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Differentiation of the irrigation regime on soils with groundwater supply from dammed river plain

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Abstract: The soils from dammed meadow present a groundwater supply at low depths on much of the territory, giving plants a consistent supply of water raised by capillarity. The volume of groundwater intake differs according to a complex of conditions: depth of ground water level, soil texture, crop, the vegetation stage of the plant. Experimental determinations, performed on physical models (lysimeters) and in the field, in dammed meadow Big Island of Braila, established the parameters of the phreatic input, for the main agricultural crops, remarkable useful in the management of irrigation. The irrigation regime in the meadow is applied differentially referring to the number of number of irrigation, the watering norms, the irrigation interval, depending on the hydrogeological framework. Thus, at the depths of watertable below 1 m, the crops do not irrigate, when water table is 1.5 m depth, irrigate 2-3 times with 500-600 m^3 per hectar, In the paper are presented the experimental results obtained that have grounded the technology of differential application irrigation on the meadow soils of the Big Island of Braila, with an area of 72.000 hectares.

Keywords: groundwater, irrigation scheduling, hydroameliorative arrangements

Introduction

In the current period are witnessing a global process heating, process research studies performed in the Braila Station for the North Baragan, and parameterized by analyzing observations of climate multiannual attesting changes by the year 2025, with decreasing precipitation to 440mm, and with annual increase of air temperature to 11.3^{0}C, appropriately increasing the amount of the normal annual potential evapotranspiration to 730 mm.

These climate changes will put a strong impact on agriculture on the whole country and especially North Baragan area where we are, imposing technical solutions for better management of soil water and suitable refolding technologies. The territory of Braila county, with an arable area of 385.867 ha, includes North Baragan and part of Central Baragan (in South), with majority plan relief in plain and slightly undulating meadows Danube, Siret, Buzau and Calmatui rivers. The main types of soils are formed on loess, Cernisoil class and Chernozem on 43%, leachated chernozem (cambic) 6% on plain and class undeveloped soils, alluvial soils and alluvial protisoil on about 33% in meadows, good fertile soils, mainly in classes I-III. With lower weights and very low fertility soils are halo form (Solonchak, Solonetzs and complex Solonchak-Solonetz) on 5% and Psamo-pelitic soils, class undeveloped soil still on 5% of the territory, located both in the plain and the meadow.

From a climate perspective, in North Baragan input from rainfall is 442 mm, outflows water in balance by potential evapotranspiration of 715 mm, resulting in a climatic deficit water in soils 273 mm with wide variations, from 53 mm in humid year (2009-2010), to 528 mm in very dry agicultural year (2006-2007). In the monthly dynamics, the climate shows a cold period (October-March), water accumulation in soil multiannual worth approximate 100 mm and a warm period (April-September) dominated water consumption, water scarcity reaching the level of 373 mm, Figure 1.

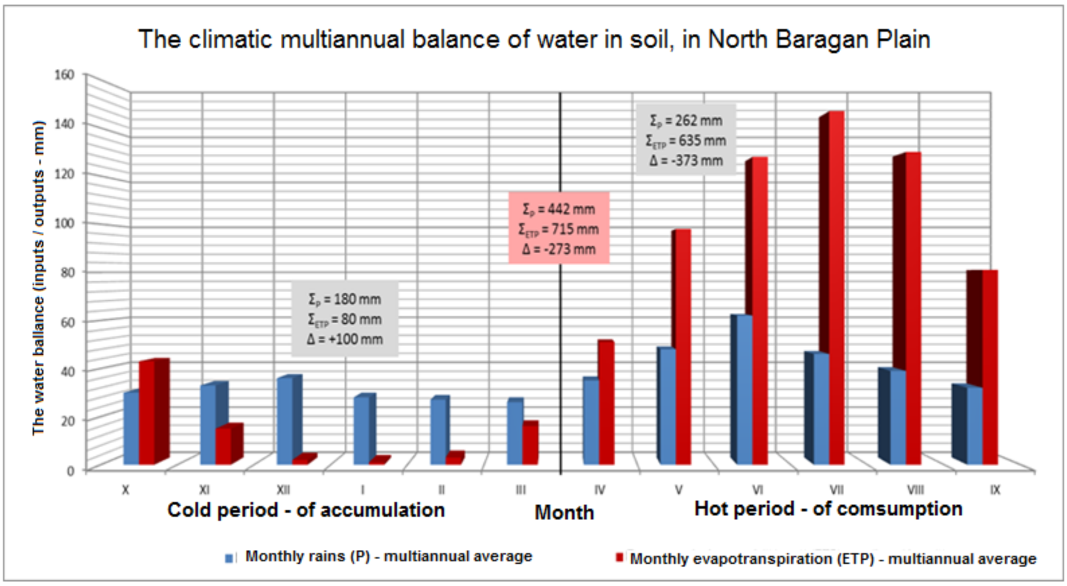

Figure 1. Monthly multi-annual dynamics of rainfall and potential evapotranspiration

