INFLUENCE OF THE PEDOLOGICAL DROUGHT ON WATER CONSUMPTION, YIELD AND WATER USE EFFICIENCY IN SUGARBEET CROP IN THE CONDITIONS FROM ORADEA

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Abstract

The research was conducted at the Agricultural Research and Development Station Oradea in the preluvosoil condition. It is considered that a crop receive the optimum regime of water if the moisture on watering depth is maintained between easily available water content and field capacity. The decrease of the soil water reserve on watering depth bellow easily available water content is considered "pedological drought" and the decrease bellow wilting point is considered "strong pedological drought". Pedological drought was registered both in 2013 and 2014. In the period studied to maintain the water supply between easily available content and field capacity, the irrigation regime was different from one year to another depending on rainfall. In 2013 to supply optimal water consumption of sugarbeet were used 3.300 m^3/ha water (were applied 8 irrigations), and in 2014 irrigation rate used was 3600 m^3/ha and were applied 10 irrigations. Since pedological drought was present both in 2013 and 2014, irrigation is necessary to sugarbeet crop, as compared to unirrigated variant the yield gain are statistically significant.

Key words*:* pedological drought, sugarbeet, irrigation, yield, quality.

INTRODUCTION

In the "Dictionary of soil science" pedological drought is defined as "drought mainly due to low soil moisture, even under satisfactory atmospheric conditions, does not allow absorption by plants of sufficient of water in the soil" (Conea et al., 1977). Domuţa (2004) considers the words "low humidity" too vague and suggests that this notion of pedological drought to be related with hydro indices and especially the easily available water content that is "point of the accessible range of moisture to the soil moisture may decrease without crops being sensitive affected "and proposed the following concepts:

- pedological drought, defined as the period where the soil reserve on watering depth of crops are below easily available water content;
- strong pedological drought , considered to be the period when the water supply of crops on irrigation depth is below the wilting point, meaning that the wilting point as a point from fixed interval.

Bimonthly determining of soil moisture and graphic representation of soil water reserve on watering depth highlighting the soil hydro indexes allow determining the number of days with pedological drought on sugarbeet.

Worldwide, areas planted with sugarbeet decreased after 1990, being 5.447 thousands ha in 2006. In 2009, the area stood at 4,324 thousand hectares, with an average yield of 53.078 kg / ha.

In Romania, the area occupied with sugarbeet was 21300 ha in 2009 with an average yield of 28.942 kg / ha.

Romania has favorable conditions for growing sugarbeet crop and can assure the necessary of total sugar, with the condition that to be interest of the farmers for this valuable industrial plant. (Muntean et al., 2011).

Sugarbeet is one of the most productive crop plants. In terms of proper cultivation technologies can achieve yields of roots 40-50 t/ha in unirrigated crop and over 60 t/ha in irrigated areas. (Domuța, 2010, 2011).

MATERIAL AND METHOD

The research was conducted in 2013 - 2014 in the research field of soil water balance set at the Agricultural Research and Development Station Oradea Field research is fitted with an arrangement that allows accurate measurement and uniform distribution of irrigation water.

The experimental device included variants:

- unirrigated;
- irigated with maintaining of soil water reserve between easily available content and field capacity on depth by 0-75.

Experimental plot area: 50 m^2. The number of repetitions is four. Rubin sugarbeet hybrid was used.

The fertilizer system included: manure 40 t/ha; 180 kg nitrogen/ha; phosphorus 150 kg/ha; potassium 80 kg /ha.

