THE IRRIGATION INFLUENCE ON POTATO CROP IN THE CRISURILOR PLAIN CONDITIONS

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Abstract

The researches were carried aut during 1976-2012 in the field for soil water balance study placed on the preluvosoil from Agricultural Research and Development Station Oradea. The irrigation was needed. The irrigation was needed every year becouse on the watering depth (0-75 cm) decreased bellow easily available water content every year and pedological drought was presented. In 26% from year studied the strong pedological drought was presented in unirrigated potato.The use of the irrigation improved the potato microclimate and the value of the report water/temperature+light (Domuţa climate index) increased with 58% in the period April-August; the biggest difference in comparison with unirrigated variant was registered in July. Daily water consumption increased in the irrigated variant and the biggest relative difference was registered in August (57%). As consequence the value of the total water consumption increased with 38.3% in comparison with unirrigated variant, variation interval: 13-129.1%. Along the year, the irrigation participation in the covering sources of the total water consumption was between 7.1% and 61.1%.

Irrigation determined an average yield gain of 61.8%, the improve of the yield stability and a bigger percentage of the big tuberous in the yield, 84.4% vs 75.6%.

The average value of the water use efficiency was bigger in the irrigated variant (7.06 kg/m^3 vs 6.03 kg/m^3). Irrigation water use efficiency was of 7.84 kg yield gain/m^3 irrigation water.

Key words: potato, irrigation, pedological drought, water consumption, yield gain, water use efficiency

INTRODUCTION

Domuţa C. (1995, 2005) considered the pedological drought the decrease of the soil water reserve on the watering depth below easily available water content. The strong pedological drought is considered the decrease of the soil water reserve on the watering depth below wilting point; the wilting point is considered a point from an interval and no a fixe point.

Pedological drought has a strong influence on potato crop because the potato is one of the plants with the biggest requirement for continuously water provisionment. (Domuţa C., 2005, Borza I., Stanciu A., 2010, Muntean L.S. et al., 2011). Irrigation is the main possibility for drought control in the potato crop from Crişurilor Plain, too (Grumeza N. et al 1989, Domuţa C., 1995, 2005, Sandor M., 2008). The paper presents the influence of the pedological drought on water consumption, yield and water use efficiency in potato crops based on the researches obtained in the research field for soil water balance study from Agricultural Research and Development Station Oradea.

The researches carried out in the Crisurilor Plain (Domuţa C, 1995, 2003, 2009 a,b, 2011,2012) emphasized the presence of the pedological drought and strong pedological drought in unirrigated potato and their negative influence on plants water consumption, yield level, yield stability and water use efficiency.

This paper quantifies the period with pedological drought and strong pedological drought during 1976-2012 and their influence on water consumption, yield level, and land water use efficiency.

MATERIAL AND METHODS

The soil from research field is preluvosoil. Research field was placed at Agricultural Research and Development Station Oradea in 1976 by Stepănescu E. in the network research of the research Institute for Irrigation and Drainage Băneasa Giurgiu. (Domuţa C., 2009). According to Domuţa C. et al, 2012, the main properties of the preluvosoil from the research field for study of the soil water balance are: humus content is of 2.1% in the Ap (0-20cm depth) horizon, pH of 6.3, phosphorus of 31.5 ppm and potassium of 190.2 ppm; the value of the bulk density is of 1.44 g/cm^3 and the total porosity is about 47%. Field capacity (24.3%) and wilting point (9.1%) have the median values.

The irrigation water parameters are: pH = 7.2; Na^+ = 12.9%; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52. The chemical parameters of the irrigation water indicate a very good quality of the water used.

The potato watering depth is 0-75 cm. Once every ten days the soil moisture was determined. Irrigation was carried out when the soil water reserve on 0 – 75 cm depth decreased to easily available water content. Water consumption was determined using the soil water balance method. The water use efficiency (WUE) was calculated as a ratio between yield and water consumption and the irrigation water use efficiency (IWUE) was calculated as the ratio between the yield gain achieved through irrigation and the irrigation rate. (Domuta C., 1995).

The research results were processed by variance analysis and using the regression functions (Domuţa C., 2009).

