PEDOLOGICAL DROUGHT INFLUENCE ON WATER USE EFFICIENCY IN SUNFLOWER, ORADEA 2009-2011

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Abstract

The researches were carried out during 2009-2011 in the research field for soil water balance study placed on the preluvosoil from Agricultural Research and Development Staton Oradea. Pedological drought is defined by the decrease of the soil water reserve on watering depth bellow easily available water content; in unirrigated sunflower pedological drought was determined every year of the studied period: 107 days in 2009, 19 days in 2010 and 97 days in 2011. Strong pedological drought was determined in 2009 (31 days) and in 2011 (20 days). Maintaining the soil water reserve on watering depth between easily available water content and field capacity need to use the irrigation rates of 3200 m^3/ha in 2009, of 450 m^3/ha in 2010 and of 3050 m^3/ha in 2011; pedological drought registered in the unirrigated sunflower determined smaller values of the daily water consumption in comparison with irrigated variant; the biggest differences were registered in July: 60% in 2009; 18% in 2010 and 60% in 2011. As consequence, total water consumption of the sunflower in the irrigated variant increased in comparison with unirrigated variant with 70% in 2009, with 14% 2010 and with 46% in 2012; pedological drought determined the yield losses very significant statistically every year: 2050 kg/ha (51%) in 2009, 810 kg/ha (37%) in 2010, 2150 kg/ha (51%) in 2011; water use efficiency decreased under the pedological drought influence, the differences registered in comparison with irrigated variant were of 15% in 2009, of 6% in 2010 and of 13 % in 2011.

The results researches emphasize the need of the sunflower irrigation in the conditions of the moderate wet area of the Crisurilor Plain.

Key words: pedological drought, strong pedological drought, irrigation, water use efficiency, sunflower

INTRODUCTION

The Crişurilor Plain offers favorable conditions for sunflower. The sunflower plants need moderate moisture until the emergence of inflorescence, but the yield is strongly affected when water deficit appears during flowering and in the following stages: the most harmful drought effect on yield manifests itself 20 days before and 15–20 days after flowering. (Borza I., Stanciu A., 2010; Domuţa Cr., 2010 a, b; Muntean L.S. et al., 2011, Şandor M., 2008 a, b)

Pedological drought is considered to be the decrease in the soil water reserve at the watering depth, below easily available water content, while strong pedological drought is considered the decrease in the soil water reserve at the watering depth below wilting point, which is considered a point from an interval and not a fixed point (Domuta C., 1995, 2005, 2009 a,b, 2011, 2012).

Long term researches carried out in the Crisurilor Plain emphasized the presence of the pedological drought and strong pedological drought in unirrigated sunflower and their negative influence on plants, water consumption, yield level, yield stability and water use efficiency (Domuta C., 2003, 2012).

MATERIAL AND METHODS

The soil from research field is preluvosoil. The research field was set at the Agricultural Research and Development Station Oradea in 1976 by E. Stepănescu and at the Research Institute for Irrigation and Drainage, Băneasa-Giurgiu. The main properties of the luvosoil from the research field for the study of soil water balance are: humus content of 2.1% in the Ap (0-20cm depth) horizon, pH of 6.3, phosphorus of 31.5 ppm and potassium of 190.2 ppm; the value of the bulk density is of 1.44 g/cm^3 and total porosity is about 47%. The field capacity (24.3%) and wilting point (9.1%) have median values. (Brejea R., Domuta C., 2011)

The irrigation water parameters are: pH = 7.2; Na^+ = 12.9%; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

In the Crisurilor Plain conditions, the sunflower watering depth is 0-75 cm. Every ten days the soil moisture was determined. Irrigation was carried out when the soil water reserve at 0 – 75 cm depth decreased below easily available water content. (Brejea R., 2010)

Water consumption was determined using the soil water balance method.

The research results were processed by variance analysis (Domuţa C., 2006).

