IRRIGATION, A COMPONENT OF THE SUSTAINABLE TECHNOLOGY OF THE SUNFLOWER FROM CRISURILOR PLAIN

Brejea Radu, Domuta Cornel, Sandor Maria, Sabau Nicu Cornel, Borza Ioana, Domuta Cristian*

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: domuta_cornel@yahoo.com

Abstract

The researches carried out during 1976-2011 in the experiment for establishing the soil water balance placed on the preluvosoil from Agricultural Research and Development Station Oradea. Soil moisture was determined ten to ten days. The decrease of the soil water reserve on watering depth (0-75 cm) bellow easily available water content was considered pedological drought and the decrease bellow wilting point was considered strong pedological drought. The graphs of the soil water reserve dynamics permeted to count the number of days with pedological drought. This phenomenon was determined every year and the strong pedological drought was determined in 40% from years studied. In comparison with the variant with optimum irrigation regime, pedological drought determined smaller values of the daily and total water consumption, an yield losses of 33%, very significant statistically; a bigger dispersion degree of the yields around the average was registered, standard deviation increasing with 9,5%. Pedological drought determined a smaller decrease (0.58 kg/m^3 vs. 0.59 kg/m^3) of the water use efficiency. The researches sustain the need of the irrigation, the main measure for pedological drought control.

Key words: pedological drought, irrigation, Domuta climate index, water consumption, yield, sunflower.

INTRODUCTION

Ecological conditions for sunflower crop from Crisurilor Plain are favorable because the plants have need a moderate moisture till inflorescence opening, but the yield is strongly affected when water deficit appears during flowering and in the following stages; the most harmful drought effect on yield manifests beginning with 20 days before flowering till 15 – 20 days after it. (Bîlteanu Gh., V. Birnaure, 1979)

Pedological drought (Domuţa C., 1995) was registered every day in unirrigated sunflower and the irrigation is the main measure for drought control. Numerous research regarding the sunflower irrigation, have been performed on the world plane (Grumeza N. et al., 1989). Romanian research included the aspects regarding the soil management of the irrigated sunflower, irrigation influence on water consumption and yield, correlation water consumption and yield, irrigation scheduling.

Our paper quantified the irrigation opportunity in the moderate wet area from Western Romania and is based on the researches carried out during 1976 – 2010 in Oradea regarding the pedological drought on

sunflower watering depth (0 – 75 cm), irrigation regime needed to maintain the soil water reserve on 0 – 75 cm depth between easily available water content and field capacity, the irrigation influence on microclimate, water consumption, yield and water use efficiency, the correlations in the soil – water – plant system. (Donen D. and D.W. Westcot, 1988., Grumeza N., et all, 1987)

MATERIAL AND METHODS

The researches were carried out in Agricultural Research and Development Station Oradea during 1976-2010. The preluvosoil from research field has a humus content of 1.8% and a pH of 6.5. After 36 years of stationary researches (characterized by a superior crop management), the content of available phosphorus into ploughed layer ranged from 30.6 ppm to 130.5 ppm; the content of potassium is of 190.6 ppm.

The rainfall multiannual average (1931 - 2010) registered during an agricultural year is of 615.5 mm and the air average temperature of 10.2˚C; air humidity has the value of 78% and sun brilliance is of 2039.8 hours.

The pedological drought was quantified based on the soil moisture determination ten to ten days. The soil moisture determination was made by gravimetric method. The soil moisture data were used for soil water reserve calculation and for their representing in the annual graphs. The decrease of the soil moisture on watering depth (0-75 cm in this case) bellow easily available water content (Wea) was considered the pedological drought (8).

Easily available water content (Wea) was established in function of clay content (Botzan, 1966) using the following formula: Wea = WP + 2/3 (FC - WP); wich: WP = wilting point; FC = field capacity

The water consumption was determined by the soil water balance method on 0 – 150 cm depth.

Water use efficiency (WUE) was calculated like a report between yield and water consumption and irrigation water use efficiency (IWUE) was calculated like report between yield gain determined by irrigation and irrigation rate used.

Optimum crop technology for this area was used: hybrids (Romsun 1976 – 1988, Select 1988 – 2000, Alex 2000 - 2011), plants density (60.000 plants/ha in irrigated conditions, 50.000 plants/ha in unirrigated conditions), fertilization ($N_{120}P_{120}K_{60}$), weeds, diseases and pests control.

RESULTS AND DISCUSSION

Pedological drought

Soil moisture decreased bellow easily available water content on 0 – 75 cm depth in the all 30 years studied, maximum frequency was registered

in August, 100%, but in July (96.7%) and in June (93.3%), the frequencies are very high, too. Period with pedological drought into the soil represents 62.6% from sunflower vegetation period and 60.4% from sunflower irrigation period. (table 1)

Table 1

Pedological drought in unirrigated sunflower, Oradea 1976 – 2010

Specification	Month						Vp days	Days with WR < Wea % from:	
	April	May	June	July	August	TOTAL		Vp	Ip
Minimum value	0	0	0	0	10	10	110	9.1	8.2
Maximum value	10	31	30	31	31	125	164	76.2	100
Average value	1.9	11.0	19.3	26.5	26.9	85.6	136.6	62.6	60.4
Frequency %	1.0	46.7	93.3	96.7	100	100	-	-	-

Vp = vegetation period; Ip = irrigation period = 122 days

Soil moisture decreased below wilting point in 11 years, the biggest frequency, 36.6%, registered in August, following July (26.7%), June (16.7%) and September (13.3%). Wilting point was considered a point from an wilting interval and wasn't considered a fix point because in the field conditions, the plants can survive at a moisture bellow the wilting point.

