PLANTS POPULATION INFLUENCE ON WATER USE EFFICIENCY IN MAIZE FROM CRIŞURILOR PLAIN

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Abstract: *The plants population is very important in optimizing of the maize vegetation factors regime, the researches were carried out in the Agricultural Research and Development Station Oradea during 2006-2009. Turda super is one of the most known cultivar from the area, was use five graduation of the plants population (of 25000 plants/ha, 40000 plants/ha, 55000 plants/ha, 70000 plants/ha and of 85000 plants/ha) and studied their influence on yield in unirrigated and irrigated conditions, on water consumption, water use efficiency and irrigation water use efficiency. In the irrigated variant, for maintaining the soil water reserve on watering depth (0-75 cm) between easily available water content (2240 m³/ha) and field capacity (2782 m³/ha) the soil samples were prelevated ten to ten days; the sprinkler irrigation was used. The experiment had four repetisions placed by block methods. Total consumption of the crop increased together with the plants population increase based on the use of the soil water reserve but the water consumptin of the every plants decreased together with plants tickness increase. The biggest yields were obtained in the variant with 55000 plants/ha in the unirrigates conditions but in the drought years the best plant population was 40000 plants/ha. In six years the best plant population for irrigated conditions was 70000 plants/ha. These plants population determined the bigest average yields for every meter of water used and the bigest yields gains for every meter of irrigation water used. The researches sustain the known need of the meteorological prognosis because in the droughty years a plants populations with 25-30% smaller than optimum value is recomanded. The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 "Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesivelly by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality".*

***Key words*:** *maize, plants population, water use efficiency, irrigation*

INTRODUCTION

It is considered that the maize plant represents the most surprising system that nature provided to pile energy. Out of one seed weighing about one third of a gramme, it springs and grows in approximately nine weeks two-three meters plant, and in approximately eight weeks it will yield 600-1000 seeds. This process is explained through the existence of an extraordinary "solar" energy transformation "laboratory" into organic energy and, secondly, through the stocking of a great quantity of energy into such concentrated product as the maize seed is. (CRISTEA M. et co. 2004). Optimizing of the water regime provides the integral use of the yield potential of the maize hybrids. In the same time, natural resources of the water are more and more used and as a consequence decrease continuously. The increase of the water use efficiency in maize, the main crops from Romania, it is important.

Water is an essential element for every stage of plant development starting from germination to harvesting. In the international and Romanian literature the quantification of the water use efficiency is realized by indicators wich emphasize all the water quantity used or

irrigation water use (MUNTEAN L.S. and al, 2008). The indicators present the problem of water use from two points of view: emphasize the quantity of yield or yield gain obtained on one liter of water and emphasize the water used on one kilograme of yield.

Researches from the international literature (OGOLA J.B.O et al, 2005, PEAKE A.S et al, 2008, HSIAO THEODORE C., and al., 2009, LEE KHENG HENG and al, 2009) emphasized the influence of the plans population, and irrigation on the water use efficincy in maize.

In the Crisurilor Plain, the researches regarding maize water use efficiency were published by GRUMEZA N. *et all* 1987, DOMUTA C., 2005, 2009; BORZA IOANA 2006, 2009 emphasized the climate and the technology elements influence on the water use efficiency.

MATERIAL AND METHODS

The experience was placed by subdividing plots in the Agricultural Research and Development Station Oradea. The surface of the plot experience: 30 m^2. Number of repetition: 4. The experience had two factors: the water supply regime (irrigated and non-irrigated) and plants populations (25.000 plants/ha, 40.000 plants/ha, 55.000 plants/ha, 70.000 plants/ha and 85.000 plants/ha).

The plants' water consumption was provided by the decade control of the soil moisture and by the application of the irrigation when the water reserve decreased bellow easily available water content on the irrigation depth of the maize crop (0-75 cm). The optimum water consumption results at the end of the vegetation period, after the water balance in the soil is accomplished. (DOMUTA C., 2005). The water use efficiency (WUE) was calculated as a ratio between yield and water consumption, and the irrigation water use efficiency (IWUE) was calculated as the ratio between the yield gains achieved through irrigation and the irrigation rate. (DOMUTA C., 2005).

