MODIFICATIONS IN SOIL – WATER – PLANT SYSTEM UNDER THE IRRIGATION INFLUENCE IN SUNFLOWER CROP IN CRIª PLAIN, DURING 1976–2000

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ABSTRACT

The paper presents the results of the researches carried out during 1976-2000 under field conditions, for soil water balance from Oradea. Ten to ten days determinations of the soil moisture show, on 0-75 cm depth, the decrease of the soil water reserve below minimum available water content (MAW) every year and below wilting point (WP) in ten out of the 25 studied years. The irrigation regime used for maintaining the soil water reserve below minimum available water content and field capacity included an irrigation rate of 2,285 m^3/ha (variation interval 300-4,020 m^3/ha) applied in five rates. The irrigation determined the improvement of the water/temperature + light rapport (Domuþa hydroheliothermic index); the microclimate of the irrigated sunflower was characterized „wet I" vs. „moderately droughty" under nonirrigated sunflower. The values of the daily water consumption increased, the greatest differences between irrigated and dryland variant were registered in July-August. Total water consumption increased, on an average, with 50.9% in irrigated variant. Rainfall registered during the sunflower vegetation period had the biggest participation in covering the water consumption, 72.9% in dryland variant and 48.3% in irrigated variant. The irrigation participation was of 38.9%, the variation interval 6–62%. Irrigation determined the obtainment of an average yield gain of 1,132 kg/ha (3,401 kg/ha vs. 2,269 kg/ha). The variation interval of the relative differences between the variants was of 6.1% (in 1979) – 109.9% (in 2000). During ten years, water use efficiency had smaller values under irrigated variant and during 15 years under dryland variant. The statistically ensured inverse links, were quantified in the soil – water – plant system between number of days with soil hydric stress (water reserve below minimum available water content and wilting point) and yield, water use efficiency, respectively. The statistically ensured direct links, were quantified too, between number of days with soil water reserve below minimum available water content and yield gain obtained by irrigation, between water consumption and yield and between the water/temperature + light rapport (Domuþa hydroheliothermic index) and yield. Also, all links sustain the irrigation opportunity in sunflower under Criº Plain conditions.

Key words: hydric stress, irrigation, soil – water – plant system, sunflower.

INTRODUCTION

Sunflower is capable to achieve reasonable seed and oil quantities even under hydric stress conditions, because of a favourable rapport between evapotranspiration deficit and yield diminution (Vrânceanu, 2000). At the same time, sunflower satisfies itself with moderate moisture, till the inflorescence opening, but the yield is strongly affected when water defficiency appears during flowering and in the following stages (Bîlteanu, 1974). Robelin (quoted by Bîlteanu and Bîrnaure, 1979) shows that the most harmful drought effect on yield manifests beginning with 20 days before flowering till 15–20 days after it, and Sandoiu, quoted by the same authors, shows that another critical point for water is at 4–5 weeks after emergence during the floral internodes formation.

On the world plane, numerous research regarding the sunflower irrigation, have been performed. The Romanian research had in view the irrigated sunflower management irrigation influence on water consumption and yield, correlation water consumption – yield, watering prognosis and warning (Vrânceanu, 2000).

The sunflower ecological map performed by Vrânceanu (1974) places the Cris Plain into the third favourableness area of the crop. Research regarding different aspects of sunflower technology in this area were published by Mate (1972), Zahan et al. (1984), Ciobanu (1988), Csep (2000), Ciobanu and Popescu (1996), Bucurean and Voinescu (1995). The irrigation influence on water consumption and yield, watering prognosis and warning were performed by Grumeza et al. (1987). Domuta published researches regarding the contribution of the water layer subadjacent to watering depth to the total water consumption, influence of watering rate diminution on yield and water efficiency, influence of irrigation on microclimate (Domuta 1995; Domuta et al., 2000).

