THE INFLUENCE OF THE IRRIGATION SUSPENDING ON WATER CONSUMPTION, YIELD AND ON WATER USE EFFICIENCY IN MAIZE INTHE CRIŞURILOR PLAIN CONDITION

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Abstract

The paper researches were carried out during 2007-2009 in Agricultural Research and Development Station Oradea in an experiment with the following variants: unirrigated, optimum irrigated, irrigation suspending in May, June, July or August. Irrigation suspending in different months of the vegetation period determined to obtain a smaller values of the daily water consumption and smaller values of the regression function; the values of the total water consumption decreased and finally the yields losses assured statistically were obtained. The water use efficiency had smaller values in the variants with irrigation suspending in comparison with the variant without irrigation suspending.

Keywords: maize, irrigation suspending, water consumption, yield, water use efficiency

INTRODUCTION

The Crişurilor Plain occupies the central part of the Western Plain of Romania and maize and wheat are cropped on the biggest surfaces (Borza 2006, 2007). The first researches from this area regarding the maize irrigation were started on the chernozem from Girişu de Criş in 1967 by Stepănescu and Mihăilescu, Domuţa, 2003b (Domuţa, 2010).

The researches regarding the irrigation participation in the total water consumtion from in the Crişurilor Plain were carried out during 1976-2010 on the preluvosoil from Oradea in the research field from soil water balance study. The results researches emphasized the need of the irrigation in the optimum water consumption, the increase of the water consumption and yields gains very significant statistically in irrigated variant vs. unirrigated variant. Most of the years, the water use efficiency improved under the irrigated variant (Domuţa, 1995, 2003, 2005, 2009, Grumeza, Kleps, 2005). The researches from the other areas emphasize the positive influence of the irrigation on water use efficiency (Stan, Năescu, 1997 Nagy, 2010, Pakurar et al., 2010).

Irrigation suspending in different months of the vegetation period determines the yield losses and the smaller water use efficiency (Borza, 2007, Domuţa, 2010).

MATERIAL AND METHODS

The paper based on the researches were carried out in Agricultural Research and Development Station Oradea during 2007-2009 on the preluvosoil. There is a big hydro stability (47.5%) of the aggregates (Φ = 0.25 mm) on ploughingland; bulk density (1.41 g/cm^3) indicates a low settling and total porosity is median; hydraulic conductivity is big (21.0 mm/h) on 0-20 cm. The watering depth (0-75 cm) was a fixed one (Grumeza N. et al., 1989) and field capacity (FC = 24.2% = 2782 m^3/ha) and wilting point (WP = 10.1 = 1158 m^3/ha) have median values. Easily available water content (Wea) was established in function of texture: Wea = WP + 2/3 (FC – WP); (Domuţa, 2009); their values for 0-75 cm are 19.5% and 2240 m^3/ha.

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

In comparison with multiannual average (1931-2005) of 621.1 mm during the studied period the annual rainfall were of 684.7 mm in 2006; of 556.1 mm in 2007 and of 585.7 mm in 2008.

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, 4-9 leaves, V_4 = Irrigated, with irrigation suspending in June, 10-18 leaves; V_5 = Irrigated, with irrigation suspending in July, tassel growth – grains filling; V_6 = Irrigated, with irrigation suspending in August, grains filling-ripening. 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: Fundulea 376. Fertilization system: $N_{120}P_{90}K_{60}$.

Soil moisture of 0 – 75 cm depth was determined ten to ten days. 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.

Water consumption was determined using the soil water balance method and water use efficiency was determined like report between field and water consumption.