RESULTS AND DISCUSSIONS

Pedological drought in unirrigated potato

In the unirrigated conditions, the soil water reserve on 0-75 cm depth decreased bellow easily available water content every year. The average of the number of days with pedological drought was of 79 days. The biggest number of days with pedological drought was registered in July, 24 days. A

big number with pedological drought was registered in August (21 days) and June (18 days) (table 1)

Table 1

Pedological drought (PD) in unirrigated potato, Oradea 1976-2012

Specification	April	May	June	July	August	April-August
Number of days with PD	6	1	18	24	21	79
Frequency the years with PD	45	51	83	93	90	100

Strong pedological drought in unirrigated potato

Strong pedological drought was determined in 26% of the years studied, the soil water reserve on 0-75 cm decreased below wilting point in July and August. (table 2)

Table 2

Strong pedological drought (SPD) in unirrigated potato, Oradea 2009-2012

Specification	April	May	June	July	August	April-August
Number of days with SPD	-	-	-	3	3	6
Frequency the years with SPD	-	-	3	21	26	50

Irrigation influence on microclimate

The quantification of the ratio between water (rainfall, irrigation, air humidity) and temperature+light calculated using Domuta climate index (ICD) show bigger values in irrigated conditions. The relative differences in comparison with the unirrigated variant were of 6% in April (variation interval 0-124), of 57% in May (variation interval 0-296%), of 56% in June (variation interval 0-332%) of 125% in July (variation interval 0-831% and of 59% in August (variation interval 0-279%); on average, in the period April-August, the difference was of 58%. The potato microclimate was characterized as moderate drought in unirrigated conditions (table 3)

Table 3

Irrigation influence on water/temperature + light ratio (Domuța climate index, ICD) in potato, Oradea 1976-2012

Variant	April		May		June		July		August		April-August	
	ICD	%	ICD	%	ICD	%	ICD	%	ICD	%	ICD	%
Unirrigated	8.9	100	8.1	100	10.5	100	7.5	100	5.8	100	8.2	100
	MD		MD		MW		MD		D		MW	
Irrigated	9.4	106	12.7	157	16.4	156	16.9	225	9.2	159	12.9	158
	MW		W I		W II		W II		MW		MW	
Variation interval of the differences	0-124		0-296		0-332		0-831		0-279		-	

MD = median drought; MW = median wet; D = drought WI = Wet I; W II= Wet II

In the months of the potato vegetation period, the microclimate was characterized like "drought" in August, "moderate drought" in April, May and July and "moderate wet" in June in unirrigated variant and "Wet II" in June and July, "Wet I" in May and "moderate wet" in April and August.

Using Domuţa climate index (ICD), a direct link, very significant statistically, was quantified between microclimate conditions of the unirrigated and irrigated potato: $y= 0{,}1237x^2+4.701x-3.3765$; $R^2= 0.62$***

The irrigation influence on potato water consumption

In comparison with unirrigated variant, in irrigated conditions, the daily water consumption increased by 6% in April, 14% in May, 49% in June, 53% in July and 57% in August (table 4).

Table 4

Irrigation influence on daily water consumption Σ(e+t) in potato, Oradea 1976-2012

Variant	April		May		June		July		August	
	m^3/ha/day	%	m^3/ha/day	%	m^3/ha/day	%	m^3/ha/day	%	m^3/ha/day	%
Unirrigated	18.0	100	27.0	100	33.3	100	33.7	100	21.9	100
Irrigated	19.2	106	30.9	114	49.9	149	51.4	153	34.6	157

As consequence, the total water consumption value in irrigated variant (5374 m^3/ha) increased in comparison with the potato water consumption registered in the unirrigated variant by 38.3% in the variation interval 13-129.1%. On average on the studied period, the irrigation covered 34.6% from optimum water consumption; along the time, the variation interval was of 7.1%-61.1%. The rainfall registered during the potato vegetation period was of 3006 m^3/ha and the participation of the rainfall in the water consumption was of 17-89% in irrigated variant and of 39-107% in unirrigated variant. Potato used a bigger quantity of water from soil water reserve in unirrigated variant than in irrigated variant, 877 m^3/ha vs. 506 m^3/ha. (table 5)

Table 5

Total water consumption in potato and the covering sources, Oradea 1976-2012

Variant	Total water consumption		Covering sources of the water consumption						
			Soil water reserve		Rainfall		Irrigation		
	m^3/ha	Variation interval %	m^3/ha	%	m^3/ha	%	m^3/ha	%	Variation interval %
Unirrigated	3884	100	877	23	3006	9-107	-	-	-
Irrigated	5374	113-229.1	506	9	3006	17-89	1861	34.6	7.1-61.1

A direct link, statistically assured, was quantified between water consumption and potato yield. For period 1987-1993 this correlation has the following form: $y= 1.6479x^2-5.3522x+14.647$; $R^2= 0.7369$***.

