MULTIANNUAL RESEARCHES REGARDING THE IRRIGATION INFLUENCE IN SUNFLOWER FROM CRIŞURILOR PLAIN

Şandor Maria*, Domuţa Cornel, Borza Ioana, Domuţa Cristian, Brejea Radu, Vuşcan Adrian

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

Abstract

The paper is based on the researches carried out during 1976 – 2010 in a long term trial placed in Oradea. Rainfall registered during sunflower vegetation period were between 95 mm and 531.6 mm. Ten to ten days determinations of the soil moisture emphasized the decrease of the soil water reserve bellow easily available water content on watering depth (0 – 75 cm) every year. In these conditions, the optimum water consumption of the sunflower was assured by irrigation, variation interval of the irrigation rate was between 30 mm/ha and 402 mm/ha. Irrigation determined the improve of the water/temperature + light report (Domuta climate index) the increase of the daily and total water consumption; the average of the yield increased with 46% vs. Unirrigated variant, variation yield interval of differences was 6 - 110%. Inverse correlation between soil moisture stress and yield, direct correlations between climate index and yield, between water consumption and yield, between soil moisture stress and yield gain are the arguments too, for sunflower irrigation in Western Romania.

Key words: sunflower, irrigation, Domuţa climate index

INTRODUCTION

Sunflower can generate reasonable quantities of seeds and oil even under hydric stress conditions because there is a favourable rapport between evapotranspiration deficit and yield diminution (Vranceanu, 2000). In the same time, Bilteanu 1979 considers that the sunflower 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.

Numerous research regarding the sunflower irrigation, have been performed on the world plane (Donnen and Westcot, 1988, Doorembos and Kassam, 1986 e.t.c.). Romanian research included the aspects regarding the soil management of the irrigated sunflower (Ionescu – Sisesti Vl., 1983), irrigation influence on water consumption and yield, correlation water consumption and yield, irrigation scheduling (Bora, 1991; Domuta 1995, 2003, 2005; Grumeza et all, 1987, 1989, Stepanescu and Mate 1972; Vajiala, 1978; Vranceanu, 2000).

Our paper wants to establish 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.

MATERIALS AND METHODS

The preluvosoil from research field has a humus content of 1.8% and a pH of 6.5. After 25 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 - 2008) 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 sunflower irrigation was carried out when the soil water reserve on 0 – 75 cm depth the decreased below easily available water content (19.2%; 216.3 mm/ha) established at 2/3 from the active moisture interval (2655 – 1181 mm/ha). (Brejea 2009, 2010)

In order to maintain the soil water reserve between easily available water content and field capacity on 0 – 75 cm, determinations of the soil moisture were carried out ten to ten days.

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

Climate characterization was realized using the indicators "Domuta climate index" (ICD): ICD = $\frac{100W + 12,9A}{\sum t + Sb}$; which: W = water (rainfall, irrigation, ground water), mm; A = air humidity, %; ∑t = sum of the daily average temperature, ˚C; Sb = sun brilliance, hours.

Climate characterization classes by ICD are: < 3 excessive droughty; 3.1 – 5 very droughty; 5.1 – 7.0 droughty; 7.1 – 9 median droughty; 9.1 – 12 median wet; 12.1 – 15 wet I; 15.1 – 18 wet II; 18.1 – 25 very wet; >25 excessive droughty.

The water consumption was determined by the soil water balance method on 0 – 150 cm depth (Grumeza et al, 1989).

Optimum crop technology for this area was used: hybrids (Romsun 1976 – 1988, Select 1988 – 2000, Alex 2000 - 2005), 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 was quantified by two parameters:

- number of days with soil water reserve below easily available water content on 0 – 75 cm;
- number of days with soil water reserve below wilting point on 0 – 75 cm.

These parameters were proposed by Domuta 1995, starting from the definition (Botzan, 1966) of the easily available water content: the point from the available moisture interval until wich the soil moisture can decrease without affecting evidently the yields. The parameters quantification are based on the yearly moisture graphs realized after the determinations every ten days of the soil moisture on watering depth (0 – 75 cm). The fixe depth for watering depths is used in the most part of Romania and 0 – 75 cm is the watering depth for sunflower, maize, sugarbeet, potato, soybeen, alfalfa 1st. years.

