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IRRIGATION, THE METHOD FOR PEDOLOGICAL DROUGHT CONTROL IN THE CONTEXT OF THE SUSTAINABLE TEHCHNOLOGIES IN CROPS FOR GRAINS FROM NORTH-WESTERN ROMANIA, 1976-2012

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Abstract. *The researches were carried out during 1976-2012 in the Agricultural and Development Station Oradea on the preluvosoil.* ***Ten to ten days, the soil moisture was determined and the graphs of the soil water reserve dynamics were realized for the depth 0-50 cm in winter wheat and for the depth 0 - 75 cm in maize, sunflower and soybean. The decrease of the soil moisture bellow easily available water content was considered pedological drought and the decrease of the soil moisture bellow wilting point was considered strong pedological drought. Pedological drought was determined every year and strong pedological drought was determined in 30% of the years studied, generally. The irrigation determined the increase of the plants water consumption values, yield gains very significant statistically, the increase of the yields stability and the improve of the water use efficiency.***

Keywords: crops for grains, irrigation, pedological drought, sustainable technologies

1. Introduction

Drought and desertification are the major problems of the world and United Nations Organization established the day of 27 June like The World Day of Desertification and Drought [1].

In Romania, the areas with desertification are considered Dobrogea and a part of South-Eastern Romania. An important part of Moldova, the Romanian Plain and a smaller area across the border with Hungary are considered the areas with transfer to desertification [2-6].

The drought are the extreme climate phenomena, the most complex and the most known natural hazard. The damages produced include the drought in the

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natural dezasters together with floodings, earthquakes, hurricanes, volcano eruptions. [7,8]

There are a lot of indices for drought characterization. In Romania, meteorological drought is one of the most known indies and 14 consecutive days without rainfall in the cold season (October-March) and 10 consecutive days without rainfall in the warm season are considered the period with meteorological drought. [9,10]

Domuţa C. (2004) proposed a new definition of the pedological drought in link with the one of the most important hydro physics indices: easily available water content. Pedological drought is defined like a period when the soil water reserve on the watering depth is situated bellow easily available water content. In the same time Domuţa C. (2004) proposed the drought indices called "strong pedological drought"; this indices is defined like period when the soil water reserve on the watering depth is situated bellow wilting point; wilting point is understanded like a point from an interval not like a fixe point.[11-14]

The paper presents the results researches obtained during 1976-2012 in the Western Romania at the Agricultural Research and Development Station Oradea, an area considered like a moderate wet one.

2. Materials and Methods

The researches were carried out on the preluvosoil with the following soil profile: Ap = 0-24 cm; El = 24-34 cm; Bt_1=34-54 cm; Bt = 54-78 cm; Bt/c =78-95 cm; C = 95-145 cm.

There is a big hydro stability (47.5%) of the aggregates (Φ = 0.25 mm) on ploughed land; bulk density (1.41 g/cm^3) indicates a low settling and 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 watering depth (0-75 cm) was a fixed one and field capacity (FC = 24.2% = 2782 m^3/ha) and wilting point (WP = 10.1 = 1158 m^3/ha) have median values. Easily available water content (Wea) was established in function of texture: Wea = WP + 2/3 (FC – WP); (6); their values for 0-75 cm depth are 19.5% and 2240 m^3/ha.

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 35 years of good practices of 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.

The multiannual average (1931-2011) of the annual rainfall were of 613.4 mm, 246.4 mm in the cold season (October- March) and 367.0 mm in the warm season (April - September). The annual average temperature is of the 10.2^{o}C and the air humidity is 78%.

The research field was placed in 1976 and it was one of the 30 research fields placed by the Research Institute for Irrigation and Drainage Băneasa Giurgiu in the all areas with irrigation possibilities for Romania.

The institute research programe called "The exploitation of the irrigation and drainage systems" and it was managed by Grumeza N. The variants studied were unirrigated and irrigated. In the irrigated variant in the research field from Oradea, the soil water reserve on the watering depth (0-50 cm for wheat, 0-75 cm for maize, sunflower, soybean) between easily available water content and field capacity. As consequence the soil moisture was determined ten to ten days and the irrigation was used when the soil water reserve decreased at the level of the easily available water content. Soil moisture was determined by gravimetric method (1976-1985) by gravimetric+neutron method (1985-2000) and by gravimetric method after that.

Using the soil moisture data on the watering depth, the graphs of the soil water reserve dynamics was realized These annual graphs permeted to count the days with soil water reserve bellow easily available water content and bellow wilting point.

