RESEARCH REGARDING THE PEDOLOGICAL DROUGHT ON WATER CONSUMPTION, YIELD AND WATER USE EFFICIENCY IN SUNFLOWER FROM CRIȘURILOR PLAIN

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Abstract

Sunflower is one the crops which are less sensitive to drought, and the research conducted from 2014 to 2016 at the Agricultural Research and Development Station Oradea aimed to establish the occurrence of pedological drought during the vegetation period of this crop, as well as the water consumption and the sources needed to provide for it in order to show the appropriateness of irrigating sunflower in the Crișurilor Plain.

Pedological drought occurred in all three years included in the research, and in order to maintain water storage between easily available water contentand field capacity at a depth of 0-75cm the following irrigation rates were used: 2,900 m^3/ha in 2014, 1,370 m^3/ha in 2015 and 900 m^3/ha in 2016 .

As a result of irrigation, the total water consumption increased, the contribution of irrigation water to the optimum water consumption being 46% in 2014, 26% in 2015 and 26% în 2016.

Irrigiation led to statistically significant yield gains against the non-irrigated conditions, with relative differences of 87% in 2014, of 38.1% in 2015 and of 40% in 2016.

The results show the appropriateness of irrigating sunflower in the conditions of the Crişurilor Plain too.

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

INTRODUCTION

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. (Bâlteanu Gh., 1979) shows that the worst effect of drought on yield occurs when it sets in 20 days before blooming and goes 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 Gh. (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

In the years of research the climate conditions were different. In the vegetation period of sunflower 245.2mm precipitation were recorded in 2014, 281.0mm in 2015 and 353.3mm in 2016.

The research was conducted from 2014 to 2016, on the preluvosoil from Agricultural Research and Development Station Oradea. The soil is characterised by a very high hydro stability of soil aggregates larger than 0.25mm, 47.5% at the layer of 0 -20cm. The total soil porosity is normal at the depths of 0-20cm, 20-40cm, 40-60cm and low at those of 60-80cm, 80-100cm and 100-150 cm. The total porosity of the soil profile decreases from the surface to depth.

Hydraulic conductivity is high at the depth of 0-20cm, average at the depth of 20-40cm and 40-60cm, low and very low for the following depths studied. The apparent density value – 1.41g/cm^3 – shows a weakly compacted soil at the depth of 0-20 cm; at the other depths studied, the apparent weight shows soil compactions which are moderate and strong. At the watering depth of 0-75cm and at that of 0-150cm the soil is strongly compacted.

Field capacity has a moderate value over the entire soil profile, and the wilting point also has a moderate value up to the depth of 80cm and high below that. Available water content (AWC), or available water capacity, has a high value at the depth of 0-80cm and a moderate one at the depth of 80 - 150cm. At the watering depth used in the research plot the available water content has a high value. The water supply regime of the research plot for soil water balance in Oradea was studied in 2 version: non-irrigated and irrigated, in the latter one with maintaining water storage between easily available water content and field capacity at the depth of 0-75cm.

Soil moisture could be maintained between allowed depletion and field capacity as a result of establishing the gravimetric soil moisture content every 15 days.

Soil moisture was calculated using the well-known formula (Botzan M., 1967; Grumeza N. et al, 1989).

Easily available water content(AW) was calculated using the formula suggested by Canarache (1980), which takes into account soil texture and the degree of compaction:

$$Wea = WP + f (FC + WP)$$

where: Wea = easily available water content (% g/g);

f = fraction of the available water content for which the following values are used:

- 2/3 for sandy soils, strongly compacted sandy loam soils, clay loam soils with moderate and strong compaction, and loam soils

The total water consumption was calculated using the equation of soil water balance in closed system (without the contribution of the water table) (Grumeza, 1975, Grumeza et al, 1986, Apetroaiei, 1997, Ionescu Şişeşti, Popescu, 1992)

Water use efficiency (WUE) was calculated using the formula:

$$WUE = \frac{Yield}{Total\ water\ consumption}$$

The indicator used shows the amount of sunflower corresponding to $1m^3$ of water used (Nagy Z., 2005)

Harvesting of the experiments and calculation of results were done observing the instructions provided by the experimental techniques. (Săulescu N.A., Săulescu I. D., 1967; Domuța C., 2006).

Interpretation of results was performed using variance analysis.

RESULTS AND DISCUSSIONS

Pedological drought in unirrigated sunflower

A crop is considered to have optimum water supply when water storage at the watering depth is maintained between easily available water content and field capacity. When water storage drops below easily available water content we speak of pedological drought.

In the case of sunflower, the watering depth is 0-75cm. By establishing soil moisture every 15 days, it was possible to identify the periods when water storage dropped below easily available water content, the situation in the three years of the research being different from one year to another, depending on the precipitation regimes.

In 2014, pedological drought started in May, when there were 3 days in which water storage dropped below easily available water content. In June the number of days with pedological drought was 16, while in July and August this number rose to 20 days. The result was a total of 61 days with pedological drought.

