CORRELATION CLIMAE-YIELD IN WHEAT UNDER THE INFLUENCE OF THE CROP ROTATION AND IRRIGATION IN THE CONDITIONS OF NORT-WESTERN ROMANIA

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Abstract
The paper is based on the researches carried out during 2003-2008 in a long term trial placed in 1990 on the preluvosoil from Oradea. Climate indicator "de Martonne aridity index" (IdM) was used for quantification the correlation between climate and wheat yield in unirrigated and irrigated conditions and new class called "arid" was purposed for climate index characterization. Maintaining the soil water reserve on 0-50 cm depth between easily available water content and field capacity using the irrigation determined the increase of the IdM values for period IV – VI with 79% in 2003, 73% in 2004, 36% in 2005,16% in 2006, 162% in 2007 and with 131% in 2008; using the irrigation and the improvement of the microclimate conditions determined to obtain the yield gains, very significant every year and every crop rotation studied; both in unirrigated conditions and in irrigated conditions, the smallest yields wheat were obtained in monocrop and the biggest in the wheat – maize – soybean crop rotation; in the all three crop rotation, the direct links statistically assured were registered between the values of the De Martonne aridity index and yields in unirrigated and irrigated wheat. These correlations sustain the need of the irrigation in wheat from Crisurilor Plain; correlation between De Martonne aridity index is stronger (R^2 = 0.7361^{xx}) in the wheat – maize – soybean crop rotation in comparison with wheat – maize crop rotation (R^2 = 0.6215^{x}) and with wheat monocrop (R^2 = 0.6105^{x}). As consequence, crop rotation of wheat-maize-soybean is recomanded because the climate and microclimate conditions are better use

Keyword: correlation climate-yield, , irrigation, de Martonne aridity index wheat, crop rotation

INTRODUCTION

Crop rotation influence on wheat is very known (Budoi Gh. and Penescu A., 1996, Guş et al. 1998, 2003). The climate influence on wheat and the irrigation influence on yield level and stability are very known too (Botzan M., 1966; Grumeza N. et al., 1989, Domuţa C., 1995; Ardelean I., 2006)

Climate characterization after one of its elements (rainfall, temperature etc) is not enough because the problem is much more complex. A possibility of the climate characterization consist of the use of the climate indicators; along the time numerous climate indicators were purposed (Grumeza N and al, 1989); ones include two climate elements (De Martonne aridity index, Seleaninov hydrothermic coefficient, Teaci index, etc), three elements (hydroheliothermic index) or four climate elements (Domuţa climate index). These indicators include gross climate date. Others indicators include different stage of the climate data preparation and finally the calculation formula (Domuţa C., 2003, 2005).

The most known climate indicator from Romania is "De Martonne aridity index" (Grumeza N and al 1989, Domuța C. 1995, 2003, 2005). This indicator was choisen for quantification of the climate influence on yield.

MATERIAL AND METHOD

The researches are based on the results carried out in Oradea during 2003 – 2008 in a long term trial placed in 1990 on a preluvosoil. The experiment includes two factors: Factor A – crop rotation: a_1 = wheat monocrop; a_2 = wheat – maize; a_3 = wheat – maize – soybean. Factor B – water regime: b_1 = unnirrigated; b_2 = irrigated. Number of repetitions: 4; place method used: subdivided plot.

Soil moisture on 0 – 50 cm was maintained between easily available water content and field capacity in the irrigated variant and soil moisture was determined 15 to 15 days for that. The values of the soil hydrophisics indexes for 0-50 cm depth are: wilting point = 9.7% (720 m^3/ha); field capacity = 24,0% (1787 m^3/ha); easily available water content= 19.2% (1431 m^3/ha)

Monthly De Martonne aridity index was calculated using the formula:

$$\text{IdM} = \frac{12p}{t+10}$$

in wich:

p = monthly rainfall, mm;

t = average of the air temperature, ˚C.

