RESEARCHES REGARDING THE RELATIONSHIPS BETWEEN DIFFERENT PARAMETERS OF THE SOIL-WATER-PLANTS-ATMOSPHERE SYSTEM AND YIELD IN SOYBEAN FROM CRIŞURILOR PLAIN

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Abstract

The soil-water-plant-atmosphere system is characterized by the following indicators: number of days with pedological drought; de Martonne aridity index and plants water consumption.

The researches carried out during 2007-2009 in an experiment with 6 variants with different water provisionment placed on the preluvosoil from Agricultural Research and Development Station Oradea.

Pedological drought was considered the period when on the watering depth (0-75 cm) the soil water reserve decreased below easily available water content; ten to ten determination of the soil moisture and the graphs of the soil water reserve dynamics permitted to quantify these periods. An inverse links, very significant statistically were determined between pedological drought and water consumption respectively quantity and quality (protein content) of the yields and a direct link very significant statistically was quantified between this indicator and yield gains determined by irrigation. The increase of the de Martonne aridity index values determined the increase of the plants water consumption, the yield gains and the increase of the grain protein content; the correlations are very significant statistically. Direct link very significant statistically, was registered between plants water consumption and soybean yields. All these correlations sustain the irrigation opportunity in soybean from Crisurilor Plain.

Key words: pedological drought, de Martonne aridity index, plant water consumption, irrigation, yield, soybean.

INTRODUCTION

The Crişurilor Plain is situated in Western Romania. This area is favorable for soybean but the cropped surfaces are not large; one of the explanations for the small soybean surfaces is the presence of the drought (Domuţa C., 2003, 2005, Grumeza and Klepş, 2005, Borza, 2010, Domuţa et al., 2009a, 2010). The researches regarding the irrigation in soybean from Crişurilor Plain started in 1973 in Girişu de Criş on the chernozem; after 1976 the researches regarding the irrigation in soybean was made in Oradea on the preluvosoil in the research field for water balance study (Domuţa, 2010).

To characterize the relationships between soil-water-plant-atmosphere system three kinds of indicators were used: pedological drought, climate indicator, de Martonne aridity index, plant water consumption (Grumeza and Klepş, 2005, Şandor, 2008, Domuţa, 2009).

MATERIAL AND METHODS

The researches were carried out during 2007-2009 on the preluvosoil from the Agricultural Research and Development Station Oradea and the following variants were studied:

V1 – Unirrigated;
V2 – Irrigated, without suspending irrigation;
V3 – Irrigated, with irrigation suspension in May;
V4 – Irrigated, with irrigation suspension in June;
V5 – Irrigated, with irrigation suspension in July;
V6 – Irrigated, with irrigation suspension in August.

On the Ap horizon the preluvosoil is characterized by the following chemical parameters: all the soil profiles are low acid (6.11 – 6.8), humus content (1.44 – 1.75 %) is small and total nitrogen is low median (0.127 – 0.157). After 35 years of good practices of soil management, the soil phosphorus content became very good (from 22.0 ppm to 150.8 ppm); on ploughing depth, potassium content (124.5 ppm) is median.

The watering depth (0-75 cm) (Grumeza N. et. al., 1989) was a fixed one and field capacity (FC = 24.2% = 2782 m^3/ha) and wilting point (WP = 10.1 = 1158 m^3/ha) had median values. Easily available water content (Wea) was established depending on texture: Wea = WP + 2/3 (FC – WP).

A drill in the water source for irrigation and their quality for irrigation was very good: pH = 7.2; Na^+ = 12.9%; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

De Martonne aridity index (IdM) was determined using the formula (Brejea R., 2009, 2010):

$$\mathrm{IdM} = \frac{12\mathrm{p}}{t+10} \text{ in which:}$$

p= monthly rainfall (mm); t= average temperature on the month (^{o}C)

In irrigated conditions, irrigation rate was added to the rainfall, and the data interpretation was realized after the classes proposed by Domuţa (1995): 15-24 Demiarid; 25-30 Moderate drought; 31-35 Moderate wet I; 36-40 Moderate wet II; 41-50 Wet; 51-60 Wet I; 61-80 Wet II; 81-100 Very wet; >100 Excesive wet. The experiment data was calculated by variance analysis method (Domuţa C., 2006, Borza, Stanciu, 2010).

RESULTS AND DISCUSSION

Relationships of the indicator "pedological drought"

The decrease of the soil water reserve on watering depth (0-75 cm in soybean) bellow easily available water content is considered pedological drought. Ten to ten determination of the soil moisture and the graphs of the soil water reserve dynamics permitted to count the days with pedological drought. In unirrigated variant the pedological drought was determined in 104 days in 2008, in 81 days in 2009 and in 108 days in 2010. The pedological drought was determined in the months with irrigation suspension, too (table 1).