3. Results and Discussions

3.1. Pedological drought and strong pedological drought in unirrigated winter wheat, Oradea 1976-2011

In the irrigation systems from Romania, a fixe watering depth was used and is used. In North Western Romania, Domuţa C. (2005) recomands 0-50 cm in unirrigated wheat; the soil water reserve on the watering depth decreased bellow easily available water content every year of the period 1976-2012; in 30% from year studied the soil water reserve decreased bellow wilting point. The biggest number with pedological and strong pedological drought were registered in June (Table 1)

Table 1.Pedological drought (PD) and strong pedological drought (SPD) in unirrigated winter wheat, Oradea 1976-2012

Specification	April	May	June	July	Total April-June
Pedological drought (PD)					
Number of days with PD	13.1	22.1	23.5	9.3	59
Frequency of the PD	28	96	100	69	100
Strong pedological drought (SPD)					
Number of days with SPD	-	1.7	5	2	6.8
Frequency of the SPD	-	18	30	18	30

3.2. Pedological drought and strong pedological drought in unirrigated maize

Pedological drought was determined starting with the April, sowing months in maize from North Western Romania. The biggest number with pedologial drought was determined in August; in August the biggest frequency of the pedological drought (100%) was determined, too. In the maize irrigation season (April-August) a number of 77.5 days with pedological drought was determined (Table 2).

Strong pedological drought was determined starting with July and the frequency of the phenomenon was 34%. August was the month with the biggest frequency of the strong pedological drought (table 2).

Table 2. Pedological drought (PD) and strong pedological drought (SPD) in unirrigated maize, Oradea 1976-2012

Specification	April	May	June	July	August	September	Total April-August
Pedological drought (PD)							
Number of days with PD	1.7	8.6	14.4	23.5	29.3	25.8	77.5
Frequency of the PD	14	41	79	89	100	93	100
Strong pedological drought (SPD)							
Number of days with SPD	-	-	-	3.3	7.6	4.5	10.9
Frequency of the SPD	-	-	7	28	34	24	34

3.3. Pedological drought and strong pedological drought in unirrigated sunflower, Oradea 1976-2011

In the all vegetation period of the sunflower, the pedological drought was determined: the biggest number of days with pedological drought (27.3) and the highest frequency (100%) was determined in August. A big number of days with pedological drought (27.0) and a high frequency (96%) of the phenomenon were registered in July, the month with the maximum values of the optimum water consumption (table 3).

Table 3.Pedological drought (PD) and strong pedological drought (SPD) in unirrigated sunflower, Oradea 1976-2012

Specification	April	May	June	July	August	Total April-July
Pedological drought (PD)						
Number of days with PD	2.1	11	18.8	27	27.3	58.9
Frequency of the PD	4	44	92	96	100	100
Strong pedological drought (SPD)						
Number of days with SPD	-	-	1.3	5.4	8.7	15.4
Frequency of the SPD	-	-	16	28	38	38

3.4. Pedological drought and strong pedological drought in unirrigated soybean, Oradea 1976-2012

Pedological drought was determined every year. The biggest number with pedological drought was registered in August, 27.2 days; it is followed by the July with 21.6 days. The frequency of the phenomenon was of 100% in August and of 93% in July (Table 4).

In the soybean irrigation season, the strong pedological drought was determined in June (14% from year studied), in July (30% from years studied) and in August (37% from years studied) (Table 4)

Table 4. Pedological drought (PD) and strong pedological drought (SPD) in unirrigated soybean, Oradea 1976-2012

Specification	April	May	June	July	August	September	Total April-August
Pedological drought (PD)							
Number of days with PD	-	7.2	13.5	21.6	27.2	18.0	69.5
Frequency of the PD	-	55	76	93	100	79	100
Strong pedological drought (SPD)							
Number of days with SPD	-	-	1.2	4.7	8.6	9.2	14.5
Frequency of the SPD	-	-	14	30	37	40	37

3.5. Pedological drought influence on plants water consumption

In comparison with the variant where the soil water reserve on watering depth was maintained between easily available water content and field capacity, in the unirrigated variants the values of the daily water consumption of the plants decreased.

The biggest differences were registered in June in winter wheat and in August in maize, sunflower and soybean (Table 5).