Results research was processed by variance analysis and with the regression functions (Domuța, 2006)

RESULTS AND DISCUSSIONS

Irrigation regime in the studied variants

In the variant without irrigation suspending, to maintain the soil water reserve between easily available water content on 0-75 cm depth determined to use the following irrigation rate: 2950 m^3/ha in 2007, 3320 m^3/ha in 2008 and 4200 m^3/ha in 2009. In the variant with irrigation suspending the values of the irrigation rate decreased. (table 1)

Table 1

Irrigation (Σm) and number (n) of rates used in maize crop from different variants, Oradea 2007-2009

Variant	2007		2008		2009	
	Σm	n	Σm	n	Σm	n
Irrigated, without suspending irrigation	2950	8	3320	8	4200	9
Irrigated, suspending irrigation in May	2550	7	2820	6	3300	7
Irrigated, suspending irrigation in June	2450	7	2300	5	3700	8
Irrigated, suspending irrigation in Julyt	1750	4	2220	5	2900	6
Irrigated, suspending irrigation in August	2400	6	2620	6	3200	7

The influence of irrigation suspending on maize water consumption

The irrigation determines the increase of the daily water consumption of the maize (Domuța, 1995, 2005, 2009, Domuța, 2010). In the all irrigated variants studied the values of the water consumption increased in comparison with the values from unirrigated variant. Mathematical modellation of the daily water consumption indicated that the biggest value of the regresion function was obtained in the variant without irrigation suspending and the smallest in the unirrigated variant. (figure 1)

The irrigation determined the increase of the total consumption value vs. unirrigated variant with the values between 39% (in the variant with irrigation suspending in July) and 59% (in the variant without irrigation suspending). Irrigation suspending determined the decrease of the total water consumption till 13% (in the variant with irrigation suspending in July) (table 2)

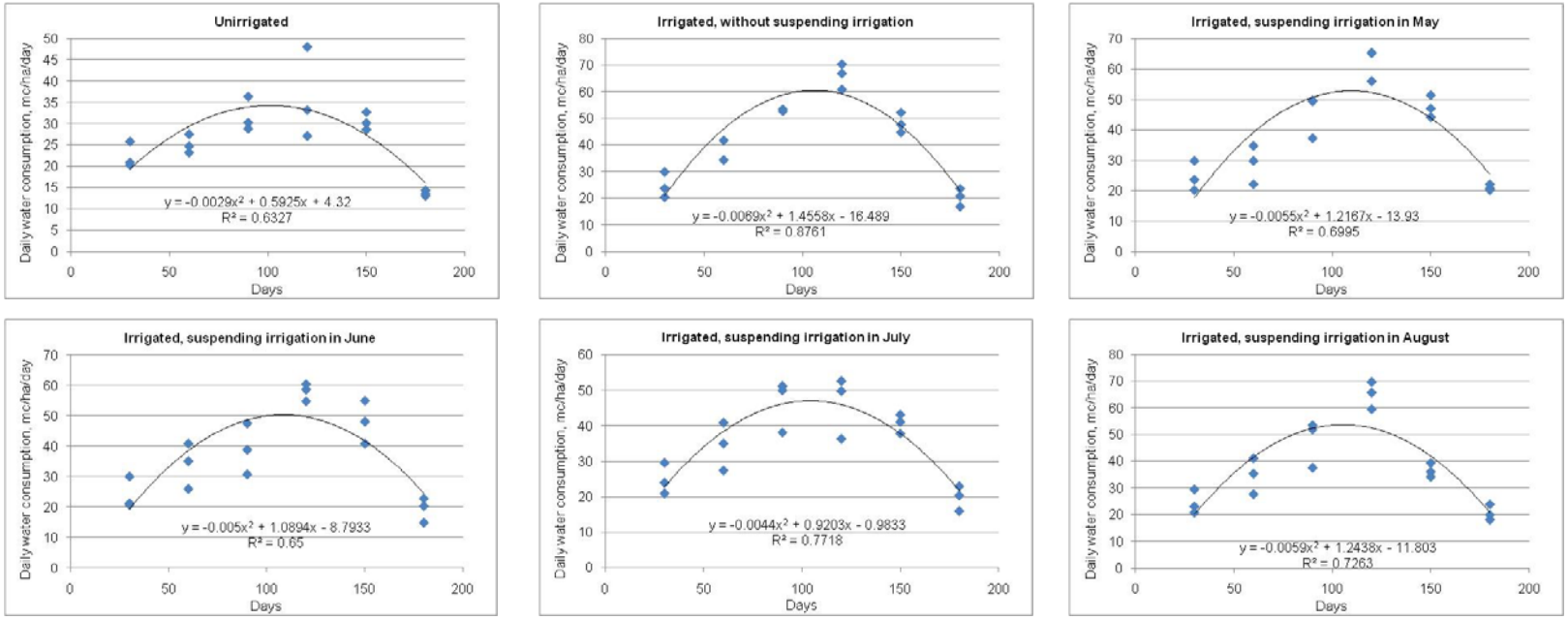

Fig. 1 Regression function of the maize daily water consumption in the studied studied variant, Oradea 2007-2009