Soil moisture decreased bellow easily available water content on 0 – 75 cm depth in the all 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 hydric stress into the soil represents 62.6% from sunflower vegetation period and 60.4% from sunflower irrigation period. (table 1)

Table 1

Days with soil water reserve (WR) bellow easily available water content (Wea) on 0 – 75 cm depth, in unirrigated sunflower, Oradea 1976 – 2008

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	2.1	11.0	18.8	27	27.3	86	136.6	62.6	60.4
Frequency %	4	44	92	96	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

Optimum irrigation regime in sunflower, Oradea 1976 – 2008

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/temperature + light report

A possibility to characterize the crop climate and microclimate is the utilization of the climatic indices. There are a lot of climatic indices; among the well known in Romania are De Martonne aridity index, Seleaninov coefficient, Teaci index, Palfai aridity index. Domuta, 1995 proposed the hydroheliothermic index based on water, air temperature and sun brilliance; in 2000 the quoted author included in the formula the air humidity, too. Sabau et all (1998) obtained the best results for correlation between climate and yield using hydroheliothermic index, Ciobanu et all, 2001, Palcut, 2003 obtained better results for correlation between climate and yield using Domuta climate index, in comparison with hydroheliothermic index, Seleaninov coefficient and De Martonne aridity index.

Irrigation improve the sunflower microclimate, the water/temperature + light rapport of the April – August period characterize a "wet I" microclimate in comparison with "moderate droughty" the microclimate of the Unirrigated variant. In July was registered the biggest differences (115.3%) between the values of the Domuta climate index from irrigated and Unirrigated variants. (table 3).

Table 3

Irrigation influence on water/temperature + light rapport (Domuta climate index, ICD) in sunflower, Oradea 1976 - 2008

Variant	Specif.	April	May	June	July	August	April - August
Unirrigated	1	9.5	9.8	11.9	9.7	7.3	8.62
	2	M. w.	M. d.	M. w.	M. d.	M. d.	M. d.
Irrigated	1	9.5	10.9	17.1	18.3	11.4	13.4
	2	M. w.	M. w.	W. II	V. w.	M. w.	W. I
Dif. irrigated – Unirrigated, %		0	33.0	61.1	115.3	77.0	55.5

M.w. = median wet; M.d. = median droughty; D. = droughty; W. I = wet I; W. II = wet II
V.w. = very wet.

Irrigation influence on water consumption

Sunflower water consumption in the irrigated variant increased in comparison with unirrigated 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 4).

Table 4

Irrigation influence on sunflower total water consumption, Oradea 1976 – 2008

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	399.4	100	117.3	29.6	282.1	71.3	95 – 531.6	-	-	-
Irrigated	591.7	150	86.6	14.6	282.1	47.6	95 – 531.6	218.0	38.8	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 5).

Table 5

Irrigation influence on sunflower yield, Oradea 1976 – 2008

Variant	Average		Variation interval		Standard deviation	
	kg/ha	%	kg/ha	%	kg/ha	%
Unirrigated	2.330	100	1.350 – 3.140	100	680	100
Irrigated	3.470	148.9	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 26 years were bigger. (table 6).

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 (Domuta, 2005, 2009).

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 6

Irrigation influence on some indicators of water use in sunflower, Oradea 1976 – 2008

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	5.88	100	0.26 – 0.81	100	-	-	606	100
Irrigated	5.86	99.7	0.31 – 0.89	54 - 139	5.22	-	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 7).

Table 7

Correlations in soil – water – plant system in unirrigated and irrigated sunflower, Oradea 1976 – 2008

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^{**}
Domuta climate index x Yield	$Y = 626.84x^{0.6152}$	0.77^{***}

All the correlation 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 soil hydric stress control, for microclimate conditions improve and for water consumption increase.

