PEDOLOGICAL DROUGHT INFLUENCE ON YIELD AND WATER USE EFFICIENCY IN ALFALFA 2nd CROP IN THE CRIŞURILOR PLAIN

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Abstract
The paper based on the researches carried out during 2007-2009 on the preluvosoil from the research field of the soil water balance in Agricultural Research Development Station Oradea. Pedological drought and strong pedological drought (soil moisture bellow easily available water content, respectivelly wilting point) were determined every year based on the ten to ten determination of the soil moisture. Pedological drought determined the decrease of the daily water consumption values as conseqvence the total water consumption decreased with 48 % in average on the studied period; the yield losses very significant statistically were registered every year and in average on the studied period the yield losses was of 44%. Pedological drought determined the decrease of the water use efficiency with 19%.

Key words: pedologycal drought, alfalfa, yield

INTRODUCTION

Pedological drought represents the period with soil moisture bellow easily available water content on watering depth.

The decrease of the soil moisture bellow wilting point is considered a strong pedological drought (Domuţa, 2005). It was quantified an inverse links, statistically assured, between number of days with pedological drought and alfalfa yields and between number of days with strong pedological drought and alfalfa yields (Domuţa, 2009).

The alfalfa crop is very important fodder crop both in the Crişurilor Plain (Domuţa, 1995, 2003, 2005, 2009; Ciobanu, Domuţa, 2003; Brejea, 2010) and in the other areas of the Romania (Grumeza et al, 1989; Grumeza, Kleps, 2005; Luca, Nagy, 1999). It is known, too that the alfalfa has the biggest water consumption.

Our paper quantified the period with pedological drought and strong pedological drought and the influences on water consumption, yield and water use efficiency.

MATERIALS AND METHODS

The researches were carried out during 2007-2009 in the Agricultural Research and Development Station Oradea on a preluvosoil. All the soil 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 30 years of good soil management good practices 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 ploughing land and bulk density (1.41 g/cm^3) indicates a low settling and total porosity is median. On the subjacent depth of the ploughing layer 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.

Pedological drought was considered the decreased of the soil moisture bellow easily available water content on watering depth.

Strong pedological drought was considered the period with soil moisture bellow wilting point on watering depth. In alfalfa 2nd year the watering depth is 0-100 cm (Domuța, 2009).

Soil moisture of 0 – 100 cm depth was determined ten to ten days and monthly on 0 – 150 cm depth. In the irrigated variant, the moment of the irrigation use was when the soil water reserve on 0 – 100 cm depth decreased to easily available water content.

Plants water consumption was determined by soil water balance method. The depth of the balance used was 0-150 cm.

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

RESULTS AND DISCUSSIONS

The annual rainfall during the studied period were of 556,1 mm in 2007, of 585,7 mm in 2008 and of 501,4 mm in 2009; the average temperatures were of 12,6°C in 2007, of 11,0°C in 2008 and of 11,6°C in 2009; the values of the air humidity were of 66% in 2007, of 72% in 2008 and of 70% in 2009.

Pedological drought in unirrigated alfalfa

Pedological drought is considered the periods with soil water reserve on watering depth bellow easily available water content (Domuta, 2005). The periods with soil water reserve bellow wilting point is considered strong pedological drought (Domuta, 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 164 in 2007, of 163 in 2008 and of 165 in 2009 (table 1).

Table 1

Number of days with pedological drought in unirrigated alfalfa 2nd year, Oradea 2007-2009

Year	Month						Total
	April	May	June	July	August	September	
2007	30	31	26	31	28	18	164
2008	24	31	30	31	31	14	161
2009	28	31	18	31	27	30	165
Average	27	31	25	31	29	21	164

Strong pedological drought was determined every year: 14 days (10 days in July and 4 days in August) in 2007, 30 days (7 days in July, 13 days in August and 10 days in September) in 2008 and 58 days (12 days in June, 13 days in July, 16 days in August and 17 days in September) in 2009 (table 2).

Table 2

Number of days with strong pedological drought in unirrigated alfalfa 2nd year, Oradea 2007-2009

Year	Month						Total
	April	May	June	July	August	September	
2007	0	0	0	10	4	-	14
2008	0	0	0	7	13	10	30
2009	0	0	12	13	16	17	58
Average	0	0	4	10	11	9	34

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 2007 was of 4650 m^3/ha, in 2008 of 5300 m^3/ha and in 2009 of 5400 m^3/ha. The number of rates were of 10 in 2007, of 11 in 2008 and of 12 in 2009. The biggest month irrigation rate were used in Aprilie (1150 m^3/ha) in 2007, in July (1500 m^3/ha) in 2008 and in May and July (1300 m^3/ha) in 2009.

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 May (117%) in 2007, in May, too (146%) in 2008 and in June (128%) in 2009. The average of the research period show that the maximum daily water consumption were registered in June (59.5 m^3/ha/day) in irrigated conditions and in July (36.4 m^3/ha/day) in unirrigated conditions. The relative maximum difference between irrigated and unirrigated variant was registered in May (129%) (table 3).