There is a reverse link, very significant statistically, between the number of days with pedological drought and yield. The same type of link was quantified between pedological drought and protein content of the soybean grains. (fig. 1, 2)

Table 1

Number of days with pedological drought in soybean from different variants with water provisionment in the conditions from Oradea, 2008 - 2010

Variant	Month					IV-VIII
	IV	V	VI	VII	VIII	
2008						
Irrigated, without suspending irrigation	0	0	0	0	0	0
Irrigated, suspending irrigation in May, vegetative growth	0	14	1	0	0	15
Irrigated, suspending irrigation in June, vegetative growth – flowering	0	0	16	2	0	18
Irrigated, suspending irrigation in July, flowering – grains filling	0	0	0	17	5	22
Irrigated, suspending irrigation in August, grains feeling – the start of grains maturing	0	0	0	0	20	20
Unirrigated	8	24	26	25	21	104
2009						
Irrigated, without suspending irrigation	-	0	0	0	0	0
Irrigated, suspending irrigation in May, vegetative growth	0	6	0	0	0	6
Irrigated, suspending irrigation in June, vegetative growth – flowering	0	0	18	0	0	18
Irrigated, suspending irrigation in July, flowering – grains filling	0	0	0	21	0	21
Irrigated, suspending irrigation in August, grains feeling – the start of grains maturing	0	0	0	0	27	27
Unirrigated	0	6	20	24	31	81
2010						
Irrigated, without suspending irrigation	0	0	0	0	0	0
Irrigated, suspending irrigation in May, vegetative growth	0	24	2	0	0	26
Irrigated, suspending irrigation in June, vegetative growth – flowering	0	0	5	1	0	6
Irrigated, suspending irrigation in July, flowering – grains filling	0	0	0	23	3	26
(Irrigated, suspending irrigation in August, grains feeling – the start of grains maturing	0	0	0	0	30	30
Unirrigated	3	31	12	31	31	108

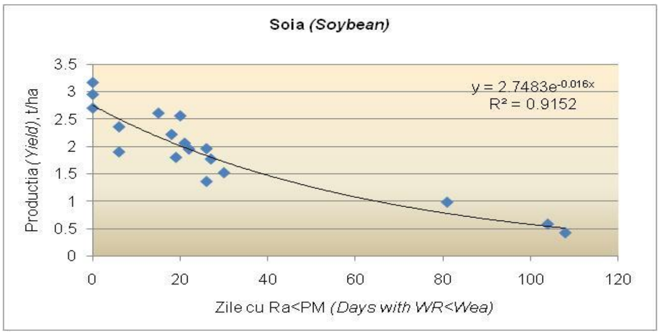

Fig. 1. Correlation between the number of days with pedological drought (WR-Wea) and soybean yields, Oradea 2008-2010

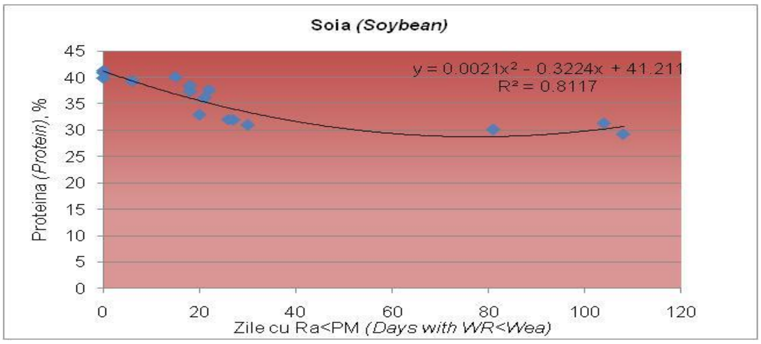

Fig. 2. Correlation between the number of days with pedological drought (WR-Wea) and the protein content of the soybean grains, Oradea 2008-2010

Relationships of the indicator “de Martonne aridity index”

In 2008, the optimum irrigation determined the increase of the “de Martonne aridity index” value by 111%. In the variant with irrigation suspension, the values of climate indicator decreased in comparison with the variant without irrigation suspension; the biggest differences were registered in the variant with irrigation suspension in July. In 2009, the optimum irrigation determined an increase in the climate indicator value by 135%. Irrigation suspension in August determined the lowest value of the climate indicator, the difference in comparison with the variant with optimum irrigation being of 22%. The highest difference in comparison with the unirrigated variant, 164%, was registered in 2010. Irrigation suspension determined the decrease of the climate indicator; irrigation suspension in August determined the highest difference in comparison with the optimum irrigated variant. (Table 2).

