THE IRRIGATION INFLUENCE ON SOYBEAN IN THE CRISURILOR PLAIN CONDITIONS

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Abstract: *This paper based on the researches carried out during 2006-2008 in Agricultural Research and Development Station Oradea on a preluvosoil. All the soil profile 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 30 years of good soil management, good practices 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 source of irrigation water was a drill of 15 m depth. Irrigation water quality was very good: pH = 7.2; Na^+ = 12.9; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.Ten to ten days determination of the soil moisture on 0-75 cm depth emphasized the presence of the pedological drought every year: 39 days in 2006; 104 days in 2007 and 81 days in 2008; soil moisture decreased below wilting point every year too: 5 days in 2006 and 2008 and 6 days in 2007.Irrigation use – 1100 m^3/ha in 2006, 2900 m^3/ha in 2007, 3350 m^3/ha in 2008 – for maintaining the soil water reserve between easily available water content and field capacity determined the improve of the soybean microclimate. The values of de Mrtonne aridity index (IdM) fpor optimum irrigated soybean characterized the microclimate like „wet" in 2006 (IdM = 45.2) and 2007 (IdM = 44.2) and like „wet I" in 2008 (IdM = 53.4). Irrigation suspending in the different months of the soybean irrigation season determined a smaller values of IdM and a worse microclimate, too.The biggest soybean yield were obtained in the irrigated variant without irrigation suspending in the soybean irrigation season: 3510 kg/ha in 2006, 3170 kg/ha in 2007 and 4050 kg/ha in 2008. In comparison with this variant the yield losses from unirrigated variant were of 25.4% in 2006; of 81.7% in 2007 and of 66.6.% in 2008; the yield losses are very significant statistically. Very significant statistically are the yield losses from the variants with irrigation suspending in the months of soybean irrigation season, too.The inverse link between pedological drought and yield and the direct link between de Martonne and yield sustain, too the need of the irrigation for pedological drought control and for microclimate improve in soybean from Crişurilor Plain.*

Key words**:** *soybean, yield, pedological drought, irrigation suspending, de Martonne aridity index*

INTRODUCTION

Pedological drought is defined like a situation when the soil moisture on watering depth (fixe one, or variable one) is situated bellow easily available water content; when the soil moisture decreased bellow wilting point a very strong pedological drought is considered (DOMUȚA C., 2005). Wilting point is defined like a point into interval and not like a fixe point (CANARACHE A. 1990).

A possibility to characterize the crop microclimate is offered by climate indicators (GRUMEZa N. et al, 1989; GRUMEZA N . and KLEPŞ CR., 2005, MAN T.E. and all, 2007). There are the indicators wich include one climate elements (rainfall-Topor index), two elements (rainfall and temperature – de Martonne aridity index, Seleaninov coefficient), or thre elements (rainfall, temperature, sun brilliance – Domuța hydroheliothermic index)

The first researches regarding the soybean irrigation was started in 1976 by Stepănescu E. and Mihăilescu V. (DOMUȚA C. 1995, 2003, 2009) in the Girişu de Criş.

Researches regarding the effect of the irrigation suspending in different vegetatuion period of the soybean were made by TUŞA C., 1997)

MATERIAL AND METHODS

The researches were carried out during 2007-2009 in Agricultural Research and Development Station Oradea on a preluvosoil.

All the soil profile 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 30 years of good soil management, good practices 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. There are a big hydro stability (47.5%) of the aggregates (φ = 0.25 mm) on ploughingland and bulk density (1.41 g/cm^3) indicates a low settling and total porosity is median. On the subjacent depth of the ploughing layer bulk density characterizes the soil like moderate and very settled and total porosity is small and very small. Hydraulic conductivity is big (21.0 mm/h) on 0-20 cm; median (10.5 mm/h; 4.4 mm/h) on 20 – 40 cm and 40 – 60 cm and very small (1.0 mm/h) on 60 – 80 cm.