In this framework, fertile soils but increased water deficit, high potential for extiding degradation by salting (to about 70% of the area), agriculture improvement requirement has been imposed in which prevail capitalization at a level as high as all natural water sources (climate, groundwater) and irrigation water.

They conducted extensive research in the field of hydromeliorative, research useful in the design and operation of land arranged hydromeliorative that the county totaled: damming – 146.070 ha, draining – 21.853 ha, irrigation – 358.785 ha landscaped in the functional – 275.401 ha (77 % from total).

The aim of research is to see how the groundwater supplies can help crops in the pedological drought conditions.

Materials and Methods

The paper presents some results of research carried out on physical models (Lysimeter) in field and laboratory and which included: establishing a system of hydrogeological observation wells to networks within agricultural farm; drawing hydrogeological maps for representative period in terms hydro climatic; establishing intake of water by Lysimeter determination, depending on the depth of the groundwater, the crops, growing stages and representative soils of meadow. Irrigation requirement was based on hydrological balance, technology also been set-up irrigation system differentiated by groundwater intake, for agricultural crops from farm.

Results and Discussion

Previous researches carried out by the resort and the recent developed in projects targeting issues irrigation on dammed medows namely PS 2.2.4 Sectorial project "Research for efficient use of natural water resources in irrigation facilities to reduce consumption of irrigation water and conserve the fertility of the soil" (2011-2014) and MOSES project "Model investigation and warning watering hydro climatic using satellite services" (2015-2018) brought a contribution account in efficient water use for irrigation of crops, in arranging complex Big Island of Braila.

The groundwater reservoir of the dammed and hydromeliorative arranged meadow.

A profile geomorphologic transversal through the meadow - Figure 2 is a series of the geomorphology formation starting from the Danube to the inside of the meadow: sand bank, the intermediate zone and lower zone, highlighting a difference in the intensity of water supply from groundwater by raising capillary: the low supply formations high sand banks at a very high supply lowlands, former bottoms lake, on backwaters and supply middle on the intermediate zones. Geomorphological zoning in the Big Island of Braila shows conformation: the sand bank of the river and adjacent interior bottoms, occupy 36% of the total enclosure, intermediate zone occupies 41% and low area covers 23% of the total area of the enclosure.

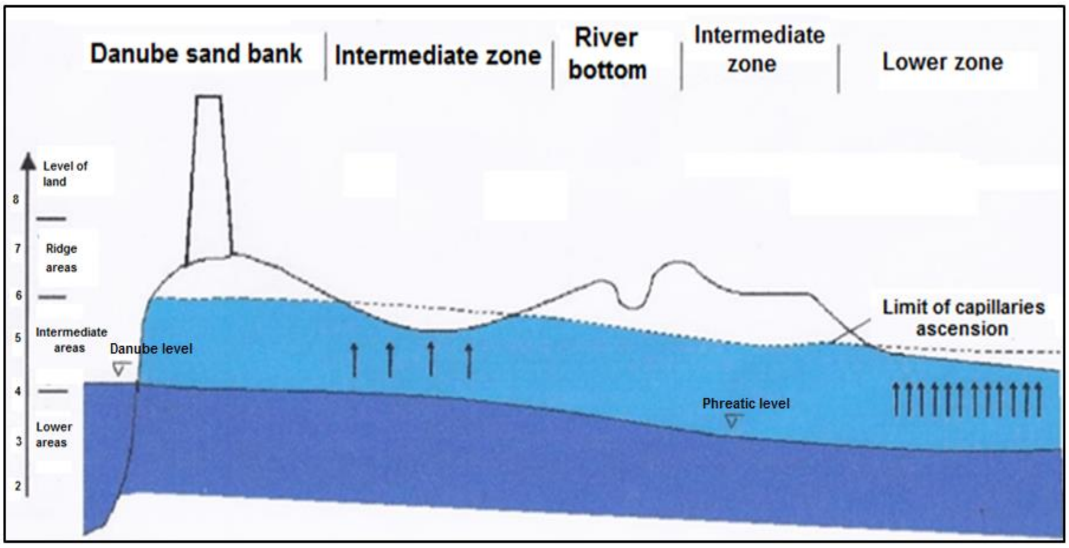

Figure 2. Profile geomorphological cross the meadow and the location of groundwater tank