Table 5. Pedological drought influence on plants water consumption, Oradea 1976-2012

Crop	Variant	Daily water consumption											
		April		May		June		July		August		September	
		mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%
Winter wheat	Optimum irrigation	3.09	100	4.50	100	4.89	100	2.04	100	-	-	-	-
	Unirrigated	2.59	84	3.26	72	3.33	68	1.69	83	-	-	-	-
Maize	Optimum irrigation	1.81	100	3.04	100	4.15	100	6.09	100	4.80	100	2.65	100
	Unirrigated	1.53	85	2.58	85	3.59	86	3.99	66	2.70	56	1.62	61
Sunflower	Optimum irrigation	2.08	100	3.07	100	5.37	100	6.00	100	3.79	100	1.99	100
	Unirrigated	1.90	91	2.73	88	3.99	74	3.82	64	2.03	54	1.61	81
Soybean	Optimum irrigation	-	-	2.81	100	4.29	100	5.59	100	4.61	100	2.30	100
	Unirrigated	-	-	2.68	99	3.67	86	3.74	67	2.19	48	1.74	76

Tabel 6. Pedological drought influence on total water consumption -∑ (e+t) – in crops for grains from Crisurilor Plain, 1976-2012

Crop	Variant	∑ (e+t)		Covering sources of the water consumption				
				Soil reserve	Rainfall	Irrigation		
		mm/ha	%	mm/ha	mm/ha	mm/ha	%	Variation interval %
Winter wheat	Optimum irrigation	432.9	100	48.5	235.4	149.0	34	0-54
	Unirrigated	316.0	73	80.6	235.4	-	-	-
Maize	Optimum irrigation	630.0	100	53.6	327.9	245.2	39	7.4-61.2
	Unirrigated	434.3	69	106.4	327.9	-	-	-
Sunflower	Optimum irrigation	591.7	100	95.4	281.9	215.3	36	6-63
	Unirrigated	399.4	68	117.3	281.9	-	-	-
Soybean	Optimum irrigation	589.3	100	57.3	308.9	223.5	38	7-64
	Unirrigated	391.9	66	83.6	308.3	223.5	-	-

As consequence, the pedological drought determined the decrease of the values of the plants water consumption in comparison with optimum irrigated variant with 34% in soybean, with 32% in sunflower, with 31% in maize and with 17% in winter wheat.

In optimum water consumption of the plants the irrigation contribution was of 39% in maize, of 38% in soybean, of 36% in sunflower and of 34% in winter wheat. In the covering sources of the optimum water consumption, the irrigation participated with 34% (variation interval 0 - 54%) in winter wheat, with 39% (variation interval 7.4 – 61.2%) in maize, with 36% (variation interval 6- 13%) in sunflower and with 38% (variation interval 7 - 64%) in soybean. (Table 6).

3.6. Pedological drought influence on yield level and stability and on water use efficiency

Pedological drought determined an average of the yield decrease in comparison with the optimum irrigated variant of 44% in maize, of 42% in soybean, of 33% in sunflower and of 28% in winter wheat.

Yield stability of the yields was smaller in the unirrigated variants in comparison with optimum irrigated variant, as consequence the standard deviation values increase in the variants with pedological drought, the relative difference were of 74% in maize, of 49% in soybean, of 44% in winter wheat and of 9% in sunflower (Table 7).

Water use efficiency had the smaller values in the variant with pedological drought in comparison with the variants with optimum irrigation; the differences were of 19% in maize, of 13% in soybean, of 2% in sunflower and of 1% in winter wheat. (Table 8).

Table 7. Pedological drought influence on yield in the crops for grains, Oradea 1978-2012

Crop	Variant	Yield			Standard deviation	
		Average		Variation interval		
		kg/ha	%	kg/ha	kg/ha	%
Winter wheat	Unirrigated	6399	100	3993-8300	642	100
	Irrigated	4620	72	2736-7100	922	144
LSD 5%= 230; LSD 1%=370; LSD 0,1%= 630						
Maize	Unirrigated	12232	100	7850-16480	1879	100
	Irrigated	6870	56	1510-11840	3271	174
LSD 5%= 370; LSD 1%=490; LSD 0,1%= 720						
Sunflower	Unirrigated	3470	100	1757-4580	530	100
	Irrigated	2330	67	1350-3140	580	109
LSD 5%= 210; LSD 1%=380; LSD 0,1%= 720						
Soybean	Unirrigated	3130	100	1380-4048	547	100
	Irrigated	1806	58	300-3400	814	149
LSD 5%= 190; LSD 1%=310; LSD 0,1%= 640						

Table 8. Pedological druoght influence on water use efficiency (WUE) in the crops for grains, Oradea 1976-2012