The source of irrigation water was a drill of 15 m depth. Irrigation water quality was very good: pH = 7.2; Na^+= 12.9; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

During the soybean vegetation period the rainfall registered were of 349.9 mm in 2006, of 377.6 mm in 2007 and of 302,0 mm in 2008. During the agricultural year the following rainfall were felt: 684.7 mm in 2006, 556.1 mm in 2007, 585.7 mm in 2008; multianual average (1931-2005) of rainfall for Oradea is of 621.1 mm.

The following variants were studied: V_1 = unirrigated; V_2 = Irrigated without the irrigation suspending in the maize irrigation season; V_3 = Irrigated, with irrigation suspending in May, V_4 = Irrigated, with irrigation suspending in June; V_5 = Irrigated, with irrigation suspending in July; V_6 = Irrigated, with irrigation suspending in August. The surface of the experiment plot was 50 m^2. Number of repetition = 4; Irrigation method used was sprinkler with modifications for rectangular plots. Cultivar used: Agat. Fertilization system: $N_{60}P_{90}K_{60}$.

Soil moisture of 0 – 75 cm depth was determined ten to ten days and monthly on 0 – 150 cm depth. In the variant without irrigation suspending the moment of the irrigation use was when the soil water reserve on 0 – 75 cm depth decreased to easily available water content. In the variant with irrigation suspending in different months didn't irrigate in these months.

De Martonne aridity index (IdM) was calculated using the following formula:

$$I_{dM} = \frac{12 \cdot p}{t + 10}$$ in wich:

p = monthly rainfall, mm; t = air average temperature, °C; 12; 10 = coeficients

In irrigated conditions, irrigation rate was added to the rainfall, and the data interpretation was realized after the classes purposed by Domuța (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 (DOMUȚA C., 2006)

RESULTS AND DISCUSSIONS

Pedological drought in soybean

The graphs of the soil water reserve on 0-75 cm depth emphasized the values bellow easily available water content every year in unirrigated conditions: 39 days in 206, 104 days in 2007 and 81 days in 2008 (table 1)

The irrigation was needed in 2006 only in July and irrigation suspending in this month determined a pedological drought in 36 day, 27 days in July and 9 days in August. In 2007, in

unirrigated soybean, the pedological drought was presented starting with April and the biggest value was registered in June, unusually phenomen for this area because June is the month with maximum rainfall of the year. Irrigation suspending determined the pedological drough in that month and a few daysin the next month; this phenomen was presented every year. In 2008, pedological drought started in May and maximum value (31 days) was registered in August.

Table 1

Number of days with pedological drought in soybean from different water provisionment variants, Oradea 2007-2009

Variant	Month					IV-VIII
	IV	V	VI	VII	VIII	
2007						
V_1	0	0	0	0	0	0
V_2	0	0	0	0	0	0
V_3	0	0	0	0	0	0
V_4	0	0	0	27	9	36
V_5	0	0	0	0	0	0
V_6	0	0	0	29	10	39
2008						
V_1	0	0	0	0	0	0
V_2	0	14	1	0	0	15
V_3	0	0	16	2	0	18
V_4	0	0	0	17	5	22
V_5	0	0	0	0	20	20
V_6	8	24	26	25	21	104
2009						
V_1	-	0	0	0	0	0
V_2	0	6	0	0	0	6
V_3	0	0	18	0	0	18
V_4	0	0	0	21	0	21
V_5	0	0	0	0	27	27
V_6	0	6	20	24	31	81

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated, irrigation suspending in May (vegetative growth)
V_3 = Irrigated, irrigation suspending in June (vegetative growth - flowering)
V_4= Irrigated, irrigation suspending in July (flowering- grains fill)
V_5 = Irrigated, irrigation suspending in August (grains fill- grains start maturing)
V_6 = Unirrigated

The soil water reserve on 0-75 cm depth decreased bellow wilting point every year: 5 days in July in 2007, 4 days in July and 2 days in August in 2008, 5 days in August in 2009. (table 2)

Table 2

Number of days with strong pedological drought in unirrigated soybean, Oradea 2007-2009

Year	IV	V	VI	VII	VIII	IV-VIII
2007	0	0	0	5	0	5
2008	0	0	0	4	2	6
2009	0	0	0	0	5	5

Optimum irrigation regime

Maintaining the soil water reserve between easily available water content and field capacity determined to use the irrigation rates of 1100 m^3/ha in 2007, of 2900 m^3/ha in 2008 and of 3350 m^3/ha in 2009; the number of rates was of 3 in 2007 and of 8 in 2008 and 2009 (table 3).

