THE RESEARCH FROM SOIL-WATER-BALANCE FIELD (1976 – 2009) FOR ESTABLING THE IRRIGATION OPPORTUNITY IN THE CRISURILOR PLAIN

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Abstract

The paper is based on the research carried out in the research field for establishing the soil-water-balance placed in 1976 in Agricultural Research and Development Station Oradea on the preluvosoil. The pedological drought was present each year for alfalfa year I and for alfalfa year II. The optimum regimen of average irrigation included norms of irrigation of 3050 m^3/ha for alfalfa year II and of 2595 m^3/ha for alfalfa year I, the average number of irrigations being 7, respectively 6. Under the influence of irrigation the values of pF and the values of porosity of aeration were improved. The water/temperature + light report characterizes the microclimate of the irrigated alfalfa as „wet II" and of the non irrigated as „average drought". The daily consumption of water of irrigated alfalfa and the total consumption of water of alfalfa. The irrigation determined the obtaining of an average increase of production of 57,6% (year I) and 51,9 % (year II).

Key words: alfalfa, pedological drought, water consumption, yield, water use efficiency

INTRODUCTION

Alfalfa is characterized by a great resistance to the drought due to the characteristic to be supplied with water from the deep layers of the soil. The roots have a strong force of absorption of the water and in the periods of prolonged drought the plant slows it growth and the water consumption is more reduced. In the first year of life the roots of alfalfa are weakly developed and, as a consequence, the need of water has to be satisfied by a high humidity of the soil in the superficial layers. The alfalfa doesn't bear high temperatures from the soil, these cause sometimes even the death of the plants. Even if it is very resistant to drought, the alfalfa gives great productions only in the regions in which the sum of annual precipitations is greaer than 500 mm, and the precipitations are uniformly divided. In the regions with less precipitations the alfalfa gives high productions only on the low forms of relief, in grasslands, or in conditions of irrigation. The alfalfa doesn't bear also the excess of humidity; its cultivation on the too wet fields and in the regions in which the precipitations are over 1000 mm per year doesn't lead to obtaining good results (Bărbulescu, 1972, quoted by Domuţa, Domuţa, 2010).

MATERIAL AND METHOD

The researches were performed at Agricultural Research and Development Station Oradea on a preluvosoil. The researches were began in 1976 by placing an experiment with 10 crops, that gave the creating of an ameliorative crop rotation (alfalfa I – alfalfa II – alfalfa III – maize – soybean – sun flower – sugar beet – beans – wheat – potato. The fertilization system was an optimum one, to the crops of potato and sugar beet being applied 40 t/ha of manure. The reseaches from the review field were developed in the program „Exploitation of the irrigation system of Research Institute for Irrigation and Drainage (ICITID) Băneasa –Giurgiu. The tehnology used was an optinum one. The researches from Oradea were coordinated by Stepănescu E. (1976 – 1980), Mihaela Butca (1981 – 1982), Maria Colibaș (1983 – 1985), Maria Colibaș and Maria Șandor (1986), and begining with 1987 by Domuța C.

The oportunity of irrigation for the alfalfa was established determining the following parameters:

- the pedological drought (the decrease of the water reserve on the irrigation depth under the level of the easly available water content (Wea) the strong pedological drought, the decrease of the water reserve also under the level of wilting point; were determined by the methodology (Domuța, 1995, 2003, 2005, 2006, 2009, 2012);
- the water reserve from the soil, the accesibility of the water, the porosity of aeration (Canarache, 1990; Domuța, 1995; Brejea, 2010, 2014; Brejea, Domuța, 2011);
- microclimate created by the irrigation; the Domuța climate index was used (Domuța, 2009);
- water consumption (Botzan, 1972; Grumeza et al., 1986, 1987, 1989). Water consumption was established using the method of the soil-water-balance; the balance depth used was 0-150 cm.
- establishing the yield level and stability (Domuţa, 2006);
- water use efficiency was established using the known formula (Domuța, 2011).

RESULTS AND DISCUSSION

Pedological drought

The decadal determinations of the soil humidity performed in the period 1976-2009 show that in the conditions from Oradea, on the depth of 0-75 cm for the alfalfa year I and on the depth of 0-100 cm for alfalfa year II, the water reserve decreased under the level of the easly available water content each year, the greatest number of days with pedological drought being registered in August for alfalfa year I and for alfalfa year II (Table 1).