The useful zoning forms of micro relief sand bank, intermediate zone and low zone, is the pedological conditions that differentiates physical, hydrophysical and hydrological attributes, of soils, elements that contribute to different technical measures that apply on agricultural and hydromeliorative exploitation of these drainaged and irrigated lands, removed from the water overflow.

Groundwater supply effect on agricultural yields dammed meadow soils.

Observations and measurements made on the behavior of crops under water supplies from groundwater indicated essential differences agricultural yields correlated with the depth of the groundwater, determined by geomorphological conformation of the territory. It established the curve of the production of the main crops, depending on the depth of the groundwater. Production curves in wheat, maize, sunflower and alfalfa crops shows peaks in the depths from 0.75 m to 1.25 m, optimal water supply and the production decreases, to the depth of 2.5 m, emphasizing the shortages of water and also the depth decreases below 0.75 m due to the existence of conditions of excess water, figure 3. It could provide useful technical information such agricultural beneficiaries in better management of the farms in the design and execution of technological systems applied to crops.

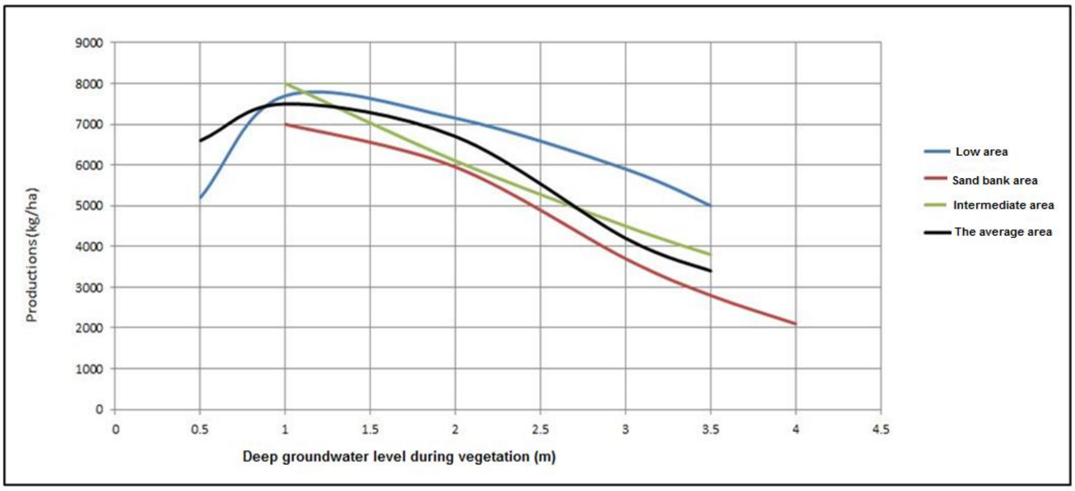

Figure 3. Curves of variation of corn crop production depending on the depth of groundwater on geomorphological areas

The supply of water from the ground water of crops in the dammed meadow

Water supply for crops from groundwater was determined by observations and measurements with Lysimeter researches in the field. For the main culture, wheat, maize, sunflower and alfalfa, ground water levelat depth of 1m; 1.5m; 2m; 2.5m and 3m, underground water intake was measured (dark blue) and expressed in percent of the total consumption of the plant, the intake of precipitation (blue) and the gap covered by the irrigation water (white) with values differentiated by depth of the water table, Figure 4.

The intensity of the ground water intake increases starting from great depths (2.5-3 m) to small (0.75-1 m), increases from the wheat, to the corn, sunflower and alfalfa then correlated with the specific consumption of the plant water and rooting. Thus, for the rooting depth area, water intake of the cultures studied, the contribution of groundwater showed a variation of 1% to 39% the total consumption of the plant, correlate with the decrease of the depth of the groundwater from 3 m to 1 m.