Table 2

Total water consumption (Σm) and covering sources in maize crop, Oradea 2007-2009

Variant	Σ(e+t)			Covering source (m^3/ha)		
	m^3/ha	%	%	Soil water reserve	Rainfall	Σm
Unirrigated	4501	100	63	1347	3154	-
Irrigated without the irrigation suspending in the maize irrigation season	7142	159	100	498	3154	3490
Irrigated, with irrigation suspending in May, 4-9 leaves	6716	149	94	672	3154	2890
Irrigated, with irrigation suspending in June, 10-18 leaves	6739	150	94	767	3154	2817
Irrigated, with irrigation suspending in July, tassel growth – grains filling	6239	139	87	802	3154	2283
Irrigated, with irrigation suspending in August, grains filling-ripening	6622	147	93	728	3154	2740

In the covering sources of the maize total water consumption, in average on the period 2007-2009, in the optimum conditions for water provisionment, the irrigation covered 49.49%, the rainfall 44.44% and the soil water reserve 7.7% The irrigation suspending determined the decrease of of their participation in the covering sources of the total consumption (figure 2)

The influence of irrigation suspending on yield

All the years studied the irrigation suspending in the one of the months of the irrigation period determined the yield losses very significant statistically. The differences were between -7.8% (irrigation suspending in May) and -39.8% (irrigation suspending in June) in 2007, between -7.2% (irrigation suspending in May) and -18.7% (irrigation suspending in August) in 2008 and between -14% (irrigation suspending in May) and -27% (irrigation suspending in August) in 2009. (table 3)

Irrigation suspending influence on water use efficiency

The irrigation suspending in different months of the irrigation season had the different effects in the studied years. In 2007, the irrigation suspending in June, determined the biggest decrease of the water use efficiency -38%; in 2008 and 2009 the biggest decreases were determined by irrigation suspending in June determined the biggest decrease of water use efficiency, -19%; it is followed by irrigation suspending in July (-17%), August (-16%) and May (-4%). In unirrigated conditions the water use efficiency decreased with 22% in comparison with the optimum irrigated variant. (table 4).

