RESEARCHES REGARDING THE IRRIGATION INFLUENCE ON WATER USE EFFICIENCY IN POTATO IN THE CRIŞURILOR PLAIN CONDITIONS

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Abstract: *The researches were carried out during 2006-2009 on the preluvosoil from Agricultural Research and Development Station Oradea in the research field for soil water balance study. The preluvosoil from the research field is characterized by the presence of the horizons Bt_1 (34-54 cm depth) and Bt_2 (54-78 cm depth); the colloid clay eluviation determined to appear the El horizon with 31.6% colloid clay. The source of irrigation water was a drill of 15 m depth. The chemical parameters of the irrigation water were the following: fixed mineral residue 0.5 g/l; SAR index 0.52; CSR index= -1.7%; N. Florea class = II; there are not some problemes regarding the use of irrigation use. Water use efficincy (WUE) was determined as a report between yield (kg/ha) and water consumption (m^3/ha). In the irrigated variant the soil water reserve was maintained between easily available water content (2240 m^3/ha) and field capacity (2782 m^3/ha) on watering depth (0-75 cm). Crop technology was the optimum one: foreruner was the wheat, chemical ($N_{160}P_{120}K_{80}$) and organic (40 t/ha) fertilizers were used, the treatments against the diseas and pests were applied in function of the needs. The irrigation determined the increase of the daily water consumption; total water consumption increased too. There were the yield gains very significant statistically every year; the percentage of the big tuberous in the yield increased with 12% and the water use efficiency increased in comparison with unirrigated variant with 35%. The increase of the water consumption, the yield gains very significant statistically obtained every year, the increase of the big tuberous percentage in the yield and the improve of the water use efficiency are the arguments for irrigation opportunity in the Crisurilor Plain. The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 "Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesivelly by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality".*

Key words: *potato, water use efficiency, irrigation*

INTRODUCTION

Potato is one of the plants with the biggest requirement for continously water provisionment. Drought and water logging, both short and long period have a „strong effects" on level and quality of the yield (BÎLTEANU GH., BÎRNAURE V., 1979). Irrigation is the main possibility for drought control in the potato crop from Crisurilor Plain, too (GRUMEZA N. and all 1987, DOMUȚA C., 1995, 2005) and the paper presents the influence of the irrigation on water use efficiency based on the researches carried out during 1976-2007 in Oradea in a long term trial. Water use efficiency is presented both the quantity of yield obtained using 1 m^3 water and the water quantity used for 1 kilo of yield (DOMUȚA C., 2003).

MATERIAL AND METHODS

The researches were carried out on the preluvosoil from Oradea. This soil has a good structure degree (47.5%). On soybean watering depth (0-75 cm), the wilting point value is of

10.1% (1158 m^3/ha), and the field capacity is of 24.2% (2782 m^3/ha). The clay content determined the easily available water content of 2/3 from a difference between field capacity and wilting point, the value of this parameter is 19.5% (2240 m^3/ha). The chemical properties of the preluvosoil on the Ap horizon are :1.8 % humus; 6.5 pH; 131.2 ppm phosphorous (in the start of the experiment the phosphorous content was of 32.5 ppm), 210 potassium.

Irrigation water source is a drilling and the water quality is a very good one (CSR=-1.7; SAR=0.52). The irrigation method used was that of spraying water, and the irrigation equipment allowed very precise measurements of the water quantity used.

The soil moisture was determined every 10 to 10 days. Soil water reserve was maintained between easily available water content and field capacity on 0 – 75 cm, using the irrigation every time it was needed.

Water consumption was determined by soil water balance method (GRUMEZA ET all 1989), the depth for balance used was 0 – 150cm.

RESULTS AND DISCUSSIONS

Optimum irrigation water regime

Maintaining the soil water reserve on 0-75 cm depth determined to use the irrigation every year. The irrigation rate used was of 3200 m^3/ha in 2007, of 2800 m^3/ha in 2008 and of 3500 m^3/ha in 2009. The number of rates used was of 8 in 2007, of 7 in 2008 and of 9 in 2009. (table 1)

Table 1

Optimum irrigation water regime in potato crop, Oradea 2007-2009

Year	April		May		June		July		August		Total	
	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm
2007	1	400	2	900	2	800	2	800	1	400	8	3200
2008	-	-	1	500	3	1100	2	700	1	500	7	2800
2009	2	800	3	1200	2	700	2	800	-	-	9	3500
Average	1	400	2	870	2	870	2	770	1	300	8	3170

n = number of rate
Σm = irrigatin rate

Influence of the irrigation on potato water consumption

Better provisionment with water as consequence of the irrigation used determined to increase of the daily water consumation of the potato crop. Both in irrigated and unirrigated variant the maximum value of the daily water consumption was registered in June; the biggest difference between daily water consumption of irrigated and unirrigated potato was registered in July, 18,1 m^3/ha/zi. (table 2).