In this paper, the soil – water – plant system is analysed by the subsystems soil – water (peri-

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ods with the water reserve below both minimum available water content and wilting point) and water – plant (water consumption), emphasizing the irrigation influence on microclimate, yield and water efficiency; also, the correlations between different parameters of soil – water – plant system, are quantified.

MATERIALS AND METHODS

The researches were performed in the field of soil water balance placed at Oradea on a brown luvic soil, with 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 and the content of potassium reached 190.6 ppm.

The climatic elements were registered at Oradea meteorological station. The rainfall multiannual average (1931–2000) registered during an agricultural year is 615.5 mm and that of air average temperature of 10.2°C; air humudity has the value of 78% and the sunshine duration is of 2,039.8 hours.

The sunflower irrigation was carried out when the soil water reserve on 0–75 cm depth reached the minimum available water content (19.2; 2,163 m^3/ha) established at 2/3 from the active moisture interval (2,655–1,181 m^3/ha).

In order to maintain the water reserve between the minimum available water content and the field capacity, determination of soil moisture was necessary every ten days. The determination of soil moisture was gravimetrically realized on 10 cm depths till 1985 and gravimetrically on 0–50 cm + neutronically on 50–150 cm, during 1986–2000. For the neutronic determination, the UVA-2 equipment performed by the Institute of Physics and Nuclear Power, Bucuresti-Magurele, was utilized. The good calibration of the equipment into field determined the obtainment of an increased precision – 1.24% standard deviation of differences between neutronic moisture and gravimetric one on 50-150 cm depth and 0.45% on 100–150 cm (Domuta, 1995).

For the microclimate characterization, the „Domuta hydroheliothermic index" was utilized; this indicator proved to be superior to other indicators used in Romania (Sabau et al., 1999; Domuta et al., 2000).

The water consumption was determined by the soil water balance method, the utilized depth being 0-150 cm (Grumeza et al., 1987, 1989).

The optimum crop technology for the area, was utilized. All along the years, the Romsun hybrids were sown, and from 1988 till 2000 they were replaced by Super hybrid. The sowing density was of 60,000 pl./ha under irrigation and 50,000 pl./ha under dryland conditions. The fertilization consisted of 120 kg N/ha, 120 kg P_2O_5/ha and 60 kg K_2O/ha.

RESULTS AND DISCUSSION

Soil hydric stress in nonirrigated sunflower

The special literature has accepted the definition of minimum available water content given by Botzan in 1966 as „the point from the available moisture interval until which the soil moisture can decrease without affecting evidently the yields" (Canarache, 1990). As follows, the periods with water reserve below the minimum available water content represent periods with soil hydric stress. The identification of these periods was possible because the decadal determinations were graphically represented, on millimetric paper, into dynamics; annual diagrams which allowed the enough clear identification of periods in which the water reserve on 0–75 cm depth was below the minimum available water content, have resulted. During some years, the water reserve on 0–75 cm depth (sunflower wetting depth) decreased even below the wilting point. As regards the wilting point, the explanations given by Simota (1959), quoted by Canarache (1990) should be teken into consideration, showing that it is correct to define an wilting interval in which the wilting coefficient has a conventional place, because, under field conditions, the plants can survive at a moisture below the wilting point.

The soil hydric stress was quantified by two parameters:

– number of days with water reserve below the minimum available water content on 0–75 cm depth;

– number of days with water reserve below wilting point on 0–75 cm depth.

The data analysis regarding the number of days with water reserve below the minimum available water content on 0-75 cm depth in nonirrigated sunflower, emphasizes the fact that the phenomenon was registered every year out of 25 tested ones. The mean number of days with hydric stress during the sunflower irrigation (15th April – 15th August) was of 87 days; in 11 years (44%) the number of days was between 60 and 90, in 7 years (28%) was between 90 and 120, in 3 years (12%) was between 30–60 and 120–150 respectively, and in one year, the number of days was smaller than 30. The longest periods with water reserve below the minimum available water content were registered in August (27 days) and July (28 days) (Table 1).