CONCLUSIONS

The researches carried out during 1976-2010 in Agricultural Research and Development Station Oradea determined the following conclusions:

- Pedological drought affected the unirrigated sunflower every year.
- For the water reserve maintenance between the easily available water content and field capacity on 0 – 75 cm depth, an average irrigation rate of 218.0 mm/ha (variation interval 30.0 – 402.0 mm/ha), was used.
- The irrigation determined the improvement of water/temperature + light rapport (Domuta climate index) , the irrigated crop microclimate being characterized as "wet I" vs. "moderately droughty" under Unirrigated conditions. The total water consumption of irrigated variant increased 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 an average 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 2010). The irrigation determined the yield stability increasing.
- During 20 years, the WUE had greater values under irrigation conditions and during 26 years had greater values than unirrigated conditions.
- Correlation registered in the soil – water – plant system (inverse links between pedological drought and yield, respectively water use efficiency and direct links between pedological drought and yield gain, between water consumption and yield, between microclimate and yield) sustain the irrigation opportunity in the Crisurilor Plain, too.

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REFERENCES

1. Bilteanu Gh., Birnaure V., 1979. Fitotechnia. Ceres Publishing House, Bucharest; 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); 121 – 124.
3. Botzan M., 1966. Irrigated crops. Agro – forestry Publishing House Bucharest; 65 – 70; 162 – 164.
4. Brejea R., 2009, Tehnologii de protecție sau refacere a solurilor. Editura Universității din Oradea, p. 78-92
5. Brejea R., 2010, Ştiința solului – îndrumător de lucrări practice. Editura Universității din Oradea, p.34-80
6. Ciobanu Gh., Domuta C., Ciobanu C., 2002. Investigations of climatic conditions influence on wheat yield in long term field experiments in brown luvic soil from Oradea. Publishing of University of Oradea. Fac. Environmental Protection; 49 - 57.
7. Domuta C, 1995 – Contributions in establishing of the water consumption in main crops from Crisurilor Plain conditions. Ph.d.thesis. Academy for Agricultural and Forestry Science Bucharest, 37-176.
8. Domuta C., 2003. Irrigation opportunity in the Cris Plain. University of Oradea Publishing House. 47 – 56; 165 – 186.
9. Domuta C., 2005. Irrigation crops. University of Oradea Publishing House; 85 – 90; 100 – 107; 265 – 270.
10. Donen D. and Westcot D.W., 1988. Irrigation practice and water management. Irrigation and Drainage Paper FAO Rome.
11. Doorembos J. and Kassam A.M., 1986. Yield response to water. FAO Rome.
12. Domuța C., 2009, Irigarea culturilor. Editura Universității din Oradea; p. 245 – 278
13. Domuta C., 2009, Irigațiile în Câmpia Crişurilor. Editura Universității din Oradea; p. 125-148
14. Grumeza N., Merculiev O., Kleps C., 1987. Correlation water consumption – yield and irrigation scheduling in the conditions of the Western Plain. Cereals and technical plants. Rev. 7; 37 – 49.
15. Grumeza N., Merculiev O., Kleps C., 1989. Irrigation scheduling in the irrigation systems. Ceres Publishing House Bucharest. 38 – 47.; 111 – 163.
16. Ionescu Sisesti Vl., 1982 – Irrigation crops. Ceres Publishing House Bucharest.123 – 129; 369 – 370.
17. Palcut N., 2002. The behavior of some late corn hybrids under the pedo – climatic conditions of the Crisurilor River Plain. Proceedings of the European Worshop on Environmental Stress and Sustainable Agriculture, Bulgaria, 110-112
18. Sabau N.C., Domuta C., Cristea M., Pasca M., 1998. Climate characterization of the central part of Western Romania using Palfai aridity index (PAI). Proceedings of Faculty of Environmental Protection, Oradea; 112 – 123.
19. Vajaiala M., 1978. Researches regarding the water consumption in main irrigated crops from brown soil area. Ph. D. thesis. University for Agricultural Science and Veterinary Surgence Bucharest; 79 – 102.
20. Vranceanu V.A., 2000. Hybrid sunflower. Ceres Publishing House Bucharest.