The maximum value of the monthly irrigation rate was needed in July, 1100 m^3/ha in 2007 and 1000 m^3/ha in 2008 and 2009.

Table 3

Irrigation regime of the soybean in different variants with water provisionment, Oradea 2007-2009

Variant	IV		V		VI		VII		VIII		IV-VIII	
	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n
2007												
V_1	-	-	-	-	-	-	1100	3	-	-	1100	3
V_2	-	-	-	-	-	-	1100	3	-	-	1100	3
V_3	-	-	-	-	-	-	1100	3	-	-	1100	3
V_4	-	-	-	-	-	-	-	-	-	-	-	-
V_5	-	-	-	-	-	-	1100	3	-	-	1100	3
2008												
V_1	200	1	400	1	700	2	100	2	600	2	2900	8
V_2	200	1	-	-	700	2	100	2	600	2	2500	7
V_3	200	1	400	1	-	-	100	2	600	2	2200	6
V_4	200	1	400	1	700	2	-	-	600	2	1900	6
V_5	200	1	400	1	700	2	100	2	-	-	2300	6
2009												
V_1	-	-	500	1	850	2	1000	2	1000	2	3350	8
V_2	-	-	-	-	850	2	1000	2	1000	2	2850	6
V_3	-	-	500	1	-	-	1000	2	1000	2	2500	5
V_4	-	-	500	1	850	2	-	-	1000	2	2350	5
V_5	-	-	500	1	850	2	1000	2	-	-	2350	5

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated, irrigation suspending in May (vegetative growth)
V_3 = Irrigated, irrigation suspending in June (vegetative growth - flowering)
V_4= Irrigated, irrigation suspending in July (flowering- grains fill)
V_5 = Irrigated, irrigation suspending in August (grains fill- grains start maturing)
∑m = Irrigation rate, m^3/ha; n= Number of rates

Irrigation influence on soybean microclimate

The values of de Martonne aridity index (IdM) characterized the unirrigated soybean microclimate like „moderate wet I" in 2007 (IdM = 35,6) and „demiarid" in the year 2008 (IdM= 21.0) and in the year 2009 (IdM = 22.8) (table 4)

Table 4

Values of the de Martonne aridity index (IdM) in different variants of the water provisionment in soybean, Oradea 2007-2009

Variant	IdM		
	Value	%	%
2007			
V_1	35.6	100	-
V_2	45.2	127.0	100
V_3	45.2	127.0	100
V_4	45.2	127.0	100
V_5	35.6	100	79
V_6	45.2	127.0	100
2008			
V_1	21.0	100	-
V_2	44.2	211	100
V_3	41.4	197	94
V_4	39.6	188	90
V_5	37.6	179	85
V_6	40.3	192	91
2009			
V_1	22.8	100	-
V_2	53.4	235	100
V_3	49.0	215	92
V_4	46.9	206	88
V_5	45.7	201	86
V_6	41.6	183	78

V_1 = Unirrigated
V_2 = Irrigated without irrigation suspending
V_3 = Irrigated, with irrigation suspending in May
V_4 = Irrigated, with irrigation suspending in June
V_5= Irrigated, with irrigation suspending in July
V_6 = Irrigated, with irrigation suspending in August

In the variant without irrigation suspending the soybean microclimate was characterized like „wet" in 2007 (IdM= 45.2) and in 2008 (IdM= 44.2) and like „wet I" in 2009 (IdM= 53.4). The relative differences in comparison with unirrigated variant were of 27% in 2007, of 111% in 2008 and of 135% in 2009.

