THE INFLUENCE OF IRRIGATION ON THE SOIL – WATER – PLANT SYSTEM RELATIONSHIPS IN THE MAIZE CROP FROM THE CRISURILOR PLANE

INFLUENTA IRIGAȚIEI ASUPRA RELAȚIILOR DIN SISTEMUL SOL – APĂ – PLANTĂ LA CULTURA PORUMBULUI DIN CÂMPIA CRIŞURILOR

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Abstract *The paper is based on the decadal determinations of the soil moisture and the dynamics graphs of the soil water reserve on the watering depth. These show the decrease of the soil water reserve under the easily available water content every year, and in ten years under the wilting point. An inverse correlation between the number of days with pedological drought and maize yield very significant statistically was quantified; a direct correlation between the number of days with drought and the yield gain was also quantified. Irrigation determined an improvement of the conditions of the microclimate (water consumption and water use efficiency). The correlations quantified in the soil – water – plant – atmosphere system sustain the opportunity of maize irrigation the Crisurilor Plane.*

Rezumat*: Lucrarea se bazează pe determinările decadale ale umidității solului şi graficele dinamicii rezervei de apă din sol pe adâncimea de udare. Acestea evidențiază scăderea rezervei de apă din sol sub plafonul minim în fiecare an, iar în 10 ani şi sub coeficientul de ofilire. A fost cuantificată o corelație inversă între numărul de zile cu secetă pedologică şi producția de porumb, foarte semnificativă din punct de vedere statistic; s-a mai cuantificat o corelație directă între numărul de zile cu secetă şi sporurile de producție. Irigația a determinat o îmbunătățire a condițiilor de microclimat (consum de apă şi eficiența valorificării apei). Corelațiile cuantificate în sistemul sol-apă-plantă-atmosferă susțin oportunitatea irigării porumbului în Câmpia Crişurilor.*

Keywords: *wilting point, easily available water contet, field capacity, irrigation, maize, yield*
Cuvinte cheie: *coeficient de ofilire, plafon minim, capacitate de câmp, irigație, porumb, producție*

INTRODUCTION

The relationship from the soil – water – plant – atmosphere system can be emphasized by various indicators: number of days with soil water reserve bellow easily available water content, number of days with soil water reserve bellow wilting point, plants water consumption, water use efficiency (DOMUTA C, 2003). The paper analyzes the influence of the irrigation on these parameters based on the results of the research obtained in the long term trial for water consumption determination from Oradea.

MATERIALS AND METHODS

The researches were carried out on the preluvosoil from Oradea. This soil has a good structure degree (47.5%). On soybean watering depth (0-75 cm), the wilting point value is of 10.1% (1158 m^3/ha), and the field capacity is of 24.2% (2782 m^3/ha). The clay content determined the easily available water content of 2/3 from a difference between field capacity and wilting point, the value of this parameter is 19.5% (2240 m^3/ha).

The number of days with soil water reserve on 0 – 75 cm bellow easily available water content and bellow wilting point were established based on the bimonthly soil moisture determinations and after that on the graphs with soil water reserve dynamics realized every

year. The water consumption was determined by using the soil water balance method on 0 – 150 cm using the following formula:

$$IR + Rv + \Sigma m = FR + \Sigma (e+t)$$

In which: IR = initial water reserve, m³/ha; Rv= Rainfall during the vegetation period, m³/ha; Σm= irrigation rate, m³/ha; Σ (e+t) = water consumption, m³/ha;

Water use efficiency was determined emphasizing the quantity of yield obtained for 1m³ of water (WUE) and the quantity of water used for 1 kg yield (CWUE).

In order to characterize the relation between the plant – atmosphere subsystem the climate indicator"Domuta climate index" (ICD) was used:

$$ICD = \frac{100W + 12.9A}{\sum T + Sb}$$

In which: w= water (rainfall, irrigation, groundwater) mm; A= air humidity (%); t= average temperature (ºC); Sb= sun brilliance. The characterization limits for ICD are:<3 excessive drought; 3,1 – 5 very droughty; 5,1 – 7 drought; 7,1 – 9 median drought; 9,1 – 12 median wet; 12,1 – 15 wet I; 15,1 – 18 wet II; 18,1 – 25 wet III; >25 excessive wet. Other researches (Sabau et all, 1008, Palcut N 2003, Sabau and all 2002, Petrescu E. 2005, referenced by Domuța C., 2005) recommend these indexes in what concerns the results obtained when compared to the de Martonne aridity index, Palfai aridity index.

RESULTS AND DISCUSSIONS

In the days with the soil water reserve under the easily available water on the watering depth (0-75 cm for maize in the Crisurilor Plane), yield losses occur. The analysis of the research data emphasizes the presence of the soil hydric stress in unirrigated maize every year; the month with the biggest frequency of the phenomenon was August; the biggest number of days with soil water reserve bellow easily available water content on watering depth was August, too. (table 1)

Table 1

Number of days with soil water reserve bellow easily available water content (WEA) on 0 – 75 cm, in unirrigated maize, Oradea 1976 – 2007

Specification	Month						Period
	IV	V	VI	VII	VIII	IX	IV - VIII
Number of days with WR < WEA on 0 – 75 cm	1,7	8,6	14,4	23,5	29,3	25,8	78
Years frequency with WR < Wea	14	41	79	89	100	93	100

