THE IRRIGATION INFLUENCE ON WATER USE EFFICIENCY IN ALFALFA 2nd YEAR, ORADEA 2010-2013

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Abstract

The paper presents the research results which carried out on the preluvosoil from Agricultural Research and Development Station Oradea during 2010-2013. Ten to ten day determination of the soil moisture emphasized the decrease of the soil water reserve on watering depth (0-100 cm) bellow easily available water content (every year) for maintaining the soil water reserve between easily available water content and field capacity an irrigation rate of 80.0 mm in 2010, 390.0 mm in 2011, 530 mm in 2012 and 357.0 mm in 2013. The irrigation determined the increase of the daily water consumption and, finally, total water consumption increased with 18% in 2010, with 81% in 2011, with 92% in 2012 and with 48% in 2013. The irrigation was the mai source for water consumption covering all the year. The results obtained emphasizes the irrigation opportunity in alfalfa 2nd year from Crişurilor Plain.

Keywords: pedological drought, irrigation, water consumption, yield, water use efficiency

INTRODUCTION

The irrigation influence in alfalfa was studied in the Crişurilor Plain starting with 1969 (Domuţa 2003, 2005, 2009) and the positive influence on soil water reserve, microclimate, plants water consumption, yield and water use efficiency were quatified. Other researches (Grumeza, 1989, 2005, Luca, 1999) quantified the same influence in the other areas of Romania.

Alfalfa's role as an N source is made possible by its ability to fix symbiotically large amounts of atmospheric N. Published estimates of annual N_2 fixation by alfalfa range from 70 to 400 kg N/ha (Peterson and Russelle, 1991)

MATERIAL AND METHOD

The paper presents the researches carried out during 2010-2013 in the long term trial for soil water balance study, placed in 1976 in Agricultural Research and Development Station Oradea, Western Romania in the conditions of a preluvosil. All the preluvosoil profile are low acid (6.11 – 6.8), humus content (1.44 –1.75%) is small and total nitrogen is low median (0.127 – 0.157). After 36 years of good soil management, the soil phosphorus content became very good (from 22.0 ppm to 150.8 ppm) on ploughing depth, potassium content (124.5 ppm) is median.

There are a big hydro stability (47.5%) of the aggregates (Φ = 0.25 mm) on ploughingland; the bulk density (1.41 g/cm^3) indicates a low settling soil, total porosity is median. On the subjacent depth of the ploughing layer the bulk density characterizes the soil like moderate and very settled and total porosity is small and very small. Hydraulic conductivity is big (21.0 mm/h) on 0-20 cm; median (10.5 mm/h; 4.4 mm/h) on 20 – 40 cm and 40 – 60 cm and very small (1.0 mm/h) on 60 – 80 cm.

The source of irrigation water was a drill of 15 m depth. Irrigation water quality was very good: pH = 7.2; Na^+= 12.9; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

In Romania, the watering depth for alfalfa 2nd year is fixe one, 0-100 cm foor this area. Soil moisture of 0 – 100 cm depth was determined ten to ten days and monthly on 0 – 150 cm depth. In the variant irrigated, the moment of the irrigation use was when the soil water reserve on 0 – 100 cm depth decreased to easily available water content. On the 0-100 cm the value of the easily available water content (Wea) is of 19.7% (3055 m^3/ha). Easily available water content was established in function of clay content (Brejea R., 2009, 2010) using the formula: Wea = WP+2/3 (FC-WP); in wich: FC= field capacity (24.3%) and WP= wilting point (10.5%).

The water consumption was determined by the soil water balance method. Water use efficiency was calculated like report between yield and water consumption. (Domuța, 2009, Borza and Stanciu, 2010)

The experiment data were calculated using the variance analysis method (Domuța, 2006).

