IMPACT OF PEDOLOGICAL DROUGHT AND IRRIGATION ON POTATO WATER CONSUMPTION AND YIELD IN THE CRISURILOR PLAIN CONDITIONS

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Abstract

The research was conducted at the Agricultural Research and Development Station Oradea in the condition of the preluvosoil. It is considered that exists pedological drought if the water reserve on irrigation depth (0-75 cm) decrease below easily available water content. If soil water reserve descends below the wilting point is considered that there is a period of strong pedological drought. Decadal determinations of soil moisture on 0-75cm depth show that in unirrigated potato crop, the water reserve decreased below the easily available water content, 78 days in 2013 and 91 days in 2014. To maintain the water reserve on 0-75 cm depth between the easily available water content and field capacity were used for the following irrigation rates: 2800 m^3/ha in 2013 and 3700 m^3/ha in 2014. In 2013 irrigation determined an yield gain of 18.500 kg/ha, very significant statistic. In 2014 irrigation determined an yield gain very significant statistically of 21060 kg / ha.

Key words*:* pedological drought, potato, irrigation, easily available water content, wilting point, yield

INTRODUCTION

The potato is rightly considered the "second bread of the world" had and continues to have an important role in increasing food resources in many geographical areas of the world. (Muntean, 2003, 2008, 2011)

The potato is one of the plants most demanding of continuous water supply. Droughts, even short term, as excess water, is it even temporarily, have repercussions on the growth, the level of yield and quality (Brejea, 2009, 2014, Domuța, 2010). Absence of water during tuber formation impedes or it spaced, resulting fewer tubers with different ages, leading to unevenness boiling resistance and reduced harvest. (Borza, Stanciu, 2010)

Research carried out in the research fields of soil water balance during 1969-1985 show that, to maintain water reserve between easily available water content and field capacity on the watering depth were needed irrigation rate about 653 m^3/ha in Suceava in northern Moldova, 2050 m^3/ ha at Tecuci in southern Moldova, 4065 m^3/ha at Valul lui Traian in Dobrogea, 1878 m^3/ha at Marculesti in Bărăgan, 3841 m^3 / ha at Maglavit in west part of Oltenia. Irrigation rate or number of irrigation had specific values depending on each year (Grumeza, Kleps, 2005).

In the moderate area from Crisurilor Plain, research conducted by the same methodology in the field of soil water balance in Oradea (Domuta, 2014), highlights the following potato irrigation scheme in the period 1976-2014:

	Irrigation rate (m^3/ha)	Number of irrigation
Minim value	500	1
Maxim value	3360	8
Average value	1861	5

The average irrigation regime corresponds to the following scheme (Ionescu Șișești, 1986) for the application of irrigation:

IV	V	VI	VII	VIII
0	1	1	2	1

At potato crop cannot drive an optimal irrigation regime after a predetermined scheme. Such a system is achieved by the provisions included in warning bulletins of irrigations, taking into account the particularities of that year's climate and the hydrophysical indices of soil were growing potatoes. Irrigation regime established is based on the direct knowledge of relations from soil-water-plant system, eliminating the uncertainties elements about it. (Domuța, 2009, 2012)

MATERIAL AND 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.

Potato crop technology was meant to be optimal. (Bîlteanu, 2001, Borcean, 2004)

The variety used was Desiree.

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 midLSDe 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 IUA. (Table 1).

Table 1.

Physical and hydrophysical properties of luvosoil in the Oradea research field

Depth - cm -	Total agregate %	Clay 0,002%	PT %	K mm/h	DA g/cm^3	Field capacity		Wilting point		Easily available water content	
						%	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
20-40	-	34.1	49	10.5	1.52	23.6	717	9.4	286	18.9	575
40-60	-	39.8	48	4.4	1.58	25.1	768	11.1	351	19.9	630
60-80	-	39.3	43	1.0	1.65	24.4	828	10.8	356	20.4	672
80-100	-	38.8	40	0.5	1.57	23.8	766	12.2	383	20.4	640
100-150	-	37.6	39	0.1	1.54	24,0	1833	14,2	1093	20.6	1586

Depending on soil texture easily available water content was set at 2/3 IUA.

Bulk density - 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, 2014). On watering depth (0-50 cm, 0-75 cm) and on 0-150 cm the soil is strongly compacted. Field capacity had a midLSDe value throughout the soil profile and wilting coefficient is also worth to midLSDe depth of 80 cm and higher below this depth.

The average annual temperature in 2013 was 11.58 °C and in 2014 of 12.55°C. Annual precipitation were below multiannual average value (616.3 mm), both in 2013 (418.9 mm) and 2014 (453.8 mm). (Table 2).

Table 2.

Characterization of climatic conditions from Oradea between 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

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) (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 N.A, Saulescu I.D, 1967).

RESULTS AND DISCUSSION

Pedological drought at potato crop

It is considered that exists pedological drought if the water reserve on irrigation depth (0,75 cm) decrease below easily available water content, and if it descends below the wilting point is considered that there is a period of strong pedological drought (Domuţa C., 2009).