The decrease of the water reserve below the wilting point was registered in ten years (40% frequency); the longest period (63 days) was registered in 1992. The highest frequency of the phenomenon was registered in August (Table 2).

Irrigation regime utilized for the maintaining of water reserve between minimum available water content and field capacity

During the investigation years, the mean irrigation rate used for the maintaining of water reserve between minimum available water content and field capacity on 0-75 cm depth had the value of 2,285 m^3/ha, and the mean watering number was of five; the variation intervals: 300-

Table 1. Analysis of periods with soil water reserve (WR) below minimum available water (MAW) content on 0–75 cm depth, in nonirrigated sunflower. Oradea, 1976–2000

Specification	April	May	June	July	August	Total days with: WR<MAW	Vegetation period (days)	Irrigation period*) (days)	Days with WR < MAW, % from: vegetation period	irrigation period
Minimum value	0	0	0	0	10	10	110	122	9.1	8.2
Maximum value	10	31	30	31	31	125	164	122	76.2	102.5
Mean value	2	11	19	27	28	87	135	122	64.4	71.3
Frequency%	4.0	44.0	92.0	96.0	100	100	–	–	–	–

* Irrigation period: 15 April – 15 August = 122 days

Table 2. Years with water reserve below the wilting point on 0–75 cm depth, in nonirrigated sunflower, under conditions from Oradea, during 1976–2000

Year	June	July	August	September	May – August	May – September
1987		17	31	15	48	63
1988			13		13	13
1990			8		8	8
1991	18	18	12	10	48	58
1992	2	31	31	–	64	64
1993	13	16	31	–	60	60
1994		31	31	–	62	62
1995		5	31		36	36
1998			5	–	5	5
2000	3	18	31	9	52	61

Table 3. Irrigation regime utilized for the maintaining of water reserve between minimum available water content and field capacity, on sunflower watering depth (0–75 cm). Oradea, 1976–2000

Specification	Annual regime		Monthly regime									
			April		May		June		July		August	
	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n
Minimum value	300	1	0	0	0	0	0	0	0	0	0	0
Maximum value	4,020	8	320	1	1,000	2	1,280	3	1,660	3	1,040	2
Mean value	2,285	5	–	–	275	1/2	530	11/2	990	2	490	1

4,020 m^3/ha, 1–8 waterings respectively. The highest mean value of monthly irrigation rate (990 m^3/ha) was registered in July (Table 3).

Irrigation influence on water/temperature + light rapport

A possibility to characterize the crop climate and microclimate is the utilization of climatic indices. There are lots of climatic indices, among the well-known ones being De Martonne aridity index, Donciu climatic index and recently, Palfai aridity index. The Domuta hydroheliothermic index was proposed in 1995, and Sabau et al. (1998) obtained better results with this index in comparison with the above mentioned indices. The hydroheliothermic index was calculated after the formula:

$$IhD = 100W/\sum t + D.s.s.;$$

in which:

W = water (rainfall, irrigation, underground water), mm;

$\sum t$ = biologically active temperature sum, ^{0}C;

D.s.s. = sunshine duration, hours.

The characterization of irrigated crops microclimate by the climatic indicators emphasizes only the irrigation influence on water factor. The irrigation influence on air temperature and humidity should be taken into consideration, too (Domuta et al., 2000).

On an average, during the studied years, the irrigation season was characterized as „wet I" under irrigation conditions vs. „moderately droughty" under dryland conditions, the difference between IhD values in those two variants being of 55.5%. In July, the month with the highest irrigation rate, the difference between irrigated and dryland conditions was of 115.3% (Table 4).

Irrigation influence on sunflower water consumption

As a rule, the sunflower was sown in the last decade of April, so that in this month, the mean values of daily water consumption were of 17.5 m^3/day under dryland conditions and of 18.2 m^3/day under irrigation.