RESULTS AND DISCUSSION

The annual rainfall during 2010-2013 were of 889.5 mm in 2010, 569.7mm in 2011, 418.9 mm in 2012 and 633.1 mm in 2013. The average temperature was of bigger than multiannual average (10.5^{o}C) in the all years: 11.3 ^{o}C in 2010, 11.4 ^{o}C in 2011, 11.3 ^{o}C in 2012 and 11.6 ^{o}C in 2013. Two years, air humidity was smaller than multiannual average (78^{o}C): in 2011, 73%, in 2012, 70%, in 2010 (79%) and in 2013, the annual average of air temperature were bigger than multiannual average. (Meteorological Station Oradea)

Pedological drought in unirrigated alfalfa

Pedological drought is considered the periods with soil water reserve on watering depth bellow easily available water content (Domuța 2005). The periods with soil water reserve bellow wilting point is considered strong pedological drought (Domuța 2005, 2009). The annual graphs of the soil water reserve dynamics realized by soil sample emphasized the values bellow easily available water content in every month of the alfalfa

vegetation period. Total days with pedological drought were of 45 in 2010, of 134 in 2011, of 161 in 2012 and of 93 in 2013. (table 1).

Table 1

Number of days with pedological drought in unirrigated alfalfa 2nd year, Oradea 2010-2013

Year	Month						Total
	April	May	June	July	August	September	
2010	12	8	5	10	10	-	45
2011	18	31	31	7	17	30	134
2012	24	31	30	31	31	14	161
2013	0	10	16	21	28	18	93

Strong pedological drought was determined 23 days in 2011 (16 days in August and 7 days in September), 30 days (7 days in July, 13 days in August and 10 days in September) in 2012, 14 days (10 days in July and 4 days in August) in 2013, and no in one day in the year 2010. (table 2).

Table 2

Number of days with strong pedological drought in unirrigated alfalfa 2nd year, Oradea 2010-2013

Year	Month						Total
	April	May	June	July	August	September	
2010	-	-	-	-	-	-	0
2011	0	0	0	0	16	7	23
2012	0	0	0	7	13	10	30
2013	0	0	0	10	4	-	14

Optimum irrigation regime

For maintaining the soil water reserve on watering depth (0-100 cm) between easily available water content the irrigation was needed every year. Irrigation rate used in 2010 was of 80.0 mm, of 390.0 mm in 2011, of 530.0 mm in the year 2012 and of 357 mm in 2013. Number of rates were of 2 in 2010, of 10 in 2011, of 12 in 2012 and of 10 in 2013.

The irrigation influence on alfalfa daily water consumption

Irrigation determined the increase of the daily water consumption. The biggest relative differences in comparison with unirrigated variant were registered in the year 2010 in May (11%), in June (128%) in 2011, in May, too (146%) in 2012 and in 2013 (117%). (table 3).

The irrigation influence on total water consumption

The irrigation determined the increase of the total water consumption with 18% in 2010, with 87% in 2011, with 92% in 2012 and with 48% in 2013. In 2011 and 2012, the irrigation was the main covering sources of the optimum water consumption; in 2010 and in 2013, the rainfall during the alfalfa vegetation period was the main sources. (table 4).

Table 3

The irrigation influence on daily water consumption in alfalfa 2nd year, Oradea 2010-2013

Year	Variant	April		May		June		July		August		September	
		mm/ha/ day	%	mm/ha/ day	%	mm/ha/ day	%	mm/ha/ day	%	mm/ha/ day	%	mm/ha/ day	%
2010	Unirrigated	3.01	100	4.12	100	4.90	100	5.58	100	4.95	100	3.35	100
	Irrigated	3.09	103	4.56	111	5.08	104	6.02	108	5.07	103	3.42	102
2011	Unirrigated	2.74	100	2.49	100	3.00	100	3.76	100	2.70	100	1.83	100
	Irrigated	4.30	157	5.68	228	6.00	200	5.47	145	4.09	151	2.65	145
2012	Unirrigated	2.90	100	2.55	100	3.32	100	3.86	100	2.79	100	2.26	100
	Irrigated	4.61	159	6.27	246	6.71	203	6.00	155	4.38	157	2.90	128
2013	Unirrigated	2.35	100	2.40	100	2.56	100	3.31	100	2.69	100	1.44	100
	Irrigated	4.59	195	5.20	217	5.15	202	4.57	138	3.92	146	2.14	149

Table 4

The irrigation influence on total water consumption [Σ(e+t)] and the covering sources in alfalfa 2nd year, Oradea 2010-2013

