LONG TERM TRIAL FROM ORADEA – PREMISA FOR ESTABLISHING THE IRRIGATION OPPORTUNITY IN SUNFLOWER FROM CRIȘURILOR PLAIN

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Abstract

The paper is based on research conducted without interruption between 1976-2016.

The research within the long term experiments called "research plot soil water balance" carried out at the Research and Development Station made possible the development of 5 criteria for establishing the appropriateness of sunflower irrigation.

Pedological drought – water storage at the depth of 0-75cm dropped below easily available water content each year, in 13 of them water storage dropped below wilting point.

Microclimate – the value of the water/temperature + light ratio in the V-VIII period was higher by 48 in the case of irrigated crops than in that of the non-irrigated ones.

Water consumption – both daily and total consumptions increased.

Yield – irrigation led to statistically very significant yield gains and to increased yield stability.

Water use efficiency – it increased very little as a result of using irrigation.

Key words: microclimate, pedological drought, sunflower, water consumption, yield

INTRODUCTION

Long term experiments are true data mines. In England (Rothamsted), Denmark (Askow), Germany (Hale) long term experiments have been conducted for over 150 years. Experiments in Romania do not exceed 50 years. The experiment research plot soil water balance has been going on uninterruptedly since 1976, and has provided extremely important results for the appropriateness of sunflower irrigation.

Sunflower is one of the most important oil plants grown on the globe (13% of the world oil production) and the most important oil plant in Romania. The oil extracted from the sunflower achenes is semi-drying and it can be described as having a pleasant colour, taste and smell, high content of vitamins (A, D, E, K) and aromatic substances; in addition, sunflower oil can be stored for a long time without changing its properties.

Sunflower oil is one of the most balanced oils in respect of fatty acid composition. It can be used both "cold" and for cooking, having a rich content of linoleic acid – a fatty acid essential for the human diet.

Oil is extracted easily by pressing, the usual extraction rate being around 45%.

Apart from its direct use in human diet, sunflower oil is also used in the canning industry and in that of margarine. The oil can also be used to obtain oleic acid, which is needed in the wool and soap industries, as an adjuvant in the production of pesticides, as boiled oil for paints. The phosphatides obtained during the extraction of oil are used on a large scale for the production of lecithin, which is much appreciated in the food industry: in the making of bread, of chocolate, of cakes, of lunch meats.

Sunflower withstands drought better than other cultivated plants due to its active and deep root system, but yield drops, depending on the duration and severity of droughts. Robelin M. (apud Bâlteanu, 1979) shows that the worst effect of drought on yield occurs beginning with 20 days before blooming and going on 15-20 days after blooming, the results being (in successive stages) the wilting of flowers, reduced pollination, abortion of young seeds, which remain empty. Săndoiu D. et al (1961), apud Bâlteanu (1979), consider that another critical moment in respect of water occurs 4-5 weeks after emergence, when floral primordia are formed (Domuța C., 2005).

MATERIAL AND METHOD

The long term experiment is called ”soil water balance” and it belonged to the research programme ”The operation of irrigation and drainage facilities” co-ordinated by Grumeza N., within the Research Institute for Engineering Technology, Irrigation and Drainage, Băneasa Giurgiu. The research plots were located in all those areas of Romania which are of concern in respect of irrigation. The soil water balance research plot at the Agricultural Research and Development Station Oradea was set up on a hapludalf with a multiannual average rainfall of 616.3 mm, a multiannual average temperature of 10.6ºC and air humidity of 78.8%. Over the years, the research was co-ordinated by Stepănescu E. (1976-1980), Mihaela Buta (1981-1982), Maria Colibaș (1983-1985), Maria Colibaș and Maria Șandor (1986), and from 1987 by Domuța C.

The data obtained from 1976 to 1987 were recorded observing the rules of filling in research sheets, and this paper presents these results from the perspective of criteria used to establish the appropriateness of sunflower irrigation. These criteria are:

- pedological drought and strong pedological drought; the indicators were calculated using the methodology proposed by Domuța C., 1995; Domuța C., 2005; Domuța C., 2009.

- Domuța climate index, for the quantification of the influence of irrigation on the water + air humidity/temperature + light ratio (Domuța C., 2005, 2009).

- water consumption of sunflower, calculated using the soil water balance method (Botzan, 1966; Grumeza et al, 1989).