Table 1

Pedological drought for alfalfa year I and II unirrigated, Oradea 1976-2009

Specification	IV	V	VI	VII	VIII	IX	IV-IX
Alfalfa year I							
No of days with Ra<Wea on 0-75 cm	4,2	12,1	19,5	27,1	28,9	26,6	119
Frequency of the years with Ra<Wea (%)	28	69	93	96	100	100	100
Alfalfa year II							
No of days with Ra<Wea on 0-75 cm	15,0	21,9	22,9	28,2	29,4	29,1	14,8
Frequency of the years with Ra<Wea (%)	45	75	94	97	100	100	100

Ra= water reserve; Wea = easly available water content

In 13 years, for l alfalfa year I and in 15 years for alfalfa year II, on the depths of 0-75 cm, respectively 0-100 cm, the pedological drought was strong, the water reserve decreasing also under the level of the wilting point (Table 2).

Table 2

Strong pedological drought for Alfalfa year I and II, Oradea 1976-2009

Specification	IV	V	VI	VII	VIII	IX	IV-IX
Alfalfa year I							
No of days with Ra<Wp on 0-75 cm	-	-	1,5	4,8	7,9	5,9	19,8
Frequency of the years with Ra<Wp (%)	-	1	3	6	10	7	10
Alfalfa year II							
No of days with Ra<Wp on 0-75 cm	-	2,2	5,2	7,7	9,6	7,6	32,6
Frequency of the years with Ra<Wp (%)	-	3	4	7	12	9	12

Ra= water reserve; Wp = Wilting point

Between the number of days with pedological drought and alfalfa production was quantified a reverse correlation of the form y=-49,572 lnx+269,8; $R^2=68^{ooo}$. Between the number of days with strong pedological drought and alfalfa production the correlation has a greater coefficient ($R^2=0,8^{ooo}$) being of the form $y=153,2x^{-1,1954}$. Between the number of days with pedological drought and the increase of production obtained by irrigation was obtained a direct correlation of the form $y=0,0008x^2+0,0169x+13,867$; $R^2=0,72^{xxx}$.

In the field of review of the water in the soil from Oradea, managing the regimen of humidity of the soil between the easly available water content and the field capacity on the depth of 0-75 cm for alfalfa year I and on 0-100 cm for alfalfa year II, in the period 1976-2009 was obtained the following regime of irrigation.

Table 3

Variation interval of the irrigation regime in alfalfa 1st and 2rd year, Oradea 1976 – 2009

	Norm of irrigation (m^3/ha)		Number of irrigations	
	Alfalfa year I	Alfalfa year II	Alfalfa year I	Alfalfa year II
Minimum value	1000	1200	1	1
Maximum value	4680	5760	10	10
Average value	2595	3050	6	7

The irrigation determines the increase of the quantity of water from the soil, the improving of the accessibility for plants and the reducing of the porosity by aeration, accomplishing a regimen water/air more favorable to the crop (Fig. 1).

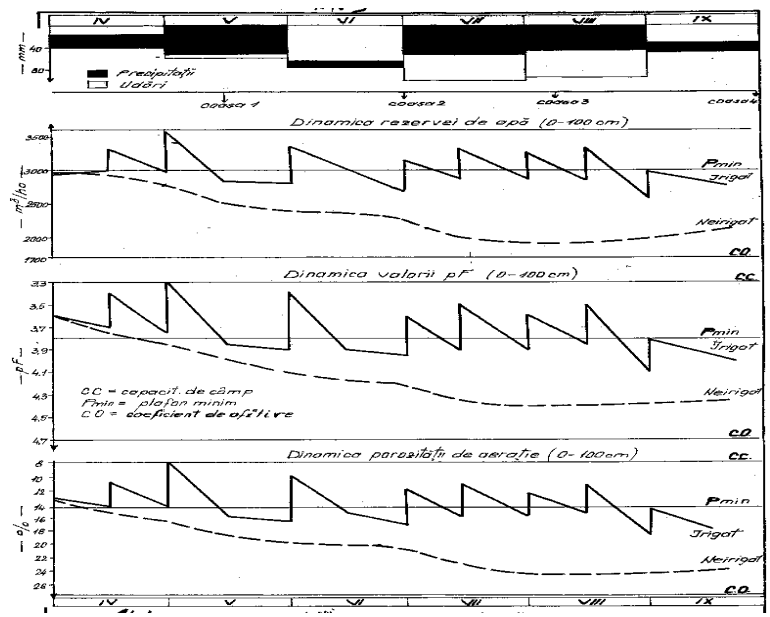

Fig. 1. Influence of the irrigation on the water reserve, its accsibility and porosity of aeration, on the irrigation depth in alfalfa year II, Oradea 1988 - 1996

Microclimate

The irrigation determines changes in the microclimate of the lucerne crop. In the conditions of the managing of the water regime in the soil on the depth of irrigation between the easly available water content and the field capacity, the report water / temperature + light expressed with the help of the climatic index Domuţa (ICD) is differentiated compared to the unirrigated to match the utilization of greater norms of irrigation, the greatest difference being registered in August, 168%, on the entire period of vegetation the difference being of 90% (Table 4).