Year	Variant	Σ(e+t)		Covering sources					
		mm/ha	%	Soil water reserve		Rainfall		Irrigation	
				mm/ha	%	mm/ha	%	mm/ha	%
2010	Unirrigated	550.0	100	29.8	5	520.2	95	-	-
	Irrigated	651.0	118	50.8	8	520.2	80	80.0	12
2011	Unirrigated	467.7	100	210.0	45	257.7	55	-	-
	Irrigated	849.7	181	202.0	24	257.7	30	390.0	46
2012	Unirrigated	538.5	100	157.1	29	381.4	71	-	-
	Irrigated	1034.2	192	122.8	12	381.4	37	530.0	51
2013	Unirrigated	523.7	100	129.5	25	394.2	75	-	-
	Irrigated	780.3	148	29.1	4	394.2	51	357.0	45

The irrigation influence on yield

The irrigation determined the yield gain very significant statistically every year studied: 14020 kg/ha (20%) in 2010, 45000 kg/ha (128,0%) in 2011 and 55400 kg/ha (180%) in 2012 and with 57900 kg. The biggest relative yield gain was obtained in the year 2012, the droughtest year. (table 5).

Table 5

The irrigation influence on yield in alfalfa 2nd year, Oradea 2007-2010

Variant	Yield		Difference		Statistically significant
	kg/ha	%	kg/ha	%	
2010					
Unirrigated	70100	100	-	-	Control
Irrigated	84120	120.0	14020	20.0	***
		LSD 5%	**710**		
		LSD 1%	**1010**		
		LSD 0.1%	**1670**		
2011					
Unirrigated	35100	100	-	-	Control
Irrigated	80100	229	45000	128	***
		LSD 5%	**820**		
		LSD 1%	**1310**		
		LSD 0.1%	**2200**		
2012					
Unirrigated	30700	100	-	-	Control
Irrigated	86100	280	55400	180	***
		LSD 5%	**610**		
		LSD 1%	**990**		
		LSD 0.1%	**1470**		
2013					
Unirrigated	40100	100	-	-	Control
Irrigated	98000	244	57900	144	***
		LSD 5%	**710**		
		LSD 1%	**1240**		
		LSD 0.1%	**1990**		

The irrigation influence on water use efficiency

The use of the optimum irrigation determined the increase of the yield main quantity obtained by 1 mm of water used with 23.5 % in 2010, with 26% in 2011 with 46% in 2012 and with 6% in 2013. (table 6)

Table 6

The irrigation influence on water use efficiency (WUE) in alfalfa 2nd year, Oradea 2010-2013

Variant	WUE		Difference
	kg/mm	%	%
2010			
Unirrigated	Unirrigated	Unirrigated	Unirrigated
Irrigated	Irrigated	Irrigated	Irrigated
2011			
Unirrigated	75.05	100	-
Irrigated	94.3	126	26
2012			
Unirrigated	57.0	100	-
Irrigated	83.25	146	46
2013			
Unirrigated	76.57	100	-
Irrigated	126.0	164	64

CONCLUSION

Alfalfa is an important fodder crop for the Western Romania and the researches regarding the irrigation influence carried out during 2010-2013 in Oradea determined the following conclusions:

- Ten to ten determination of the soil moisture on the watering depth emphasized the presence of the pedological drought in 45 days in 2010, in 1134 days in 2011, 161 in 2012 and in 93 days in 2013; the soil moisture decreased bellow wilting point 23 days in 2010, 30 days in 2011 and 14 days in 2013.
- Maintaining the soil water reserve between easily available water content and field capacity determined to use the irrigation: 80. mm in 2010, 390.0 mm in 2011, 530 mm in 2012 and 357.0 mm in 2013.
- The irrigation determined the increase of the daily water consumption and, finally, total water consumption increased with 18% in 2010, with 81% in 2011, with 92% in 2012 and with 48% in 2013. The irrigation was the mai source for water consumption covering all the year.
- The influence of the irrigation on yield was the yield gain very significant statistically every year: 20% in 2010, 128% in 2011, with 180% in 2012 and with124% in 2013.
- The presence of the pedological drought and of the strong pedological drought every year and the yield gains very significant statistically are the arguments that the irrigation is a main method for drought control.

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