 22 mm / h and in the irrigated soil 120 years from 38 to 12 mm / h (fig. 4).

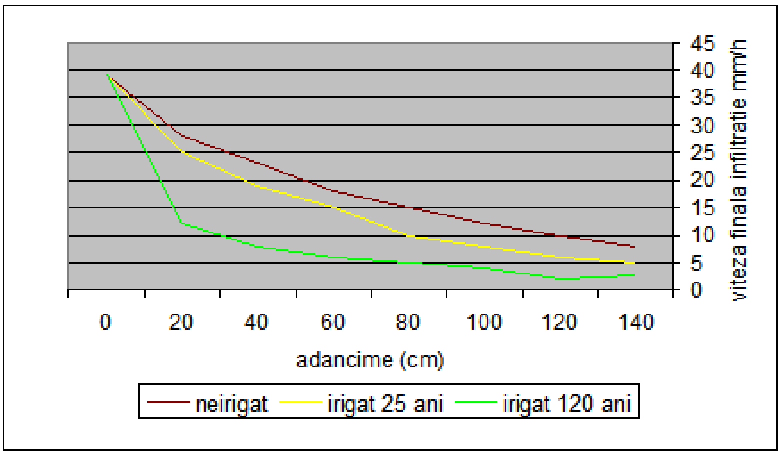

Fig. 1 Infiltration rate variation

In depth it reaches 9 mm / h in non-irrigated soil, 6 mm / h in irrigated soil for 25 years and 5 mm / h in 120-year irrigated soil.

Although the soil of a rice field must not have too high permeabilities, in order to keep the soil flooded without heavy losses by infiltration, it is necessary to improve it, at least in the upper part, in order to influence the biochemical processes in a positive way.

CONCLUSIONS

Submersion irrigation applied at different time intervals, has contributed to raising the groundwater level and to significant changes in morphological, physical and chemical properties as follows:

- pseudogleization on a depth from 80 to 120 cm;
- intensification of the glazing process;
- lowering the effervescence level by 60 and 160 cm respectively and deepening the layer with large calcareous neoformations;
- elongation of horizon B by 30-60 cm;
- easy migration of clay on the profile with the increase of the index of textural differentiation from 1.25 to 1.40;
- making large structural aggregates;
- increase of the apparent density by 15 - 24% in the plowed layer and by 4-6% on the profile;
- reduction of the total porosity by 17 - 20% and of the aeration by 52 - 54% in the upper part of the soil;
- decrease in water permeability.

BIBLIOGRAPHY

BERTICI, R., GROZAV, A., ROGOBETE, G., & ȚĂRĂU, D. 2012 - Experimental research of vertic phenomena during of 45th years in Cheglevici-Romania. Analele Univ. din Craiova, Edit. Universitară.

DICU D., TARAU D.,ROGOBETE GH., BERTICI R., NITA L., IENCIU ANISOARA, FOTA O., 2019, Soil fund structure and soil quality in the middle and lower course of the river Timiş, Romania, Research Journal of Agricultural Science, Vol. 55, nr. 1, Ed. Agroprint, Timisoara

FLOREA N., BĂLĂCEANU V., CANARACHE A., 1987, Metodologia elaborării studiilor pedologice, vol. I, II, III, ICPA Bucureşti, pag. 10-15 (I), 30-71 (II), 29-100 (III).

HERBEI, M. V., SALA, F. 2020 - Evaluation of urban areas by remote sensing methods in relation to climatic conditions: Case study City of Timisoara. Carpathian journal of earth and environmental sciences, 15(2), 327-337.

HERBEI, M., NEMES, I. 2012 - Using GIS analysis in transportation network, 12th International Multidisciplinary Scientific GeoConference. 1193-1200

HERBEI, R. C., HERBEI, M. V., MATEI, A., MORARU, R. I. 2014 - Use of Modern Technology for Adapting the Tourist Areas Affected by the Mining Exploitations. Inżynieria Mineralna, 15.

ONCIA, S., HERBEI, M., POPESCU, C. 2013 - Sustainable development of the Petrosani city, the Hunedoara county, based on GIS analysis. Journal of Environmental Protection and Ecology, 14(1), 232-239.

POPESCU, C. A., HERBEI, M. V., SALA, F. 2020 - Remote sensing in the analysis and characterization of spatial variability of the territory. a study case in Timis County, Romania. Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development, 20(1).

ROGOBETE Gh., Ţărău D., Dicu D., GROZAV Adia, 2015, Research Journal of Agricultural Science, Vol. 47, nr. 3, Ed. Agroprint, Timisoara

NIŢĂ L., ŢĂRĂU D., ROGOBETE GH., SIMONA NIŢĂ, BERTICI R., IONA TUTA SAS, SAS I., DICU D., 2018, The role of ecopedological parameters in management sustainability of Banat lands, Rev. Chim. (Bucharest) 69, Nr.3,

NIŢĂ L., ŢĂRĂU D., SIMONA NIŢĂ, ALINA HEGHES, BERTICI R., DICU D, 2019, Soil Quality in the Poganis, Ramnei and Doclin Hills, Measures of Impovment, Rev. Chim. (Bucharest) 70, Nr.7,

ŢĂRĂU D., ROGOBETE GH., DICU D.D.,ADIA GROZAV,NIŢĂ L.D., ILIUŢĂ A.Ș.,CLARA MAGDA TUDOR, BERTICI R., 2019, Pământuri şi locuri dintre Dunăre-Vârful Gugu-Crişu Negru, Ed. Eurobit Timişoara,

ŢĂRĂU, D., ROGOBETE, G., DICU, D., BERTICI, R. 2013 - Using pedological information to define land productivity and environmental protection in mountain and pre-mountain area of Timis county, Research Journal of Agricultural Science, 45(2), 303-308.

ŢĂRĂU D., ROGOBETE GH., DAVID GH., DICU D., 2015, Ecopedological resources from Banat and their suitability for the main agricultural crops and tree species, Research Journal of Agricultural Science, 47(3).

*** O.S.P.A. TIMIŞ– *Studii pedologice şi agrochimice.*