Between the climatic index Domuţa (ICD) and the production of lucerne there is a direct connection assured statistically, this sustaining the need of irrigation in the area, the irrigation being the main possibility of improving the inputs of water in the soil-plant system (Domuţa, 1995). For alfalfa year I, the correlation between the climatic index Domuţa (ICD) and

production is of the form $y=2,0549x^{1,3399}$; $R^2=0,52^{xxx}$, and for alfalfa year II this is of the form $y=7,3873x^{0,9368}$; $R^2=0,64^{xxx}$.

Table 4

The influence of the irrigation on the conditions of microclimate (climatic index Domuța, ICD) for the crop of Alfalfa year II, Oradea 1976-2009

Version	IV	V	VI	VII	VIII	IX	IV-IX
Unirrigated	9,1 Average wet	8,8 Average drought	10,7 Average wet	7,5 Average drought	6,0 Drought	7,5 Average drought	8,3 Average drought
Irrigated	13,0 Wet I	16,9 Wet II	18,2 Wet II	18,2 Wet III	16,1 Wet II	12,5 Wet I	15,8 Wet II
Difference %	43	92	70	143	168	71	90

The water consumption of alfalfa

The daily water consumption of the alfalfa crop is improving as a consequence of using the irrigation. In the conditions from Oradea it reached a value almost double compared to unirrigated in August, in this month being registered also the greatest absolute difference compared to unirrigated for alfalfa year II and month July for alfalfa year I (Table 5).

The water consumption cumulated of the lucerne crop at first mower is greater in the irrigated version, 210 m^3/ha, at second mower the difference between the irrigated and unirrigated is of 800 m^3/ha, at third mower the difference is of 1950 m^3/ha, and for the foruth mower the difference is of 2934 m^3/ha (Fig. 2).

Table 5

The influence of the irrigation on the daily consumption of water of the alfalfa Oradea, 1976-2009

Version	Specification	IV	V	VI	VII	VIII	IX
ALFALFA year I							
Unirrigated	Average	18,7	28,2	32,5	33,4	25,2	20,5
	Int. of variation	6-33	17-45	18-63	14-44	3-44	8-31
Irrigated	Average	20,7	32,8	47,1	53,6	41,2	31,1
	Int. of variation	7-34	18-42	27-69	36-79	27-64	18-56
ALFALFA year II							
Unirrigated	Average	28,2	32,6	31,9	34,1	25,6	21,8
	Int. of variation	14-36	17-49	15-47	13-51	4-46	3-45
Irrigated	Average	30,3	40,2	47,2	55,3	50,0	32,1
	Int. of variation	15-36	26-62	28-66	38-83	37-71	21-52

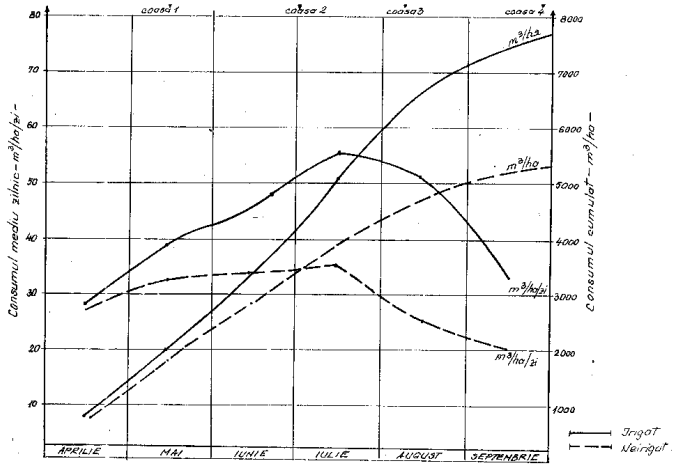

Fig. 2. The daily and cumulated consumption of water of alfalfa year II unirrigated and irrigated, Oradea 1976 – 1997

The optimum supply with water of the alfalfa has determined the increase of the total consumption of water with 43.0% for alfalfa year I and with 54.0% for alfalfa year II, in its covering the irrigation having a percentage of 38.1% (interval of variation 9.1=64.7%) for alfalfa year I and a percentage of 39.2% (interval of variation 14.3-61.2%) for alfalfa year II (Table 6).

Between the water consumption and the alfalfa production there is a direct connection with different mathematical expressions depending on the pedoclimatic area (Grumeza et al., 1989). This connection underlines the opportunity of irrigation, this being the main agro technical measure by which it can be determined the significant increase of the water consumption of the alfalfa crop, as for the other cropsand in the conditions from Oradea were underlined such correlations very significant statistically (Domuţa, 2003).