Table 3

Pedological drought influence on daily water consumption in alfalfa 2nd year, Oradea 2007-2009

Year	Variant	April		May		June		July		August		September	
		m^3/ha/ day	%	m^3/ha / day	%	m^3/ha/ day	%	m^3/ha/ day	%	m^3/ha/ day	%	m^3/ha/ day	%
2007	Irrigated	46	100	52	100	54	100	46	100	39	100	21	100
	Unirrigated	24	52	24	46	26	48	33	72	27	69	14	67
2008	Irrigated	46	100	63	100	67	100	60	100	44	100	29	100
	Unirrigated	29	63	26	41	30	45	39	65	28	63	18	62
2009	Irrigated	43	100	57	100	60	100	55	100	41	100	27	100
	Unirrigated	27	62	25	44	30	50	38	70	27	66	18	66
Average	Irrigated	45	100	57	100	60	100	54	100	41	100	26	100
	Unirrigated	27	60	25	44	29	48	37	68	27	67	17	64

The irrigation influence on total water consumption

The irrigation determined the increase of the total water consumption with 70% in 2007, with 92% in 2008 and with 114% in 2009. The irrigation was the main source for optimum water consumption covering; their participation was of 53% in 2007, of 51% in 2008 and of 54% in 2009. In the irrigated variant, the alfalfa used a smaller quantity from soil water reserve in comparison with alfalfa from unirrigated variant (table 4).

Table 4

Pedological drought influence on total water consumption [Σ(e+t)] and the covering sources in alfalfa 2nd year, Oradea 2007-2009

Year	Variant	Σ(e+t)		Covering sources					
		m^3/ha	%	Soil water reserve		Rainfall		Irrigation	
				m^3/ha	%	m^3/ha	%	m^3/ha	%
2007	Irrigated	8883	100	291	3	3942	44	4650	53
	Unirrigated	5237	60	1295	25	3942	75	-	-
2008	Irrigated	10342	100	1228	12	3814	37	5300	51
	Unirrigated	5835	56	1571	29	3814	71	-	-
2009	Irrigated	9977	100	2020	20	2577	26	5400	54
	Unirrigated	4677	47	2100	45	2577	55	-	-
Average	Irrigated	9734	100	1173	12	3444	35	5177	53
	Unirrigated	5100	52	1656	32	3444	68	-	-

The irrigation influence on yield

The irrigation determined the yield gains very significant statistically every year studied: 58200 kg/ha (42%) in 2007, 44800 kg/ha (108,4%) in 2008 and 44400 kg/ha (126,5%) in 2009. The biggest relative yield gain was obtained in the year 2009, the droughtest year.

In average on the studied period the yield in irrigated variant, the yield (88967 kg/ha) was bigger than the yield from unirrigated variant with 126,5% (table 5).

Table 5

Pedological drought influence on alfalfa yield, Oradea 2007-2009

Variant	Yield		Difference		Statistically significant
	kg/ha	%	kg/ha	%	
2007					
Irrigated	98300	100	-	-	Control
Unirrigated	40100	41	- 58200	- 59	000
2008					
Irrigated	86100	100	-	-	Control
Unirrigated	41300	48	- 44800	- 12	000
2009					
Irrigated	79500	100	-	-	Control
Unirrigated	35100	44	- 49400	- 56	000
Average 2007-2009					
Irrigated	87967	100	-	-	Control
Unirrigated	38830	44	- 49137	- 56	000

Table 6

Pedological drought influence on water use efficiency (WUE) in alfalfa 2nd year Oradea 2007-2009

Variant	WUE		Difference	
	kg/m^3	%	kg/m^3	%
2007				
Irrigated	11.01	100	-	-
Unirrigated	7.66	70	-3.35	-30
2008				
Irrigated	8.32	100	-	-
Unirrigated	7.01	84	-1.31	-16
2009				
Irrigated	7.97	100	-	-
Unirrigated	7.50	94	0.47	-6
2007-2009				
Irrigated	9.1	100	-	-
Unirrigated	7.39	81	-1.71	-19

CONCLUSIONS

The paper based on the researches carried aut during 2007-2009 on the preluvosoil from Agricultural Research and Development Station Oradea and the following conclusions:

- Pedological drought was determined every year of the studied period: 164 days in 2007, 163 days in 2008 and 165 days in 2009.
- Strong pedological drought was determined in 14 days in 2007, 30 days in 2008 and 58 days in 2009.

- Maintaining the soil water reserve between easily available water content and field capacity determined to ues the irrigation: 4650 m^3/ha in 2007, 5300 m^3/ha in 2008 and 5400 m^3/ha in 2009.
- Pedological drought determined the decrease of the daily water consumption in comparison with the variant optimum water provisionmed. As conseqvence the total water consumption decreased with 40 % in 2007, with 56 % in 2008 and with 47 % in 2009. In the optimum water consumption the irrigation participated with 53 % in 2007, with 51 % in 2008 and with 54 % in 2009.
- Pedological drought determined the yield losses very significant statistically every year. In 2007 the yield loss was of 59 %, in 2008 of 52 % and in 2009 of 56 %.
- In the pedological drought conditions, the water use efficiency decreased with 30 % (7,66 kg/m^3 vs 11,01 kg/m^3) in 2007, with 16 % (7,01 kg/m^3 vs 8,32 kg/m^3) in 2008 and with 6 % (7,50 kg/m^3 vs 7,97 kg/m^3) in 2009.

The data obtained emphasized the presence of the pedological drought in the all the years studied and their negative influence on plants water consumption, yield and water use efficiency.

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