RESULTS AND DISCUSSIONS

Pedological drought in unirrigated sunflower

The decrease of the soil water reserve below easily available water content on watering depth (0-75 cm) in unirrigated variant was registered every year: 107 days in 2009 (4 days in April, 31days in May, July and August; 10 days in June); 19 days in 2010 (5 days in June, 8 days in July, 6 days in August) and 97 days in 2011 (6 days in April, 31 days in May, 30 days in June, 10 days in July and 20 days in August).(Table 1)

Table 1

Number of days with pedological drought (PD) in un-irrigatd sunflower, Oradea 2009-2011

	Days with PD					
	April	May	June	July	August	Total
2009	4	31	10	31	31	107
2010	-	-	5	8	6	19
2011	6	31	30	10	20	97

Strong pedological drought in unirrigated sunflower

Strong pedological drought was registered for 31 days in 2009 (6 days in June, 12 days in July and 13 days in August). There was no strong pedological drought in 2010 while the strong pedological drought in 2011was determined for 20 days: 4 days in June, 6 days in July and 10 days in August. (Table 2)

Table 2

Number of days with strong pedological drought (SPD) in unirrigated sunflower, Oradea 2009-2011

	Days with PD					
	April	May	June	July	August	Total
2009	0	0	6	12	13	31
2010	0	0	0	0	0	0
2011	0	0	4	6	10	20

Optimum irrigation regime

Maintaining the soil water reserve on 0-75 cm depth between easily available water content and field capacity determined to use an irrigation rate of 3200 m^3/ha in 2009: 400 m^3/ha in April, 800 m^3/ha in May, 600 m^3/ha in June, 1000 m^3/ha in July and 400 m^3/ha in August. In 2010, the irrigation was used in July, only (450 m^3/ha). The irrigation rate used in 2011 was of 3050 m^3/ha: 250 m^3/ha in April, 600 m^3/ha in May, 1100 m^3/ha in June and 500 m^3/ha in July. (Table 3)

Table 3

The irrigation regime used for maintaining the soil water reserve on 0-75 cm depth, between easily available water content and field capacity in sunflower, Oradea 2009-2011

Year	April		May		June		July		August		September		Total	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
2009	400	1	800	2	600	1	1000	2	400	1	-	-	3200	7
2010	-	-	-	-	-	-	450	1	-	-	-	-	450	1
2011	250	1	600	2	1100	3	600	2	500	1	-	-	3050	9

Σm= Irrigation rate; n= number of rates

The irrigation influence on sunflower water consumption

In comparison with the irrigation variant, optimally assured with water using irrigation, the pedological drought determined the decrease of the daily water consumption. The biggest differences were registered in July (60% in 2009, 18% in 2010, and 60% in 2011) and August (38% in 2009, 1% in 2010 and 40% in 2011) (table 4).

Table 4

Pedological drought influence on daily water consumption - Σ(e+t)- in sunflower, Oradea 2009-2011

Variant	April		May		June		July		August	
	m^3/ha /day	%	m^3/ha/ day	%	m^3/ha/ day	%	m^3/ha/ day	%	m^3/ha/ day	%
2009										
Irrigated	32.6	100	41.0	100	57.8	100	70.1	100	43.9	100
Unirrigated	25.3	78	33.1	81	38.0	66	28.0	40	27.0	62
2010										
Irrigated	21.0	100	38.5	100	45.2	100	60.1	100	40.2	100
Unirrigated	20.9	99	38.1	98	44.0	98	48.2	82	39.7	99
2011										
Irrigated	31.3	100	40.8	100	56.3	100	69.4	100	44.0	100
Unirrigated	24.2	78	32.0	80	37.2	66	27.6	40	26.1	60

In the droughty years 2009 and 2011, the use of irrigation determined the increase of the total water consumption by 70% (7095 m^3/ha vs. 4176 m^3/ha) in 2009 and by 46% (6459 m^3/ha vs. 3709 m^3/ha) in 2010; in the rainy year 2010, the use of the irrigation (450 m^3/ha) determined an increase of 14%. In the covering of the optimum water consumption, the irrigation participated with 45% in 2009, with 10% in 2010, with 47% in 2011. (Table 5)

Table 5

Total water consumption and the covering sources in sunflower, Oradea 2009-2011

Year	Variant	Σ(e+t)		Ri-Rf		Pv		Σm	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
2009	Unirrigated	4176	100	1720	41	2456	59	-	-
	Irrigated	7095	170	1439	20	2456	35	3200	45
2010	Unirrigated	4310	100	57	1	4253	99	-	-
	Irrigated	4950	114	217	4	4253	86	450	10
2011	Unirrigated	3709	100	1310	34	2399	66	-	-
	Irrigated	6459	146	860	13	2399	37	3050	47