10 = coefficient

In the irrigated variant, the value of the irrigation rate was included together with rainfall (Domuța C. 1995). Domuța C. (1995) adapted the characterization limit of the De Martonne aridity index (Danciu, referenced by Grumeza N. and al 1989) to irrigated conditions and purposed and argumented the need of the dividing and extension for class "wet". In these conditions the new characterization classes of the De Martonne aridity index, the same for unirrigated and irrigation conditions, are the follow: 12 – 24 = semiarid; 24.1 – 30 = moderate drought; 30.1 – 35 = moderate wet I; 35.1 – 40 = moderate wet II; 40.1 – 50 = wet I; 50.1 – 60 = wet II; 60.1 – 80 = wet III; 80.1 – 100 = very wet; > 100 = excessive wet.

The programme Windows XP was used for calculation the correlations, between the De Martonne aridity index and unirrigated and irrigated wheat yield from crop rotation studied.

RESULTS AND DISSCUSIONS

During the vegetation period from spring to harvesting of the wheat the next quantity of the rainfall were registered: 110.7 mm in 2003; 177.6 mm in 2004; 223.0 mm in 2005 and 287.2 mm in 2006, 143.4 mm in 2007 and 218.8 mm in 2008.

Optimum irrigation regime of the wheat

Maintaining of the soil water reserve on 0 – 50 cm depth between easily available water content needed to use the next irrigation rate: 1040 m^3/ha in 2003, 1400 m^3/ha in 2004, 720 m^3/ha in 2005 and 400 m^3/ha in 2006, 3250 m^3/ha in 2007 and 1900 m^3/ha in 2008. Monthly and annual irrigation regime used during 2003 – 2008 in wheat is presented in the Tab 1.

Table 1

Irrigation regime used in wheat for maintaining the soil water reserve on 0 – 50 cm between easily available water content and field capacity, Oradea 2003 – 2008

Year	IV		V		VI		IV – VI	
	∑m	n	∑m	n	∑m	n	∑m	n
2003	-	-	620	2	420	1	1040	3
2004	-	-	800	2	600	2	1400	3
2005	-	-	-	-	720	2	720	2
2006	-	-	400	1	-	-	400	1
2007	1050	3	1000	2	1200	3	3250	8
2008	800	2	1100	3	-	-	1900	5

∑m – irrigation rate; n – numbers of irrigations

Irrigation influence on microclimate

Irrigation determined to improve of the water/temperature ratio and increase of the De Martonne aridity index values.

In 2003, the microclimate of the unirrigated wheat was characterized by "semiarid" (IdM = 16.9) in comparison with "moderate wet I" (IdM = 30.3) in irrigated wheat, De Martonne aridity index of the irrigated variant was bigger than index of unirrigated variant with 79%. April was moderate wet and May and June were semiarid in unirrigated conditions. Both in May and in June the values of the IdM was situated bellow the inferior level of the class "semiarid". As consequence to introduce of the new class "arid" id very necessary; this class will be a characteristic of the climate when the IdM will have the values bellow 12. Irrigations of the wheat in May and June 2003 changed the microclimate like "moderate wet II" and "moderate drought". The relative differences vs. IdM from irrigated variant were of 212 and 165%. (Table 2)

Table 2

Values of the De Martonne aridity index (IdM) registered in unirrigated and irrigated wheat, Oradea 2003 – 2008

Year	Variant	Month							
		IV		V		VI		IV – VI	
		IdM	%	IdM	%	IdM	%	IdM	%
2003	Unirrig.	29.8	100	11.6	100	8.0	100	16.3	100
	Irrig.	29.8	100	36.3	312	24.9	265	30.3	179
2004	Unirrig.	45.4	100	24.8	100	16.4	100	28.9	100
	Irrig.	45.4	100	63.7	257	40.9	249	50.0	173
2005	Unirrig.	35.9	100	26.2	100	23.2	100	28.4	100
	Irrig.	35.9	100	26.2	100	53.7	231	38.6	136
2006	Unirrig.	49.1	100	36.6	100	31.7	100	39.1	100
	Irrig.	49.1	100	55.5	152	31.7	100	45.4	116
2007	Unirrig.	1.7	100	34.3	100	18.8	100	18.3	100
	Irrig.	58.5	3441	76.8	224	63.7	33.9	66.3	362
2008	Unirrig.	37.7	100	19.3	100	15.1	100	24.0	100
	Irrig.	82.1	218	68.4	354	15.1	100	55.5	231
Average	Unirrig.	33.3	100	25.5	100	19.1	100	26.0	100
	Irrig.	50.2	151	54.5	214	35.4	185	46.7	180

In 2004 the microclimate of the unirrigated wheat was characterized like "moderate droughty" (IdM = 28.9) in comparison with "wet" (IdM = 50), the characterization of the irrigated wheat microclimate. Irrigation didn't need in April and the microclimate was characterized "wet". The use of the irrigations in May and June changed the microclimate in "wet II" and "wet" in comparison with "moderate droughty" and "semiarid".