- yield gain obtained as a result of irrigation; the data obtained were processed using variance analysis .

- yield stability, by calculating the standard deviation (Domuța C., 2006).

- water use efficiency (Domuța C., 1995, 2005, 2009).

The technology used for the sunflower crop was an optimum one, and in the case of the irrigated version, water storage was maintained between easily available water contentand field capacity, samples being taken every 10 days.

RESULTS AND DISCUSSION

Criterion 1. Pedological drought in the case of the non-irrigated sunflower crop

In the case of non-irrigation, water storage at the crop watering depth drops below easily available water content. The results obtained in Oradea between 1976 and 2008 show that pedological drought occurred in each year. The month with the highest number of days (27.3) and the highest frequency of water stress (100%) was August. A high number of days with pedological drought (27) and a frequency very close to that of August were recorded in July (Tab. 1).

Table 1

Pedological drought in the case of the non-irrigated sunflower crop
Oradea, 1976-2008 (Domuța C., 2009)

Description	IV	V	VI	VII	VIII	IV-VIII
Number of days with Ws<AD at 0-75cm	2.1	11	18.8	27	27.3	86
Frequency of water stress %	4	44	92	96	100	100

Ws = water storage; AD = allowed depletion

In 13 years (38%) water storage at a depth of 0-75cm also dropped below wilting point, the highest number of days with severe pedological

drought (5.4) and the highest frequency of the phenomenon (40%) being recorded in August.

Between pedological drought and yield a statistically supported negative correlation was quantified, while between pedological drought values and yield gains obtained by irrigation a positive correlation was quantified. A positive correlation was also quantified between the number of days with water storage below easily available water contentat the watering depth and water use efficiency (WUE). All these correlations support the appropriateness of sunflower irrigation even in an area with moderate sub-humid climate, as that of the Crişurilor Plain (Domuţa C. et al, 2002).

Table 2

Pedological drought in the case of the non-irrigated sunflower crop
Oradea, 1976-2008 (Domuta C., 2009)

Description	IV	V	VI	VII	VIII	IV-VIII
Number of days with Ws<WP at 0-75cm	0	0	1.3	5.4	8.7	15.4
Frequency of severe water stress %	0	0	16	28	38	40

Ws = water storage; WP = wilting point

Criterion 2. Influence of irrigation on the sunflower microclimate

Irrigation led to a significant improvement in the microclimate conditions. Thus, in the moderate subhumid conditions of the Crişurilor Plain, the water/temperature + light ratio in the irrigated months increased by up to 89% (in July); as a result, the V-VIII period became "humid I" in irrigation conditions, the difference between the DCI of the two versions being 48% (Tab. 3).

Table 3

Changes in the water/temperature + light ratio (Domuţa climate index, DCI) under the influence of irrigation, Oradea. 1976-2008 (Domuţa C., 2009)

Version	V		VI		VII		VIII		V-VIII	
	DCI	%	DCI	%	DCI	%	DCI	%	DCI	%
Non-irrigated	9.8	100	11.9	100	9.7	100	7.3	100	9.7	100
	Moderate humid		Moderate humid		Moderate humid		Moderate droughty		Moderate droughty	
Irrigated	10.9	111	17.1	144	18.3	189	11.4	156	14.4	148
	Moderate humid		Humid II		Humid III		Moderate humid		Humid I	

In the case of the sunflower crop too a clear positive correlation could be noticed between the values of the climate indicators and yield (Domuţa C., 1997, 2004). Between the Domuţa climate index (DCI) and yield this relation takes the form of $y=6.0865x^{0,6318}$; $R^2=0.68^{xxx}$.

Criterion 3. Daily and total water consumption of sunflower

The daily water consumption increases when irrigation is used. In the conditions existing in Oradea, over the 1976-2008 period the average differences between the daily water consumption of the irrigated sunflower and that of the non-irrigated one were up to 86.6%. When irrigated, the highest water consumption was recorded in July, 60.0m^3/ha/day against 39.9 m^3/ha/day in June for the non-irrigated version (Tab. 4).