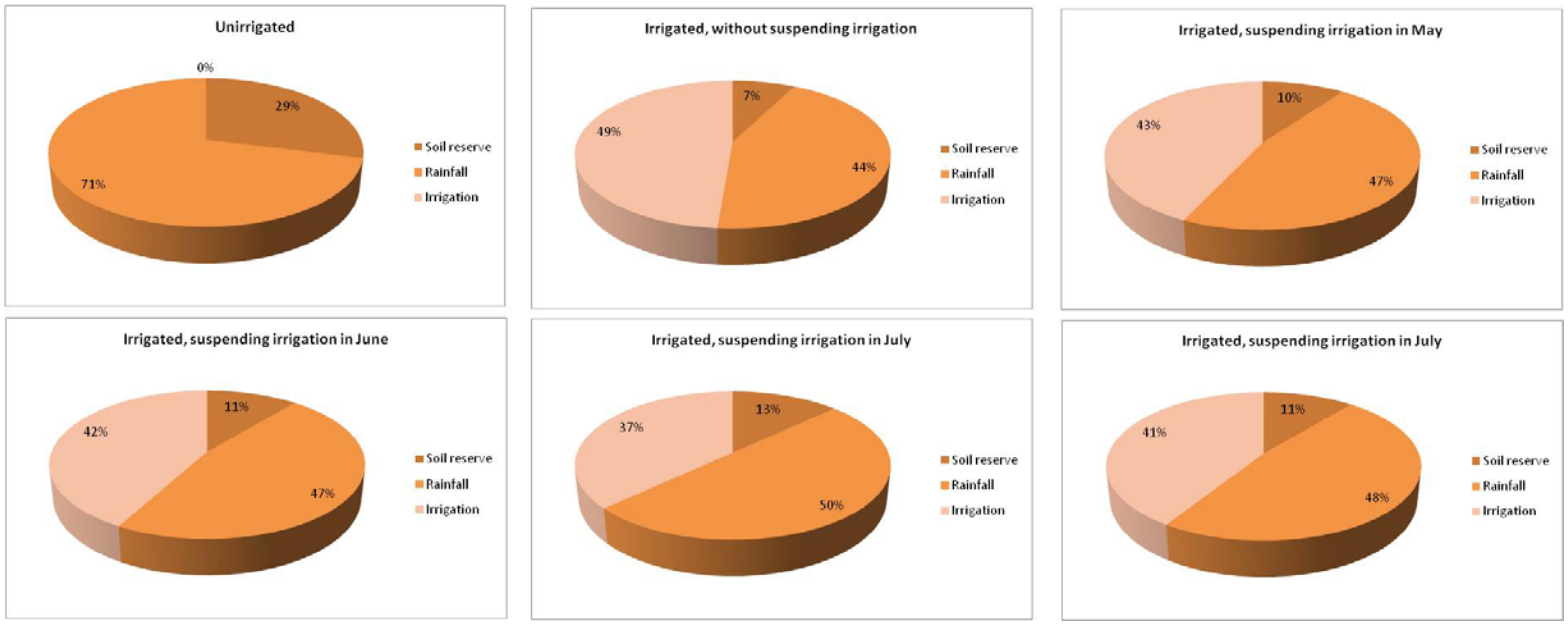

Fig. 2 The covering sources of the maize water consumption, Oradea 2007-2009

Table 3

The influence of the irrigation suspending in different months of the vegetation period on maize yield in the conditions from Oradea, 2007-2009

Variant	Yield		Difference		Statistical significance
	kg/ha	%	kg/ha	%	
2007					
Irrigated, without suspending irrigation	13120	100	-	-	Mt
Irrigated, suspending irrigation in May, 4-9 leaves	12100	92.2	-1020	-7.8	000
Irrigated, suspending irrigation in June, 10-18 leaves)	7900	60.2	-5220	-39.8	000
Irrigated, suspending irrigation in July, tassel growth – grains filling	8300	63.6	-4820	-36.4	000
Irrigated, suspending irrigation in August, grains filling-ripening	10490	79.9	-2630	-20.1	000
Unirrigated	6470	49.3	-6650	-50.7	000
$LSD_{5\%} = 240$; $LSD_{1\%} = 410$; $LSD_{0,1\%} = 790$					
2008					
Irrigated, without suspending irrigation	12500	100	-	-	Mt
Irrigated, suspending irrigation in May, 4-9 leaves	11525	92,8	-975	-7.2	000
Irrigated, suspending irrigation in June, 10-18 leaves)	10250	81.8	-2275	-18.2	000
Irrigated, suspending irrigation in July, tassel growth – grains filling	10162	81.3	-2338	-18.7	000
Irrigated, suspending irrigation in August, grains filling-ripening	9100	72.8	-3400	-27.2	000
Unirrigated	5910	47.3	-6590	-52.7	000
$LSD_{5\%} = 190$; $LSD_{1\%} = 310$; $LSD_{0,1\%} = 570$					
2009					
Irrigated, without suspending irrigation	11800	100	-	-	Mt
Irrigated, suspending irrigation in May, 4-9 leaves	10100	86	-1700	-14	000
Irrigated, suspending irrigation in June, 10-18 leaves)	10020	85	-1780	-15	000
Irrigated, suspending irrigation in July, tassel growth – grains filling	8450	72	-3350	-18	000
Irrigated, suspending irrigation in August, grains filling-ripening	8600	73	-3200	-27	000
Unirrigated	5300	45	-6500	-55	000
$LSD_{5\%} = 210$; $LSD_{1\%} = 330$; $LSD_{0,1\%} = 640$					