Irrigation suspending in different months of the soybean irrigation season determined the decrease of the values of de Martonne aridity index in comparison with the variant without irrigation suspending.

Irrigation influence on soybean yield

The biggest yields were obtained in the variant without irrigation suspending in the months of the soybean irrigation season: 3510 kg/ha in 2007, 3170 kg/ha in 2008, 4050 kg/ha in 2009. There were the the yield losses very significant statistically in the unirrigated variant: 890 kg/ha (25.4%) in 2007, 2590 kg/ha (81.7%) in 2008, 2700 kg/ha (66%) in 2009 (table 5.)

The irrigation suspending in the months of the soybean irrigation season determined the yield losses very significant statistically, in comparison with the variant without irrigation suspending. Irrigation suspending in June and July determined the biggest yield losses in 2008 and irrigation suspending in August determined the biggest yield loss in 2009.

Table 5

Influence of the irrigation suspending in different months of the soybean irrigation season on yield, Oradea 2007-2009

Variant	Yield		Difference		Statisticaly significant
2007					
V_1	3510	100	-	-	Mt
V_2	3490	99.4	-20	-0.6	-
V_3	3460	98.6	-50	-1.4	-
V_4	2610	74.4	-900	-25.6	ooo
V_5	3530	100.6	20	0.6	-
V_6	2620	74.6	-890	-25.4	ooo
LSD 5%= 180 LSD 1%= 312 LSD 0.1%= 560					
2008					
V_1	3170	100	-	-	Mt
V_2	2610	82.3	-500	-17.7	oo
V_3	1800	56.8	-1370	-43.2	ooo
V_4	1950	61.5	-1220	-38.5	ooo
V_5	2560	80.8	-610	-19.2	ooo
V_6	580	18.3	-2590	-81.7	ooo
LSD 5%= 150 LSD 1%= 310 LSD 0.1%= 580					
2009					
V_1	4050	100	-	-	Mt
V_2	3240	80.0	-810	-20	ooo
V_3	3040	75.1	-1010	-24.9	ooo
V_4	2830	69.9	-1220	-30.1	ooo
V_5	2430	60.0	-1620	-40.0	ooo
V_6	1350	33.4	-2700	-66.6	ooo
LSD 5%= 190 LSD 1%= 382 LSD 0.1%= 624					

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated, irrigation suspending in May (vegetative growth)
V_3 = Irrigated, irrigation suspending in June (vegetative growth - flowering)
V_4= Irrigated, irrigation suspending in July (flowering- grains fill)
V_5 = Irrigated, irrigation suspending in August (grains fill- grains start maturing)
V_6 = Unirrigated

Correlation between pedological drought and yield

An inverse link, very significant statistically, was quantified betwen number of days with soil water reserve on 0-75 cm bellow easily available water content and yields obtained in

the studied variants. The correrlation coefficient of the exponential function ($y=3.504e^{-0.0147x}$) had the biggest value ($R^2= 0.84$) (figure 1) for polynomial function, the correlation coefficient was of $R^2= 0.79$ and for linear function the correlation coefficient was of $R^2=0.77$ (fig.1)

