IRRIGATION THE COMPONENT OF THE SUSTAINABLE TECHNOLOGY OF THE AUTUMN CABBAGE FROM CRIŞURILOR PLAIN

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Abstract

The research concerning the irrigation of autumn cabbage was carried out on the preluvosoil from Oradea Agricultural Research and Development Station during 2013 and 2014. In order to maintain the soil water reserve on 0-50 cm depth easily available water content and field capacity irrigation water was required both in 2013 and 2014, 3.000 m^3/ha and 3.600 m^3/ha respectively .The total water consumption of the irrigated autumn cabbage increased in comparison with unirrigated variant of 108% in 2013 and of 131% in 2014. The contribution of the irrigation in the total water consumption (57% in 2013 and 53% in 2014) was higher than that of precipitations in the period from planting to harvesting, that is, 35% and 29%, and than that of soil water storage (7% and 8%). The water use efficiency iproved significantly as a result of irrigation, the amount of cabbage head corresponding to 1 m^3 of water used increaed in comparison the unirrigated crop by 93% in 2013 and by 120% in 2014. The increase in yield corresponding to 1 m^3 of irrigation water was 15.24 kg in 2013 and 13.97 kg in 2014.

Key words*:* irrigation, cabbage, easily available water content, efficiency, yield

INTRODUCTION

The great number of vegetable species, varieties and forms are important ingredients of a wide range of food, significantly improving and enriching meal choices. Most vegetable species have a pleasant taste, with great differences from a variety to another, and some of them are rich in essential oils, glycosides, pigments, and vitamins etc., which stimulate appetite. (Șandor, 2013)

Staggered production cycles and constant supplying markets with fresh vegetables have become crucial issues, as adding various vegetables to daily meals should be possible over the whole year and not only during summer or winter, which are the top harvesting seasons. Besides supplying markets with fresh produce, vegetables are also important raw materials for the food industry. (Domuța, 2010)

Vegetable growing allows good land exploitation due to the possibility of large scale successive cultures, either using open fields but mainly in greenhouses. In this way, by obtaining higher yields per unit area, the land use rate increases and the investment required to set up the business and to run it becomes more efficient. Cabbage is a vegetable species grown extensively in Romania, mainly due to its high versatility. Cabbage heads

contain 8-19 % of dry matter, which consists mainly of carbohydrates 4-6.5%, protides 1.5-2 %, as well as vitamins: C (45-75 mg), carotene (0.2-2 mg), B1, B2, B6, P, K and minerals: potassium (200-220 mg), phosphorus (40 mg), calcium (33-68 mg), magnesium (20-24 mg), per 100 g of fresh matter, as well as volatile components with bacteriostatic effects. Cabbage is also important for its therapeutic properties. (Jude 2012, Jude et. al., 2013)

Cabbage requires plenty of water, both in the soil and in the atmosphere. The daily water consumption varies between from 0.2-0.4 litres to 2.5-5 litres / plant depending on the growth stage (Domuta 2005, 2009, 2010).

In order to ensure the required moisture, autumn cabbage is irrigated 10-12 times, with amounts of 300-400 m^3 of water / ha, depending on the temperature and the growth stage. The irrigation water amount for the entire growing season of the autumn cabbage is approximately 4000 m^3 / ha.

MATERIAL AND METHOD

The research was conducted during 2013-2014 in the field of soil water balance from Oradea on a preluvosoil. Two water supply regimes were studied:

- unirrigated,
- irrigated – maintaining water storage between easily available water content and field capacity within a depth of 0-50 cm.

Vestri F1 autumn hybrid cabbage was used in the research. This is a summer-autumnn hybrid used mainly in the food industry. The growing season is approximately 115 days from planting. The plants are firm-headed and leafy. Their heads are spherical; they weigh approximately 8 kg, are particularly compact and have a very good taste. This kind of cabbage is processed in many different ways by the food industry, but is also used as a fresh vegetable. It has good resistance to splitting and harvest can be staggered. It is resistant to Fusarium spp. The recommended planting density is 25.000-33.000 plants / ha. (Fig. 1.)

