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RESEARCH REGARDING THE IMPORTANCE OF THE IRRIGATION IN THE SUSTAINABLE AGRICULTURE SYSTEM FROM NORTH WESTERN PART OF ROMANIA

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Abstract. *The paper is based on the research carried out during 1976-2014 in Oradea, in a long term trial at ten different crop.*

The melioration crop rotation with alfalfa, the fertilization system with manure and optimum chemical fertilization determined to maintain the structured degree in the irrigated variant on the level of the crop rotation with unirrigated wheat- maize

Soil water reserve on irrigation depth decreased bellow easly available water content every year and in the 30 % from years even bellow wilting point.

The irrigation improved the microclimate conditions and the optimum water consumtion can be assured using the irrigation, only .

Irrigation determined the increase of the yield level in average with 39 % (wheat) to 127 %(maize for silo); yield stability (standard deviation) improved with 8,7 % (sunflower) to 50,4 % (maize for silo). Yield quality and water use efficiency were improved, too, in the irrgated conditions.

The correlations quantified in the soil-water-plant- atmosphere system sustain too the importance of the irrigations in the sustainable agriculture system from Western part of Romania, too.

Keywords: irrigation, microclimate, sustainable agriculture, yield, water use efficiency.

Introduction

The concept of sustainable agriculture appeared in the sixth decade of the last century as a response to the enviromental pollution. The resort “we have one land who must be protected” at The United National Conference for Human Environment from Stockholm in 1972 and “Broundland Report” of ONU Conference on Enviroment and Development from Rio de Janeiro was the crucial moments in definition of the development sustainable concept, especially sustainable agriculture. The researchers who published about this problem were

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Tinbergen (1956), Odum, 1971, Clarck and Mun, 1986, Hall, 1995 and all (referenced by Puia and Soran, 1999).

In Romania, in 1999 there was a reference moment regarding this problem; Hera.Cr, organized the symposium ”The performant sustainable agriculture”, scientifical manifestation of Plant Crop Section belonged to ASAS “Gheorghe Ionescu Şişeşti”. From many and interesting papers referenced and published the symposium those written by Puia and Soran, Toncea, Săulescu, Iliescu, Sin, Picu (Hera 1999). Budoi and Penescu (1996), Guş and all (1998) in the treatises of Soil Management had an important contribution in knowledge of this concept, too. All these papers sustain the crop rotation like central pivot and presume a variating structure of crops. In this system, the organic fertilization is very important, the chemical fertilization can be used with moderate rates, the soil tillage must be right executed, the plants protection is realised by integrated management; all this thinks assured the conservation of the soil, water and biodiversity reserve and obtaining an ecological and profitable yields.

If it’s used correctly, the irrigation is a component of sustainable agriculture (Doorembos and Kassam, 1986, Doorembos and Pruitt, 1992).

The papers starts from this reason and through the researches concerning of soil structure, soil moisture stress, the irrigation influence upon microclimate and plants water consumption, the level, stability and quality of the yield , and the water use efficiency demonstrate that irrigation is an important component of sustainable agriculture system from western Plain of Romania.

MATERIAL AND METHOD

The research were obtained in Oradea in the north part of Crişurilor Plain during 1976-2014, in a long term trial on preluvosoil.

On the ploughed depth, the preluvosoil has a hydraulic conductivity with big value, median on 20-60 cm depth and very small below 60 cm depth. On 0-20 cm depth the soil is small settled (BD = 1.41 g/cm^3) and very settled on the irrigation depth of the crops studied and on the depth (0-150 cm) for soil water balance. Field capacity (FC) is median on the all soil profile and wilting point (WP) has a median value till 80 cm depth and big value below this depth. Easily available water content (W_{ea}) was established by formula (Botzan 1966, Grumeza and all, 1989): W_{ea} = WP + 2/3 (FC - WP);

Soil reaction is low acid, the humus content (1.8 %) is small and the total nitrogen content (0,127-0,156 ppm) is small- median; the mobile potassium content is small – median, too. The annual fertilization with the doses specifical for irrigated crops increased the phosphorus content from 22.0 ppm to 150.8 ppm.