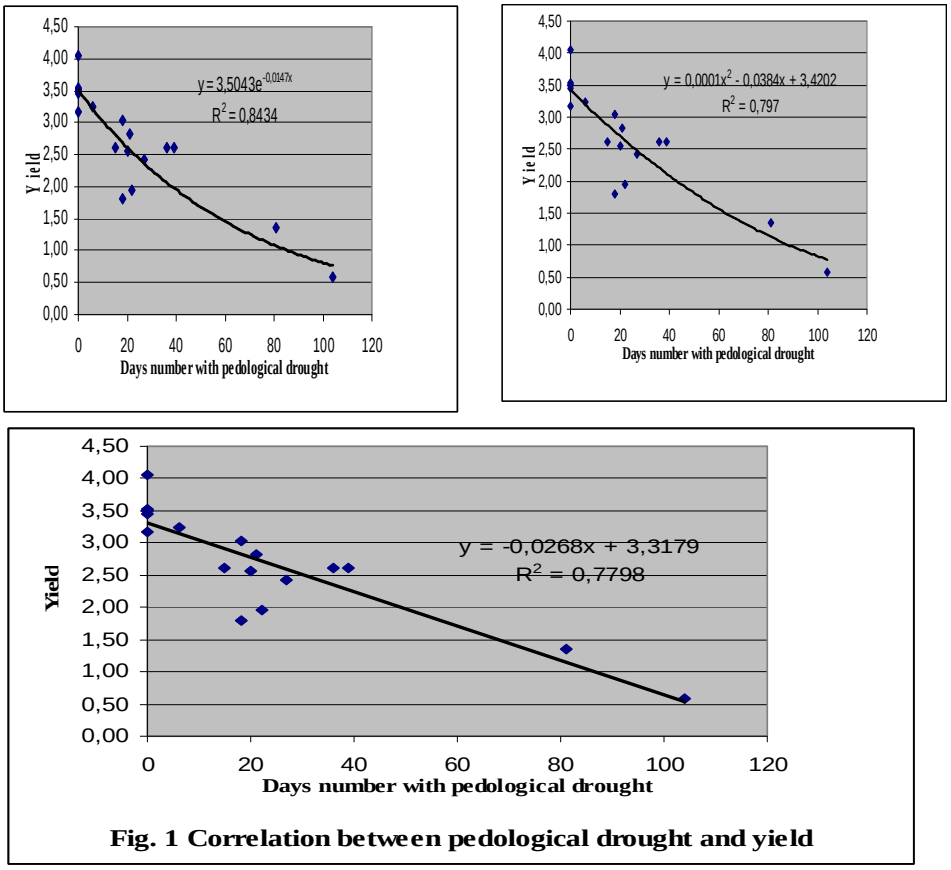

Fig. 1 Correlation between pedological drought and yield

Correlation between de Martonne aridity index and yields

There is a direct link between the values of the Martonne aridity index and soybean yield and the best quantification was obtained using the power function: $y= 0.004x^{1.7223}$; $R^2= 0.83$ (figure 2) The other correlations coefficient were: $R^2= 0.82$ for polynomial function, $R^2= 0.81$ for linear function; $R^2= 0.79$ for logaritmic function.

CONCLUSIONS

Ten to ten determinations of the soil moisture emphasized the decrease of the soil moisture on 0-75 cm bellow easily available water content and pedological drought was prezented in unirrigated soybean: 39 days in 2007, 104 days in 2008 and 81 days in 2009. Soil moisture decrease bellow wilting point 5 days in 2007, 6 days in 2008, 5 days in 2009.

Irrigation use – 1100 m^3/ha in 2007, 2900 m^3/ha in 2008, 3350 m^3/ha in 2009 – for maintaining the soil water reserve between easily available water content and field capacity

determined the improve of the soybean microclimate. The values of de Mrtonne aridity index (IdM) fpor optimum irrigated soybean characterized the microclimate like „wet" in 2007 (IdM = 45.2) and 2008 (IdM = 44.2) and like „wet I" in 2009 (IdM = 53.4). Irrigation suspending in the different months of the soybean irrigation season determined a smaller values of IdM and a worse microclimate, too.