Number of days with soil water reserve below wilting point on watering depth

Researches were made along the time established that in the field conditions soil moisture can decrease bellow wilting point without any plants dying. (Simota H 1959 referenced by Canarache in 1990; Domuta C 1995, Tusa C, 1997, Petrescu E, 1999, Domuta C and all 2000, Domuta C, 2005). In the conditions from Oradea, soil water reserve on 0 – 75 cm decreased bellow easily available in 34% of the years studied. August was the month with the biggest frequency of the phenomenon. (table 2)

Table 2

Number of days with soil water reserve (WR) below wilting point on 0 – 75 cm in unirrigated maize, Oradea 1976 – 2007

Specification	Month						Period
	IV	V	VI	VII	VIII	IX	IV – VIII
Number of days with WR < WP on 0 – 75 cm	-	-	-	3,3	7,6	4,5	11
Frequency of the years with WR < WP on 0 – 75 cm	-	-	-	28	34	24	34

Irrigation influence on maize microclimate

The decrease of soil water reserve on watering depth bellow easily water content every year and optimum water supply of the plants required the use of irrigation every year. The variation interval of the irrigation rate was of 480 – 4390 m³/ha. Irrigation determined the improve of the microclimate conditions; after the Domuta climate index , the values of the microclimate were wet II (15,5) in irrigated conditions, and median wet II (19,7) in unirrigated conditions. The biggest differences between irrigated and unirrigated variants (104.1% and 92.7%) were registered in August and July. The variation interval of the relative differences between ICD from the irrigated and unirrigated maize is the biggest in August, 28 – 3126%, other large intervals were registered in July 0 – 795%. (table 3).

Table 3

Irrigation influence of the maize microclimate (Domuta climate index, ICD), Oradea 1976 – 2007

Variant	Month				Period V - VIII
	V	VI	VII	VII	
Unirrigated	9.8	11.9	9.7	7.3	9.7
Irrigated	12.1	16.1	18.7	14.9	15.5
Variation interval of the differences %	0 – 383	0 - 302	0 - 795	28 - 3126	-

The irrigation influence on the maize water consumption

Daily water consumption of the irrigated maize increased in comparison with unirrigated variant with 84% in August (49,2% m³/ha/day vs 26,7 m³/ha/day) with 69% in September (26,7 m³/ha/day vs 15,6 m³/ha/day), with 52% in July (60,5 m³/ha/day vs 39,8 m³/ha/day), with 25% in June (45,1 m³/ha/day vs 36,1 m³/ha/day) with 18% in May (30,3 m³/ha/day vs 25,7 m³/ha/day).

As a consequence, the total water consumption of the irrigated maize increased with 46%, variation interval 9 – 145%. In the optimum water consumption of the maize crop, irrigation participated every year, the variation interval of the participation was of 7.4 – 61.2 %. (table 4).

Table 4

Influence of the irrigation on the total water consumption of the maize, Oradea 1976 – 2007

Variant	Σ(e+t)	Covering sources of the Σ(e+t)				
					Σ	
	m³/ha	Variation interval	SWR m³/ha	RV m³/ha	m³/ha	Var. interval %
1. Unirrigated	4308	100	1050	3528	-	-
2. Irrigated	6255	109 – 245	548	3258	2449	7,4 – 61,2

SWR = soil water reserve; RV = rainfall during vegetation period; Σm = irrigation rate.

The water use efficiency

Irrigation determined an average yield of 12078 kg/ha vs 6737 kg/ha in unirrigated conditions. The differences were very significant every year and relative differences were between 7% and 812%. In these conditions for every m³ of water used, 1.93 kg of yield were obtained in irrigated conditions, with 23.8% more than in unirrigated conditions. For 1 kilo yield in irrigated conditions a smaller quantity of water was used, 0.52 m³/kg vs 0.67 m³/ha. The results demonstrate a better use of the water in the irrigated variant. (table 5)

Table 5

Variant	WUE		CWUE	
	Kg/m³	%	m³/kg	%
Unirrigated	1.56	100	0.67	100
Irrigated	1.93	123.8	0.52	77.6

The inverse links statistically assured were quantified between easily available water content and yield (y=158.882 R^2 = 0.54^{oo}) between wilting point and yield (y=601.33x, R^2 = 0.77^{ooo}).

The direct links statistically assured, were quantified between Domuta climate index and yield (y=0.2931x^2+13.575x-21.108; R^2=0.6) and between water consumption and yield (y=0.0004x^2+0.6312x-124.48; R^2=0.59).

CONCLUSIONS

Hydro physics indexes are the parameters of the soil – water – plant – atmosphere system and bimonthly determinations of soil moisture determination and the graphs of the soil water reserve dynamic emphasized the decrease of the soil water reserve on 0 – 75 cm bellow easily available content every year in 34% of the years bellow wilting point too. Inverse links, statistically assured, were quantified between these indexes and yields and a direct link between available water content and yield gain produced by irrigation was also quantified.

Irrigation determined the improve of the water/temperature + light ratio (Domuta climate index) and the inverse of the water consumption index, and the increase of the water consumption values. In the optimum water consumption irrigation represented 7.4% - 61.2%. Direct links, statistically assured were quantified between the Domuta climate index and yield, respectively water consumption and yield.

Irrigation determined very significant yield gains, also significant statistically and the difference compared to the unirrigated variant was of 7 and 812%. Irrigation determined the increase of the quantity of yield obtained for 1 m³ water used and the decrease of the quantity of water used for every 1 kilo yield.

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