Beginning with May, the utilization of irrigation determined an increase of the daily water consumption of 48.4% vs. dryland conditions. June is the month with the greatest rainfall; the better supply with water determined daily water consumption values close to those of irrigated sunflower, the relative difference being of 26.9%. The highest absolute difference between the two variants was registered in July (21.8 m^3/day), and the highest relative difference was registered in August, 107.7% (Table 5).

The maximum value of sunflower water con-

Table 4. Irrigation influence on water/temperature + light rapport (Domuþa hydroheliothermic index, IhD) in sunflower. Oradea, 1976–2000

Variant	Specification	April	May	June	July	August	April – August
Nonirrigated	Value	9.5	8.7	10.3	8.5	6.1	8.62
	Characterization	Moderately wet	Moderately droughty	Moderately wet	Moderately droughty	Droughty	Moderately droughty
Irrigated	Value	9.5	11.6	16.6	18.3	10.8	13.4
	Characterization	Moderately wet	Moderately wet	Wet II	Very wet	Moderately wet	Wet I
Diff.irrigated – nonirrigated (%)		0	33.0	61.1	115.3	77.0	55.5

Table 5. Mean daily water consumption of sunflower, under both irrigation and dryland conditions. Oradea, 1976–2000

Specification	April		May		June		July		August	
	m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
Dryland										
Mean value	17.5	100	26.4	100	40.4	–	38.6	–	19.5	–
Variation interval	5.2-23.8	–	13.5–42.9	–	19.6–64.8	–	5.7–50.1	–	3.3–36.0	–
Irrigation										
Mean value	18.2	104	39.2	148.4	51.3	126.9	60.4	156.5	40.5	207.7
Variation interval	10.0–35.0	–	19.5–45.0	–	36.2–68.3	–	32.0–79.5	–	29.5–59.0	–
Diff. irrigated – nonirrigated	+0.7	4.0	+12.8	48.4	+10.9	26.9	+21.8	56.5	+21.0	107.7

sumption was registered in June (40.4 m³/ha/day), under dryland conditions, while under irrigation the maximum value of water consumption was registered in July (60.4 m³/ha/day). Figure 1 presents the evolution of daily water consumption in the two tested variants and the regression functions.

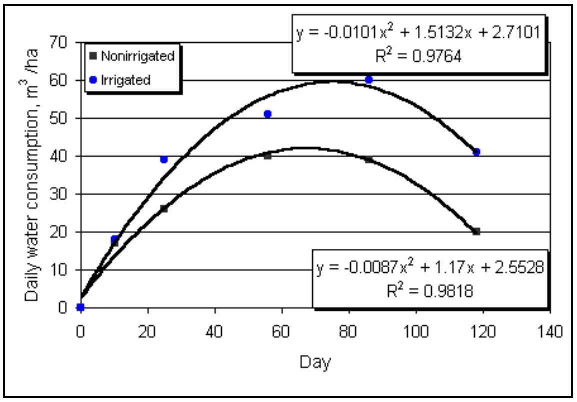

Figure 1. The irrigation influence on daily water consumption in sunflower. Oradea, 1976–2000

Under these conditions, the total water consumption in irrigated sunflower increased with 50.9% vs. dryland variant (5,876 m³/ha vs. 3,893 m³/ha), variation interval 7–166%. During the years, the total water consumption values were between 4,781 m³/ha (in 1979) and 7,083 m³/ha (in 1989) under irrigation conditions and between 2,340 m³/ha (in 1992) and 5,847 m³/ha (in 1978) under dryland conditions.

The precipitation during the sunflower vegetation period represents the main source for covering sunflower water consumption under both irrigation (48.3%) and dryland conditions (72.9%). During sunflower vegetation period, the rainfall ranged between 95.0 mm (in 2000) and 531.6 mm (in 1978).

The irrigation had a moderate weight in precipitation supplying of 38.9%, the variation interval being between 6% (in 1998) and 62% (in 2000) (Table 6).