Irrigation influence on yield

The optimum irrigation determined an average yield of 37942 kg/ha, 61.8% bigger than the yield obtained in unirrigated variant (23441 kg/ha). Variation interval of the relative differences was of 6- 364%. In unirrigated conditions, the smallest yield obtained was of 11,500 kg/ha and the biggest yield was of 37,912 kg/ha; in irrigated variant the smallest yield was of 20,670 kg/ha and the biggest yield was of 66,050 kg/ha. The yield stability increased, the value of the standard deviation decreasing by 40.9%, 5840 kg/ha vs 9440 kg/ha. (table 6)

Table 6

The irrigation influence on level and stability of the yield in potato, Oradea 1976-2012

Variant	Yield average		Variation interval of the yield		Standard deviation	
	Kg/ha	%	Kg/ha	%	Kg/ha	%
Unirrigated	23441	100	11500-43700	100	9440	100
Irrigated	37942	161.8	20670-66050	106-464	5840	58.1

$LSD_{5\%}$= 350 $LSD_{1\%}$= 720 $LSD_{0.1\%}$= 1340

The participation of the big tuberous in the yield was of 84.4% in irrigated variant and of 75.6% in unirrigated variant. Along the time, the participation of the big tuberous in the yield was of 71.6-82.5% in unirrigated variant and of 80.1%-92.4% in irrigated variant (table 7).

Table 7

The irrigation influence on big tuberous participation in the potato yield, Oradea 1976-2012

Variant	Participation of the big tuberous		Variation interval of the big tuberous in the potato yield
	Value %	%	%
Unirrigated	75.6	100	71.6 – 82.5
Irrigated	84.4	111.6	80.1 – 92.4

Water use efficiency in potato

In comparison with the unirrigated variant, the yield obtained for 1 m^3 water used (6.62 kg/m^3) in the irrigated variant, a value of 7.02 kg/m^3 was obtained; the relative difference is of 17.4%. The variation interval of the water use efficiency was between 2.6-13.0 kg/m^3 in unirrigated variant and between 3.6-12.9 kg/m^3 in irrigated variant. Generally, the water use efficiency was bigger in irrigated variant but not all the years. (table 8)

Irrigation water use efficiency had an average value of 7.84 kg yield gain/1m^3 irrigation water used. The variation interval was between 1.57 and 17.52 kg yield gain/1m^3 irrigation water used.

Table 8

Water use efficiency (WUE) and irrigation water use efficiency (IWUE) in potato, Oradea 1976-2012

Variant	WUE				IWUE	
	Average		Variation interval			
	Kg/m^3	%	Kg/m^3	%	Average	Variation interval
Unirrigated	6.03	100	2.6-13.0	100	-	-
Irrigated	7.06	117	3.6-12.9	81-188	7.84	1.57-17.52

CONCLUSIONS

The results researches were carried out in the field for soil water balance study placed in 1976 on the preluvosoil from Agricultural Research and Development Station Oradea, reaching the following conclusions regarding the potato irrigation:

- The irrigation was needed every year because the watering depth (0-75 cm) decreased below easily available water content every year and pedological drought was present. In 26% of the studied year, the strong pedological drought was presented in unirrigated potato.
- The use of the irrigation improved the potato microclimate and the value of the report water/temperature + light (Domuţa climate index) increased by 58% in the period April-August; the biggest difference in comparison with unirrigated variant (225%) was registered in July.
- Daily water consumption increased in the irrigated variant and the biggest relative difference was registered in August (57%). As a consequence, the value of the total water consumption increased by 38.3% in comparison with the unirrigated variant, variation interval: 13-129.1%. Along the year, the irrigation participation in the covering sources of the total water consumption was between 7.1% and 61.1%.
- Irrigation determined an average yield gain of 61.8% (variation interval 6-364%), the improvement of yield stability (standard deviation decreased by 41.9%) and a bigger percentage of the big tuberous in the yield, 84.4% vs 75.6%.
- The average value of the water use efficiency was bigger in the irrigated variant (7.06 kg/m^3 vs. 6.03 kg/m^3), but in some rainy years the values of the water use efficiency were smaller in the irrigated variant. Irrigation water use efficiency was of 7.84 kg yield gain/m^3 irrigation water, variation interval 1.57-17.52 kg yield gain/m^3 irrigation rate.

The research results obtained during 1976-2012 sustain the need for potato irrigation in the Crişurilor Plain.

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