Σ(e+t) = Total water consumption; Ri= Initial water reserve (at seeding); Rf= Final water reserve (at harvesting); Pv= Rainfall during the vegetation period; Σm= Irrigation rate

Pedological drought influence on sunflower yield

In comparison with the variant with optimum water provisionment, in unirrigated conditions, the pedological drought determined the yield losses: 2050 kg/ha (- 51%) in 2009, 810 kg/ha (-37%) in 2010 and 2150 kg/ha (-51%) in 2011. During these three years, the yield losses determined by pedological drought were very statistically significant. (Table 6)

Table 6

Pedological drought influence on sunflower yield, Oradea 2009-2011

Variant	Yield		Difference		Statistically significant
	Kg/ha	%	Kg/ha	%	
2009					
Irrigated	4020	100	-	-	Control
Unirrigated	1970	49	-2050	-51	ooo
$LSD_{5\%}$= 190; $LSD_{1\%}$= 380; $LSD_{0.1\%}$=630					
2010					
Irrigated	4330	100	-		Control
Unirrigated	3520	63	-810	-37	ooo
$LSD_{5\%}$= 230; $LSD_{1\%}$= 490; $LSD_{0.1\%}$=720					
2011					
Irrigated	4200	100	-	-	Control
Unirrigated	2050	49	2150	-51	ooo
$LSD_{5\%}$= 185; $LSD_{1\%}$= 298; $LSD_{0.1\%}$=512					

Pedological drought influence on water use efficiency

Water use efficiency calculated as a ratio between the yield (kg/ha) and water consumption (m^3/ha) shows the negative influence of the pedological drought. In comparison with the irrigated variant, in unirrigated sunflower the values of the water use efficiency were smaller by 15% in 2009 (0.48 kg/m^3 vs 0.57 kg/m^3), by 6% in 2010 (0.82 kg/m^3 vs. 0.88 kg/m^3) by 13% in 2011 (0.56 kg/m^3 vs. 0.65 kg/m^3); on average in the studied period, the difference was of 11% (0.62 kg/m^3 vs. 0.70 kg/m^3). (Table 7)

Table 7

Pedological drought influence on water use efficiency (WUE) in sunflower, Oradea 2009-2011

Variant	WUE		Difference	
	Kg/ m^3	%	Kg/ m^3	%
2009				
Irrigated	0.57	100	-	-
Unirrigated	0.48	85	-0.09	-15
2010				
Irrigated	0.88	100	-	-
Unirrigated	0.82	94	-0.06	-6
2011				
Irrigated	0.65	100	-	-
Unirrigated	0.56	87	-0.09	-13
2009-2011				
Irrigated	0.70	100	-	-
Unirrigated	0.62	89	-0.08	-11

CONCLUSIONS

Considering the pedological drought as a period with soil water reserve below easily available water content on watering depth (0-75 cm in sunflower) and strong pedological drought as a period with soil water reserve on watering depth bellow wilting point, the researches carried out

during 2009 and 2011 at the Agricultural Research and Development Station Oradea in the field of soil water balance study led to the following conclusions:

- in unirrigated sunflower, pedological drought was determined every year during the studied period: 107 days in 2009, 19 days in 2010 and 97 days in 2011. Strong pedological drought was determined in 2009 (31 days) and in 2011 (20 days). Maintaining the soil water reserve on watering depth between easily available water content and field capacity needed to use the irrigation rates of 3200 m^3/ha in 2009, of 450 m^3/ha in 2010 and of 3050 m^3/ha in 2011;

- pedological drought registered in the unirrigated sunflower determined smaller values of the daily water consumption in comparison with the irrigated variant; the biggest differences were registered in July: 60% in 2009; 18% in 2010 and 60% in 2011. Consequently, total water consumption of the sunflower in the irrigated variant increased in comparison with unirrigated variant by 70% in 2009, 14% in 2010 and 46% in 2012;

- pedological drought determined the yield losses, which were statistically significant every year: 2050 kg/ha (51%) in 2009, 810 kg/ha (37%) in 2010, 2150 kg/ha (51%) in 2011;

- water use efficiency decreased under the influence of the pedological drought, the differences registered in comparison with irrigated variant were of 15% in 2009, of 6% in 2010 and of 13 % in 2011.

The research results emphasize the need of the sunflower irrigation in the conditions of the moderate wet area of the Crisurilor Plain.

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