The water sources for irrigation is water ground (15 m depth). The irrigation water has a low natrium content (12.9 %), the salinization potential is low (CSR = -1.7) and SAR index (0.52) is low too.

The irrigation equipment of the research field permitted to measure exactly and to distribute uniformelly the irrigation water.

Soil moisture determined ten to ten days maintaining the soil water resrve on irrigation depth (0-50 cm for wheat and bean; 0-75 cm for maize, soybean, sunflower, potato, sugarbeet, alfalfa 1st year, maize for silo; 0-100 cm for alfalfa 2nd year).

Domuţa Climate Index was calculated after following formula: ICD = $\frac{100W + 12{,}9A}{\sum t + Sb}$;

were: W = water (irrigation, rainfalls, water ground);
A = air humidity, %;
Σt = the sum of daily average temperature, °C;
Sb = sun brilliance, hours

The climate carachterization after ICD value is: < 3 exces droughty; 3.1-5.0 very droughty; 5.1-7.0 droughty; 7.1-9 median droughty; 9.1-12 median wet; 12.1-15 wet I; 15.1-18 wet II; 18.1-25 – wet III; > 25 exces wet.

The crops technologies wish to be the optimum one, for this part of the country. Crop rotation used were: alfalfa 1st year – alfalfa 2nd year- maize – bean – wheat – soybean – sugarbeet – sunflower – potato. The fertilization system had a rate of 40 t/ha manure for sugarbeet and potato and annual medium rate on crop rotation of N 140 kg/ha a.s., P 110 kg/ha a.s. and K 90 kg/ha a.s. were used.

The structure of soil was determined with Cseratzki method. Plants water consumption was determined by soil balance; the depth balance was 0-150 cm.

RESULTS AND DISCUSSIONS

The influence of irrigation on soil

A right leading of irrigation regime (through maintaining the soil water reserve between easily available water content and field capacity on irrigation depth), the application of melioration crop rotation and a organo-mineral system of fertilization for irrigated crops determined the realization of structured degree of 35.98 %, with 3 % bigger than structured degree determined in wheat- maize rotation. In unirrigated melioration crop rotation the structured degree (47,52 %) was bigger than the wheat – maize crop rotation with 34 % (table 1).

Table 1. The influence of the melioration crop rotation and irrigation on macrostructure stability of the preluvosoil, Oradea 1976-2014

Nr. crt	Crop rotation	Ø 5 mm		Ø 2 mm		Ø 1 mm		Ø 0.25 mm		Σ	
		Agreg %	Dif. %	Agreg %	Dif. %	Agreg %	Dif. %	Agreg %	Dif. %	Agreg %	Dif. %
1	Wheat-maize unirrigated	1.93	100	1.76	100	2.45	100	29.12	100	35.26	100
2	Melioration unirrigated	3.93	204	0.96	55	1.96	80	40.67	139	47.52	134
3	Melioration irrigated	0.56	29	0.63	36	1.12	48	33.42	114	35.98	103

The influence on microclimate

The irrigation determined the improve of microclimate conditions. The value of report water/temperature + light (Domuţa Climate Index, ICD) calculated for irrigated maize crop was bigger with 135 % in August, 115 % in July, 49 % in June and 32 % in May. In irrigated maize, the microclimate was characterized "median wet" vs "median droughty" in May, "wet II" vs "median wet" in June, "wet III" vs "median droughty" in July, "wet I" vs "droughty" in August (table 2).

Table 2 The modifications of the water/temperature + light report (Domuţa Climate Index) under the influence of the irrigation in maize crop, Oradea 1976-2014

Variant	V		VI		VII		VIII	
	ICD	%	ICD	%	ICD	%	ICD	%
Unirrigated	8.9	100	10.7	100	8.6	100	6.3	100
Irrigated	11.8	132	15.91	149	18.5	215	14.8	235
Variation interval of differences	0-383		0-302		0-795		28-3126	

The irrigation influence on water consumption

The irrigation determined the increase of the values of daily water consumption. In this case the total water consumption had values bigger than total water consumption of unirrigated crops, the differences was registered between 36.6 % (wheat) and 108.4 % (maize for silo double crop).The most important part from total water consumption was covered with rainfalls registered in the period of the vegetation crops. For the assurance of optimum water consumption of these crops (maintaining the water reserve below easily available water content anf field capacity) the irrigation was necessary every year; the participation averages in the covering sources have values between 33.7 % (wheat) and 58.7 % (maize for silo double crop); the maximum values of the variation interval were registered between 61.0 % (maize) and 103.2 % (maize for silo double crop).

