RESEARCHES REGARDING THE CORRELATIONS BETWEEN THE DROUGHT AND CLIMATE INDEX AND MAIZE YIELD IN THE CONDITIONS OF THE NORTH-WESTERN ROMANIA

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Abstract

The paper is based on the researches carried out in Oradea during 2006-2008 in the following variants: V_1= Irrigated, without irrigation suspending; V_2= Irrigated, irrigation suspending in May; V_3 = Irrigated, irrigation suspending in June; V_4= Irrigated, irrigation suspending in July; V_5= Irrigated, irrigation suspending in August; V_6= Unirrigated. The hybrid used: Fundulea 376. Total nitrogen content of the maize grains was determined in the laboratory of the Agricultural and Development Research Station Oradea. In the variant with optimum irrigation, water reserve on 0-75 cm depth was maintained between easily available water content and field capacity. Pedological drought was determined every year and the irrigation was also needed. The irrigation determined the increase of the total water consumption and yield gain in comparison with unirrigated variant. Irrigation suspending in different months determined the yield losses very significant statistically. The biggest protein content was registered in the variant without irrigation suspending; the values registered in the variants with irrigation suspending in May, June, July and August and in the unirrigated variant are smaller, with differences statistically assured. There was a direct link between de Martonne aridity index values and water consumption, yield and protein content and an inverse link between pedological drought and yield quantity and protein content. These are the arguments for irrigation opportunity in maize from Crişurilor Plain

Keyword: pedological drought, de Martonne aridity index, yield, protein content, correlations

INTRODUCTION

In the North-Western Romania, the maize and wheat are cropped on the biggest surfaces. The first researches regarding the maize irrigation were realized starting 1967 by Stepănescu E. and Mihăilescu in Girişu de Criş and water regime of the maize using the furrow irrigation was studied: Stepănescu and Mate Şt. (1972) published the researches regarding easily available water content (50% and 70% for utile water capacity) and watering depth (0.50 m; 0.85 m; 1.2 m) in maize on the chernazem from Girişu de Criş. The researches regarding the soil management in irrigated crops were made by Mate Şt. (1970-1987), Ţucudean I. (1987-1998) in Girişu de Criş and by Domuţa C. in Oradea after that (Stepănescu, Mate Şt. 1972; Domuţa C, 1995, 1998).

During 1973-1975 in Girişu de Criş, Stepănescu E. was realized researches regarding the water consumption of the unirrigated and irrigated maize, covering sources, crop coefficient for pan evaporation class A and reference evapotranspiration Thornthwaite, water consumption-yield relationship. Starting 1976 the researches were carried out in Oradea on the preluvosoil and Stepănescu E. (1976-1980), Buta Mihaela (1981-1982), Colibaş Maria (1983-1985) and Şandor Maria (1986), Domuţa C. (1987-2008) were the coordinators. The results of the researches during 1973-1985 were published by Grumeza N. and al. (1987) and sustained the irrigation opportunity in maize and established the parameter needed for irrigation projects and irrigation scheduling. Domuța C. (2005) published the researches regarding the contribution of the subjacent layer of the watering depth in water consumption, pedological drought and their correlations with yield and yield determined by irrigation, microclimate, leaves turgescence and plant nutrition modifications under the irrigation influence, influence of the irrigation rate decrease on water consumption, yield, water use efficiency in maize, economical efficiency of the irrigation in maize. Borza Ioana (2006, 2007) published the researches regarding the influence of the phytotechnyal factors – crop rotation, weeds, fertilization, water regime – on maize yield and water use efficiency in maize.

MATERIALS AND METHODS

The researches were carried out in Agricultural Research and Development Station Oradea on the preluvosoil with the following soil profile: Ap = 0-24 cm; El = 24-34 cm; Bt_1=34-54 cm; Bt = 54-78 cm; Bt/c =78-95 cm; C = 95-145 cm. There are a big hydro stability (47.5%) of the aggregates (□ = 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 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); (Canarache, 1990); their values for 0-75 cm are 19.5% and 2240 m^3/ha.