Under dryland conditions, sunflower utilized 1,036 m³/ha from the soil reserve (precipitation registered during the preceding crop harvesting–sunflower sowing) and with 282 m³/ha less than under irrigation conditions; as follows, the soil water reserve registered at the sunflower harvesting had higher values under irrigation, allowing a qualitative ploughing.

The irrigation influence on yield

During 1976-2000, the irrigation determined an average yield of 3,401 kg/ha, with 49.9% greater than in dryland variant.

During the years, the yield relative differences were between 6.1% (in 1979) and 109.9% (in 2000). The greatest yield difference was registered in the year with the smallest rainfall quantity during the sunflower vegetation period, but the smallest yield difference registered does not coincide with the year with the greatest rainfall quantity. In five years, the yield relative differences were below 20%, in other five years the yield differences were between 20 and 40%, in four years the yield differences were of 80–100%, in three years the relative differences were of 40–60% and up to 100% respectively and in other years the relative differences were between 60 and 80% (Table 7).

Previous researches performed under the same conditions show that the irrigation determined the improvement of yield stability, the value of standard deviation being smaller with 8.6% than in dryland variant (Domuta et al., 2000).

Table 6. Total water consumption of irrigated and nonirrigated sunflower and the sources for water supplying. Oradea, 1976–2000

Variant	Total water consumption		Sources of water consumption supplying							
			Soil reserve		Precipitation			Watering		
	m³/ha	%	m³/ha	%	m³/ha	%	Variation interval (m³/ha)	m³/ha	%	Variation interval (%)
Nonirrigated	3,893	100	1,036	27.1	2,837	72.9	950–5,316	–	–	–
Irrigated	5,876	150.9	754	12.8	2,837	48.3	950–5,316	2,285	38.9	6-62

Table 7. Irrigation influence on sunflower yield under conditions of Oradea, during 1976–2000

Year	Precipitation (mm)		Yield (kg/ha)		Yield difference irrigated – nonirrigated	
	October – March	April – September	Unirrigated	Irrigated	Kg	%
1976	146.2	355.7	2,020	2,730	710	35.1
1977	296.8	299.8	1,810	2,310	500	27.6
1978	255.3	575.6	1,520	1,760	240	15.8
1979	165.5	279.8	2,310	2,450	140	6.1
1980	176.5	493.1	1,700	1,820	120	7.1
1983	207.7	312.1	2,920	3,300	380	13.0
1984	173.3	351.5	1,500	2,390	890	59.3
1985	194.1	416.0	3,090	4,070	980	31.7
1986	283.8	354.8	2,530	3,760	1,230	48.6
1987	208.8	368.7	2,410	4,550	2,140	88.8
1988	348.2	328.0	2,770	4,580	1,810	65.3
1989	135.5	420.4	2,990	4,460	1,470	49.2
1990	164.8	254.4	2,000	4,110	2,110	105.5
1991	195.5	391.6	2,690	4,470	1,780	66.2
1992	226.9	226.5	1,570	3,220	1,650	105.1
1993	262.3	271.5	1,750	3,360	1,610	92.0
1994	271.8	358.1	1,350	2,620	1,250	94.0
1995	219.6	343.9	1,860	3,470	1,610	86.5
1996	257.6	623.1	2,915	3,630	715	24.5
1997	226.1	524.3	destroyed	by hail	–	–
1998	178.2	603.2	3,152	3,660	510	16.2
1999	289.3	447.2	2,960	3,670	710	23.9
2000	352.0	175.4	2,110	4,430	2,330	109.9

Water use efficiency

There are many categories of indicators of water use efficiency estimation (Grumeza et al., 1989; Domuta et al., 2000). Among them, in the paper are analysed: water use efficiency (WUE) – calculated as a rapport between yield obtained and the total water consumption; transpiration coefficient (TC) calculated as a rapport between water quantity (kg) consumed for the obtainment of 1 kg of dry matter of main yield and by product. After Merrien, quoted by Vrânceanu (2000), the water use efficiency was calculated as a rapport between dry matter quantity from stems and the consumed water (litres) as well as rapport between dry matter from achenes and consumed water (litres).