Table 2

The values of the de Martonne aridity index (IdM) in the irrigation season of soybean in the conditions of the irrigation suspending in different months, Oradea 2008-2010

Variant	*Soybean*		
	IdM	%	%
2008			
1. Unirrigated	21.0	100	-
2. *Irrigated, without suspending irrigation*	44.2	211	100
3. *Irrigated, suspending irrigation in May*	41.4	197	94
4. *Irrigated, suspending irrigation in June*	39.6	188	90
5. *Irrigated, suspending irrigation in July*	37.6	179	85
6. *Irrigated, suspending irrigation in August*	40,3	192	91
2009			
1. Unirrigated	22,8	100	-
2. *Irrigated, without suspending irrigation*	53,4	235	100
3. *Irrigated, suspending irrigation in May*	49,0	215	92
4. *Irrigated, suspending irrigation in June*	46,9	206	88
5. *Irrigated, suspending irrigation in July*	45,7	201	86
6. *Irrigated, suspending irrigation in August*	41,6	183	78
2010			
7. Unirrigated	20,5	100	38
8. *Irrigated, without suspending irrigation*	54,1	264	100
9. *Irrigated, suspending irrigation in May*	42,3	206	78
10. *Irrigated, suspending irrigation in June*	47,2	230	87
11. *Irrigated, suspending irrigation in July*	38,6	188	71
12. *Irrigated, suspending irrigation in August*	37,3	182	69

The direct links statistically assured were quantified between de Martonne aridity index and plants water consumption, yields quantity and yield protein content of the soybean grains (Fig. 3, 4, 5).

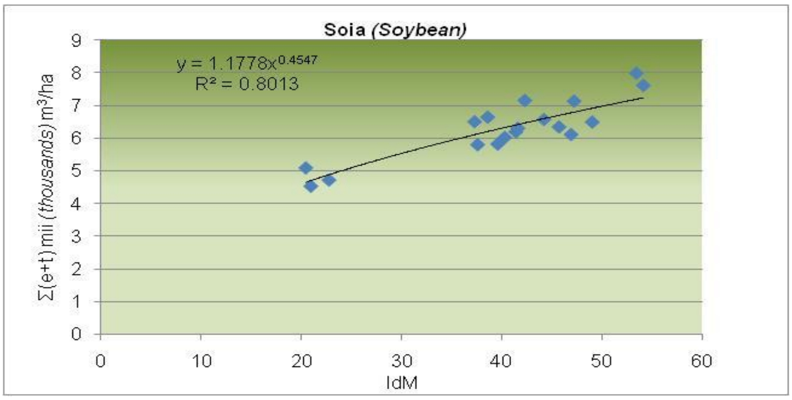

Fig. 3. Correlation between de Martonne aridity index (IdM) and the water consumption, ∑(e+t), of the soybean, Oradea 2008-2010

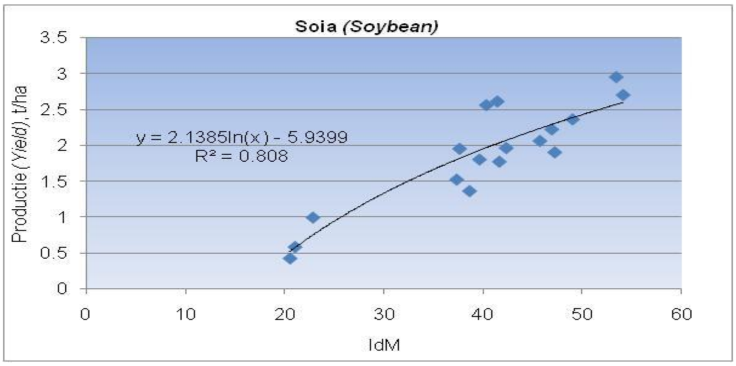

Fig. 4. Correlation between the values of the de Martonne aridity index (IdM) and yields in soybean crop, Oradea 2008-2010

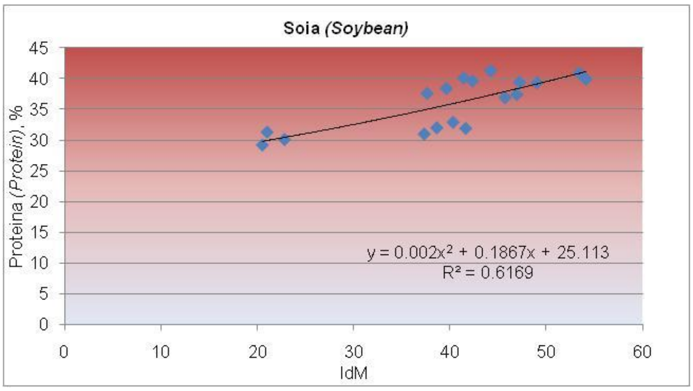

Fig. 5. Correlation between the values of the de Martonne aridity index (IdM) and the protein content of the soybean grains, Oradea 2008-2010

Correlation plant water consumption-yield

For maintaining the soil water reserve on 0-75 cm depth between easily available water content and field capacity, the following irrigation rates were used: 2900 m^3/ha in 2008, 3350 m^3/ha in 2009 and 4300 m^3/ha in 2010. Optimum irrigation determined the increase of the total water consumption by 45% in 2007, by 69% in 2008 and by 50% in 2009. Irrigation suspension determined lower values of the total water consumption (table 3).