Manure, phosphorus (superphosphate) and potassium (potassium salt) were applied before the execution of autumn plowing, ammonium nitrate was applied in spring before sowing. (Muntean et al., 2008, 2011)

The crop was maintained free of weeds by manual hoeing; also were carried out of preventive treatments for diseases of sugarbeet. Also, the entire technology applied aimed to create optimal conditions for sugarbeet crop. (Borza, Stanciu, 2010)

The researches field from Oradea was made in the preluvosoil conditions with the following profile: Ap = 0-24 cm, El = 24-34 cm; Bt_1 = 34-54 cm; Bt_2 = 54-78 cm; Bt/c = 78-95 cm, C = 95-145 cm. It is noted that migration of colloidal clay causes the apparition of horizon El with 31.6% colloidal clay and two horizons of colloidal clay accumulation with Bt_1 and Bt_2 with 39,8% and 39,3% colloidal clay. (Brejea, 2009, Brejea, Domuța, 2011)

Gravimetric moisture (Canarache, 1990) was calculated using the formula:

$$U_g = \frac{b - c}{c - a} \times 100 \qquad [\%]$$

în which: U_g = gravimetric moisture (%);
b = moisture soil weight(g);
c = dry moisture weight (g);
a = vial table (g);
100 = percent reporting factor

Soil water reserve was determined by the formula (Botzan, 1966, 1972; Domuța, 2009):

$$Ra = Ug \times DA \times H$$

In which:
Ra = soil water reserve; m^3/ha;
U = gravimetric soil moisture %;
DA = bulk density; g/m^3;
H = depth, cm.

Yield results and results regarding of protein content were calculated by the method of variance analysis (Domuta, 2006).

Total water consumption was calculated using the equation of soil water balance in closed circuit (without phreatic input) (Grumeza 1975, Grumeza et al., 1986):

$$R_i + P_v + \sum m = R_f + \sum (e+t),$$

In which:
R_i = initial water reserve, m^3/ha;
P_v = rainfall during the maize vegetation period, m^3/ha;;
$\sum m$ = irrigation rate (m^3/ha);
R_f = final water reserve (at harvesting), m^3/ha;
$\sum (e+t)$ = plants water consumption; m^3/ha

In the period studied the climatic conditions were not very different, both years were characterized as drought. The annual average temperature in 2013 was 11.58 °C and in 2014 of 12.55°C. Annual rainfalls were below multiannual average value (616.3 mm), both in 2013 (418.9 mm) and 2014 (453.8 mm) (table 1).

The yield results was calculated using the variance analysis method (Săulescu, 1967)

Table 1

Elements of climate at Oradea in the period 2013 - 2014
(after the Meteorological Station Oradea)

Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
Air temperature °C													
2013	12.0	7.8	0.5	0.6	3.6	4.3	12.4	17.4	20.1	22.4	23.6	14.6	11.58
2014	12.6	8.7	1.1	1.4	5.4	9.2	12.8	16.8	21.0	22.5	21.1	18.0	12.55
Multiannual average*	10.6	6.7	3.2	-2.2	0.3	5.0	10.5	15.8	19.1	20.8	21.6	16.2	10.63
Rainfalls - mm													
2013	15.6	0.0	54.0	23.2	23.0	4.6	40.7	65.0	94.1	70.8	6.5	21.4	418.9
2014	52.2	46.4	8.3	46.6	18.3	14.2	35.0	52.4	44.1	38.7	65.0	32.6	453.8
Humidity (%)													
2013	72	80	89	86	81	57	66	69	68	62	52	59	70
2014	76	84	86	88	85	66	73	71	55	70	72	74	75.00
Multiannual average*	79	84	89	85	86	77	72	72	73	72	82	75	78.8

* Multiannual average between 1931 - 2012

RESULTS AND DISCUSSION

Pedological drought on unirrigated sugarbeet crop

In 2013 pedological drought was present from May to September, totaling 88 days. In 2014 the total number of days with pedological drought was 114; this phenomenon is also met since May and continuing until September. In 2014 was registered the smallest number with pedological drought (table 2).