The data obtained point out a better water use efficiency (WUE) in dryland variant as compared with the irrigated one, 0.58 kg/m^3 vs. 0.57 kg/m^3. During the years, ten situations have been registered when the WUE value in irrigated variant was smaller than in dryland one and 15 situations when the WUE value was greater in irrigated variant than in dryland one. The greatest negative difference between the WUE value from the two variants was re-gistered in 1977 (–45.5%), and the greatest positive difference (39.0%) was registered in 1991 (Table 8).

Table 8. Irrigation influence on WUE by sunflower crop under the conditions of Oradea, during 1976–2000

Variant	Water use efficiency		Variation interval	
	kg/m^3	%	kg/m^3	%
Nonirrigated	0.58	100	0.26-0.81	100
Irrigated	0.57	98.2	0.31-0.89	54.6-139.1

The dry matter quantity determined for the total stem mass was, on an average, of 4,400 kg in nonirrigated sunflower and of 9,020 kg in irrigated one. Under these conditions, by the calculation of transpiration coefficient, the mean difference registered between the two variants (19.6%), is bigger than the difference registered at the previous indicator.

The calculation of the WUE as rapport between dry matter quantity obtained to 1 litre of consumed water emphasizes greater values in irrigated variant, 1.54 g/l vs. 1.13 g/l. At the same time, the dry matter quantity from achenes obtained as follows of 1 litre water consumption has smaller values under irrigation conditions vs. dryland ones, 0.64 g/l vs. 0.65 g/l (Table 9).

Table 9. Irrigation influence on value of some WUE indicators in sunflower. Oradea, 1976–2000

Variant	Transpiration coefficient		Efficiency			
			Total dry matter		Dry matter in achenes	
	kg dry matter/kg consumed water	%	g/l	%	g/l	%
Nonirrigated	606	100	1.13	100	0.65	100
Irrigated	487	81.1	1.54	136	0.64	98.4

Table 10. Correlations in soil–water–plant system at nonirrigated and irrigated sunflower crop. Oradea, 1976–2000

Correlations	Regression functions	Correlation coefficient (r)
Day number with water reserve < Pmin. x Yield	$Y = -0.4388x^2 + 60.843x + 614.7$	0.81^{000}
Day number with water reserve < WP x Yield	$Y = -0.5156x^2 + 11.79x + 2,970.9$	0.86^{000}
Day number with water reserve < Pmin. x WUE	$Y = -3E\text{-}0.5x^2 + 0.002x + 0.6902$	0.71^{000}
Day nymber with water reserve < Pmin. x Yield gain	$Y = 25.06x^{0.8906}$	0.82***
Water consumption x Yield	$Y = -9E\text{-}0.5x^2 + 0.1294x - 10.816$	0.62**
Hydroheliothermic index x Yield	$Y = 626.84x^{0.6152}$	0.77***

Correlations in soil – water – plant system at sunflower crop under both irrigation and dryland conditions

The correlations of „number of days with water reserve below the minimum available water content" indicator emphasize a statistically very significant inverse link, between day number with water reserve below the minimum available water content and yield obtained under dryland conditions.

The same link type was registered in the correlation with WUE too, but the correlation coefficient has smaller value; the phenomenon is explained by the fact that during 1976–1983 many situations in which the WUE had values inferior to the values obtained under dryland conditions, have been registered because of the utilized hybrids as well as statistically very significant direct link, with the yield gain obtained by the irrigation utilization.

The correlation „day number with soil reserve below the wilting point" indicator with the yield obtained under dryland conditions indicates a statistically very significant inverse link (Table 10).

Between the sunflower water consumption under dryland and irrigation conditions a distinctly significant direct link was registered. The correlation coefficient value (0.69) is smaller than the correlation coefficients obtained at other crops from area (Domuta et al., 2000).