Table 6

The total consumption of water of alfalfa and its sources of covering in the conditions from Oradea, 1976-2009

Version	Total consumption of water		Sources of covering the water consumption					
			Ri-Rf	Pv		$\sum_m$		
	m^3/ha	%	m^3	m^3/ha	%	m^3/ha	%	Interval of variation-%
Alfalfa year I								
1. Unirrigated	4765	100	1149	3616	-	-	-	-
2.Irrigated	6809	143	598	3616	-	2593	38,1	9,1-64,7
Alfalfa year II								
1. Unirrigated	5137	100	1314	3823	-	-	-	-
2.Irrigated	7930	154	992	3823	-	3113	39,2	14,3-61,2

Ri-Rf= Reserve of the soil; Pv= Precipitations from the period of vegetation;
$\sum_m$= norm of irrigation

Yield

In the conditions of applying an optimum system of irrigation by maintaining the water reserve between the easly available water content and the field capacity on the irrigation depth, for alfalfa year I, in the conditions of the Crisurilor Plain, the average yield of green table on the period 1976-2009 was of 68844 kg/ha, with 25171 kg/ha (57.6 more than in conditions of unirrigation, the interval of variation of the relative differences being between 13 and 304%. For alfalfa year II, the average yield on the mentioned period 97889 kg/ha, was greater than in conditions of non irrigation with 51.9% (33441 kg/ha), interval of variation of the relative differences being between 19-195% (Table 7).

Table 7

The influence of the irrigation on the level and stability of alfalfa yield, Oradea 1976-2009

Version	Average yield		Interval of variation		Standard deviation	
	kg/ha	%	kg/ha	%	kg/ha	%
Alfalfa year I						
1. Unirrigated	43673	100	18500-89800	100	37950	100
2.Irrigated	68844	157,6	30500-120850	113-404	33630	88,6
LSD 5% 790; LSD 1% 1560; LSD 0,1% 3400						
Alfalfa year II						
1. Unirrigated	64448	100	29500-118590	100	30160	100
2.Irrigated	97889	151,9	57000-145240	119-295	25720	85,3
LSD 5% 720; LSD 1% 1260; LSD 0,1% 1960						

The irrigation has determined the improving of the stability of yield, the value of standard deviation decreasing from non irrigated with 11.4% for alfalfa year I and with 14.7% year II.

At the green table obtained in conditions of irrigation decreases the percentage of dry substance, but by increasing the yield increases the quantity of dry substance in a ha. For this reason, the irrigated alfalfa presents more difficulty in the process of drying for the hay.

For the irrigated alfalfa it decreases the percentage of total nitrogen and the percentage of protein, but the increase of yield obtained following the utilization of irrigation determines the increase of the quantity of protein at the surface unit. There are researches that show that the hay of irrigated lucerne is richer in Phosphorus, Potassium and Calcium (Vasiliu, 1965, Hulpoi, 1966, quoted by Domuţa, 2005).

Water use efficiency

In the center of Western Plain, in average on the period 1976-2009, the irrigation determined the increase of the efficiency of the exploitation consumed with 10.6% for alfalfa year I and with 6.2% for alfalfa year II. The exploitation of the water of irrigation was made better for alfalfa year

II, to this being obtained 12.31 kg increase /m^3 compared to 8.41 kg/m^3 for alfalfa year I (Table 8).

Table 8

The efficiency of the exploitation of the consumed water (EVA) and the efficiency of the exploitation of irrigation water (EVAI) for alfalfa, Oradea 1976-2009

Version	EVA				EVAI kg increase/m^3
	kg/m^3	%	Difference		
			kg/m^3	%	
Alfalfa year I					
1. Unirrigated	9,18	100	-	-	-
2.Irrigated	10,15	110,6	0,97	10,6	8,41
Alfalfa year II					
1. Unirrigated	11,67	100	-	-	-
2.Irrigated	12,40	106,2	0,67	6,2	12,31

CONCLUSIONS

The conclusions of the research are the following:

- the pedological drought was present each year for alfalfa year I and for alfalfa year II;
- the optimum regimen of average irrigation included norms of irrigation of 3050 m^3/ha for alfalfa year II and of 2595 m^3/ha for alfalfa year I, the average number of irrigations being 7, respectively 6;
- under the influence of irrigation the values of pF and the values of porosity of aeration were improved;
- the water/temperature + light report characterizes the microclimate of the irrigated alfalfa as „wet II" and of the non irrigated as „average drought";
- the daily consumption of water of irrigated alfalfa and the total consumption of water of alfalfa;
- the irrigation determined the obtaining of an average increase of production of 57,6% (year I) and 51,9 % (year II).

The degree of stability of the productions obtained was improved.

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