Irrigation influence on yield

In the all three year, the irrigation determined the yield gains very significant statistically. In the year 2007, the yeald gain obtained in the irrigated variant in comparison with unirrigated variant was of 111%. A bigger relative yield gain was obtained in 2008, 119%. The biggest absolute and relative yield gain (21340 kg/ha; 210%) was obtained in 2009. In average on the studied period the zield from irrigated variant (34200 kg/ha) was with 137.2% (19780 kg/ha) bigger than yield obtained in the unirrigated variant (table 4)

In the conditions from Oradea the study of the 9 crops (potato, wheat, maize, bean, soybean, sunflower, sugarbeet, alfalfa 1st year, alfalfa 2nd year, maize for silo) emphasized that the potato was the most sensitive crop for decrease of irrigation rate was 50%; the number of the irrigation rate was the same like in the with without irrigation rate diminuation. As consequence the potato yield represented 54,0% from the yield obtained in the variant without irrigation rate diminuation. (DOMUȚA C., 2009)

Table 2

The irrigation influence on daily water consumption in potato, Oradea 2007-2009

Year	Variant	April		May		June		July		August	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
2007	Unirrigated	16.1	100	23.3	100	31.0	100	33.1	100	25.7	100
	Irrigated	26.5	165	38.7	166	58.3	188	41.8	126	32.8	127
2008	Unirrigated	27.2	100	28.8	100	40.7	100	28.9	100	21.9	100
	Irrigated	28.4	104	36.9	128	56.2	138	50.2	174	25.8	118
2009	Unirrigated	24.4	100	27.6	100	36.9	100	30.2	100	25.0	100
	Irrigated	26.9	110	38.8	141	60.2	163	52.4	174	27.6	110
Average	Unirrigated	22.6	100	26.6	100	36.2	100	30.7	100	24.2	100
	Irrigated	27.3	121	38.1	143	58.2	161	48.1	157	28.7	119

Table 3

The irrigation influence on total water consumption (Σ(e+t) and the covering sources in potato crop, Oradea 2007-2009

Year	Variant	Σ(e+t)		Covering sources					
		m^3/ha	%	Soil water reserve		Rainfall		Irrigation	
				m^3/ha	%	m^3/ha	%	m^3/ha	%
2007	Unirrigated	3868	100	1037	27	2831	73	-	-
	Irrigated	5915	153	84	1	2831	48	3000	51
2008	Unirrigated	4237	100	1193	28	3044	72	-	-
	Irrigated	5975	141	131	2	3044	51	2800	47
2009	Unirrigated	3670	100	1177	32	2493	68	-	-
	Irrigated	6353	173	360	6	2493	39	3500	55
Average	Unirrigated	3927	100	1136	29	2789	71	-	-
	Irrigated	6081	155	192	3	2789	46	3100	51

Table 4

The irrigation influence on yield in potato crop, Oradea 2007-2009

Variant	Yield		Difference		Statistically significant
	Kg/ha	%	Kg/ha	%	
2007					
Unirrigated	17600	100	-	-	Control
Irrigated	37100	211	19500	111	***
$LSD_{5\%}$ 270	$LSD_{1\%}$ 490		$LSD_{0.1\%}$ 830		
2008					
Unirrigated	15500	100	-	-	Control
Irrigated	34000	219	18500	119	***
$LSD_{5\%}$ 430	$LSD_{1\%}$ 690		$LSD_{0.1\%}$ 1070		
2009					
Unirrigated	10160	100	-	-	Control
Irrigated	31500	310	21340	210	***
$LSD_{5\%}$ 510	$LSD_{1\%}$ 720		$LSD_{0.1\%}$ 1150		
Average 2007-2009					
Unirrigated	14420	100	-	-	Control
Irrigated	34200	237.2	19780	137.2	***
$LSD_{5\%}$ 403	$LSD_{1\%}$ 633		$LSD_{0.1\%}$ 1017		

