RESEARCH THE DROUGHT INFLUENCE ON SOYBEAN CROP IN THE CONDITIONS OF CRIȘURILOR PLAIN

Cenușa Nicolae*

*University of Oradea, Faculty of Environmental Protection, Oradea, Romania,
e-mail: cenusa.nicolae@yahoo.com

Abstract

Results of research were obtained in the research field of soil water balance from Agricultural Research and Development Station Oradea. Soil water reserve on the 0-75 cm depth dropped below the easily available water content 81 days in 2013 and 108 days in 2014. Water storage on the 0-75 cm depth also dropped below the wilting point, 8 days in 2013 and 26 days in 2014. As a result, in order to maintain water storage between the easily available water content and field capacity on the 0-75 cm depth, 3.350 m^3/ha irrigation rate was used in 2013 and 4.300 m^3/ha in 2014. The irrigation participated in the optimum water consumption with 69% in 2013 and with 50% in 2014. Consequently, higher yields resulted, the differences against the non-irrigated crop being 2,590 kg/ha (446%) in 2013 and 2,280 kg/ha (543%) in 2014, which are very significant statistically.

Keywords*:* pedological drought, water supply, soil water reserve, yield, soybean

INTRODUCTION

Hera Cr. and Canarache (2004) believes that drought is a "natural phenomenon that occurs when rainfall is significantly lower than those recorded normal, causing water balance disorders that adversely affect land resource production systems". According to this definition, the drought can be present in different climate zones, in the years when there is, deficiency of rainfall from the multiannual average.

Droughts constitute extreme climate events which, by their effects, are natural disasters regular event, consisting of a drastic reduction of rainfall and water resources, over long periods of time. The scarcity of rainfall leads to reduced water reserves available for all utilities as well as environmental protection. The drought is considered the most complex and least understood natural hazard, with stronger effects than other hazards. (Domuta, 2009, 2010, Borza, Stanciu, 2010)

Two types of drought are well known and widely used by Romanian specialists in climatology and agriculture: pedological drought and meteorological drought. Climatic indicators are another way of assessing the presence of drought. Even if the criterion Hellman after which is defined meteorological drought should include this indicator between climatic indicators, we felt that it should be treated as a separate indicator given the reputation it enjoys. (Jude, 2012)

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 (2003) 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 punt from fixed interval.

Highlighting the number of days with water reserve on watering depth below the easily available water content and the number of days with water reserve under wilting point coefficient on this depth was achieved by Domuta (1995) and then by Tusa (1992), Petrescu (1999), Radulescu (1999).

MATERIAL ȘI METHOD

The research was conducted during 2013-2014 in the field of soil water balance from Oradea.

Two variants were studied:

- unirrigated,
- irrigated, with maintaining of water reserve between easily available water content and field capacity on watering depth of 0-75 cm\

Main physical and hydrophysical properties

Preluvosoil from the research field is characterized by a very high hydrostability of soil aggregates more than 0.25 mm, 47.5% of layer by 0-20 cm.

The soil had a total medium porosity at depth by 0-20 cm, 20-40 cm, 40-60 cm and less in depth by 6-80 cm, 80-100 cm and 100-150 cm. Total porosity values decrease on the soil profile from the surface to depth. Hydraulic conductivity is high on the depth 0-20 cm, medium on depth by 20-40 cm and 40 cm, low and very low on the following depths studied.

Active humidity interval (IUA) or useful water capacity had a high value in the depth 0-80 cm and the middle at depth 80-150 cm. On watering depth used on the research field the active humidity range had a great value (Domuţa C., 2009, 2012). Depending on soil easily available water content was set at 2/3 active humidity moisture (AHM). (Table 1).

Table 1.

Physical and hydrophysical properties of luvosoil in the Oradea research field

Depth - cm -	Total agregate %	Clay 0,002%	TP %	K mm/h	BD g/cm^3	Field capacity		Wilting point		Easily available water content		AHM	
						%	m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha
0-20	47.5	31.5	21	21.0	1.41	24.2	682	9.2	259	19.2	542	15.0	423
20-40	-	34.1	49	10.5	1.52	23.6	717	9.4	286	18.9	575	14.2	431
40-60	-	39.8	48	4.4	1.58	25.1	768	11.1	351	19.9	630	13.2	417
60-80	-	39.3	43	1.0	1.65	24.4	828	10.8	356	20.4	672	14.3	472
80-100	-	38.8	40	0.5	1.57	23.8	766	12.2	383	20.4	640	12.2	383
100-150	-	37.6	39	0.1	1.54	24,0	1833	14,2	1093	20.6	1586	9.6	740

Bulk density (BD) - 1.41 g/cm^3 - characterizes a poorly compacted soil at depth 0-20 cm; on other depths studied the apparent weight highlights a moderately and strongly compacted soil (Brejea, 2010, 2014). On watering depth (0-50 cm, 0-75 cm) and on 0-150 cm the soil is strongly compacted. Field capacity had a middle value throughout the soil profile and wilting coefficient is also worth to middle depth of 80 cm and higher below this depth.