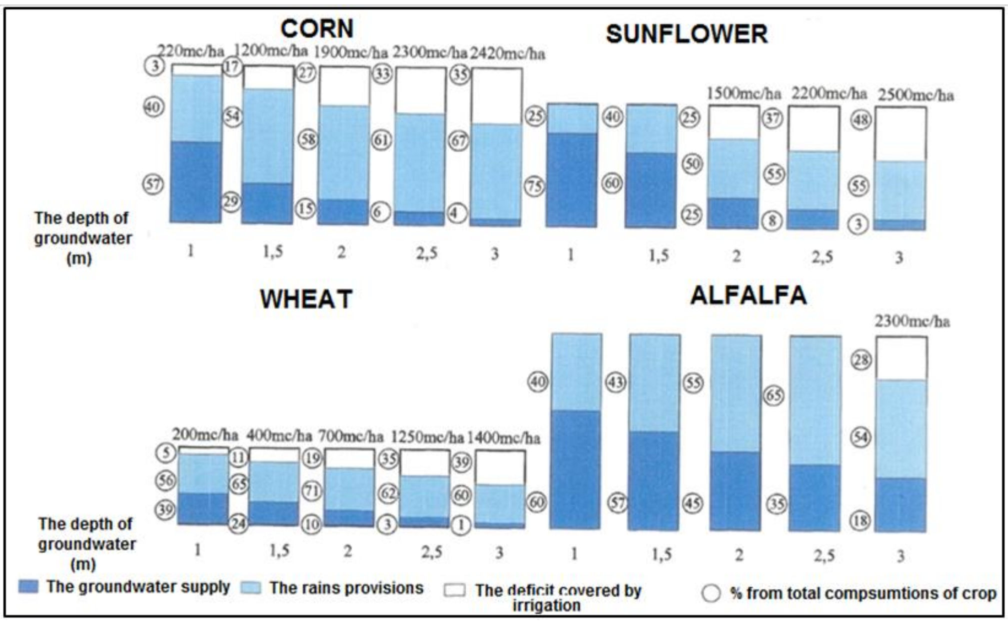

Figure 4. The supply of water from the reservoir groundwater on fine texture soils and the influence on the irrigation water requirement to maize on Big Island of Braila

These weight parameters of underground water intake of the total consumption of the plant shows increased values, from 4% to 57% for maize, from 3% to 75% for sunflower and for alfalfa ranges from 18% to 60%, as the decrease in the depth of the groundwater from 3 m to 1 m. Deficits of water, expressing the requirement for irrigation reported the total consumption of water of the plant, shows the values increasing from 5% to 39% at wheat, from 3% to 35% at corn, from 25% to 48% at sunflower oil with increasing depth of 1 m from 3 m. The exception is alfalfa that’s deep rooting and allows providing the necessary full of water up to 2.5 m, deficits of more than 18% of the plant consumption occurring in depths greater than 3 m.

Table 1 shows the ground water supply from the main crops (wheat, soybean, corn, sunflower, alfalfa), and the total monthly during the growing season, for the four depths of the ground water level (0.5 m, 1.0 m 1.5 m, 2.0 m), resulting in the findings:

- contribution groundwater in total vegetation period increases from wheat to the soybean, corn, sunflower and alfalfa, correlated with the specific rooting (depth, intensity) and measure consumption the total water of the plant. Thus if we consider the depth of the ground water level of 1 m, the consumption of the tank groundwater increases from wheat (129 mm), to soybean (263 mm), corn (253 mm), sunflower (304 mm) and alfalfa (561 mm).

Table 1 Phreatic contribution on soil with fine texture
(Lysimeters measurements in Big Island of Braila)

Crops	The depth of phreatic level (m)	Monthly phreatic contribution (mm)						Total phreatic contribution in vegetation period (mm)
		IV	V	VI	VII	VIII	IX	
Wheat	0,5	24	65	92	-	-	-	181
	1,0	8	44	77	-	-	-	129
	1,5	5	19	67	-	-	-	91
	2,0	4	5	12	-	-	-	21
	2,5	2	2	2	-	-	-	6
Corn	0,5	0	12	28	111	129	70	350
	1,0	0	6	9	65	103	70	253
	1,5	0	6	4	23	77	44	154
	2,0	0	2	2	4	6	6	20
	2,5	0	2	2	2	4	5	15
Sunflower	0,5	0	5	80	170	100	-	365
	1,0	0	4	50	150	100	-	304
	1,5	0	3	27	68	100	-	198
	2,0	0	3	10	45	40	-	98
	2,5	0	2	4	12	20	-	38
Soybeam	0,5	0	8	47	120	140	100	415
	1,0	0	5	23	65	80	90	263
	1,5	0	4	4	15	30	40	93
	2,0	0	4	2	3	7	5	21
	2,5	0	2	2	2	4	3	14
Alfalfa	0,5	40	107	126	130	150	100	653
	1,0	35	91	90	115	130	100	561
	1,5	30	86	70	93	122	100	501
	2,0	7	71	60	80	90	85	292
	2,5	5	31	50	46	59	70	281
	3,0	5	20	25	30	35	35	150
	3,5	5	10	10	10	10	15	60