Crop	Variant	WUE		
		Average		Variation interval
		kg/mm	%	kg/mm
Winter wheat	Optimum irrigation	14.8	100	6.8-24.6
	Unirrigated	14.6	99	4.9-24.5
Maize	Optimum irrigation	19.4	100	10.7-25.7
	Unirrigated	15.8	81	3.1-24.8
Sunflower	Optimum irrigation	5.8	100	3.1-8.9
	Unirrigated	5.9	98	2.6-8.1
Soybean	Optimum irrigation	5.3	100	-
	Unirrigated	4.6	87	-

Conclusions

The researches carried out during 1976-2012 in Oradea, in the moderate wet area, determined the following conclusions:

(1)Ten to ten determinations of the soil moisture and the graphs of the soil water reserve dynamics permeted to establish the number of days with pedological drought and strong pedological drought. The pedological drought is considered to be decrease of the soil water reserve on watering depth bellow the easily available water content; the strong pedological drought is considered to be the decrease of the soil water reserve on watering depth below wilting point.

(2)In unirrigated conditions the pedological drought was registered every year and strong pedological drought was registered in 30% of years studied in winter wheat, in 34% in maize, in 38% in sunflower and in 37% in soybean.

(3)Pedological drought determined the smaller values of the daily water consumption of the plants; the biggest differences in comparison with the daily water consumption from the variants with optimum irrigation were registered in June for wheat and in August for maize, sunflower and soybean. As consequence, the pedological drought determined the decrease of the total water consumption values.

(4)In average, for optimum water consumption, the irrigation participated with 34% in winter wheat, with 39% in maize, with 36% in sunflower and with 38% in soybean.

(5)In comparison with the optimum irrigated variant, the pedological drought determined the smaller yield with 44% in maize, with 42% in soybean, with 33% in sunflower and with 28% in winter wheat. The yields stability was smaller in the unirrigated variants and as consequence the values of the standard deviation increased with 44% in winter wheat, with 74% in maize, with 9% in sunflower, with 49% in soybean.

(6)The irrigation determined a bigger quantity of the yields for every one milimeter of the water used. Pedeloggical drought determined a smaller values of the water use efficiency with 1% in winter wheat, with 19% in maize, with 2% in sunflower and with 13% in sunflower.

References

[1] Lloyd-Hughes , B., Saunders, M. A. A drought climatology for Europe, International Journal of Climatology, pp.1571–1592, 15, 2002;
[2] Cattivelli, L. *et al.*, Drought tolerance improvement in crop plants: An integrated view from breeding to genomics, Field Crops Research, Vol. 105, Issues 1–2, 2 Jan, pp.1–14. , 2008;
[3] Domuţa, C., Oportunitatea irigaţiilor în Câmpia Crişurilor, Ed. Universităţii din Oradea, pp. 165-196, 2003;
[4] Domuţa, C., Irigarea culturilor, Editura Universităţii din Oradea, pp. 256-260, 2005;
[5] Domuţa, C., Tehnică experimentală, Ed. Universităţii din Oradea, pp. 112-150, 2005;
[6] Domuţa, Cr., Cercetările privind irigarea soiei în Câmpia Crişurilor. Ed. Universităţii din Oradea, pp. 45-120, 2012;
[7] Heim, R.R, Drought: a global assessment. pp 159-167, 2000;
[8] Pengxin, W., Zhengming, W., Jianya, G., Xiaowen, L., Jindi, W., Advances in Drought Monitoring by Using Remotely Sensed Normalized Difference Vegetation Index and Land Surface Temperature Products Advances in Earth Science, Vol.18(4), pp.527-533, 2003;
[9] Domuţa, C., Irigarea culturilor, Editura Universităţii din Oradea, pp. 95-124, 2009;
[10] Domuţa, C., (coord.), Irigaţiile în Câmpia Crişurilor, Ed. Universităţii din Oradea, 2009;
[11] Brejea,R., Ştiinţa solului – îndrumător de lucrări practice. Ed. Universităţii din Oradea, pp. 84-105, 2010;
[12] Brejea, R., Practicum de pedologie, Editura Universităţii din Oradea, 2011
[13] Domuţa, Cr., Subasigurarea cu apă a porumbului, soiei şi sfeclei de zahăr din Câmpia Crişurilor, Ed. Universităţii din Oradea, pp.142-161, 2011;
[14] Borza, I., Valorificarea apei de către cultura porumbului din Câmpia Crişurilor Ed. Universităţii din Oradea, pp. 75-112, 2007;
[15] Borza, I., Stanciu, A., Fitotehnie. Ed. Universităţii din Oradea, pp. 332-352, 2010.