The irrigation influence on yields level

The average of the yields obtained during 1976-2014 in irrigation conditions were bigger than in unirrigated conditions. The relative differences registered had the values between 39 % (wheat) and 127 % (maize for silo double crop).The amplitude of the variation interval for yield differences between two variants was 104 % at sunflower, 116 % at wheat crop, 176 % alfalfa crop 2nd year, 218 % sugarbeet crop, 291 % at alfalfa 1st year, 353 % soybean, 358 % at potato, 800 % at bean, 806 % maize for corn and 25745 % at maize for silo double crop (table 3).

Table 3. The level of yields in main crop, in irrigated and unirrigated conditions, Oradea 1976-2014

Crop	Variant	Yield level			
		Average		Variation interval	
		kg/ha	%	kg/ha	%
1.Wheat	Unirrigated	4547	100	2736-7100	100
	Irrigated	6343	139	3993-8300	105-221
2.Maize	Unirrigated	6608	100	1510-12600	100
	Irrigated	11993	181	17880-16480	107-912
3.Soybean	Unirrigated	1836	100	300-3400	100
	Irrigated	3087	168	1380-4080	107-460
4.Bean	Unirrigated	1439	100	180-2720	100
	Irrigated	2170	151	1321-3770	105-905
5. Sun flower	Unirrigated	2289	100	1350-3140	100
	Irrigated	3394	148	1757-4580	106-210
6.Sugar beet	Unirrigated	39895	100	18960-80900	100
	Irrigated	64453	162	44850-87800	109-327
7.Potato	Unirrigated	24137	100	11500-43700	100
	Irrigated	38284	159	20670-66050	106-464
8. Alfalfa 1st year	Unirrigated	45472	100	18500-89800	100
	Irrigated	69905	154	30500-120850	113-404
9. Alfalfa 2nd year	Unirrigated	60953	100	29500-118590	100
	Irrigated	96822	159	57000-145420	119-295
10. Maize for silo 2nd crop	Unirrigated	13890	100	0-31000	100
	Irrigated	31470	227	10160-44640	115-25860

The influence of irrigation on yield stability

The quantification of the yield stability was made using the "standard deviation " indicator. In the all crops, the irrigation determined the increase of yield stability, the differences between standard deviations for irrigated and unirrigated conditions was 8.7 % (sunflower) and 50.4 % (maize for silo double crop) (table 4).

The influence of irrigation on water use efficiency

Excepting the sunflower crop, in all the crops, the irrigation determined the improve of water use efficiency, for 1 m^3 water consumpted was obtained a bigger quantity of the main yield than unirrigated conditions, the relative differences had medium values between 2 % (wheat) and 25 % (maize for silo double crop), (table 5).

Table 4. Standard deviation in unirrigated and irrigated crops, Oradea 1976-2014

Variant	Crops for grain									
	Wheat		Maize		Sunflower		Soybean		Bean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Unirrigated	922	100	3271	100	580	100	814	100	820	100
Irrigated	642	69.6	1879	57.4	530	91.3	547	67.2	680	82.9
Crops for stalk and roots										
Variant	Sugarbeet		Potato		Alfalfa 1st year		Alfalfa 2nd year		Maize for silo 2nd crop	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Unirrigated	9240	100	9440	100	37950	100	30160	100	9310	100
Irrigated	6920	79.9	5480	58.1	33630	88.6	25720	85.3	4620	49.6