Note: The contribution of groundwater on soils with medium-coarse texture diminishes to one finely textured approx. 10% below the groundwater level to depths of 2 m and approx. 20% groundwater level to depths of more than 2 m

- the dynamic monthly correlated to the advance stages of vegetation, at a depth of 1 m, consumption increases by touching the peaks during May-June wheat (44 mm; 7 7 mm) with a peak in June, in July-August-September corn (65 mm; 103 m m; 70 mm) with a peak in August, in the July-August sunflower (150 mm;100 mm) with a peak in July, during June-July-August soybean (65 mm; 80 mm; 90 mm) with a peak in August, during June-July-August alfalfa (115; 130; 100 mm) with a peak in August.

The regime of irrigation on soils supplied water in the dammed meadow.

In the monthly dynamics, the groundwater in the meadow increases as the roots deepen and the plant's water consumption increases, but it also intensively increases the water deficit with peaks in June-August, requiring the application of a different irrigation regime depending on the depth of the groundwater. Corn is not irrigate the groundwater level to depths of less than 1 m, 2 irrigation to depths of 1-1,5 m, 3 irrigation is applied to depths of 1,5-2 m, and 3 or more as required irrigation at depths greater than 3 m, Figure 5. In the figure is indicated irrigation regime, the number of watering (the norm of 600 m^3/ha) and period (month, decade) for the application of irrigations.

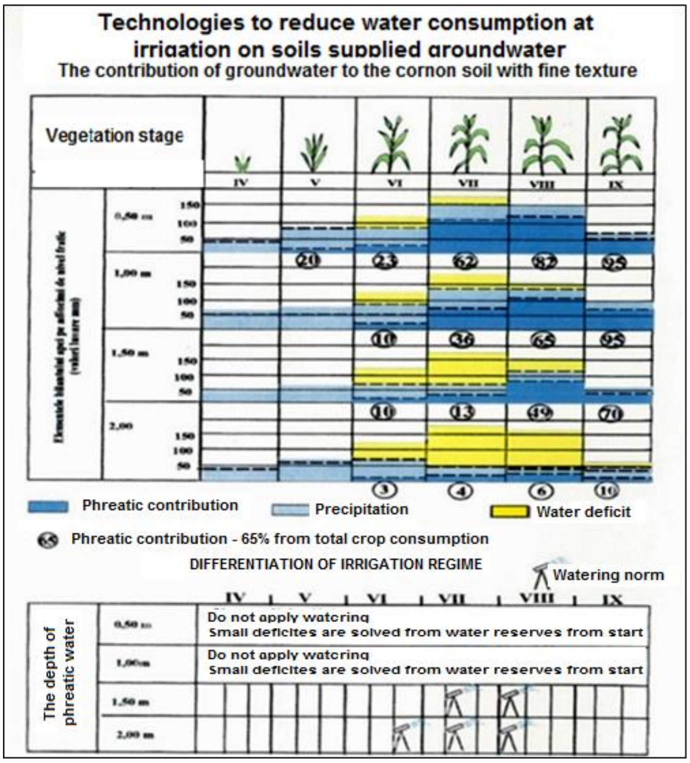

Figure 5. The technology for differentiation of the system of irrigation on fine texture soils at corn crops

On the basis of determinations in the field Lysimeter in research projects have developed technologies for implementing of irrigation differentiated by the depth of the groundwater, soil textural type for the main crops in the Big Island of Braila.

Oriented new technologies have been developed for application of the irrigation crops of wheat, corn, soybean, sunflower and alfalfa.

It shows further irrigation technology for soybean crop.