The participation of the big tuberous in the yield from irigated variant increased in comparison with unirrigated variant with 13.1% in 2007, with 16.3% in 2008 and with 21.2% in 2009. The differences were very significant statistically every year (table 5)

Table 5

The irrigation influence on the big tuberous participation in the potato yield, Oradea 2007-2009

Variant	Big tuberous		Difference		Statistically significant
	%	%	%	%	
2007					
Unirrigated	73.2	100	-	-	Control
Irrigated	82.8	113,1	9.6	13.1	***
$LSD_{5\%}$ 2.3	$LSD_{1\%}$ 4.6		$LSD_{0.1\%}$ 7.9		
2008					
Unirrigated	72.6	100	-	-	Control
Irrigated	84.5	116.3	11.9	16.3	***
$LSD_{5\%}$ 3.1	$LSD_{1\%}$ 5.2		$LSD_{0.1\%}$ 9.4		
2009					
Unirrigated	70.1	100	-	-	Control
Irrigated	85.0	121.2	14.9	21.2	***
$LSD_{5\%}$ 2.9	$LSD_{1\%}$ 5.1		$LSD_{0.1\%}$ 8.2		
Average 2007-2009					
Unirrigated	72.0	100	-	-	Control
Irrigated	84.1	116.8	12.1	16.8	***
$LSD_{5\%}$ 2.8	$LSD_{1\%}$ 5.0		$LSD_{0.1\%}$ 8.5		

Irrigation influence on water use efficiency

The quantity of the yield obtained for 1 m^3 water used increased in the irrigated variant in comparison with unirrigated variant with 37.8% in 2007 with 55.5% in 2008 and with 36.9% in 2009. In average on the studied period the water use efficiency increased in comparison with unirrigated variant with 42.7% (5.78 kg/m^3 vs.4.05 kg/m^3) (table 6)

Table 6

The irrigation influence on water use efficiency (WUE) in potato, Oradea 2007-2009

Variant	WUE		Difference		Statistically significant
	Kg/ m^3	%	Kg/ m^3	%	
2007					
Unirrigated	4.55	100	-	-	Control
Irrigated	6.27	137.8	1.72	37.8	***
2008					
Unirrigated	3.66		100	-	Control
Irrigated	5.69		155		***
2009					
Unirrigated	3.93	100	-	-	Control
Irrigated	5.38	136.9	1.45	36.9	***
Average 2007-2009					
Unirrigated	4.05	100	-	-	Control
Irrigated	5.78	142.7	1.73	42.7	***

The irrigation water use efficiency was of 6.5 kg yield gain/m^3 in 2007, of 6.6 kg yield gain/m^3 in 2008 and of 5.65 kg yield gain/m^3 in 2009. (table 7).

Table 7

The irrigation water use efficiency (IWUE) in potato crop, Oradea 2007-2009

Year	IWUE	
	Kg yield gain/m^3	%
2007	6.5	100
2008	6.6	102
2009	5.65	86

CONCLUSIONS

The results carried out in the research field for soil water balance from Agricultural and Development Research Station Oradea during 2007-2009 and the conclusions are the following:

- Maintaining the soil water reserve on watering depth between easily available water content determined to use the irrigation every year. The irrigation rate used are of 3200 m^3/ha in 2007, of 2800 m^3/ha in 2008 and of 3500 m^3/ha in 2009 and the number of rates was of 8,7, and 9.
- Irrigation determined the increase of the daily water consumption and total consumption increased with 53% in 2007, with 41.0% in 2008 and with 73% in 2009. The irrigation was the main covering source of the optimum water consumption in the years 2007 and 2009 and in the average on the studied period.
- There were the yield gain very significant statistically every year, 111% in 2007, 119% in 2008, and 210% in 2009. The participation of the big tuberous in the total yield increased very significant, too; the differences in comparison with unirrigated variant were of 9.6% in 2007, of 14.9% in 2008 and of 12.1% in 2009.
- The irrigation determined to increase the water use efficiency every year studied; the relative differences in comparison with unirrigated variant were of 37.8% in 2007, of 55.5% in 2008, of 36.9% in 2009. The positive influence on potato water consumption yield and finally on water use efficiency are the strong arguments for irrigation using in the Crisurilor Plain.

Acknowledgments

The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 ”Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesivelly by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality”.

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