Table 2

Number of days with pedological drought registered in unirrigated sugarbeet crop, Oradea 2013-2014

Year	No. of days with pedological drought						
	Month						TOTAL
	IV	V	VI	VII	VIII	IX	
2013	0	5	7	15	31	30	88
2014	0	10	12	31	31	30	114

Optimal irrigation scheduling sugarbeet

It is considered that a crop get an optimum water regime if soil moisture on irrigation depth is maintained between easily available water content and field capacity. (Grumeza et. al., 1989). In the studied period to maintain the water reserve between easily available water content and field capacity, irrigation schedule was different from one year to another depending on rainfall.

In 2013 for optimal water supply of sugarbeet have used 3300 m³ / ha water (8 irrigation were applied) and in 2014 irrigation rate used was 3600 m^3 / ha and were applied 10 irrigation (table 3).

Table 3

Optimum irrigation scheduling of sugarbeet crop,Oradea 2013-2014

Year	Month												Total	
	IV		V		VI		VII		VIII		IX			
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
2013	-	-	300	1	500	1	800	2	1200	3	500	1	3300	8
2014	-	-	300	1	500	1	1500	2	1000	3	300	1	3600	10

Σm = irrigation rate (m^3/ha); n = number of irrigations

Influence of irrigation on water consumption of sugarbeet crop

Total water consumption was determined by soil water balance method, the balance depth of 0-150 cm. Irrigation increased the daily water consumption values from sugarbeet, as a result, total water consumption values have increased.

The irrigation covered the following percentages: 48% in 2013, 50% in 2014 (table 4).

Table 4

Irrigation influence on total water used – Σ (e+t) at sugarbeet crop, Oradea 2013-2014

Year	Variant	Σ (e+t)		Covering sources					
				Ri-Rf		Pv		Σm	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
2013	Unirrigated	4010	100	1025	26	2985	74	-	-
	Irrigated	6943	173	658	9	2985	43	3300	48
2014	Unirrigated	4088	100	1110	27	2987	73	-	-
	Irrigated	7202	176	624	9	2987	41	3600	50

Σ (e+t) = total water consumption;
R_i = Initial water reserve (at sowing);
R_f = Final water reserve (at harvest);
Pv= Rainfalls from vegetation period;
Σm = irrigation rate

Under irrigation condition, in 2013, the largest share in total coverage sources of the water consumption had the irrigations registered in the period between sowing and harvesting of sugarbeet; this represented 48% from total water consumption and irrigation rate by 3300 m^3/ha represented 48% from total water consumption of sugarbeet crop (Fig.1.)

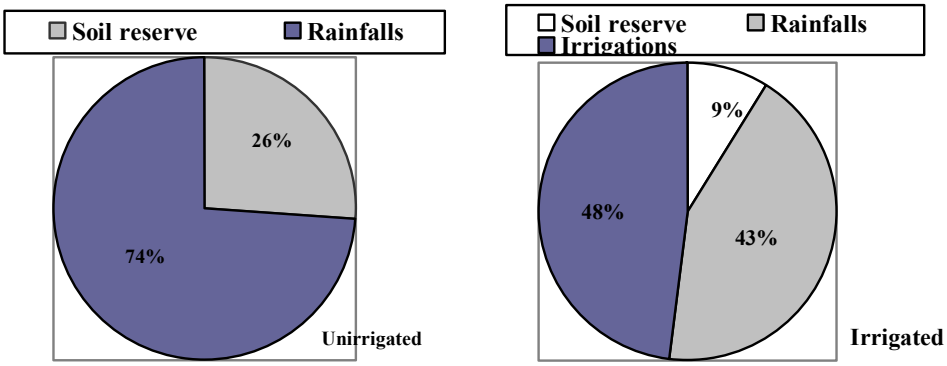

Fig. 1. Percentage of covering sources of total water consumption at sugarbeet crop in irrigated and unirrigated conditions, Oradea 2013

In 2014 in the irrigation conditions, irrigation rate had the largest covering source of total water consumption (50%) and the rainfalls registered betwen period of sowing and harvesting of sugarbeet reprezented 41% from total water consumption of sugarbeet (Fig.2).