Optimum irrigation regime

Maintaining the soil water reserve between easily available water content and field capacity on 0 – 75 cm determined to use an irrigation rate of 218.0 mm/ha (variation interval 30.0 – 402.0 mm/ha) and number of watering was of 5 (variation interval 1 - 8). The highest value of the monthly irrigation rate was registered in July. (table 2)

Table 2

Analysis of the optimum irrigation regime in sunflower, Oradea 1976 – 2011

Specification	Annual average		Monthly regime									
	∑m	n	April		May		June		July		August	
			∑m	n	∑m	N	∑m	n	∑m	n	∑m	n
Maximum value	30.0	1	0	0	0	0	0	0	0	0	0	0
Minimum value	402.0	8	32.0	1	100.0	2	128.0	3	166.0	3	104.0	2
Average value	218.0	5	-	-	26.0	0,5	52.0	1.5	92.0	2	48.0	1

∑m = irrigation rate, mm/ha; n = number of watering;

Irrigation influence on water consumption

Sunflower water consumption in the irrigated variant increased in comparison with nonirrigated variant with 47%, variation interval 5 – 122%. Rainfall registered during the sunflower vegetation period were the main covering souce of the water consumption but not all the years; 3 years, in unirrigated conditions, the soil water reserve was the main covering sources and 6 years, in irrigated conditions, the irrigation was the main covering

sources of the water consumption. An optimum sunflower water consumption was possible using the irrigation, their participation in the covering sources was of 6 – 62%. (table 3).

Table 3

Total water consumption and the covering sources in unirrigated and irrigated sunflower, Oradea 1976 – 2011

Variant	Total water consumption		Covering sources of the water consumption							
			Soil water reserve		Rainfall *			Irrigation		
	mm/ha	%	mm/ha	%	mm/ha	%	Variation interval mm/ha	mm/ha	%	Variation interval mm/ha
Unirrigated	402.7	100	115.6	28.7	287.1	71.3	95 –531.6	-	-	-
Irrigated	592.8	147	87.7	14.8	287.1	48.4	95 –531.6	218.0	36.8	6-62

* Rainfall registered during the sunflower vegetation period

Irrigation influence on level and stability of the yield

Irrigation determined the increase of the yield level (3.452 vs. 2.355 kg/ha), every year the differences were statistically assured. The relative differences between irrigated and unirrigated variant were of 6 – 110%. Irrigation determined the increase of the yield stability, too; WUE standard deviation decreased with 22.1%. (table 4).

Table 4

Analysis of the yields in unirrigated and irrigated sunflower, Oradea 1976 – 2011

Variant	Average		Variation interval		Standard deviation	
	kg/ha	%	kg/ha	%	kg/ha	%
Unirrigated	2.355	100	1.350 – 3.140	100	680	100
Irrigated	3.452	146.6	1.757 – 4.580	106 - 210	530	77.9

Water use efficiency in unirrigated and irrigated sunflower

In average on the studied period, irrigation didn't improve the water use efficiency (WUE), in comparison with other crops from this area. Ten years the values of the WUE from irrigated variant were smaller than unirrigated variant and twenty years were bigger. (table 5).

Irrigation water use efficiency (IWUE) was calculated as report between yield gain obtained using the irrigation and the irrigation rate. The values of the IWUE (5.03 kg yield gain/mm) is smaller than the values obtained in other crops for grain (maize, wheat, soybean, bean) from Western Romania (Domuța C., 2005).

Transpiration coefficient was calculated as rapport between dry matter and water consumed. Stalks quantity from unirrigated variant was of 4,400 kg/ha in comparison with 9.020 kg/ha in irrigated variant. In these conditions the value of the transpiration coefficient of the irrigated variant (487) was smaller than the transpiration coefficient of the unirrigated variant (606) with 18.9%.

Table 5

Indicators of the water use efficiency in unirrigated and irrigated sunflower, Oradea 1976 – 2011

Variant	Water use efficiency				Irrigation water use efficiency		Transpiration coefficient	
	Average		Variation interval					
	kg/mm	%	kg/mm	%	kg yield gain/mm	%	kg dry matter/kg consumed water	%
Unirrigated	5.85	100	0.26 –0.81	100	-	-	606	100
Irrigated	5.82	99.5	0.31 –0.89	54 -139	5.03	-	487	81.1

Correlations in the soil – water – plant system

Inverse correlations, very significant statistically, were quantified between number of days with pedological drought and yield, respectively water use efficiency.