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.

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, 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: Fundulea 376. Fertilization system: $N_{120}P_{90}K_{60}$.

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.

Protein content was determined using the specifically method in the laboratory of the Agricultural Research and Development Station Oradea. The experiment data was calculated by variance analysis method (Domuța C., 2006).

RESULTS AND DISCUSSION

Pedological drought in maize

Pedological drought is considered when the soil moisture bellow easily available water content on watering depth; the decrease of the soil moisture bellow wilting point is considered very strong pedological drought (Domuța C., 2004). The determination of the number of days with drought is based on the soil moisture determination and on the soil water reserve graph realized after that (Domuța C., 1995).

In unirrigated maize, in 2006, pedologiacal drought affected the plants in 46 days. Irrigation suspending in July determined 23 days with pedological drought and irrigation suspending in August determined 6 days with pedological drought (Table 1)

Table 1

Number of days with pedological drought in maize from different variants of water provisionment, in the conditions from Oradea 2006-2008

Variant	Month					IV-VIII
	IV	V	VI	VII	VIII	
2006						
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	20	3	23
V_5	0	0	0	0	6	6
V_6	0	0	5	31	10	46
2007						
V_1	0	0	0	0	0	0
V_2	0	10	2	0	0	12
V_3	0	0	17	4	0	21
V_4	0	0	0	20	5	24
V_5	0	0	0	0	17	17
V_6	14	22	26	28	20	110
2008						
V_1	0	0	0	0	0	0
V_2	0	8	2	0	0	10
V_3	0	0	14	0	0	14
V_4	0	0	0	21	3	24
V_5	0	0	0	0	28	28
V_6	0	8	16	21	31	76

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated, irrigation suspending in May (4 – 9 leave)
V_3 = Irrigated, irrigation suspending in June (10 – 18 leave)
V_4 = Irrigated, irrigation suspending in July (panicle appearance – grains fill)
V_5 = Irrigated, irrigation suspending in August (grains fill - milk-vax ripen)
V_6 = Unirrigated

The biggest number with pedological drought in unirrigated maize was registered in 2007, 110 days. Irrigation suspending in every month of the maize irrigation season determined the appearance of the pedological drought, the biggest in the variant with irrigation suspending in July (24 days) and June (21 days) and the smallest in the variant with irrigation suspending in May (12 days). (Table 1)

In 2008, number of days with pedological drought in unirrigated maize was of 76 In the variant with irrigation suspending in August (28 days) and July (24 days) and the smallest in the variant with irrigation suspending in May. (Table 1)

Irrigation water regime in maize

Optimum irrigation water regime of the maize consists of 1160 m^3/ha and 3 rated in 2006, 2950 m^3/ha and 8 rates in 2007 and 3320 m^3/ha and 8 rates also in 2008. Irrigation suspending determined the decrease of the irrigation rate (Table 2)

Table 2

Irrigation regime of the maize from different variants of water provisionment in the conditions from Oradea 2006-2008

Variant	IV		V		VI		VII		VIII		IV-VIII	
	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n	∑m	N
2006												
V_1	-	-	-	-	-	-	1160	3	-	-	1160	3
V_2	-	-	-	-	-	-	1160	3	-	-	1160	3
V_3	-	-	-	-	-	-	1160	3	-	-	1160	3
V_4	-	-	-	-	-	-	-	-	-	-	-	-
V_5	-	-	-	-	-	-	1160	3	-	-	1160	3
2007												
V_1	300	1	400	1	500	1	1200	4	550	1	2950	8
V_2	300	1	-	-	500	1	1200	4	550	1	2550	7
V_3	300	1	400	1	-	-	1200	4	550	1	2450	7
V_4	300	1	400	1	500	1	-	-	550	1	1750	4
V_5	300	1	400	1	500	1	1200	4	-	-	2400	7
2008												
V_1	-	-	500	1	1020	2	1100	3	700	2	3320	8
V_2	-	-	-	-	1020	2	1100	2	700	2	2820	6
V_3	-	-	500	1	-	-	1100	2	70	2	2300	5
V_4	-	-	500	1	1020	2	-	-	700	2	2220	5
V_5	-	-	500	1	1020	2	1100	2	-	-	2620	5