A statistically very significant direct link was registered between the Domuta hydroheliothermic index values and yields obtained under irrigation and dryland conditions. This shows that the improvement of microclimate conditions by using the irrigation determines the yield increasing. Among these five tested yield functions (linear, logarithmical, polynomial, strength and exponential), the strength function mostly quantified the link between climatic indicator and yield. All these yield functions emphasize that by the correction of soil hydric stress and the improvement of microclimate conditions and water consumption, sunflower yields superior to those obtained under dryland conditions, have been achieved. If at the hybrids used during the first years of research the WUE was inferior in dryland variant vs. irrigated one, the results from the last 10–13 years under irrigation conditions revealed a superior WUE. All these results underline the fact that the irrigation are necessary and opportune in sunflower crop under conditions of Cris Plain.

CONCLUSIONS

The ten to ten days determination of soil moisture shows that during 1976–2000 in dryland sunflower, the water reserve on 0–75 cm depth decreased below the minimum available water content every year, and in ten out of 25 studied years, the soil water reserve on the same depth decreased even below the wilting point.

For the water reserve maintenance between the minimum available water content and field capacity on 0–75 cm depth, a mean irrigation rate of 2,285 m^3/ha (variation interval 300–4,020 m^3/ha), was used. The irrigation determined the improvement of water/temperature + light rapport (Domuta hydroheliothermic index) in irrigation period, the irrigated crop microclimate being characterized as „wet I” vs. „moderately droughty” under dryland conditions. The values of daily water consumption increased, the greatest differences being registered in July and August (flowering – grain filling); mathematical models of daily consumption are as a second degree polynom. The total water consumption of irrigated variant increased, on an average, with 50.9%. The rainfall during the sunflower vegetation period had the greatest participation in water consumption covering, 72.9% under dryland conditions and 48.3% under irrigation conditions; irrigation had a participation of 38.9%, variation interval: 6–62%.

The irrigation determined the obtainment of a mean yield gain of 1,132 kg/ha (3,401 kg/ha vs. 2,269 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 15 years, the WUE had greater values under irrigation conditions and during ten years had greater values under dryland conditions. The transpiration coefficient had a value of 606 under irrigation vs. 487 under dryland conditions. The rapport between dry matter from achenes and consumed water had the mean value of 0.64 g/l under irrigation vs. 0.65 g/l under dryland conditions.

In the soil – water – plant system, statistically ensured inverse links between day number with soil hydric stress and yield, WUE respectively, have been quantified. The statistically ensured direct links between day number with soil reserve below minimum available water content and yield gain obtained by irrigation, water consumption and yield as well as between Domuta hydroheliothermic index and yield, have also been quantified. All these results underline the sunflower irrigation necessity and opportunity under Cris Plain conditions.

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Table 1. Reproduction ability of the *E. integriceps* recent generations, as compared with multiannual average (1970-2000) and with the specific years: favourable (1986) and unfavourable (1989).

Natural generation of *E. integriceps*	Prolificacy (egg/female)		
	under field conditions	under controlled conditions	
		average	maximum/female
1970-2000	40.2	57.9	311
1986	56.3	71.3	298
1989	18.8	27.1	87
1996	47.1	69.9	302
1997	46.6	68.6	197

1998	37.5	53.8	209
1999	38.8	54.5	219
2000	39.3	55.7	208

Table 2. Prolificacy level of some *E. integriceps* populations (fertile females), from generations with different fat body levels, collected from the field, at the beginning of migration and studied under controlled conditions.

Fat body	Generation	Prolificacy (egg/female)	
		average	maximum
23.4	1989-1990	32.1	97
22.5	1972-1973	33.4	127
26.5	1971-1972	46.4	148
27.9	1977-1978	67.5	186
28.0	1984-1985	83.6	210
29.7	1985-1986	95.3	234
29.8	1994-1995	104.7	246

Table 3. Level and stages of fat body diminution at *E. integriceps* (multigeneration average).