Depending on the pedo-hydrologic, the system of the soybean crop irrigation provides:

- at the average depth of the groundwater within the 0.5-1 m, and is highly water intake is not irrigated the culture;
- at the average depth of groundwater contained within the limits of 1-1.5 m, and

the intake layer is moderately, soybean crop was subject to two watering of 600 m^3/ha, in the second decade of July and first decade of August;

- on average depth of groundwater contained within 1.5-2 m, underground water intake is low and soybean crop and apply three watering in the 3rd decade of June, the second half of July and the first decade of August ;

- on average depth of groundwater exceeding 2-2.5 m, underground water intake is low or nonexistent and soybean crop and apply 3-4 start watering during June to August;

- norms of watering values were of 500-600 m^3/ha.

- in periods of high soil water deficits seeding, watering is applied to reduced emergence rules of 200-300 m^3/ ha.

By applying the technology of differentiated soybean crop irrigation is performed from irrigation water saving 1-3 watering low areas, ground water depths of less than 2-2.5 m, and the corresponding economy watering equipment.

Developing pedo-hydrological indices of tank groundwater.

In practice researches have established some indices pedo-hydrological of tank groundwater in order to characterize the capacity of water supply of crops on the farm:

- Guf – extent utilization of reservoir groundwater (%), express proportion in the territory of use by culture of the water supply from the groundwater by capillary rise, with the measurement areas of ground water depths less than 2 m, which are highly active areas in the groundwater supply of crops;

- IFU - index contribution of groundwater useful (m^3/ha), establishes the extent of the contribution groundwater useful crops, expressing the average water supply of each hectare on the farm, as a weighted average of the areas well supplied groundwater, medium, low or without phreatic supply. These indices are useful indicators in designing agricultural technologies (including irrigation system) and financial budget across farms.

An analysis based on indices pedo-hydrological of the tank groundwater for six farms in the Agricost company from the Big Island of Braila (Table 2) attesting differentiation farms on the index Guf starting from small values, farm Edera (<20%) to a big values farms Visani and Stavilaru (40-60%) and very large values farms Gemenele and Filipoiu (index 60-80%). IFU indices, shows the values of groundwater supplies and thus saving irrigation water starting from 100-200 m^3/ ha (farm Edera) at 700-1.100 m^3/ha (Visani and Stavilaru farms) to 1.100-1.400 m^3/ha (Gemenele and Filipoiu farms).

Table 2 Pedo-hydrological indices of groundwater tank for few farms in the Big Island of Braila

Farms from the Big Island of Braila	The pedo-hydrological parameters of phreatic reservoir			Economy of irrigation water mc / ha	Effects		
	The using degree of phreatic reservoir (G.u.f.) %	Index of useful phreatic contribution (I.f.u.) mc/ha	Characterization		Economical (decrease of expenses with irrigation water) lei / ha	Economical (decrease of expenses with irrigation water) thousand lei / farm	Environmental
Edera	<20	100 - 140	small	100 - 200	19-38	29 - 58	Preservation of soil fertility
Faru Armeneasa Prundu	20 - 40	320 - 620	moderate	400 - 700	76-133	143 - 250	
Vişani Stăvilaru	40 - 60	630-1.050	big	700 - 1.100	133-209	240-376	
Gemenele Filipoiu	60 - 80	900 -1.340	very big	1.100-1.400	209-266	382-486	

Ensure appropriate spending cuts with irrigation water. But more importantly by applying pedo-hydrological indices establishing irrigation system to water supplied groundwater, is the conservation of soil fertility, provided by administering rational irrigation water, as needed and where needed.

Developing an early warning system to irrigate soils meadow

For conditions meadow was developed a flowchart warning irrigation by water balance in soil (Figure 6), which takes into account climatic conditions, namely intake water, intake water from groundwater, the contribution of irrigation, and water consumption by plants.

The monitoring platform elements water balance, installed systems and devices for measuring the water inlet (precipitation-P, intake phreatic-Af, irrigation-Ir) and the output of water by consumption of plant (ETRO) with pluviometers, evaporimeters, air thermometers, tube sounding for measuring the groundwater level. The periodic tarnover of balance factors allows to determine the requirement and the measure of water intake given by irrigation.