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated, irrigation suspending in May (4 – 9 leave)
V_3 = Irrigated, irrigation suspending in June (10 – 18 leave)
V_4 = Irrigated, irrigation suspending in July (panicle appearance – grains fill)
V_5 = Irrigated, irrigation suspending in August (grains fill - milk-vax ripen)
∑m = irrigation rate; n = number of rate

Irrigation influence in maize yield

The yield obtained in 2006 in the variant without irrigation suspending in the maize irrigation season was bigger than the yield from unirrigated variant with 42.9%. The irrigation was needed in August, only and their suspending determined an yield losses of 3870 kg/ha (29.4%) in comparison with the optimum irrigated variant (table 3)

In 2007, the yield gain obtained in the varint with optimum irrigation in comparison with unirrigated variant was 6650 kg/ha (102.8%). Irrigation was needed every month of the irrigation season and their suspending determined the yield losses very significant statistically; the biggest yield losses (5220 kg/ha, 39.8%) was determined in the variant with irrigation suspending in June.

Yield obtained in 2008 in the variant without irrigation suspending (14200 kg/ha) was bigger than the yield from unirrigated variant with 86.5%. Irrigation suspending determined the yield losses, very significant staistically in all the cases; the biggest was detrmined by irrigation suspending in August, 3860 kg/ha (27.2%). (Table 3)

Table 3

Influence on yield of the irrigation suspending in different months of the maize irrigation season in the conditions from Oradea, 2006-2008

Variant	Yield		Difference		Statistically significant
	Kg/ha	%	Kg/ha	%	
2006					
V_1	13200	100	-	-	Mt
V_2	13110	99.3	-90	-0.7	-
V_3	13410	101.6	+210	+1.6	-
V_4	9330	70.6	3870	-29.4	ooo
V_5	13340	101.1	140	1.1	-
V_6	9240	70.0	3960	-30.0	ooo
LSD 5% = 230 LSD 1% = 410 LSD 0.1% = 670					
2007					
V_1	13120	100	-	-	Mt
V_2	12100	92.2	-1020	-7.8	ooo
V_3	7900	60.2	-5220	-39.8	ooo
V_4	8300	63.6	-4820	-36.4	ooo
V_5	10490	79.9	-2630	-20.1	ooo
V_6	6470	49.3	-6650	-50.7	ooo
LSD 5% = 240 LSD 1% = 410 LSD 0.1% = 790					
2008					
V_1	14200	100	-	-	Mt
V_2	13180	92.8	-1020	-7.2	ooo
V_3	11620	81.8	-2580	-18.2	ooo
V_4	11540	81.3	-2660	-18.7	ooo
V_5	10340	72.8	-3860	-27.2	ooo
V_6	7610	51.5	-6590	-48.5	ooo
LSD 5% = 190 LSD 1% = 310 LSD 0.1% = 680					

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated, irrigation suspending in May (4 – 9 leave)
V_3 = Irrigated, irrigation suspending in June (10 – 18 leave)
V_4 = Irrigated, irrigation suspending in July (panicle appearance – grains fill)
V_5 = Irrigated, irrigation suspending in August (grains fill - milk-vax ripen)
V_6 = Unirrigated

Irrigation influence on protein content of maize grains

The biggest values of the protein content were registered in the variant without irrigation suspending: 12.2% in 2006; 11.12% in 2007; 11.38% in 2008 and the lowest were registered in the unirrigated variant: 8.27% in 2006; 7.0% in 2007 and 6.57% in 2008.