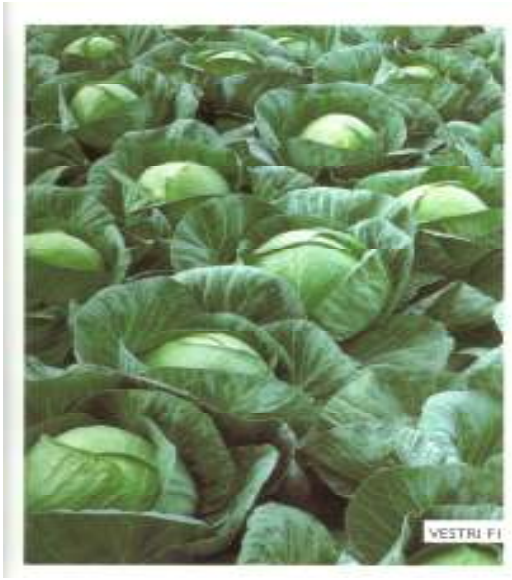

Fig. 1. Vestri F1 cabbage variety

Soil moisture (Canarache, 1990) was calculated with the formula:

$$U_g = \frac{b - c}{c - a} \times 100 \qquad [\%]$$

where: U_g = soil moisture (%);
b = mass of dry soil (g);
c = mass of wet soil (g);
a = mass of the beaker (g);
100 = relative percentage factor

Easily available water content was calculated in function of the soil texture and degree of compaction (Brejea 2010, 2014):

$$Wea = WP + f(FC + WP) = WP + f \cdot CU$$

where:
Wea = easily available content (% g/g);
f = fraction of the available water for which the following values are used :

Soil water reserve (Botzan, 1966, 1972) was calculated using the following formula:

$$SWR = U_g \times BD \times H;$$

In which: SWR = water storage (m^3/ha);
U_g = gravimetric water content (%);
BD = bulk density (%);
H = depth of soil layer (cm)

The total water consumption was calculated using the equation of soil water balance in closed system (without the contribution of the ground water) (Grumeza et al., 1989; Grumeza, Klepș, 2005):

$$R_i + P_g + \sum m = R_f + \sum(e+t),$$

In which:

R_i = initial water reserve (at sowing, planting, when the culture restarts), m^3/ha;

P_g = precipitations during the growing season of the crop, m^3/ha;

$\sum m$ = irrigation water amount (m^3/ha);

R_f = final soil water reserve (at harvesting), m^3/ha;

$\sum(e+t)$ = total water consumption, m^3/ha.

Irrigation involves a set of technical and organisational measures so that a judicious irrigation scheme can be set up, which includes assessment of the water requirement, the amount of water applied, as well as the schedule of application, all this done in strong correlation with a thorough knowledge of the soil-water-plant relationship (Brejea, 2014).

Water use efficiency (WUE) (Domuța, 2009; Borza, 2007, Vegh, 2004) was calculated using the formula:

$$WUE = \frac{Y}{\sum(e+t)} \quad [kg/m^3]$$

In which:

Y = yield (kg/ha);

$\sum(e+t)$ = water consumption (m^3/ha)

Irrigation water use efficiency (IWUE) (Vegh Z., 2004) was calculated as follows:

$$IWUE = \frac{Y_i - Y_n}{\sum m} \quad [kg\ gain/m^3]$$

where:

Y_i= irrigated yield (kg/ha);

Y_n = unirrigated yield (kg/ha);

$\sum m$ = irrigation water amount (m^3/ha).

Harvesting and calculation of results were performed observing the instructions provided for such experiments. Interpretation of results was performed using variance analysis. (Domuta, 2006)

RESULTS AND DISCUSSION

Optimum irrigation regime

In order to ensure the optimum water supply for the autumn cabbage crop, the irrigation water needed was 3.000 m^3 /ha: 300 m^3/ha in June, 700 m^3/ha in July, 1.200 m^3/ha in August and 800 m^3/ha in September (Table 1).

In 2014, the mount of irrigation water was 3.600 m^3/ha: 400 m^3/ha in June, 1.200 m^3/ha in July and in August, and 800 m^3/ha in September.

Table 1

Irrigation regime used to maintain water storage within the 0-0,5 m depth between allowable depletion and field capacity, Oradea 2013-2014

Year	VI		VII		VIII		IX		Total	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
2013	300	1	700	2	1200	3	800	2	3000	8
2014	400	1	1200	3	1200	3	800	2	3600	9

Σm = amount of water;
n = times of watering.

Influence of irrigation on the water consumption of autumn cabbage

The daily water consumption of unirrigated autumn cabbage had the highest value in the month of July both in 2013 and in 2014, 36.4 m^3/ha/day and 29.8 m^3/ha/day respectively.

When irrigated, the highest values of daily water consumption were recorded in August: 61.2 m^3/ha /day in 2013 and 63.2 m^3/ha /day in 2014 (Table 2).

The total water consumption of unirrigated cabbage was 2.558 m^3/ha in 2013 and of 2.468 m^3/ha in 2014. The optimum water supply provided by irrigation resulted in an increase of the total water consumption by 107% in 2013 and by 131% in 2014. Out of the total water consumption of the irrigated autumn cabbage in the 2 years of the research the highest share was that of irrigation: 57% in 2013 and 53% in 2014 (Table 3).

