RESEARCH FOR OPTIMIZING THE IRRIGATION SCHEDULING IN DRIP IRRIGATED PEACH TREE FROM ORADEA AREA

Domuța Cristian*, Șcheau Viorel, Șcheau Violeta, Gîtea Manuel, Brejea Radu, Borza Ioana, Jude Eugen

*University of Oradea, Faculty of Environmental Protection, 26 General Magheru St., 410048 Oradea,Romania, e-mail: cristian_domuta@yahoo.com

Abstract

Fruit-tree Oradea basin is very favourable for peach-tree crop and the paper studies the posibilities of optimizing the irrigation scheduling using the indirect method. Four method of the evapotranspiration reference determination (Thornthwaite, pan evaporimeter, Piche evaporimeter, Penman-Monteith) are studied in comparison with optimum daily water consumption of the peach-tree irrigated by drip method; the comparison is made with daily water consumption of the unirrigated peach-tree, too. Optimum water consumption of the peach-tree was obtained maintaining the soil water reserve on watering depth (0-100 cm) between easily available water content and field capacity using the drip irrigation. In the months when the irrigation was needed (May, June, July, August) in comparison with daily water consumption obtained by direct method (soil water balance, 0-150 cm depth) using the Penman-Monteith and pan evaporation methods the closest results were obtained; regarding the total water consumption, the values obtained using these methods (and Thornthwaite method, too) were bigger but unsignificant statistically. The use of the Piche evaporimeter determined to obtain the biggest values of the reference evapotranspiration. The pan evaporation method is easier to use and is recomanded in irrigation scheduling for peach-tree irrigsted by drip method.

Key words: peach-tree, pan evaporimeter, Piche evaporimeter, Thornthwaite, Penman-Monteith, drip, irrigation scheduling

INTRODUCTION

The fruit-tree basin Oradea is situated in the Bihor county. Peach-tree occupied large surfaces and Bihor was the 2nd county of the Romania concerning the peach production (19.42% from total) after the Constanța county (31.37 % from total). (Sarca, 2003)

There were many research regarding the peach-tree crop in the Oradea area: cutting methods (Sarca, 1998, 2006, 2009), crop technololgy (Bunea, 1981, 1991, Murg 1995, 1999), peach-tree cultivars (Ștefan et. al, 1993, Ștefan 1985, 1990, 1991).

Șcheau Violeta (2005) realized the PhD Thesis "The influence of the local irrigation on growth and fructifing of the peach-tree"; the tesis presented the research regarding the water consumption, irrigation scheduling for peach-tree crop irrigated by drip and microsprinkler methods, irrigation influence on yield and water use efficiency, correlation in the soil-water-plant-atmosphere system, economical efficiency of the drip and microsprinkler irrigation for the period 2000-2003; the results research emphasized the positive influence on plants growth, yield gain statistically assured, a better quality of the fruits, the improve of the relationship from soil-water-plant-atmosphere system, and a very good economical efficiency using the irrigation. Theese paper present the results research regarding the irrigation scheduling obtained in the same experiment during 2000-2013. Other results research regarding the use of the irrigation in peach-tree from Oradea area were published by Șcheau et al (2006), Domuta (2007).

Irrigation scheduling can be realized using the direct methods (neutron, tension, methods based on physiologic indices) and the indirect method based on the soil water balance on watering depth and the use of the reference evapotranspiration and crop coefficient "Kc" established in the research field (Grumeza, 2005). The paper studies 4 methods for reference evapotranspiration determination and establishes the crop coefficints for every method.

MATERIAL AND METHODS

The research was carried out in an experiment placed at Research and Development Station for Fruit Tree Oradea in 1996. The cultivar used: Superbă de Toamnă. The experiment is placed on the plateau at the base of the hill with 35% slope; the water from the hill is storaged at 1.5-2 m depth of the plateau; this situation influenced the value of the field capacity (30-33.2 %) calculated after Canarache (1996). The humus and nitrogen content is low, mobile potassium is median and mobile phosphorum content is good.