Irrigation suspending in May didn□t determine the difference statistically assured in comparison with the variant without the irrigation suspending. Irrigation suspending in June determined the difference distingue statistically and the irrigation suspending in July and August determined the difference very significant statistically. Irrigation was needed only in June in 2006 and the irrigation suspending in this month determined a very significant decrease of the protein content.

The calculating of the protein production determined the increase of the relative differences between the variants (Table 4)

Table 4

Influence of the irigation suspending in different months of the irrigation season on content of the maize protein grains, in the conditions from Oradea, 2006-2008

Variant	Protein		Difference		Statistically significant
	%	%	%	%	
2006					
V_1	12.20	100	-	-	Mt
V_2	12.16	99.6	-0.04	-0.4	-
V_3	11.96	98.0	-0.24	-2.0	-
V_4	8.4	77.0	-3.8	-32.0	ooo
V_5	12.21	100.1	0.01	+0.1	-
V_6	8.27	67.8	3.93	-32.2	ooo
LSD 5% = 0.61 LSD 1% = 1.02 LSD 0.1% = 2.29					
2007					
V_1	11.12	100	-	-	Mt
V_2	10.44	93.9	-0.67	-6.1	-
V_3	8.56	77.0	-2.56	-23.0	oo
V_4	8.39	75.4	-2.73	-24.6	ooo
V_5	7.93	71.4	-3.19	-28.6	ooo
V_6	7.00	63.0	-4.12	-37.0	ooo
LSD 5% = 0.81 LSD 1% = 1.56 LSD 0.1% =2.63					
2008					
V_1	11.38	100	-	-	Mt
V_2	10.94	96.1	-0.44	-3.9	-
V_3	9.50	83.5	-1.88	-16.5	oo
V_4	9.19	80.8	-2.19	-19.2	ooo
V_5	7.94	69.8	-3.44	-30.2	ooo
V_6	6.75	59.4	-5.13	-40.6	ooo
LSD 5% = 0.50 LSD 1% = 1.06 LSD 0.1% = 2.00					

V_1 = Irrigated without irrigation suspending
V_2 = Irrigated. irrigation suspending in May (4 – 9 leave)
V_3 = Irrigated. irrigation suspending in June (10 – 18 leave)
V_4 = Irrigated. irrigation suspending in July (panicle appearance – grains fill)
V_5 = Irrigated. irrigation suspending in August (grains fill - milk-vax ripen)

The correlations between pedological drought and yield, protein content, protein production

Five types of function – linear, logarithmic, polynomial, power, exponential – were used for cuantification of the pedologiacal drought correlations. In all the cases, polynomial function had the biggest correlation coefficient. There were inverse correlations very significant statistically, between number of days with pedological drought and yield obtained in the studied variant. The same kind of correlations were quantified between number of days with pedological drought and protein content, respectivella protein production (Fig. 1, 2, 3)

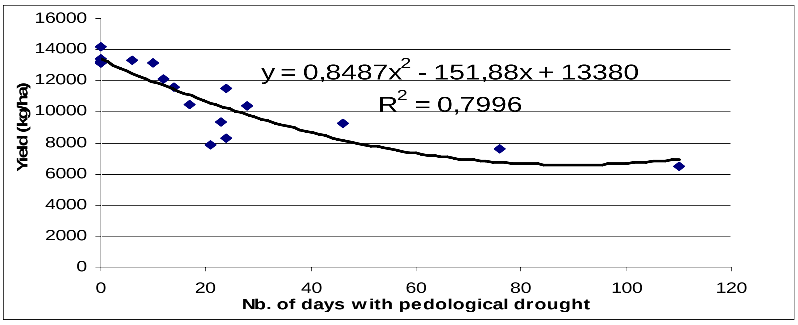

Fig. 1. Correlation between number of days with pedological drought and yield in maize