Table 4

The irrigation suspending influence in different months of the vegetation period on the water use efficiency (WUE) in maize from Oradea, average values on the period 2007-2009

Variant	Average 2007-2009		
	WUE		
	kg/m^3	%	Difference %
Irrigated, without suspending irrigation	1.84	100	-
Irrigated, suspending irrigation in May, 4-9 leaves	1.77	96	-4
Irrigated, suspending irrigation in June, 10-18 leaves)	1.48	81	-19
Irrigated, suspending irrigation in July, tassel growth – grains filling	1.52	83	-17
Irrigated, suspending irrigation in August, grains filling-ripening	1.54	84	-16
Unirrigated	1.44	78	-22

CONCLUSIONS

The researches carried out during 2007-2009 determined the following conclusion:

- The irrigation suspending in the months of the maize irrigation season determined smaller values of the daily water consumption. Mathematical modellation of the daily water consumption show the biggest values of the correlation coefficient for regression function of the variant without irrigation suspending, smaller values in the variants with irrigation suspending and the smallest value in unirrigated variant.
- The irrigation suspending determined the decrease of the total water consumption and yield losses very significant statistically. The biggest yield losses were registered by irrigation suspending in June in 2007 and by irrigation suspending in August in 2008 (-27.2%) and 2009 (-27%).
- The irrigation suspending determined the smaller values of the water use efficiency; the yields obtained for 1 m^3 water use were smaller than the yield from variant without irrigation suspending with -19% (irrigation suspending in June), -4% (irrigation suspending in May).

The research results emphasized the need of good water provisionment in the all irrigation season of the maize crop from Crişurilor Plain.

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REFERENCES

1. Botzan M., 1966, Culturi irigat, Ed. Agrosilvică Bucureşti
2. Borza Ioana Maria, 2006, Cercetări privind influenţa unor măsuri fitotehnice asupra eficienţei valorificării apei de către cultura porumbului în condiţiile Câmpiei Crişurilor Teză de doctorat la Universitatea de Ştiinţe Agricole şi Medicină Veterinară Cluj-Napoca.
3. Borza Ioana Maria, 2007, Valorificarea apei de către cultura porumbului din Câmpia Crişurilor. Editura Universităţii Oradea, 195-208
4. Domuţa C., 1995 - Contribuţii la stabilirea consumului de apă al principalelor culturi din Câmpia Crişurilor. Teză de doctorat ASAS „Gheorghe Ionescu Şişeşti" Bucureşti, 115-181
5. Domuţa C., 2003, Oportunitatea irigaţiilor în Câmpia Crişurilor, Ed. Universităţii din Oradea,165-196
6. Domuţa C., 2005, Irigarea culturilor, Editura Universităţii din Oradea, 96-100
7. Domuţa C., 2006, Tehnică experimentală Ed. Universităţii din Oradea, 25-120
8. Domuţa C., 2009, Irigaţiile în Câmpia Crişurilor, Editura Universităţii din Oradea
9. Domuţa C., 2009, Irigarea culturilor, Editura Universităţii din Oradea,
10. Domuţa Cr., 2010, Cercetări privind influenţa irigaţiei asupra culturilor de porumb, soia şi sfeclă de zahăr în Câmpia Crişurilor, 176-195
11. Grumeza N., Kleps Cr., 2005. Amenajările de irigaţii din România. Ed. Ceres Bucureşti p. 151-158
12. Nagy J., 2010.Impact of Fertilization and Irrigation on the Correlation between the Soil Plant Analysis Development Value and Yield of Maize. Communications in Soil Science and Plant Analysis, 41 pp.1293-1305
13. Pakurar M., Nagy J., Jagendorf S., Farkas I. , 2004. Fertilisation and irrigation effects on maize (Zea mays L.) grain production. Cereal Research Communications Vol 32 No 1 pp. 151-158
14. Stan I, Năeescu V., 1997 – Maize response to water deficit. Romanian Agricultural Research no. 7 – 8; pp.77-81