Table 2

Influence of irrigation on the daily water consumption of autumn cabbage, Oradea 2013-2014

Year	Variant	VI		VII		VIII		IX	
		m^3/ha/ day	%	m^3/ha/day	%	m^3/ha/day	%	m^3/ha/day	%
2013	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
2014	Unirrigated	27.6	100	29.8	100	29.2	100	24.3	100
	Irrigated	33.4	121	51	171	63.2	217	41.3	170
	Difference	5.8	21,0	21.2	71	34	117	17	70

Table 3

Total water consumption of the unirrigated and irrigated autumn cabbage and the water sources

Variant	Total water consumption		Water sources					
			Soil water reserve		Rainfall		Irrigation	
	m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha	%
2013								
Unirrigated	2.558	100	630	25	1.928	75	-	-
Irrigated	5.310	207	382	7	1.928	36	3.000	57
2014								
Unirrigated	2.468	100	810	33	1.651	67	-	-
Irrigated	5.711	231	460	8	1.651	29	3.600	53

Influence of irrigation on the autumn cabbage yield

In 2013, irrigation caused an increase in yield by 299% (45,710 kg/ha), an amount that is very significant statistically (Table 4).

Table 4

Influence of irrigation on autumn cabbage yield, Oradea 2013

Variant	Yield		Difference		Statistical significance
	kg/ha	%	kg/ha	%	
Unirrigated	15.240	100	-	-	Mt
Irrigated	60.950	399	45.710	299	xxx

LSD 5% 620 LSD 1% 980 LSD 0.1% 1,530

In 2014, the lowest unirrigated autumn cabbage yield was recorded: 12,300 kg/ha. Irrigation caused an increase in yield by 409% (50,300 kg/ha), an amount that is very significant statistically (Table 5)

Table 5

Influence of irrigation on the autumn cabbage yield, Oradea 2014

Variant	Yield		Difference		Statistical significance
	kg/ha	%	kg/ha	%	
Unirrigated	12.300	100	-	-	Control
Irrigated	62.600	509	50.300	409	***

LSD 5% 590 LSD 1% 940 LSD 0,1% 1,610

Influence of irrigation on the efficiency of water used by the autumn cabbage crop

The autumn cabbage head corresponding to 1 m^3 of water used in non-irrigated conditions was 5.96 kg in 2013 and 4.98 kg in 2014. Irrigation caused an increase in the autumnn cabbage amount corresponding to 1 m^3 of water by 93% in 2013 and by 120% in 2014 (Tabel 6).

The increase in yield corresponding to 1 m^3 of irrigation water was 15.24 kg in 2013, and 8% less in 2014 (Table 7).

Table 6

Influence of irrigation on the water use efficiency (WUE) used by the autumn cabbage crop, Oradea 2013-2014

Variant	WUE		Difference	
	kg/m^3	%	kg/m^3	%
2013				
Unirrigated	5.96	100	-	-
Irrigated	11.48	193	5.52	93
2014				
Unirrigated	4.98	100	-	-
Irrigated	10.96	220	5.98	120

Table 7

Irrigation water use efficiency (IWUE) in the auumn cabbage crop, Oradea 2013-2014

Year	IWUE		Difference	
	kg/m^3	%	kg/m^3	%
2013	15.24	100	-	-
2014	13.97	92	-1.27	- 8

CONCLUSIONS

The research concerning the irrigation of autumn cabbage was carried out on an area with preluvosoil at the Oradea Agricultural Research and Development Station in the year 2013 and 2014, and the conclusions are as follows:

- in order to maintain water moisture within the 0-50 cm depth between easily available water content and field capacity irrigation water was required both in 2013 and 2014, 3.000 m^3/ha and 3.600 m^3/ha respectively .
- irrigation caused an increase in the daily water consumption of the autumn cabbage in all months of the irrigation season; the highest differences against the unirrigated variant were recorded in August, 162% in 2013 and 117% in 2014.
- the total water consumption of the irrigated autumn cabbage increased in comparison with the unirrigated variant with 108% in 2013 and with 131% in 2014. The share of irrigation in the water consumption (57% in 2013 and 53% in 2014) was higher than that of precipitations in the period from planting to harvesting, that is, 35% and 29%.
- Irrigation determined the yield gains very significant statistically, 299% (45.710 kg/ha) in 2013 and 409% (50.300 kg/ha) in 2014.
- Water use efficiency was iproved significantly as a result of irrigation, the amount of cabbage head corresponding to 1 m^3 of water used increased in comparison with the unirrigated crop by 93% in 2013 and by 120% in 2014.

The research shows that an optimum water content within the watering depth of the autumn cabbage can be maintained only by irrigation, which causes an increase in the water consumption and statistically significant increases in comparison with unirrigated of the water use efficiency. These conclusions support the need for irrigation in the autumn cabbage from the Crişurilor Plain.

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