RESULTS AND DISCUSSIONS

The influence of the plants population on maize yield

In the year 2006, in the non-irrigated as well in the irrigated conditions, the biggest yield of the maize was obtained in 70.000 plants/ha plants population, 9370 kg/ha, respectively 11240 kg/ha. Irrigation determined an yield gain of 1550 kg/ha, very significant statistically. (table 1)

Table 1

The influence of the plants population on maize yield of the Turda super hybrid (kg/ha) in non-irrigated and irrigated conditions, Oradea 2006

Nr. crt.	Variant	Water regime		Average on plants population
		Unirrigated	Irrigated	
1.	25.000 plants/ha	7300	8010	7655^{Mt}
2.	40.000 plants/ha	8100	9780	8940
3.	55.000 plants/ha	8610	10320	9465
4.	70.000 plants/ha	9370	11240	10305
5.	85.000 plants/ha	8640	10420	953
Average on regime		8404	9954	-

	Plants population	Water regime	Water regime x plants population	Plants population x Water regime
$LSD_{5\%}$	232	346	364	286
$LSD_{1\%}$	320	530	498	420
$LSD_{0,1\%}$	518	710	828	709

In unirrigated conditions, in the year 2007, the biggest maize yield was obtained in 40000 plants/ha plants population, 6100 kg/ha, and in irrigated conditions in 70.000 plants/ha plants population, 12300 kg/ha (table 2)

Table 2

The influence of the plants population on maize yield Turda super hybrid (kg/ha) in non-irrigated and irrigated conditions, Oradea 2007

Nr. crt.	Variant	Water regime		Average on plants population
		Unirrigated	Irrigated	
1.	25.000 plants/ha	5320	9020	717
2.	40.000 plants/ha	6100	11090	8595
3.	55.000 plants/ha	5760	12100	8930
4.	70.000 plants/ha	5020	12300	8600
5.	85.000 plants/ha	4130	10970	7550
Average on regime		5266	11096	-

	Plants population	Water regime	Water regime x plants population	Plants population x Water regime
$LSD_{5\%}$	214	310	362	310
$LSD_{1\%}$	320	520	586	490
$LSD_{0,1\%}$	470	970	1020	720

The biggest yield was obtained at 55.000 plants population in unirigated conditions (7020 kg/ha) and 70.000 plants population in irrigated conditions (13100 q/ha) (table 3)

Table 3

The influence of the plants population on maize yield Turda super hybrid (q/ha) in non-irrigated and irrigated conditions, Oradea 2008

Nr. crt.	Variant	Water regime		Average on plants population
		Unirrigated	Irrigated	
1.	25.000 plants/ha	5700	9100	740
2.	40.000 plants/ha	6400	11400	840
3.	55.000 plants/ha	7020	12700	986
4.	70.000 plants/ha	5010	13100	9055
5.	85.000 plants/ha	4270	11000	7635
Average on regime		5680	1146	-

	Plants population	Water regime	Water regime x plants population	Plants population x Water regime
$LSD_{5\%}$	180	170	210	190
$LSD_{1\%}$	290	310	370	310
$LSD_{0,1\%}$	510	520	710	680

The influence of the plants population on the water consumption in non-irrigated and irrigated maize

The rainfall registered in the year 2006 in the vegetation period of maize was of 3550.0 m^3/ha, and the optimum supply with water determined by using an irrigated rate of 1160 m^3/ha. The irrigation determined the increase of the water consumption values with 22-23%. The biggest values of the water consumption were registered in the variant with the biggest plants populations of maize, 5490 m^3/ha in non-irrigated conditions and 6690 m^3/ha in irrigated conditions. (table 4)

Table 4

Total water consumption and covering sources in maize sowing in different plants populations, Oradea 2006

Variant	Water regime	Σ (e + t)		The covering sources					
				R_i-R_f		P_v		Σm	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
25.000 plants/ha	Non-irrigated	5360	100	1810	34	3550	66	-	-
	Irrigated	6560	123	1850	28	3550	54	1160	18
40.000 plants/ha	Non-irrigated	5460	100	1810	34	3550	66	-	-
	Irrigated	6860	128	2150	31	3550	52	1160	17
55000 plants/ha	Non-irrigated	5372	100	1822	34	3550	66	-	-
	Irrigated	6615	123	1905	29	3550	54	1160	17
70.000 plants/ha	Non-irrigated	5415	100	1865	34	3550	66	-	-
	Irrigated	6650	123	1940	29	3550	53	1160	18
85.000 plants/ha	Non-irrigated	5490	100	1940	35	3550	65	-	-
	Irrigated	6690	122	1980	30	3550	53	1160	17

Σ (e + t) = total water consumption
R_i - R_f = soil reserve (initial reserve – final reserve)
P_v = rainfall during the vegetation period
Σm = irrigation rate

In the year 2007 in the 85.000 plants/ha plants population, the biggest values of the total water consumption 4490 m^3/ha in non-irrigated conditions and 6648 m^3/ha in irrigated condition were registered. (table 5).