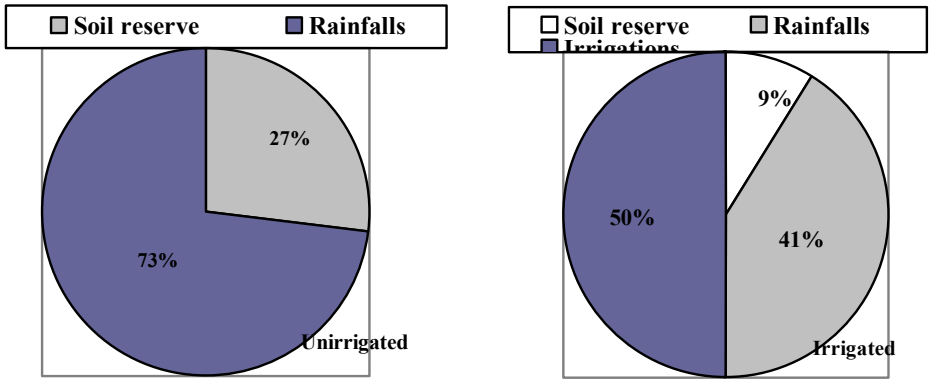

Fig. 2. Percentage of covering sources of total water consumption at sugarbeet crop in irrigated and unirrigated conditions, Oradea 2014

Influence of irrigation on yield at sugarbeet, 2013

In 2013, dry year, under unirrigation condition was obtained an sugarbeet yield of 30150 kg / ha for sugarbeet crop and in conditions of irrigation, the yield increased by 146%, resulting an yield of 74200 kg / ha roots of sugarbeet (table 5., fig. 3.).

Table 5

Influence of the irrigation on yield in sugarbeet crop, Oradea 2013

Variant	Yield		Difference		Statistic semnific.
	Kg/ha	%	Kg/ha	%	
Unirrigated	30150	100	-	-	Mt
Irrigated	74200	246	44050	146	***

$LSD_{5\%}$ 1970;
$LSD_{1\%}$ 3840;
$LSD_{0,1\%}$ 5820

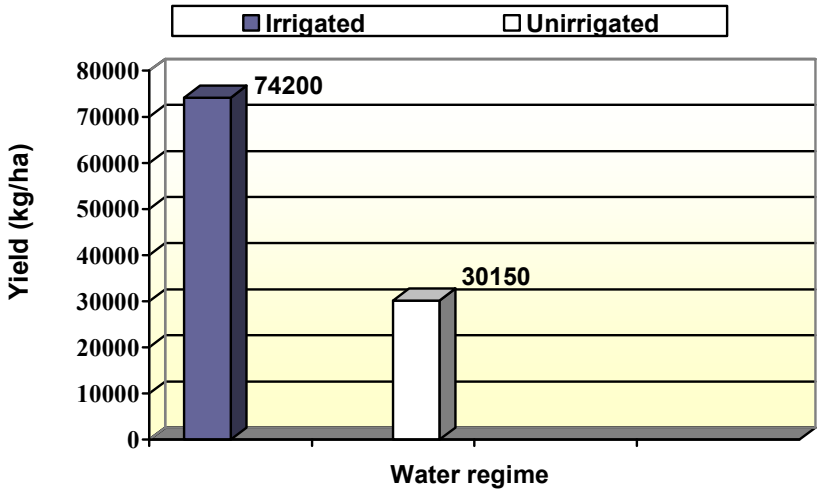

Fig. 3. Yield obtained (kg/ha) in unirrigated and irrigated at sugarbeet, Oradea 2013

In 2014, yields obtained under unirrigation (32710 kg/ha) and irrigation conditions (78000 kg / ha) was higher than the previous year. The difference between the two variants of maintenance crop: non-irrigated and irrigated (45290 kg / ha) is highly statistically significant, through applying irrigation was obtained a yield gain of 139%. (table 6., fig. 4.)