Table 3

Total water consumption,∑(e+t), in unirrigated and irrigated soybean and covering sources in the conditions from Oradea, 2008-2010

Variant	∑(e+t)			*Covering sources*					
				Ri-Rf		Pv		∑m	
	m^3/ha	%	%	m^3/ha	%	%	m^3/ha	m^3/ha	%
2008									
Unirrigated	4530	100	-	754	100	-	3776	-	-
Irrigated, without suspending irrigation	6566	145	100	-110	-	100	3776	2900	100
Irrigated, suspending irrigation in May, vegetative growth	6186	137	94	-90	-	-	3776	2500	86
Irrigated, suspending irrigation in June, vegetative growth – flowering	5815	129	89	-161	-	-	3776	2200	76
Irrigated, suspending irrigation in July, flowering – grains filling	5799	128	88	123	16	123	3776	1900	66
Irrigated, suspending irrigation in August, grains feeling – the start of grains maturing	6020	133	92	-56	-	-	3776	2300	79
2009									
Unirrigated	4715	100	-	1695	100	-	3020	-	-
Irrigated, without suspending irrigation	7978	169	100	608	36	100	3020	3350	100
Irrigated, suspending irrigation in May, vegetative growth	6487	138	81	617	36	102	3020	2850	85
Irrigated, suspending irrigation in June, vegetative growth – flowering	6110	130	77	790	47	130	3020	2300	69
Irrigated, suspending irrigation in July, flowering – grains filling	6341	135	80	971	57	160	3020	2350	70
Irrigated, suspending irrigation in August, grains feeling – the start of grains maturing	6300	134	79	930	55	153	3020	2350	70
2010									
Unirrigated	5085	100	67	2545	100		2540	-	-
Irrigated, without suspending irrigation	7608	150	100	768	30	100	2540	4300	57
Irrigated, suspending irrigation in May, vegetative growth	7149	141	94	709	28	92	2540	3900	55
Irrigated, suspending irrigation in June, vegetative growth – flowering	7131	140	94	791	31	103	2540	3800	53
Irrigated, suspending irrigation in July, flowering – grains filling	6640	131	87	1000	39	130	2540	3100	47
Irrigated, suspending irrigation in August, grains feeling – the start of grains maturing	6503	128	85	963	38	125	2540	3000	46

A direct link, statistically assured was quantified between the plants water consumption and soybean yields. (fig. 6).

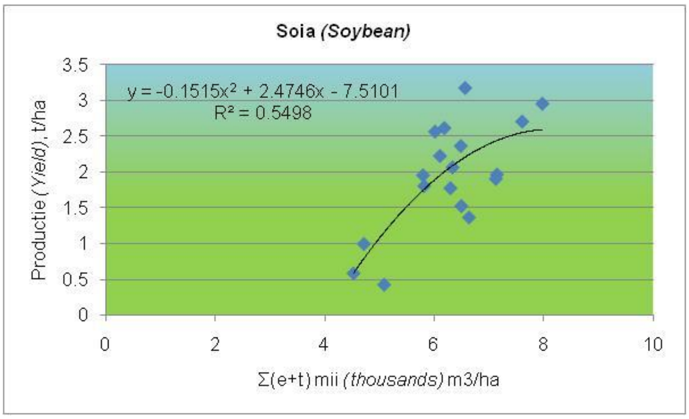

Fig. 6. Correlation water consumption-yield in soybean, Oradea 2008-2010

CONCLUSIONS

The researches carried out in 5 variants with irrigation and in unirrigated soybean led to following conclusions regarding the relationships within the soil-water-plants-atmosphere system:

- Pedological drought was determined every year of the studied period as well as the reverse link between this indicator and yield quantity and yield quality of the soybean grains.
- Irrigation determined the improvement of the microclimate conditions and direct links, statistically assured, were quantified between the values of the climate indicator “de Martonne aridity index” and plants water consumption, yield quantity and yield protein content.
- Plants water consumption increased in the irrigated variants and a direct link statistically assured was quantified between water consumption and yield.

All the relationships quantified in the soil-water-plants system support the need for the irrigation of soybean crop in Crişurilor Plain.

Acknowledgments

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