Easily available water content take into account the texture and degree of compaction of the land was calculated as follows (Canarache, 1990):

$$Wea = WP + f(FC + WP) = WP + f \cdot IUA$$

In which:

Wea = easily available water content (% g/g);
WP - wilting point
FC - field capacity
f - fraction of the active humidity interval;
IUA – active humidity interval

Total water consumption was calculated using the equation of soil water balance in closed circuit (without phreatic input) (Botzan, 1972, Grumeza et al,1989):

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

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;

Irrigation involves a set of technical and organizational measures in order to establish a rigorous rational regime of irrigation, regarding the evaluation of water necessity, to the size and sequence of irrigation application consistent with thorough knowledge of relationships between soil-water-plant systems (Domuta, 2010).

Yield research data were calculated by variance analysis method (Saulescu, 1967).

RESULTS AND DISCUSSION

Pedological drought in soybean crops

In the soybean crops, we speak of pedological drought when the soil water reserve within the watering depth (0.75 cm) drops below the easily available water content, and when it drops below the wilting point, there is a period of severe pedological drought (Domuţa, 2009). There were 81 days of pedological drought in 2013. In 2014, pedological drought set in as early as April and the total number of pedological drought days in the soybean irrigation season went up to 108 days (Table 1).

Soil water reserve (SWR) on the 0-75 cm depth dropped below the wilting point for 8 days in August 2013 and for 26 days in 2014 (Table 3).

Table 2

The number of days when soil water reserve (SWR) was below the easily available water content (Wea) on the 0-75 cm depth in the unirrigated soybean, Oradea 2013-2014

Year	Vegetation period -days-	Days with SWR < Wea					
		April	May	June	July	August	Total
2013	168	0	6	20	24	31	81
2014	170	3	31	12	31	31	108

IS– irrigation season: 1st IV – 10th VIII;

Table 3

The number of days when soil water reserve (SWR) was below the wilting point (WP) on the 0-75 cm depth in the unirrigated soybean, Oradea 2013-2014

Year	Vegetation period - days -	Days with SWR < WP in					
		April	May	June	July	August	Total
2013	168	0	0	0	0	8	8
2014	170	0	0	3	13	10	26

Optimum water supply of the soybean crop

In order to maintain water storage between the easily available water content and field capacity, the soil moisture content within the 0-75 cm depth was measured twice a month. Based on the data obtained, it was concluded that the irrigation water needed was 3,350 m^3/ha in 2013 (8 x watering) and 4,300 m^3/ha in 2014 (10 x watering) (Table 4).

Table 4

Irrigation regime required to maintain soil water reserve between the easily available water content and field capacity on the watering depth in the soybean (0-75 cm)
Oradea, 2013-2014

Year	May		June		July		August		May-August	
	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n
2013	500	1	850	2	1000	2	1000	2	3350	8
2014	1300	3	500	1	1200	3	1300	3	4300	10

∑m – irrigation rate, n – number of rates

The influence of irrigation on the water consumption of the soybean crop

Irrigation caused an increase in the total water use by 69% in 2013 and by 50% in 2014. In the case of the irrigated soybean crop, less water was used from the soil water storage (table 5).

Table 5

Total water use of the soybean crop when irrigated and unirrigated and water resources, Oradea 2013-2014

Variant	Total water consumption		Covering sources of the total water consumption (m^3/ha)		
	m^3/ha	%	ISWR-FSWR	Vegetation period	Irrigation
2013					
Unirrigated	4715	100	1695	3020	-
Irrigated	7978	169	608	3020	3350
2014					
Unirrigated	5085	100	2545	2540	-
Irrigated	7608	150	768	2540	4300

ISWR = Initial soil water reserve;
FSWR= Final soil water reserve

The influence of irrigation on soybean yield in 2013

The year 2013 was not a good one for the soybean crop, thus the yield in the case of the unirrigated crop was 580 kg/ha. Using irrigation when water storage within the watering depth dropped below the easily available water content resulted in an yield gain of 2.590 kg/ha (446%), the different is very significant statistically (Table 6, Fig. 1.)