Table 5 Irrigation influence on water use efficiency, Oradea 1976 - 2014

Variant	Crops for grain									
	Wheat		Maize		Sunflower		Soybean		Bean	
	kg/m³	%	kg/m³	%	kg/m³	%	kg/m³	%	kg/m³	%
Unirrigated	1.45	100	1.55	100	0.58	100	0.48	100	0.45	100
Irrigated	1.48	102	1.93	125	0.58	100	0.53	110	0.52	115
Crops for stalk and roots										
Variant	Sugarbeet		Potato		Alfalfa 1 st year		Alfalfa 2nd year		Maize for silo double crop	
	kg/m³	%	kg/m³	%	kg/m³	%	kg/m³	%	kg/m³	%
Unirrigated	8.64	100	6.35	100	9.71	100	11.94	100	10.08	100
Irrigated	9.22	106.7	7.23	114	10.44	108	12.42	104	10.95	109

Correlations from soil –water- plant- atmosphere system

Over the years the correlations from soil – water – plant- atmosphere system were quantified for all researched crops (Domuţa, 1995, 1997,1999, 2000, 2003, Domuţa et all, 2000). In this paper were presented the correlations at one of important crop in this area which is maize.

An inverse links were quantified between number of days with pedological drought, water reserve below easily available water content and yield, respectively water use efficiency and between number of days with water reserve on irrigation depth below wilting point and yield determined an inverse links, statistically very significantt. Between number of days with water reserve below easily available water content and yield gain obtained using the irrigation was quantified a direct link, statistically very significant.

A direct links, statistically very significant were quantified between microclimate conditions and yield, respectively between water consumption and yield. This correlations sustained the possibility of maize irrigation in this area (table 7).

Table 7. Correlation in the soil – water – plant – atmosphere system in maize, Oradea 1976-2014

Nr. crt.	Correlation	Regression function	Correlation coefficient
Correlation between soil moisture stress and yield			
1	Nr.of days with WR<WP x yield	y = 601,33 $x^{0,9047x}$	R = 0,88 ^{ooo}
2	Nr. of days with WR<Wea x yield	y = 158,88 $e^{-0,0148x}$	R = 0,66 ^{ooo}
3	Nr. of days with WR<Wea x WUE	y = 3,5236 $e^{-0,0144x}$	R = 0,62 ^{oo}
4	Nr. of days with WR<Wea xyield gain	y = 0,0935 $x^{-0,0127}$	R = 0,78 ^{xxx}
Correlation between microclimate and yield			
5	ICD x yield	$y=-0,2931x^2+13,57x-21,108$	R = 0,88^{xxx}
Correlation between water use efficiency and yield			
6	WUE x yield	$y=-0,0004x^2+0,6312x128,48$	R = 0,77^{xxx}

WR = water reserve on 0-75 cm depth; WP = wilting point; WEA = easily available water content; WUE = water use efficiency; kg/m^3; ICD = Domuţa Climate Index.

CONCLUSIONS

The paper is based on the researches carried out during 1976-2014 in Oradea, in a long term trial at ten different crops.

The presence of irrigation in the components of sustainable agriculture is sustained by following arguments:

- The evolution of soil structure. In the conditions when was used alfalfa as ameliorativ crop rotation, and the fertilization system includes manure the structured degree (35.98 %) was maintaining to the level of the structure degree from crop rotation wheat- maize unirrigated (35.26 %);
- The droughty microclimate of unirrigated crops and the positive influence of the irrigation on water/ temperature + light report (Domuta climate index), the differences obtained in maize crop arriving at 3126 % in August;
- The improve of the crops water consumption; the differences in comparison with unirrigated crops were between 36.6 % (wheat) and 108,4 % (maize for silo double crop). The optimum water consumption can be assured using the irrigation only. This participation in the covering sources was between 33.2 % (sunflower) and 58.7 % (maize for silo double crop).

- The highest level of yields, median differences, were between 39 % (wheat) and 127 % (maize for silo double crop). The maximum values of the variation interval are between 110 % (sunflower) and 25760 (maize for silo double crop).
- The big stability of the yield, standard deviation values were smaller than unirrigated conditions with relative values between 8.7 % (sunflower) and 50.4 % (maize for silo double crop);
- The increasing of water use efficiency with values between 2 % (wheat) and 25 % (maize);

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