Table 1

Number of days with pedological drought in the case of the non-irrigated sunflower crop Oradea, 2014 - 2016

Year	Number of days with pedological drought						Total
	IV	V	VI	VII	VIII	IX	
2014	-	3	16	20	22	-	61
2015	-	5	15	16	15	-	51
2016	-	6	-	-	24		30

In 2015, pedological drought started to be present in July, when water storage dropped below easily available water content on 10 days. The highest number of days with pedological drought was recorded in August, 20 days altogether. The total number of days with pedological drought in this year was 46.

In 2016, the number of days with pedological drought was 30, 6 in May and 24 in August.

The irrigation regime required to maintain water storage between easily available water content and field capacity

The highest irrigation rate, 2,500m^3/ha, was recorded in 2014. In 2015 the irrigation rate was 1,370m^3/ha, used entirely in June, and in 2016 the rate was 900m^3/ha (Tab. 2).

Table 2

The irrigation regime used to maintain water storage between easily available water contentand field capacity at the depth of 0-75cm with the sunflower crop in Oradea, 2014-2016

Year	IV		V		VI		VII		VIII		IX		Total	
	∑ m	n	∑ m	n	∑ m	n	∑ m	n	∑ m	n	∑ m	n	∑ m	n
2014	-	-	-	-	900	2	800	2	800	2	-	-	2,500	6
2015	-	-	-	-	1,370	3	-	-	-	-	-	-	1,370	3
2016					-	-	-	-	900	1	-	-	900	1

∑ m = irrigation rate, m^3/ha;
n = number of waterings

Influence of irrigation on the sunflower crop water consumption

As a result of irrigation, the daily water consumption of sunflower increased, the total water consumption increased by 53% in 2014 and by 21% in 2015. The share of irrigation water in the total water consumption was 46% in 2014 and 26% in 2015 (Tab. 3).

Table 3

Influence of irrigation on the total water consumption - ∑ (e + t) of the sunflower crop, Oradea, 2014 -2016

Year	Version	∑ (e + t)		Water sources					
				$S_i - S_f$		P_v		∑ m	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
2014	Non-irrigated	3,531	100	732	21	2,729	79	-	-
	Irrigated	5,410	153	111	2	2,729	52	2,500	46
2015	Non-irrigated	4,245	100	1,793	26	2,452	58	-	-
	Irrigated	5,142	121	1,320	29	2,452	48	1,370	26
2016	Non-irrigated	4,560	100	1,030	22	3,530	78	-	-
	Irrigated	5,480	120	1,050	19	3,530	64	900	17

∑ (e + t) = total water consumption; S_i = initial water storage (at planting); S_f = final storage (at harvesting); P_v = precipitations in the vegetation period; ∑m = irrigation rate

In the case of the irrigated crop, in 2014, in 2015 and in 2016 the highest share in the total water consumption was given by the precipitations recorded between crop sowing and harvesting (52%, 48% și 64%).

Influence of irrigation on the sunflower yield

The highest yield gain obtained as a result of irrigation was recorded in 2014, 1,760 kg/ha (87%), which is statistically very significant (Tab. 4).

The sunflower yields in 2015 were higher than those of 2014, the difference between that of the irrigated crop and the non-irrigated one (1,150 kg/ha) being statistically very significant (Tab. 5).

Table 4

Influence of irrigation on the sunflower yield, Oradea, 2014

Version	Yield		Difference		Statistical significance
	Kg/ha	%	Kg/ha	%	
Non-irrigated	2,020	-	-	-	**Control**
Irrigated	3,780	187	1,760	87	***

$DL_{5\%}$ = 230; $DL_{1\%}$ = 490; $DL_{0.1\%}$ = 720

Table 5

Influence of irrigation on the sunflower yield, Oradea, 2015

Version	Yield		Difference		Statistical significance
	Kg/ha	%	Kg/ha	%	
Non-irrigated	3,020	100	-	-	**Control**
Irrigated	4,170	138.1	1,150	38.1	***

$DL_{5\%}$ = 180; $DL_{1\%}$ = 310; $DL_{0.1\%}$ = 770

Table 6

Influence of irrigation on the sunflower yield, Oradea, 2016

Version	Yield		Difference		Statistical significance
	Kg/ha	%	Kg/ha	%	
Non-irrigated	3,300	100	-	-	**Control**
Irrigated	4,630	140	1,330	40	***

$DL_{5\%}$ = 210; $DL_{1\%}$ = 380; $DL_{0.1\%}$ = 810

CONCLUSIONS

Sunflower is one of the crops which withstand drought better, and research conducted from 2014 to 2016 at the Agricultural Research and Development Station Oradea aimed to establish whether or not drought occurred during the vegetation period, water consumption and the sources needed to provide for it in order to show the appropriateness of irrigating sunflower in the Crișurilor Plain.

Pedological drought occurred in all three years included in the research, and in order to maintain water storage between easily available water contentand field capacity at a depth of 0-75cm the following irrigation rates were used: 2,900 m^3/ha in 2014, 1,370 m^3/ha in 2015 and 900 m^3/ha in 2016. As a result of irrigation, the total water consumption increased, the contribution of irrigation water to the optimum water consumption being 46% in 2014, of 26% in 2015 and of 26% în 2016. Irrigiation led to statistically significant yield gains against the non-irrigated conditions, with relative differences of 87% in 2014, of 38.1% in 2015 and of 40% in 2016. The results show the appropriateness of irrigating sunflower in the conditions of the Crișurilor Plain too.

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