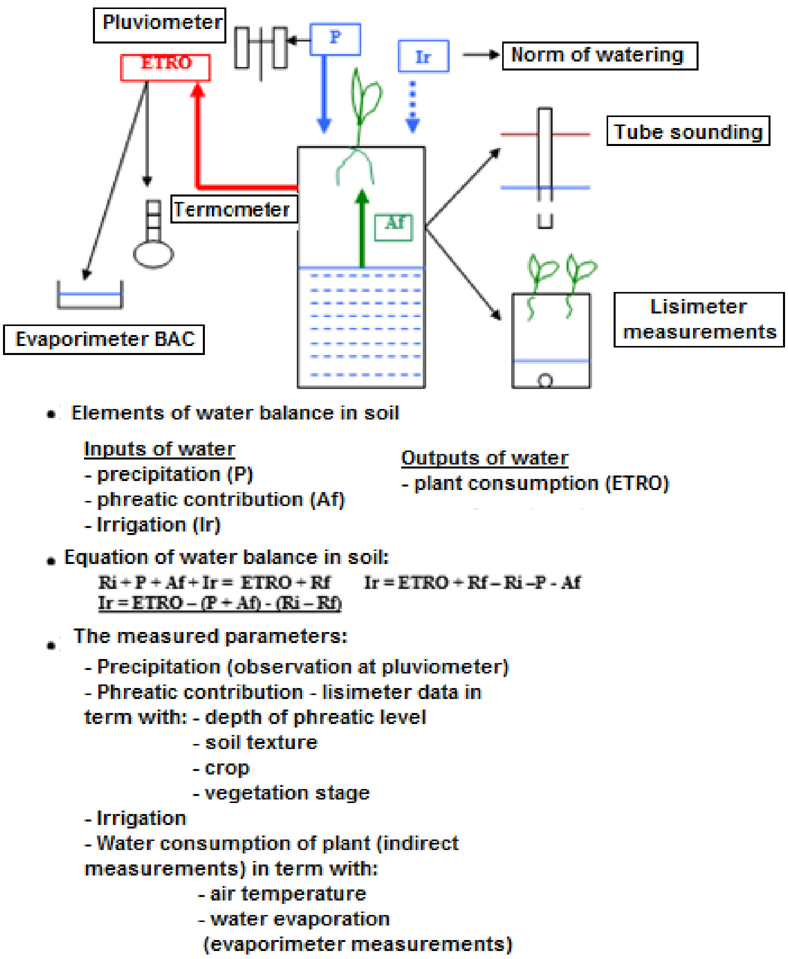

Figure 6. The flowchart of water balance in soil and the warning of irrigation in meadow soils

Creating a system for monitoring of groundwater depth

In the standard farms, which have conducted researches in the sector project PS 2.2.4., it has developed a system for monitoring the groundwater reservoir, consisting of networks hydrogeological well with measuring of groundwater depth, with a density of 1 well at approx. 200 ha. Hydrogeological well are piezometers installed in ground water reservoir, consisting of PVC tubes with a diameter of 2.5" and having a filter area in the portion introduced into the groundwater and a metal tube with 3" diameter for protection PVC tube - Figure 7. It was applied a rigorous observation and exploitation of these hydrogeological well. Was performed measurements of groundwater level providing background data periodically for hydrogeological regime, allowing differentiation of crop irrigation regime after intake of water from groundwater.

Figure 7. Photo documents – Assembling of hydrogeological well

Conclusion

The paper presents a number of contributions to efficient water use for irrigation of crops on soils meadow area North Baragan:

-pedo-morphological conformation of territory is the differentiation meadow soil properties and technical measures to be applied in agricultural and ameliorative exploitation;

- on the basis of researches on physical models (Lysimeter) and in field established the amount of underground water supply tank of the main crops, total vegetation period and monthly correlated with biological stages of plant growth and development, differentiated depth of groundwater level;

- related of the ground water supply, is increasing in the following order of crops: wheat, soybean, corn, sunflower and alfalfa, connected with the particularities of rooting and total water consumption of the plant;

-in monthly supply dynamics of groundwater reservoir grows in advance of plant vegetation touching the highest values in May-June for wheat, July to August for sunflower and July-August-September for corn, soybeans and alfalfa;

- it was developed technologies differentiation of irrigation system on the farm for the main crops, depending on the hydrogeological aspects existing in the farm teritory;

- it was developed a system of pedohydrological indexes of groundwater, indicators useful in designing agricultural technologies, irrigation regime and financial budget on the farm;

- it was developed a system of monitoring of groundwater depths on the farm teritory, groundwater reservoir parameters useful knowledge for a better utilization thereof.

Acknowledgment

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-within the MOSES project "Model of Hydro-Climate Investigation and Water Warning Using Satellite Services" (2015-2018), contract no. 1388 / 19.10.2015 concluded with INHGA Bucharest.

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