Table 6

Influence of the irrigation on yield in sugarbeet, Oradea 2014

Variant	Yield		Difference		Statistic significant
	Kg/ha	%	Kg/ha	%	
Unirrigated	32710	100	-	-	Mt
Irrigated	78000	239	45290	139	***

$LSD_{5\%}$ 1210;
$LSD_{1\%}$ 3910;
$LSD_{0,1\%}$ 7030

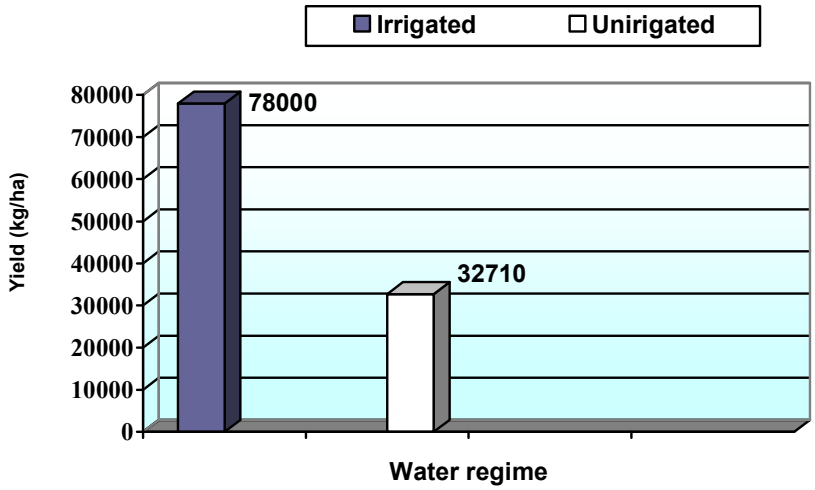

Fig. 4. Yield obtained (kg/ha) in unirrigated and irrigated at sugarbeet, Oradea 2014

Irrigation influence on water use efficiency

In the year 2013, the irrigation determined the increase of the water use efficiency with 42% In 2014, the increase was of 35%. (table 7)

The results obtained sustains the importance of the irrigation in the pedological drought control, because the sugarbeet water consumption increased, the yield gains obtained were very significant and water use efficiency improved.

Table 7

Irrigation influence on water use efficiency (WUE) in sugarbeet, Oradea 2013-2014

Variant	WUE		Difference	
	Kg/m^3	%	Kg/m^3	%
2013				
Unirrigated	7.51	100	-	-
Irrigated	10.68	142	3.17	42
2014				
Unirrigated	8,00	100	-	-
Irrigated	10.83	135	2.83	35

CONCLUSIONS

Sugarbeet is one of the crop with big water requirements, and research conducted in 2013 - 2014 in the field research of the soil water balance at the Agricultural Research and Development Station Oradea established the periods of pedological drought and it's influences on water consumption, yield and water use efficiency.

Bimonthly determinations of soil moisture shows that on depth of 0-75 cm, water reserve decreased below the easily available water content (pedological drought) both in 2013 (88 days) and in 2014 (140 days) . Under these conditions to maintain water reserve between the easily available water content and field capacity on depth 0-75 cm the irrigation was used: 3300 m³/ha in 2013, 3600 m³/ha in 2014 .

Irrigation determined obtaining of highly statistically significant yield gain in the two years studied, relative differences to unirrigated variant was 146% in 2013 and 139% in 2014.

Compared with the variant assured with irrigation, in unirrigated variant with pedological drought, the water use efficiency was smaller. The irrigation determined the increase of the water use efficiency with 31% in 2011, with 40% in 2012 and with 46% in 2013.

Because pedological drought was present in 2013 and in 2014 either it is require the use of irrigation in sugarbeet crop because gain yield in irrigated variant compared with unirrigated crop are highly statistically significant.

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