THE MAIN PARAMETERS OF THE SOIL-WATER-PLANT-ATMOSPHERE IN AUTUMN CABBAGE CROP FROM CRISURILOR PLAIN

Jude Eugen*

*University of Oradea, Faculty of Environmental Protection, Oradea, Romania

Abstract

The paper is based on the results carried out during 2011-2013 in Agricultural Research and Development Station Oradea. On the irrigation depth the autumn cabbage (0-50 cm), in unirrigation conditions was registered pedological drought in 80 days in 2011, 81 days in 2012 and 92 days in 2013, the pedological drought manifested pronounced each year.Maintaining soil moisture on depth of 0-50 cm between the easily available water content and field capacity required irrigation rate about 2250 m^3 / ha in 2011 to 3,000 m^3 / ha in 2012 and 3600 m^3 / ha in 2013 irrigation determined the increase the daily water consumption values of autumn cabbage in all months of the vegetation period; the biggest difference compared with unirrigated variant were determined in August, 135% in 2011, 162% in 2012 and 117% in 2013. The yield spore obtained at 1 m^3 of irrigation water used was of 18,94 kg in 2011 to 15,24 kg in 2012 and 13,97 kg in 2013.

Keywords: parameters, irrigation, yield, autumn cabbage,drought

INTRODUCTION

Knowledge of relations of the soil-water -plant-atmosphere system is a basic requirement in correct operation of irrigation facilities (GrumezaN., Klepş Cr., 2005). On the quantification of these relations the specialists can optimize water - air between conductors vegetation factors (Domuta C., 1995, 2005, 2009, 2012; Domuta Cr., 2010, 2011, 2012, 2013). Research for knowledge of soil-water -plant-atmosphere system components or interrelations between them in the conditions from Crisurilor Plain were made by Stepănescu E., Colibaş I., Colibaş M., Şandor M., Bronţ Ilona (citaţi de către Domuţa C., 1995), Borza I (2007), Brejea R.(2009).

This paper is considering a vegetables crop with very good tradition in the western Crisurilor Plain, cabbage autumn. Were quantified parameters related to soil-water subsystem (number of days with pedological drought, the number of days with water reserve under the minimum threshold under irrigation depth, 0-50 cm in autumn cabbage, Domuta C., 2005) and parameters of soil-water-plant system (water recovery efficiency and recovery efficiency of irrigation water).

MATERIAL AND METHOD

The researches were made at Agricultural Research and Development Station from Oradea in the preluvosoil conditions, in the experiment field made in 1990 by Domuta C.

Main physical and hydrophysical properties

Luvosoil from the research field is characterized by a very high hydrostability of soil aggregates more than 0,25 mm, 47,5% of layer by 0-20 cm.

The soil had a total medium porosity at depth by 0-20 cm, 20-40 cm, 40-60 cm and less in depth by 6-80 cm, 80-100 cm and 100-150 cm. Total porosity values decrease on the soil profile from the surface to depth.

Hydraulic conductivity is high on the depth 0-20 cm, medium on depth by 20-40 cm and 40 cm, low and very low on the following depths studied.

Bulk density - 1.41 g/cm3 - characterizes a poorly compacted soil at depth 0-20 cm; on other depths studied the apparent weight highlights a moderately and strongly compacted soil (Brejea R., 2010). On watering depth (0-50 cm, 0-75 cm) and on 0-150 cm the soil is strongly compacted.

Field capacity had a middle value throughout the soil profile and wilting coefficient is also worth to middle depth of 80 cm and higher below this depth (Borza Ioana, 2011).

Active humidity interval (IUA) or useful water capacity had a high value in the depth 0-80 cm and the middle at depth 80-150 cm. On watering depth used on the research field the active humidity range had a great value (Domuța C., 2009,2012).

Depending on soil easily available water content was set at 2/3 IUA.

Chemical properties

The soil in the research field has a slightly acid reaction throughout the depth studied, with increasing values from surface to depth.

Humus supply is poor, and the total nitrogen, low – medium on the entire depth researched.

C / N ratio has a value higher on depth of 0-20 cm (8,01) and decreases with depth determination.