Direct correlations were quantified between pedological drought and yield gain obtained using the optimum irrigation. Direct correlation were quantified, too between water consumption of the unirrigated and irrigated sunflower and yield obtained and between microclimate conditions (Domuta climate index) and yield of the unirrigated and irrigated sunflower. (table 6)

Table 6

Correlations in the soil – water – plant system in unirrigated and irrigated sunflower, Oradea 1976 – 2011

Correlations	Regression functions	Correlation coefficient (R)
Days number with WR < Wea x Yield	$Y = -0.4388x^2 + 60,843x + 614.7$	0.81^{000}
Days number with WR < WP x Yield	$Y = -0.5156x^2 + 11.79x + 2,970.9$	0.86^{000}
Days number with WR < Wea x WUE	$Y = -3E – 0.5x^2 + 0.002x + 0.6902$	0.71^{000}
Days number with WR < Wea x Yield gain	$Y = 25.06x^{0.8906}$	0.82^{***}
Water consumption x Yield	$Y = -9E – 0.5x^2 + 0.1294x – 10,816$	0.62^{**}

All the correlations quantified in the soil – water – plant system sustain the irrigation opportunity in the moderate wet area of the Western Romania, because the irrigation is the main possibility for pedological drought control, for microclimate conditions improve and for water consumption increase.

CONCLUSION

The paper based on the researches were carried out during 1976-2011 in Oradea, Agricultural Research and Development Station Oradea and the following conlusions were emphasized:

- Ten to ten determination of the soil moisture and the annual graphs of the soil water reserve on watering depth (0-75 cm) show the presence of the pedological drought every year.
- For the water reserve maintenance between the easily available water content and field capacity on 0 – 75 cm depth, irrigation rate of 218.0 mm/ha (variation interval 30.0 – 402.0 mm/ha), was used.

- The irrigation use determined the increase of the total water consumption with 47% on average. The rainfall during the sunflower vegetation period had the greatest participation in water consumption covering, 71.3% under unirrigated conditions and 48.4% under irrigation conditions; irrigation had a participation of 36.8%, variation interval: 6 – 62%.
- The irrigation determined to obtain of a mean yield gain of 1.097 kg/ha (3.452 kg/ha vs. 2.355 kg/ha). The variation interval of relative differences between the two variants was between 6.1% (in 1979) and 109.9% (in 2000). The irrigation determined the yield stability increasing.

During 25 years, the water use efficiency had greater values under irrigation conditions and during 11 years had greater values under unirrigated conditions.

Correlation registered in the soil – water – plant system (inverse links between the pedological drought and yield, respectively water use efficiency and direct links between pedological drought and yield gain, between water consumption and yield, sustain the irrigation opportunity in the Western Romania, too.

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".

REFERENCES

1. Bîlteanu Gh., V. Birnaure, 1979. Fitotehnie. Editura Ceres, Bucureşti, pag. 430 – 469.
2. Bora C., 1991. Relationship water consumption – yield and irrigation scheduling on irrigated surfaces from North Oltenia. Proceedings ICITID Baneasa – Giurgiu, VI (XVII); pag. 121 – 124.
3. Borza I. M., A. Şt. Stanciu, 2010. Fitotehnie. Editura Universităţii din Oradea, pag. 282-294.
4. Botzan M., 1996. Irigarea culturilor. Editura ABucharest; pag. 65 – 70; 162 – 164.
5. Brejea R., 2009. Tehnologii de protecţie sau refacere a solurilor. Editura Universităţii din Oradea, pag. 78-92.
6. Brejea R., 2010. Ştiinţa solului – îndrumător de lucrări practice. Editura Universităţii din Oradea, pag. 84-105.
7. Ciobanu Gh., C. Domuţa, 2003. Cercetări agricole în Crişana, Ed. Universităţii din Oradea, pag.172-183.
8. Domuţa C., 1995. Contribuţii la stabilirea consumului de apă al principalelor culturi din Câmpia Crişurilor. Teză de doctorat ASAS "Gheorghe Ionescu Şişeşti", Bucureşti, pag. 115-181.
9. Domuţa C., Cr. Domuţa, 2003. Oportunitatea irigaţiilor în Câmpia Crişurilor, Ed. Universităţii din Oradea, pag. 165-186.
10. Domuţa C., 2005. Irigarea culturilor, Editura Universităţii din Oradea, pag. 31-49; 256-260.
11. Donen D. and D.W. Westcot, 1988. Irrigation practice and water management. Irrigation and Drainage Paper FAO Rome.
12. Grumeza N., O. Merculiev, C. Kleps, 1987. Corelaţia consum de apă-producţie şi prognoza irigaţiei în condiţiile pedoclimatice ale Câmpiei de Vest. Cereale şi plante tehnice nr.7/1987, pag. 37 – 49.
13. Grumeza N., O. Merculiev, C. Kleps, 1989. Prognoza şi programarea aplicării udărilor în sistemele de irigaţie. Editura Ceres, Bucureşti, pag. 38 – 47.; 111 – 163.