In 2005, the irrigations were needed in June, only and the microclimate became "wet I" in comparison with "semiarid" in unirrigated conditions. In average on the vegetation period the microclimate of the irrigated wheat was characterized like "moderate wet II" in comparison with "moderate droughty" in unirrigated wheat.

In 2006 the irrigation were needed in May only and the microclimate of the irrigated variant was characterized like "wet I" in comparison with "moderate wet II" the characterization of the unirrigated variant microclimate.

The microclimate of the wheat from unirrigated variant was characterized like "semiarid" both in 2007 and 2008 and like "wet III" in irrigated variant both of years. In average on the studied period using the values of de Martonne aridity index the microclimate of the unirrigated wheat was characterized like "moderate wet I" in April, "moderate drought" in May and "semiarid" in June in comparison with the situation from the irrigated variant: "wet II" in April and May and "moderate wet II" in June.

<u>The influence of the irrigation and crop rotation on wheat yield</u>

In average on the three crop rotation of the experiment but in the every crop rotation the irrigation determined wheat yield gains very significant statistically. In average on the 3 crop rotations the yield gains obtained in the irrigated variant were of 50.8% in 2003, 28.6% in 2004, 19.2% in 2005, of 13.2% in 2006, of 106.4% in 2007 and of 32.1% in 2008.(Table 3).

Table 3

Irrigation influence on wheat yield (kg/ha) in the conditions of different crop rotation, Oradea 2003 – 2008

Crop rotation	Water regime		Average
	Unirrigated	Irrigated	
2003			
1. Monocrop wheat	3110	5310	4210
2. Wheat - maize	4756	6960	5358
3. Wheat – maize – soybean	5442	7810	6626
Average of regime	4436	6693	-
Crop rotation Water regime Water regime x Crop rotation Crop rotation x Water regime $LSD_{0.1\%}$ 388 321 412 468			
2004			
1. Monocrop wheat	3780	5260	4520
2. Wheat - maize	5380	6860	6125
3. Wheat – maize – soybean	6272	7710	6991
Average of regime	5144	6613	-
Crop rotation Water regime Water regime x Crop rotation Crop rotation x Water regime $LSD_{0.1\%}$ 424 428 576 624			
2005			
1. Monocrop wheat	4280	5190	4735
2. Wheat - maize	5520	6610	6065
3. Wheat – maize – soybean	6790	7980	7385
Average of regime	5530	6593	-
Crop rotation Water regime Water regime x Crop rotation Crop rotation x Water regime $LSD_{0.1\%}$ 412 354 498 636			
2006			
1. Monocrop wheat	4310	4960	4635
2. Wheat - maize	5760	6400	6110
3. Wheat – maize – soybean	7010	7930	7470
Average of regime	5693	6450	-
Crop rotation Water regime Water regime x Crop rotation Crop rotation x Water regime $LSD_{0.1\%}$ 524 374 542 512			
2007			
1. Monocrop wheat	1310	2970	2140
2. Wheat - maize	2480	5020	3750
3. Wheat – maize – soybean	3370	6810	5090
Average of regime	2390	4933	-
Crop rotation Water regime Water regime x Crop rotation Crop rotation x Water regime $LSD_{0.1\%}$ 540 310 560 436			
2008			
1. Monocrop wheat	4550	5970	5260
2. Wheat - maize	5600	7420	6510
3. Wheat – maize – soybean	6020	7980	7000
Average of regime	5390	7123	
Crop rotation Water regime Water regime x Crop rotation Crop rotation x Water regime $LSD_{0.1\%}$ 510 408 690 530			

Correlation between De Martonne aridity index and yield in differenr crop rotation

The values of the De Martonne aridity index for period IV – VI were correlated with the yields obtained in unirrigated and irrigated conditions for every crop rotation.