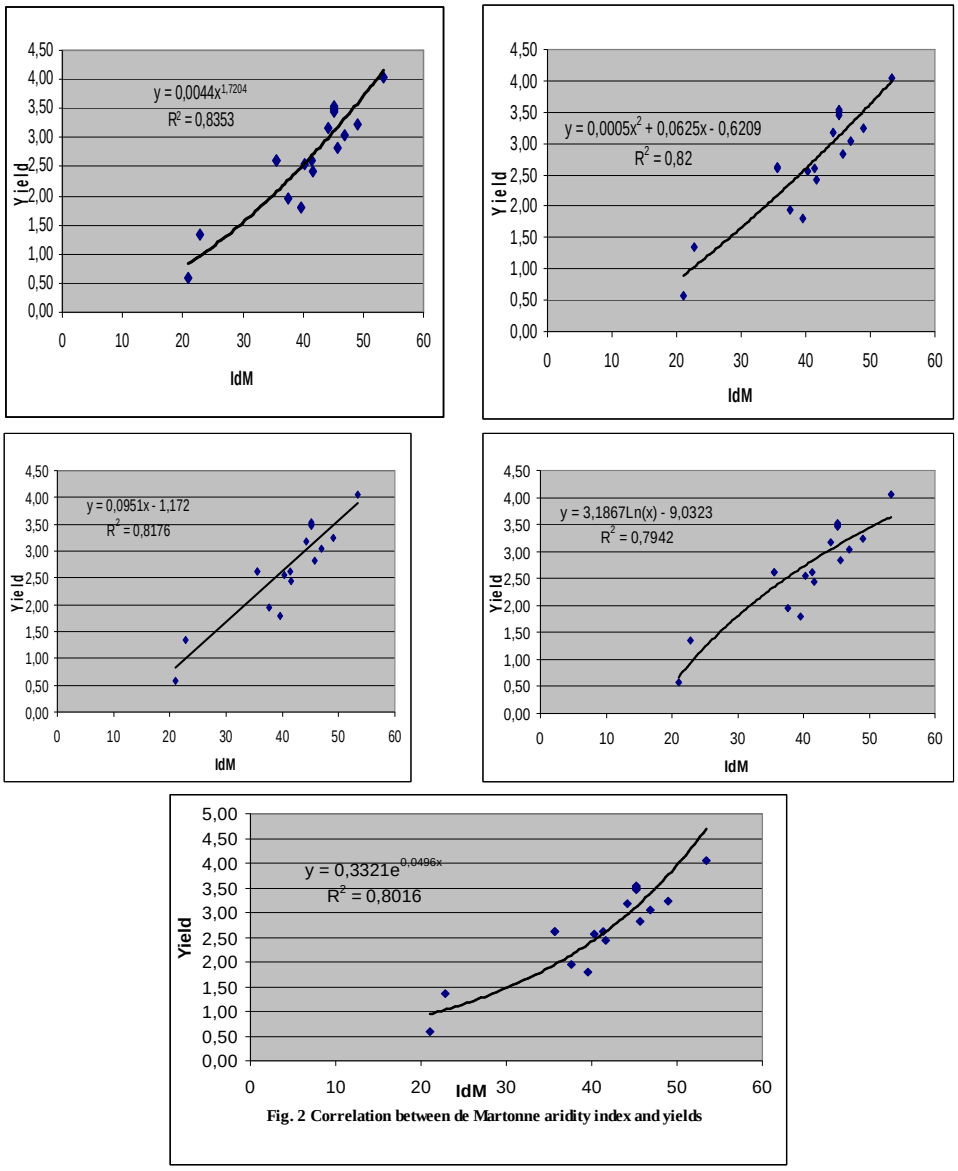

Fig. 2 Correlation between de Martonne aridity index and yields

The biggest soybean yield were obtained in the irrigated variant without irrigation suspending in the soybean irrigation season: 3510 kg/ha in 2007, 3170 kg/ha in 2008 and 4050

kg/ha in 2009. In comparison with this variant the yield losses from unirrigated variant were of 25.4% in 2007; of 81.7% in 2008 and of 66.6.% in 2009; the yield losses are very significant statistically. Very significant statistically are the yield losses from the variants with irrigation suspending in the months of soybean irrigation season, too.

The inverse correlation between number of days with pedologiacal drought and yield and the direct link between the values of the de Martonne aridity index and yield sustain the irrigation opportunity in soybean from Crisurilor Plain.

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