Fertilizing every year with doses of phosphorus specific to agrotechnical irrigated soils caused raising of phosphate level of preluvosoil from research field that after 27 years of stationary research the quantity of mobile phosphorus from soil increased on layer from 22,0 ppm (middle ground supplied) to 150.8 ppm (soil very well stocked).

Mobile potassium content of soil is low - medium, with values increasing from the arable layer (124.5 ppm on the 0-20 cm) to depth (145.4 ppm in the 100-150 cm).

The soil content in exchangeable magnesium on soil profile has a similar pattern with potassium content, the soil being middle supplied with this item's full profile.

Manganese characterize the soil from field research like a soil with medium content at depth 0-20 cm and 20-40 cm and low content at next depths.

The soil is moderately submezobazic on the entire deep studied.

The water sources for irrigation is water ground (15 cm 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.

Experience has been placed by block method in four repetitions. Area of experimental plots was 50 m^2. Variety used was De Socodor. Culture technology used was the optimal one for autumn cabbage.

The depth of irrigation was fixed: 0-50 cm (Grumeza N. et al. 1989). On this depth water reserve was maintained between the minimal and field capacity, taken the soil samples from 10 to 10 days (Brejea R., 2009, 2014). Dynamic graphs of soil water reserve allowed determining the number of days with water reserve under the minimum threshold and the number of days with water reserve under wilting coefficient, indicators considered by Domuta C (2004) that reflects a period of pedological drought or a period with pedological stressed drought.

At the end of the month, soil samples were taken to determine moisture content in the depth of 0-15 cm.

Water consumption of plants was determined by the soil water balance, depth of review used was 0-150 cm (Domuta Cr.).

The yields obtained were calculated by the method of analysis of variance (Domuta C., 2006).

Two other parameters of the soil-water-plant-atmosphere system (Borza I., 2007) were calculated using the following formulas:

$$1)\ EVA = \frac{Yield}{\Sigma\,(e + t)};$$

in which:

EVA = water used efficiency, kg/m^3

Σ (e + t) = water consumption; m^3/ha

$$2)\ EVAI = \frac{\text{Yield spore}}{\Sigma\ m};$$

in which:

EVAI = irrigation water used efficiency, kg sp

Yield spore = Yield on irrigated crop – Yield on unirrigated crop

Σ m = irrigation rate; m^3/ha

Pedological drought was considered the decrease of the soil moisture bellow easily available content and strong pedological drought was considered the decrease of the soil moisture bellow wilting point (Domuta C., 2005; Brejea R., 2011, 2014).

RESULTS AND DISCUSSION

Pedological drought in unirrigated crop of sugar beet.

In 2011, there were a total of 80 days with pedological drought; the phenomenon is present in all the days of June. Strong pedological drought was present only in August, each 5 days (table 1, table 2).

Pedological drought was present in 2012 in 81 days, the most recorded in August, 31 days. Pedological drought was present by 10 days in August and September.

The biggest number of days with pedological drought was registered in 2013 (92 days) on all days July and August recorded this phenomenon. Strong pedological drought was present still in July.

Table 1

Days with pedological drought in unirrigated cabbage crop, Oradea 2011-2013

Years	Month				
	June	July	August	September	Total
2011	30	15	20	25	80
2012	15	15	31	30	81
2013	10	31	31	20	92

Table 2

Days with strong pedological drought in unirrigated cabbage crop, Oradea 2011-2013

Years	Month				
	June	**July**	**August**	**September**	**Total**
2011	-	-	5	5	10
2012	-	-	10	10	20
2013	-	10	15	3	28

Optimum irrigation regime of autumn cabbage

In 2011, during the vegetation period of autumn cabbage were registered 35,2 mm rainfall in June, 125,3 mm in July, 8,9 mm in August and 30,8 mm in September. Therefore, to ensure an optimal soil moisture was used a standard irrigation regime of 2250 m^3 / ha (400 m^3 / ha) in June, 250 cm^3 / ha in July, 900 cm^3 / ha in August and 700m^3 / ha in September, applied 6 watering rate (table 3).

The year 2012 had a different distribution of rainfall during the vegetation period of autumn cabbage: 94,1 mm in June, 70,8 mm in July, in August 6,5 mm, 21,4 mm in September. Following the optimum water reserve of autumn cabbage crop required an irrigation rate of 3000 m^3 / ha: 300m^3 / ha in June, 700m^3 / ha in July, 1200m^3 / ha in August and 800m^3 / ha in September.