Table 5

Total water consumption and covering sources in maize sowing in different plants populations, Oradea 2007

Variant	Water regime	Σ (e + t)		The covering sources					
				R_i-R_f		P_v		Σm	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
25.000 plants/ha	Non-irrigated	4038	100	420	10	3618	90	-	-
	Irrigated	6238	155	-330	-5	3618	57	2950	48
40.000 plants/ha	Non-irrigated	4128	100	510	12	3618	88	-	-
	Irrigated	6318	153	-250	-4	3618	57	2950	47
55.000 plants/ha	Non-irrigated	4188	100	570	14	3618	86	-	-
	Irrigated	6393	153	-175	-3	3618	56	2950	47
70.000 plants/ha	Non-irrigated	4218	100	600	14	3618	86	-	-
	Irrigated	6558	155	-10	0,0	3618	55	2950	45
85.000 plants/ha	Non-irrigated	4490	100	872	19	3618	81	-	-
	Irrigated	6648	148	80	1	3618	54	2950	45

Σ (e + t) = total water consumption
R_i - R_f = soil reserve (initial reserve – final reserve)
P_v = rainfall during the vegetation period
Σm = irrigation rate

At the 85.000 plants/ha plants population was registered the biggest values of the total water consumption, 4490 m^3/ha in unirrigated conditions and 6648 m^3/ha in irrigated conditions.(table 6.)

Table 6

Total water consumption and covering sources in maize sowing in different plants population, Oradea 2008

Variant	Water regime	Σ (e + t)		The covering sources					
				R_i-R_f		P_v		Σm	
		m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
25.000 plants/ha	Non-irrigated	4370	100	1260	29	3110	71	-	-
	Irrigated	6760	155	330	5	3110	46	3320	49
40.000 plants/ha	Non-irrigated	4390	100	1280	29	3110	71	-	-
	Irrigated	6810	155	380	6	3110	46	3320	48
55.000 plants/ha	Non-irrigated	4410	100	1300	29	3110	71	-	-
	Irrigated	6900	156	470	7	3110	45	3320	48
70.000 plants/ha	Non-irrigated	4570	100	1460	32	3110	68	-	-
	Irrigated	6940	152	510	7	3110	45	3320	48
85.000 plants/ha	Non-irrigated	4620	100	1510	33	3110	67	-	-
	Irrigated	7010	152	580	8	3110	44	3320	48

Σ (e + t) = total water consumption
R_i - R_f = soil reserve (initial reserve – final reserve)
P_v = rainfall during the vegetation period
Σm = irrigation rate

The influence of the plants populations on water use efficiency (WUE) in maize

In the year 2006, the biggest value of the water use efficiency was obtained in 70.000 plants/ha plants population in non-irrigated conditions (1.73 kg/m^3) and also in irrigated conditions (1.69 kg/m^3). (table 7)

Table 7

The influence of the plants populations of the Turda super hybrid on water use efficiency (WUE) in non-irrigated and irrigated conditions,Oradea 2006

Density	Water regime	WUE		Difference
		Kg/m^3	%	%
25.000 plants/ha	Non-irrigated	1.36	100	-
	Irrigated	1.22	90	-10
40.000 plants/ha	Non-irrigated	1.51	100	-
	Irrigated	1.43	94	-6
55.000 plants/ha	Non-irrigated	1.60	100	-
	Irrigated	1.56	98	-2
70.000 plants/ha	Non-irrigated	1.73	100	-
	Irrigated	1.69	98	-2
85.000 plants/ha	Non-irrigated	1.57	100	-
	Irrigated	1.56	99	-1

In non-irrigated conditions, in the year 2007, the biggest values of the water use efficiency were registered in the 40.000 plants/ha plants population, and in the irrigated conditions in 55.000 plans/ha plants population. (table 8)

In unirrigated conditions in the year 2008, the biggest value of the water use efficincy was registered at the 55.000 plants/ha plants population, 1.59 kg/m^3, At this plant population but also in the 70.000 plants/ha plants population was registered the biggest WUE 1.89 for irrigated conditions. (table 9)

Table 8

The influence of the plants populations of the Turda super hybrid on water use efficiency (WUE) in non-irrigated and irrigated conditions, Oradea 2007