Table 6

The influence of irrigation on soybean yields, Oradea 2013

Variant	Yield		Difference		Statistical significance
	Kg/ha	%	Kg/ha	%	
Unirrigated	580	-	-	-	Control
Irrigated	3170	546	2590	446	XXX

$DL_{5\%}$ 280 $DL_{1\%}$ 512 $DL_{0,1\%}$ 760

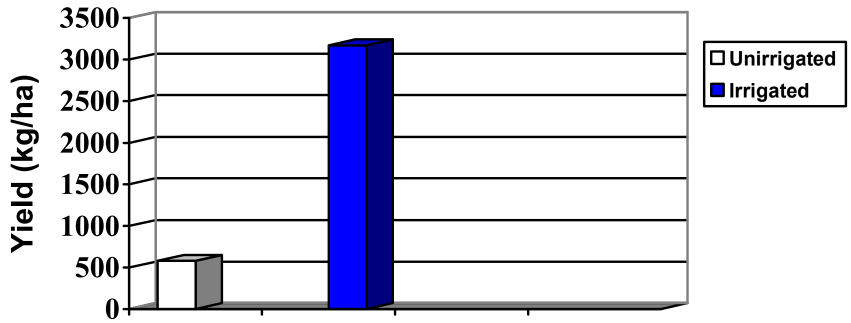

Fig. 1. Yields (kg/ha) obtained at soybean in condition of unirrigation and irrigation, Oradea 2013

The influence of irrigation on soybean yield in 2014

The year 2014 was again a bad one for the soybean crop, thus without irrigation the yield was 420 kg/ha. Using irrigation when water reserve on watering depth dropped below the easily available water content resulted in an yield of 2,280 kg/ha (543%), an amount that is very significant statistically (table 7, Fig. 2.)

Table 7

The influence of irrigation of soybean yield, Oradea 2014

Variant	Yield		Difference		Statistical significance
	Kg/ha	%	Kg/ha	%	
Unirrigated	420	-	-	-	Control
Irrigated	2700	643	2280	543	XXX

$DL_{5\%}$ 240 $DL_{1\%}$ 370 $DL_{0,1\%}$ 630

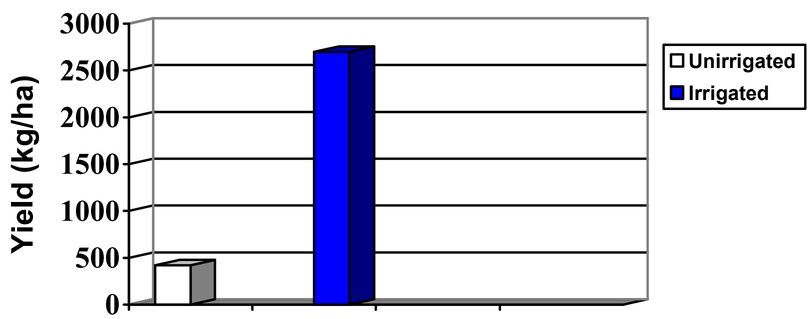

Fig. 2. Yields (kg/ha) obtained at soybean, in unirrigate and irrigated conditions from Oradea, 2014

CONCLUSIONS

Looking at the favourability of pedoclimatic conditions, the economic and agrotechnical importance, it can be said that soybean crops covers small areas in the Crişurilor Plain. One of the reasons is the drought presence. The paper presents the research carried out at the Oradea Agricultural Research and Development Station in 2013 and 2014 on the preluvusoil, and the conclusions are as follows:

❖ Soil water reserve on the 0-75 cm depth dropped below the easily available water content 81 days in 2013 and 108 days in 2014. Soil water reserve on the 0-75 cm depth also dropped below the wilting point, 8 days in 2013 and 26 days in 2014. As a result, in order to maintain the soil water reserve between the easily available water content and field capacity on the 0-75 cm depth, 3.350 m^3/ha irrigation rate was used in 2013 and 4.300 m^3/ha in 2014.

❖ Irrigation determined an increase in the total water consumption by 69% in 2013 and by 50% in 2014. Consequently, higher yields resulted, the differences against the non-irrigated crop being 2,590 kg/ha (446%) in 2013 and 2,280 kg/ha (543%) in 2014, which are very significant statistically.