Pedological drought manifested in both years studied, the number of days with water reserve below easily available water content on 0-75 cm depth was 78 days in 2013 and 91 days in 2014. (Table 3).

Table 3.

Analysis of number of days with water reserve (Wr) under easily available water content (Wea) on depth 0-75 cm, in unirrigated potato conditions, Oradea 2013-2014

Year	Vegetation period -days-	Days with Wr < PM						
		IV	V	VI	VII	VIII	VP	IS
2013	156	-	10	20	27	31	88	78
2014	91	4	31	10	31	15	91	91

VP – vegetation period
I S – Irrigation season

On the watering depth of potato crop, water reserve decreased under the wilting point coefficient about 9 days in 2013 and 27 days in 2014 (Table 4).

Table 4.

Analysis of number of days with water reserve below wilting point (Wp) on depth 0-75 cm, in unirrigated potato conditions, Oradea 2013-2014

Year	Vegetation period -days--	Days with Wr < Wp					Total
		IV	V	VI	VII	VIII	
2013	156	-	-	-	5	4	9
2014	143	-	-	4	13	10	27

VP – vegetation period
I S – Irrigation season

The optimum irrigation of potato crop

To maintain the water reserve on 0-75 cm depth between the easily available water content and field capacity were used for irrigation following rates: 2800 m^3 / ha in 2013 and 3700 m^3 / ha in 2014 (Table 5).

Table 5.

Water regime necessary for maintaining water reserve between easily available water content and field capacity on irrigation depth (0-75 cm) in potato, Oradea, 2013-2014

Year	V		VI		VII		VIII		V-VIII	
	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n
2013	500	1	11100	3	700	2	500	1	2800	7
2014	1000	2	700	2	1400	3	-	-	3700	9

∑m – irrigation rate n – number of rates

The influence of irrigation on total water consumption of potato crop. Irrigation determined the increase of the total water consumption values of potato crop by 41% in 2013 and 43% in 2014. Potato used more quantity of water from soil water reserve in comparison with irrigated variant 1193 m^3/ha vs. 131 m^3/ha in 2013 and 899 m^3/ha vs. 59 m^3/ha in 2014. (Table 6.)

Table 6.

Total water consumption of potato crop in irrigated and unirrigated conditions and the covering sources, Oradea 2013-2014

Variant	Total water consumption		Covering sources of consumption m^3/ha		
	m^3/ha	%	R_i-R_f	Rainfalls	Irrigations
2013					
Unirrigated	4237	100	1193	3044	-
Irrigated	5975	141,0	131	3044	2800
2014					
Unirrigated	3314	100	899	2415	-
Irrigated	6174	186	59	2415	3700

R_i =Initial water reserve (at planting); R_f = Final reserve (at harvest)

Influence of irrigation on yield at potato crop in 2013

In 2013 irrigation determined the obtaining of an yield gain of 18.500 kg / ha, very significant. (Table 7.)

Table7

Influence of irrigation on yield in potato crop, Oradea 2013

Variant	Yield		Difference		Statistically semnif.
	Kg/ha	%	Kg/ha	%	
Unirrigated	15500	100	-	-	Mt
Irrigated	34000	219	18500	119	XXX

$LSD_{5\%}$ = 1310 $LSD_{1\%}$ = 2180 $LSD_{0,1\%}$ = 4110

Influence of irrigation on yield at potato crop in 2014

In 2014 irrigation determined the obtaining of an yield gain very significant statistically of 21060 kg / ha. (Table 8.)

Table 8.

Influence of irrigation on yield in potato crop, Oradea 2014

Variant	Yield		Difference		Statistically semnif.
	Kg/ha	%	Kg/ha	%	
Unirrigated	10240	100	-		Mt
Irrigated	31300	306	21060	206	XXX

$LSD_{5\%}$ = 320 $LSD_{1\%}$ = 610 $LSD_{0,1\%}$ = 970

CONCLUSIONS

Crisurilor Plain is situated in moderately sub-humid area and it is favorable for potato cultivation. The research was conducted during 2013-2014 in the field of soil water balance from Agricultural Research and Development Station Oradea. Years of research are different in terms of climate.

Decadal determinations of soil moisture on 0-75cm depth show that in unirrigated potato, the water reserve decreased below the easily available water content, 78 days in 2013 and 91 days in 2014.

To maintain the water reserve on 0-75 cm depth between the easily available water content and field capacity were used the following irrigation rates: 2800 m^3/ha in 2013 and 3700 m^3/ha in 2014

Daily water consumption of irrigated potato crop increased in comparison with unirrigated crop. As consequence, the total water consumption values were higher by 41% in 2013 and 86% in 2014.

Irrigation of potato crop determined the obtaining of yield gains very significant statistically, relative differences being 119% in 2013 and by 206% in 2014.

Decreasing of water reserve below easily available water content on irrigation depth, influence of irrigation on water consumption and yield gains achieved in each year studied, highlights the opportunity of irrigation at potato crop in Crisurilor Plain.

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