In 2013 irrigation regime take values by 3600 m^3 / ha: 400 m^3 / ha in June, 1200 m^3 / ha in July and 800 m^3 / ha in September.

Table 3

Irrigation regime used to maintain the water reserve from soil at depth of 0-50 cm between minimum threshold and field capacity, Oradea 2011-2012

Year	VI		VII		VIII		IX		Total	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	N
2011	400	1	250	1	900	2	700	2	2250	7
2012	300	1	700	2	1200	3	800	2	3000	8
2013	400	1	1200	3	1200	3	800	2	3600	9

Σm = irrigation rate;
n = number of irrigations

The influence of irrigation on autumn cabbage water consumption

Daily water consumption of irrigated autumn cabbage had the highest value in July, 38,3 m^3 / ha / day in 2011, 36,4 m^3 / ha / day in 2012 and 29,8 m^3 / ha / day in 2013 . In both years studied, in August were registered rainfalls below multiannual average(table 4).

Table 4

The influence of irrigation on daily water consumption of autumn cabbage, Oradea 2011-2012

Year	Variant	VI		VII		VIII		IX	
		m^3/ha/day	**%**	**m^3/ha/day**	**%**	**m^3/ha/day**	**%**	**m^3/ha/day**	**%**
2011	Unirrigated	23,0	100	38,3	100	25,4	100	19,7	100
	Irrigated	31,3	136	50,6	132	59,7	235	34,6	176
	Difference	12,7	36	12,3	32	24,3	135	14,9	76
2012	Unirrigated	26,4	100	36,4	100	23,4	100	19,0	100
	Irrigated	35,8	136	53,7	148	61,2	262	36,0	189
	Difference	9,4	36	17,3	48	37,8	162	17,0	89
2013	Unirrigated	27,6	100	29,8	100	29,2	100	24,3	100
	Irrigated	33,4	121	51,0	171	63,2	217	41,3	170
	Difference	5,8	21,2	21,2	71	34	117	17	70

Total water consumption of irrigated autumn cabbage was 2760 m^3 / ha in 2011 and 2558 m^3 / ha in 2012. Optimal water supply through irrigation, determining the increase of total water consumption by 73% in 2011 and 107 % in 2012. To cover the total water consumption of irrigated autumn cabbage in both years, the irrigations had the highest percentage: 47% in 2011 and 57% in 2012 (table 5).

Table 5

The total water consumption of irrigated and unirrigated autumn cabbage crop and covering sources

Variant	Total water consumption	Covering sources of consumption					
		Soil reserve		Rainfalls		Irrigation	
	m^3/ha	m^3/ha	%	m^3/ha	%	m^3/ha	%
2011							
Unirrigated	2760	100	758	27	2002	73	-	-
Irrigated	4780	173	548	11	2002	42	2250	47
2012							
Unirrigated	2558	100	630	25	1928	75	-	-
Irrigated	5310	207	382	7	1928	36	3000	57
2013							
Unirrigated	2468	100	810	33	1651	67	-	-
Irrigated	5711	231	460	8	1651	29	3600	53

Influence of irrigation on autumn cabbage yield

In 2011 irrigation determined a spore of yield by 228%(42610 kg / ha), highly statistically significant (table 6).

Table 6

Influence of irrigation on yield at autumn cabbage crop, Oradea 2011

Variant	Yield		Difference		Statistically significant
	kg/ha	%	kg/ha	%	
Unirrigated	18710	100	-	-	Mt
Irrigated	61320	328	42610	228	xxx

LSD 5% 730
LSD 1% 1250
LSD 0,1% 1970

Autumn cabbage yield obtained in 2012 are lower than the yields obtained in 2011, both in conditions of unirrigation and also in conditions of irrigation. Irrigation determined an yield spore of 299% (45710 kg / ha), highly statistically significant (table 7).