The results obtained sustain the need for irrigation soybean crops from Crişurilor Plain.

REFFERENCES

1. Borza Ioana Maria, Alina Ştefania Stanciu, 2010, Fitotehnie, Ed. Universităţii din Oradea
2. Botzan M., 1972, Bilanţul apei în solurile irigate. Ed. Agro-Silvică, Bucureşti
3. Brejea R., 2010, Ştiinţa solului. Ed. Universitaţii din Oradea
4. Brejea R., Domuța C., 2011, Practicum de pedologie. Ed. Universitatii din Oradea
5. Brejea R., 2014, Tehnologii de Protecţie a Solurilor. Editura Universităţii din Oradea.
6. Canarache A., 1990, Fizica solurilor agricole, Editura Ceres, Bucureşti.
7. Domuţa C., 2003, Oportunitatea irigaţiilor în Câmpia Crişurilor. Editura Universităţii din Oradea.
8. Domuţa C., 2005, Irigarea culturilor. Ed. Universităţii din Oradea.
9. Domuţa C., 2005, Practicum de Irigarea culturilor şi agrotehnică. Ed. Universităţii din Oradea.
10. Domuţa C., 2009, Irigarea culturilor. Ed. Universităţii din Oradea.
11. Domuţa C. (coord), 2009, Irigaţiile în Câmpia Crişurilor. Ed. Universităţii din Oradea.
12. Domuța C., Domuța Cr. (coord), 2014, Cercetări privind irigațiile în Câmpia Crișurilor (1976-2014) Ed. Universităţii din Oradea.

13. Domuta Cr., Domuta C., Sandor M. , Borza I., Samuel A., Bara C., Bara L., Brejea R., Vuscan A., 2009, Irrigation, the Measure for Pedological Drought Control And for Microclimate Improve in Soybean from Crisurilor Plain. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture Vol 66, No 2
14. Domuţa Cr., 2010, Cercetări privind influenţa irigaţiei asupra culturilor de porumb, soia şi sfeclă de zahăr în Câmpia Crişurilor, Teză de doctorat, USAMV Cluj-Napoca
15. Domuţa Cr., C. Domuţa, 2010, Materii prime vegetale. Ed. Universităţii din Oradea.
16. Domuţa Cr., 2011, Subasigurarea cu apă a porumbului, soiei şi sfeclei de zahar din Câmpia Crişurilor. Editura Universităţii din Oradea
17. Domuţa Cr., 2012, Cercetările privind irigarea soiei în Câmpia Crișurilor**.** Ed. Universității din Oradea
18. Domuta Cr., 2012, Pedological Drought Influence on Quantity and Quality of the Soybean Grains, Oradea 2009-2011. Analele Universitătii din Oradea Fascicula:Ecotoxicologie, Zootehnie şi Tehnologii de Industrie Alimentară, 2012 p.351-357
19. Grumeza N. şi colab., 1989, Prognoza şi programarea aplicării udărilor în sistemele de irigaţii. Editura CERES, Bucureşti.
20. Grumeza N., Klepş Cr., 2005, Amenajările de irigaţii din România. Ed. Ceres Bucureşti.
21. Hera Cr., Canarache A., 2004 – Seceta şi deşertificarea – probleme actuale majore ale omenirii. Cereale şi plante tehnice Nr.2/2004.
22. Jude E., 2012, Ecologie generală, Ed. Universităţii din Oradea
23. Rădulescu A., 1991 – Rezultate cercetărilor privind consumul de apă al culturilor şi prognoza udărilor în condiţiile Bărăganului de Sud-Est. Analele ICITID Băneasa-Giurgiu
24. Tuşa C. 1992, Cercetări privind consumul de apă al culturilor de soia în condiţiile Câmpiei Burnasului, zona Băneasa-Giurgiu, Analele ICITID Băneasa-Giurgiu, p.42-60
25. Petrescu E., 1999, Cercetări privind reducerea consumului de apă la cultura de sfeclă de zahăr irigată în condiţiile pedoclimatice ale Câmpiei Caracalului. Teză de doctorat. ASAS "Gheorghe Ionescu Şişeşti", Bucureşti
26. Săulescu N.A., Săulescu I.D., 1967**,** Câmpul de experienţă Editura. Agro-silvică, Bucureşti.