Stages	Fat body level		Diminution	
	limits	average	limits	average
Diapause beginning	33.03-37.58	35.69	0	0
End of diapause	21.97-27.64	25.43	24.57-36.33	27.39
End of oviposition	8.12-10.39	8.78	66.50-78.69	74.43

Table 4. Mortality registered at the *Eurygaster integriceps* populations, during diapause in different generations, from Romanian area

E. integriceps natural population	Mortality (%)	
	Limits in counties	Total area (mean)
2000-2001	4.6-35.7	8.7
1995-1996	3.7-36.4	10.2
2001-2002	5.1-32.3	12.7
1985-1988	3.8-41.2	14.8
1999-2000	4.8-97.6	24.5
1973-1974	11.6-85.0	39.5
1988-1989	17.5-68.4	48.2

Table 5. Fat body value at *Eurygaster integriceps* populations, established on female groups, distributed in weight classes, at the beginning of diapause (multigeneration average).

Weight (mg)	% from the total of population		Fat body (%)	
	limits	average	limits	average
below 0.110	3.7-7.7	5.6	26.2-26.6	26.4
0.111-0.118	7.6-23.1	13.3	26.5-28.8	28.7
0.119-0.126	15.9-24.7	19.7	32.8-33.5	33.6
0.127-0.134	32.5-34.8	33.7	34.9-36.4	35.4
over 0.145	22.4-30.8	28.6	35.7-39.8	38.7

Table 6. Fat body value at *Eurygaster integriceps* populations, established on male groups, distributed in weight classes, at the beginning of diapause (multigeneration average).

Weight (mg)	% from the total of population		Fat body (%)	
	limits	aver-age	limits	aver-age
below 0.105	7.0-19.7	12.3	25.3-26.7	26.2
0.106-0.113	16.8-19.9	17.3	27.2-28.5	27.7
0.114-0.121	20.3-29.5	23.7	29.4-33.8	31.5
0.122-0.129	19.2-32.7	28.5	31.2-35.5	32.6
over 0.130	15.5-23.9	19.4	31.4-36.6	33.8

Table 7. Mortality (%) registered at *Eurygaster integriceps* female populations, depending on the fat body (multigeneration average).

Fat body (%)	Mortality (%)			
	During August-October		During November-March	
	limits	average	limits	average
26.4	17-22	20.4	59-64	61.3
28.7	13-15	12.9	43-54	47.6
33.6	9-17	12.5	41-52	46.2
35.4	4-11	6.6	29-34	33.6
38.7	4-7	5.8	26-35	30.9

Table 8. Mortality (%) registered at *Eurygaster integriceps* male populations, depending on the fat body (multigeneration average).

Fat body (%)	Mortality (%)			
	During August-October		During November-March	
	limits	average	limits	average
26.2	22-31	22.6	62-71	67.1
27.7	11-24	20.4	53-62	57.4
31.5	12-19	14.3	39-47	44.0
32.6	9-18	12.7	30-44	37.6
33.8	5-14	9.1	24-45	32.3

Table 9. Sterility and prolificacy registered at the *Eurygaster*

integriceps populations, depending on the fat body (multigeneration average).

Fat body (%)	Females sterility (%)		Mean prolificacy (egg/female)		
	limits	average	limits	average	maximum
26.4	100	100	0	0	0
28.7	60-72	63.5	4.1-6.6	5.4	42
33.6	54-63	57.3	16.2-22.8	19.5	78
35.4	35-44	39.1	26.4-33.1	30.3	135
38.7	25-32	29.8	38.9-51.7	45.8	194

Table 10. Multiplication index at the *Eurygaster integriceps* populations, depending on the fat body (multigeneration average).

Fat body (%)	Multiplication index (egg/female)	
	limits	average
26.4	0	0
28.7	0.37–2.47	1.54
33.6	4.54–9.62	6.95
35.4	28.57–40.18	35.22
38.7	49.38–64.83	56.47