Table 4

The influence of irrigation on the average daily water consumption of the sunflower crop (m^3/ha/day), Oradea, 1976-2008 (Domuța C., 2009)

Version	IV	V	VI	VII	VIII	IX
Non-irrigated	9	27.3	39.9	38.2	20.3	16.1
Irrigated	20.8	30.7	53.7	60.0	37.9	19.9
Difference %	4.5	12.4	34.5	50.3	86.6	23.6

In Oradea, in the 1976-2008 period, the total average water consumption of the irrigated sunflower was higher by 48.1% than that recorded for the non-irrigated version, the differences recorded over the years being between 15 and 122%. In order to ensure the optimum water consumption in each year, the share of irrigated water in the total water consumption was between 6 and 63% (Tab. 5).

Table 5

Total water consumption of the non-irrigated and irrigated sunflower and water sources, Oradea, 1976-2008 (Domuța C., 2009)

Version	Water sources							
				Pv		Σm		
	m^3/ha	Variation range %	Soil water storage (Si-Sf) m^3/ha	m^3/ha	Variation range %	m^3/ha	Variation range	
							%	%
1. Non-irrigated	3,994	100	1,173	2,819	47-108	-	-	-
2. Irrigated	5,917	105-222	954	2,819	24-72	2,153	36.3	6-63

Si-Sf = initial water storage-final water storage; Pv = precipitations in the vegetation period; Σm = irrigation rate

In the case of irrigated sunflower, the water storage in soil after harvesting the crop is higher, which ensures better conditions for a good quality ploughing than those of the non-irrigated version.

The correlation between water consumption and sunflower yield is a positive one and it has various forms and mathematical expressions, depending on the climate zone (Grumeza N. et al, 1989). This shows the importance of irrigation in increasing the yield of sunflower, given that irrigation is the main way of improving water consumption. In the

conditions existing in Oradea between 1987 and 1993, this correlation was a power relation.

Criterion 4. Yield

As it has been shown above, the optimum use of irrigation resulted in higher water quantities in soil for the plants and in more favourable microclimate conditions. Therefore, the water consumption of the crop improved significantly, which led to significant yield gains.

Research conducted between 1976 and 2008 in Oradea showed that by maintaining water storage between easily available water content field capacity at a depth of 0-75cm using irrigation a yield gain of 48.9% was reached, with a variation range of the differences recorded over the 33 years from 6 to 110% (Tab. 6).

Table 6

Influence of irrigation on the level and stability of sunflower yield, Oradea, 1976-2008 (Domuța C., 2009)

Version	Yield				Standard deviation of yields	
	Average		Variation range			
	kg/ha	%	kg/ha	%	kg/ha	%
Non-irrigated	2,330	100	1,350-3,140	100	580	100
Irrigated	3,470	148.9	1,757-4,580	106-210	530	91.4
DL 5% 210; DL 1% 380; DL 0.1% 720						

Irrigation leads to a higher yield stability, the value of standard deviation of yields obtained in the case of irrigated crops in Oradea between 1976 and 2008 being lower than in the case of the non-irrigated crops by 8.6%.

Criterion 5. Water use efficiency

In the conditions existing in Oradea, for the 1976-2008 period the average value of water use efficiency in the case of the irrigated version was 0.59 kg/m^3, while in that of the non-irrigated one it was 0.58 kg/m^3, in 11 years the values recorded being higher in non-irrigated conditions, and in 22 years higher in irrigated ones.

Table 7

Influence of irrigation on water use efficiency (WUE) and on irrigation water use efficiency (IWUE) of the sunflower crop, Oradea, 1976-2008 (Domuța C., 2009)

Version	WUE			IWUE kg gain/m^3
	Average	Variation range		
	kg/m^3	kg/m^3	%	
Non-irrigated	0.58	0.26-0.81	100	-
Irrigated	0.59	0.31-0.89	54.6-139.1	0.53

The differences expressed in percentages between the two versions over the years ranged from –45.4% (in 1977) to 39% in 2001 (Tab. 7).

CONCLUSIONS

Research conducted within the long term experiments ”research plot soil water balance” at the Research and Development Station made possible the development of 5 criteria for establishing the appropriateness of sunflower irrigation.

1. Pedological drought – water storage at the depth of 0-75cm dropped below easily available water content each year, in 13 of them water storage dropped below wilting point.

2. Microclimate – the value of the water/temperature + light ratio in the V-VIII period was higher by 48 in the case of irrigated crop than in that of the non-irrigated ones.

3. Water consumption – both daily and total consumptions increased.

4. Yield – irrigation led to statistically very significant yield gains and to increased yield stability.

5. Water use efficiency – it increased very little as a result of using irrigation.

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