Plants population	Water regime	WUE		Difference
		Kg/m^3	%	%
25.000 plants/ha	Non-irrigated	1.32	100	-
	Irigated	1.45	109	9
40.000 plants/ha	Non-irrigated	1.48	100	-
	Irigated	1.76	119	19
55.000 plants/ha	Non-irrigated	1.38	100	-
	Irigated	1.89	137	37
7.,000 plants/ha	Non-irrigated	1.19	100	-
	Irigated	1.88	157	57
85.000 plants/ha	Non-irrigated	0.92	100	-
	Irigated	1.65	179	79

Table 9

The influence of the plants populations of the Turda super hybrid on water use efficiency (WUE) in non-irrigated and irrigated conditions,Oradea 2008

Plants population	Water regime	WUE		Difference
		Kg/m^3	%	%
25.000 plants/ha	Non-irrigated	1.30	100	-
	Irrigated	1.35	100	-
40.000 plants/ha	Non-irrigated	1.46	105	5
	Irrigated	1.67	124	24
55.000 plants/ha	Non-irrigated	1.59	122	22
	Irrigated	1.89	140	40
70.000 plants/ha	Non-irrigated	1.09	84	-16
	Irrigated	1.89	140	40
85.000 plants/ha	Non-irrigated	0.92	71	-29
	Irrigated	1.57	116	16

The influence of the plants populations on irrigation water use efficiency (IWUE) of maize

In the year 2006, the biggest yield gain of 1.61 kg yield gain for 1 m^3 of irrigation water used was registered in 70.000 plants/ha plants population. (table 10)

Table 10

The influence of the plants populations of the maize Turda super hybrid on irrigation water use efficiency (IWUE), Oradea 2006

Plants population	IWUE		Difference	
	yield gain/m^3	%	Kg gain/m^3	%
25.000 plants/ha	0.61	100	-	-
40.000 plants/ha	1.45	237	0.84	137
55.000 plants/ha	1.47	242	0.86	142
70.000 plants/ha	1.61	264	1.00	164
85.000 plants/ha	1.53	252	0.92	152

In the year 2007, the biggest yield gain, obtained in 1 m^3 of irrigation water used was registered in 70.000 plants/haplants population 2.47 kg yield gain/m^3. (table 11).

The biggest irrigation water use efficincy was registered in the year 2008 at the 55.000 plants/ha plants population, 2.45 kg yield gain/m^3. At bigger or smaller plants population the values of the IWUE were smaller (table 12).

Table 11

The influence of the plants populations of the maize Turda super hybrid on irrigation water use efficiency (IWUE), Oradea 2007

Plants population	IWUE		Difference	
	yield gain/m^3	%	Kg gain/m^3	%
25.000 plants/ha	1.25	100	-	-
40.000 plants/ha	1.69	135	0.44	35
55.000 plants/ha	2.15	172	0.90	72
70.000 plants/ha	2.47	197	1.22	97
85.000 plants/ha	2.32	185	1.17	85

Table 12

The influence of the plants populations of the maize Turda super hybrid on irrigation water use efficiency (IWUE), Oradea 2008

Plants population	IWUE		Difference	
	yield gain/m^3	%	Kg gain/m^3	%
25.000 plants/ha	1.02	100	-	-
40.000 plants/ha	1.51	148	0.49	48
55.000 plants/ha	1.71	168	0.69	68
70.000 plants/ha	2.43	238	1.41	138
85.000 plants/ha	2.02	199	1.00	99

CONCLUSIONS

The plants populations is very important in optimizing the maize vegetation factors regime. The researches were carried out in the Agricultural Research and Development Station Oradea used five graduation of the plants populations and their influences on yield, water consumption, water use efficiency and irrigation water use efficiency were studied

In non-irrigated and also in irrigated conditions, the maize plants populations influence the values of the yield obtained. In non-irigated conditions, the biggest yield was obtained in 55.000 plants populations, except the dry year 2007, in which the biggest yield was obtained in 40.000 plants/ha plants population. In irrigating variants the greatest value of the yield was achieved at 70.000 plants/ha plants population. In 2 years in non-irrigated conditions the biggest water use efficiency (WUE) in maize was obtained at the 70.000 plants/ha plants population.

In two of the three years of the research period, the biggest values of the irrigation water use efficiency (IWUE) in maize were obtained at the 70000 plants/ha plants population. In the technology of maize Turda super hybrid, in the Crisurilor Plain conditions, the reccomandation is to use the 55.000 plants/haplants population in non-irrigated conditions and 70.000 plants/ha in irrigated conditions.

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The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 ”Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesivelly by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality”.

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