Table 7

Influence of irrigation on yield at autumn cabbage crop, Oradea 2012

Variant	Yield		Difference		Statistically significant
	kg/ha	%	kg/ha	%	
Unirrigated	15240	100	-	-	Mt
Irrigated	60950	399	45710	299	xxx

LSD 5% 620
LSD 1% 980
LSD 0,1% 1530

In 2013 were obtained the lowest yield of autumn cabbage in conditions of irrigation: 12300 kg / ha. Irrigation determined an yield spore of 409% (50300 kg / ha) highly statistically significant (Table 8).

Table 8

Influenta irigatiei asupra productiei la varza de toamnă, Oradea 2013

Variant	Yield		Difference		Statistically significant
	kg/ha	%	kg/ha	%	
Unirrigated	12300	100	-	-	Mt
Irrigated	62600	509	50300	409	***

LSD 5% 590
LSD 1% 940
LSD 0,1% 1610

Influence of irrigation on water use efficiency at autumn cabbage crop

The amount of autumn cabbages obtained from 1 m^3 of water consumed in irrigation conditions was 6,78 kg in 2011 and 5,96 kg in 2012 and 4,98 kg /

m^3 in 2013. Irrigation determined the increase of autumn cabbage amount obtained from 1 m^3 of water consumed with 88% in 2011 to 93% in 2012 and 220% in 2013 (table 9).

Yield spore obtained in 1 m^3 irrigation water used was 18,94 kg in 2011, with 20% (15,24 kg) lower in 2012 and 26% lower in 2013 (table 10).

Table 9

Influence of irrigation on water use efficiency (EVA) by autumn cabbage crop, Oradea 2011-2013

Variant	EVA		Difference	
	kg/m^3	%	kg/m^3	%
2011				
Unirrigated	6,78	100	-	-
Irrigated	12,79	188	6,01	88
2012				
Unirrigated	5,96	100	-	-
Irrigated	11,48	193	5,52	93
2013				
Unirrigated	4,98	100	-	-
Irrigated	10,96	220	5,98	120

Table 10

Irrigation water use efficiency (EVAI) by autumn cabbage crop, Oradea 2011-2013

Year	EVAI		Difference	
	kg spore/m^3	%	kg spore/m^3	%
2011	18,94	100	-	-
2012	15,24	80	-3,70	20
2013	13,97	74	-4,97	-26

CONCLUSIONS

Results performed on the preluvosoil condition from Agricultural Research and Development Station Oradea in 2011-2013 determined the following conclusions:

- On the irrigation depth the autumn cabbage (0-50 cm), in unirrigation conditions was registered pedological drought in 80 days in 2011, 81 days in 2012 and 92 days in 2013, the pedological drought manifested pronounced each year
- maintaining soil moisture on depth of 0-50 cm between the minimum threshold and field capacity required irrigation rate about

2250 m^3 / ha in 2011 to 3,000 m^3 / ha in 2012 and 3600 m^3 / ha in 2013

- irrigation determined the increase the daily water consumption values of autumn cabbage in all months of the vegetation period; the biggest difference compared with unirrigated variant were determined in August, 135% in 2011, 162% in 2012 and 117% in 2013.
- the total water consumption of irrigated autumn cabbage increasing compared with unirrigated variant with 73% in 2011, to 108% in 2012 and 131% in 2013. To cover water consumption, irrigation had higher values (47% in 2011, 57% in 2012 and 53% in 2013) than normal rainfall during the period from sowing to harvesting of autumn cabbage (42%, 35% and 29%) and compared with water reserve from soil (11%, 7% and 8 %)
- irrigation determined yield spore with different statistically significant in all three years studied: 228% (42610 kg / ha) in 2011, 299% (45710 kg / ha) in 2012 and 409% (50300 kg / ha) in 2013
- the water use efficiency was significantly improved using irrigation, the amount of cabbages obtained at 1m^3 of water consumed, increasing compared with unnirigated variant with 88% in 2011 to 93% in 2012 and by 120% in 2013. The yield spore obtained at 1 m^3 of irrigation water used was of 18,94 kg in 2011 to 15,24 kg in 2012 and 13,97 kg in 2013.

Research shows that ensuring the optimal moisture on the irrigation depth of autumn cabbage is only possible using irrigation, this leading to increased values of plants water consumption and obtaining of high yield spore very significantly assured compared with unirrigated autumn cabbage crop. All these support the necessity of irrigation at autumn cabbage in Crisurilor Plain.

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