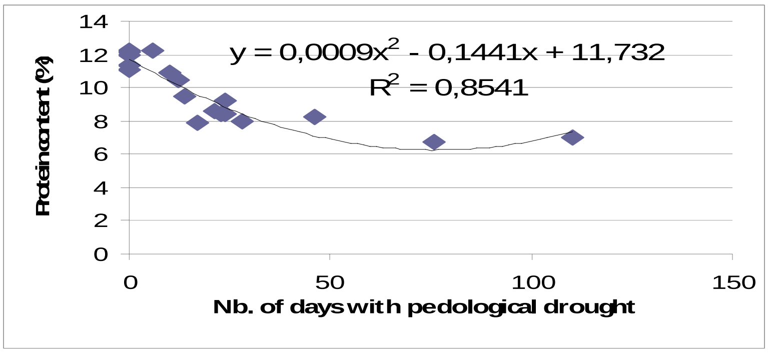

Fig. 2 Correlation between number of days with pedological drought and protein content of the maize grains

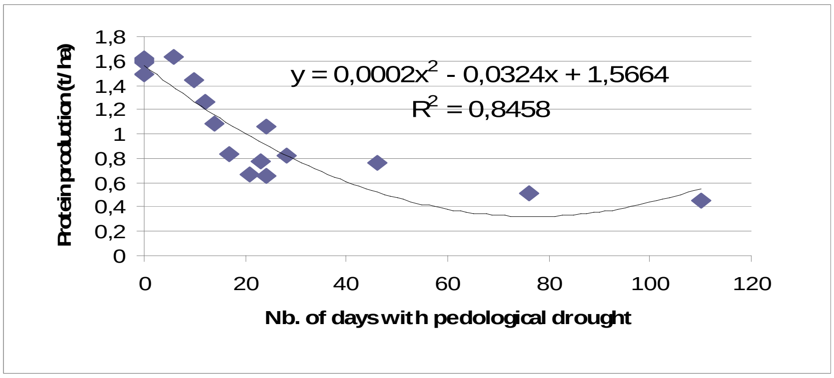

Fig. 3 Correlation between number of days with pedological drought and protein production in maize grains

The researches results sustain the needed of the optimum irrigation in maize fro Crişurilor Plain because the level of the yield and protein content and protein production is very significant influenced.

CONCLUSIONS

The researches carried out during 2006-2008 on the preluvosoil from Agricultural Research and Development Station Oradea in 6 variants regarding the water regime determined the following conclusions:

- In unirrigated maize, soil water reserve on 0-75 cm depth (watering depth) decreased bellow easily available water content (pedological drought) every year: 46 days in 2006; 110 days in 2007 and 76 days in 2008. In the variants with irrigation suspending in the months of the maize irrigation season the pedological drought was presented in these months and a few days in the next month.
- Maintaining the soil water reserve between easily available water content and field capacity determined to use an irrigation rates of 1160 m^3/ha in 2006, of 2950 m^3/ha in 2007 and of 3320 m^3/ha in 2008. The irrigation rates were smaller in the variants with irrigation suspending in different months.
- In the all 5 variants with irrigations, the maize yields were bigger than the yields from unirrigated variant: the differences were very significant statistically. Irrigation suspending in different months of the maize irrigation season determined yield gains in

comparison with the variant without irrigation suspending: in 2006 the biggest yield loss was registered in the variant with irrigation suspending in July, in 2007 in the variant with irrigation suspending in June and in 2008 in the variant with irrigation suspending in August.

- Irrigation determined the increase of the protein content in comparison with unirrigated variant. As consequence the relative difference between total protein productions increased in comparison with the relative differences between grains yields. In the variants with the irrigation suspending, protein content decreased in comparison with the variant without irrigation suspending; the differences were statistically assured.
- Inverse links, very significant statistically, were quantified between number of days with pedological drought and level of yield ($y = 0.8487x^2 - 151.88x + 13380$; $R^2 = 0.7996$), between pedological drought and protein content ($y =0,0009x^2 - 0,1441x + 11,732$; $R^2 = 0,8541$) and between number of days with pedological drought and protein production ($y = 0,0002x^2 - 0,0324x + 1,5664$; $R^2 = 0,8458$). These correlations sustain the irrigation opportunity in maize from Crisurilor Plain.

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