Results show a direct relationship between this climate indicator and wheat yield; the type of the mathematical expression of the relationship is a power one for monocrop and wheat – maize crop rotation and polynomial one for wheat – maize – soybean crop rotation. The best correlation coefficient (R^2 = 0.7545), statistically very significant, (fig.1) was obtained in the best crop rotation: wheat – maize – soybean. The worse correlation coefficient (R^2 = 0.6481) was obtained in monocrop (fig. 2); in the wheat – maize crop rotation, the correlation coefficient (R^2 = 0.6105) had a value with very few bigger than the value registered in monocrop, statistically these 2 coefficient are significant only.

All these correlations sustain the irrigation need in wheat crop from Crisurilor Plain because only using the irrigation we can improve the values of the De Martonne aridity index (water/temperature ratio) and their improve is in a direct link, statistically assured, with yield level of the wheat.

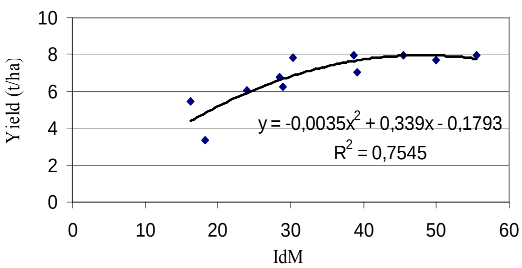

Fig. 1. Correlation between De Martonne aridity index (IdM) and yield in wheat-maize-soybean crop rotation

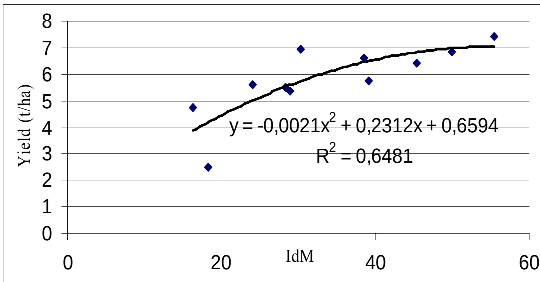

Fig. 2 Correlation between De Martonne aridity index (IdM) and wheat yield in wheat-maize crop rotation

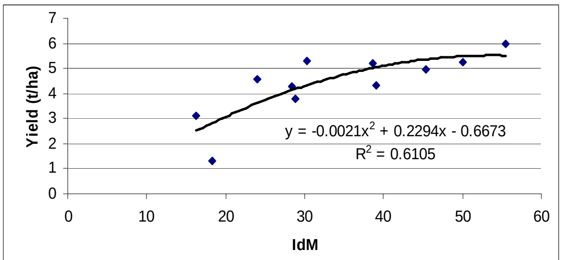

Fig. 3. Correlation between de Martonne aridity index (IdM) and wheat yield in mnocrop

CONCLUSIONS

The research carried out during 2003-2008 in the long term trial placed on preluvosoil from Oradea in 1990 determined the following conclusions:

1. Calculating the monthly values of the De Martonne aridity index (IdM) determined to obtain the values situated bellow inferior limit of the semiarid “class”. As consequence, I purpose a new class of “IdM” characterization called “arid”; this new class is composed the values of IdM smaller than 12;
2. Optimum water supply of the wheat using the irrigation determined the increase of the IdM values for period IV – VI with 79% in 2003, 73% in 2004, 36% in 2005,16% in 2006, 162% in 2007 and with 131% in 2008;
3. Using the irrigation and the improvement of the microclimate conditions determined to obtain the yield gains very significant every year and every crop rotation studied;
4. Both in unirrigated conditions and in irrigated conditions, the smallest yields wheat were obtained in monocrop and the biggest in the wheat – maize – soybean crop rotation;
5. In the all three crop rotation, the direct links statistically assured were registered between the values of the De Martonne aridity index and yields in unirrigated and irrigated wheat. These correlations sustain the need of the irrigation in wheat from Crisurilor Plain;
6. Correlation between De Martonne aridity index is stronger (R^2 = 0.7545) in the wheat – maize – soybean crop rotation in comparison with wheat – maize crop rotation (R^2 = 0.6481) and with wheat monocrop (R = 0.6105). As consequence, crop rotation of wheat-maize-soybean is recomanded because the climate and microclimate conditions are better use.

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