The experiment was placed in 4 repetition with 48 peach-tree for every repetition. The irrigation equipment made of Israel was used. The irrigation was used when the soil water reserve on 0-100 cm depth decreased at the easily available water content; in these condition, the soil moisture was determined ten to ten days. (Brejea, 2009).

The irrigation water source was the water network of the Oradea. The irrigation water quality is good: SAR= 0.53; CSR = 1.7; pH= 7.2; N. Florea class: II. View with the placement of the irrigation equipment from variant with drip irrigation is presented in the figure 1.

Soil moisture was determined by gravimetric method. Water consumption was calculated using the soil water balance method; balance depth used: 0-150 cm.

Pan evaporation and Piche evaporation were determined every day at 8 o'clock, by the same person. Three pan evaporimeter and two Piche evaporimeter were used. (fig. 2, fig. 3)

The reference evapotranspiration Thornthwaite and Penman-Monteith respectivelly were obtained using the known formula (Domuța 2005, 2009).

The crop coefficints "Kc" were determined like report between optimum water consumption of the peach-tree every month and the reference evapotranspiration determined in the methods Thornthwaite, pan evaporimeter, Piche evaporimeter and Penman-Monteith. (Domuța 2005, 2009).

a

b

c

Fig.1. The placement of the irrigation equipment (a) and view from variant with drip irrigation (b, c) from research field Oradea

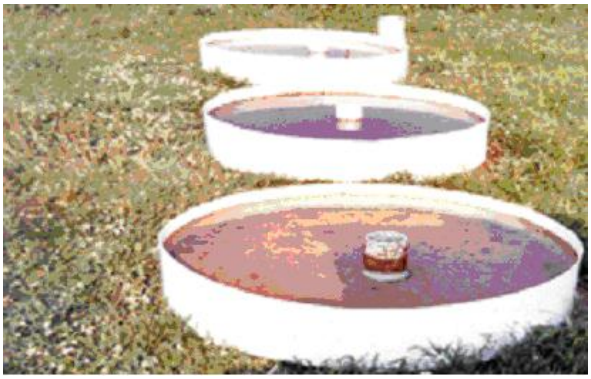

Fig.2. Pan evaporation from the irrigation scheduling, station Oradea

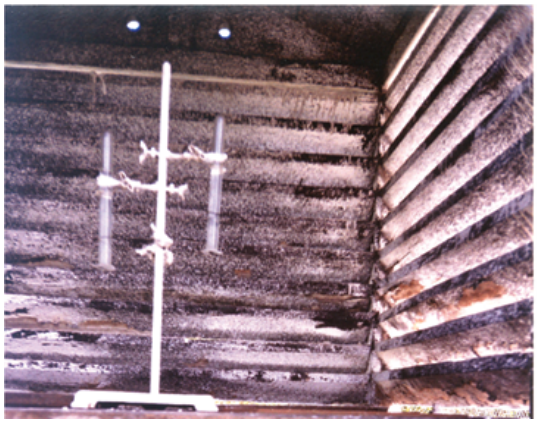

Fig.3. Piche evaporation from the irrigation scheduling, station Oradea

RESULTS AND DISCUSSION

The irrigation regime used during 2000-2013 includes the following irrigation rates: 30.0 mm in May, 40.0 mm in June, 90.0 mm in July and 56.0 mm in August. Using the variance analysis, in every month is analized daily water consumption of the unirrigated peach-tree; optimum daily water consumption of the peach-tree irrigated by drip method is comparison with the reference evapotranspiration calculated by Thornthwaite method and Penman-Monteith method and meassured by pan evaporimeter class A and Piche evaporimeter, respectivelly.

Situation from April

The irrigation didn't need in April and the difference between daily water consumption of the peach-tree irrigated by drip method and the daily water consumption of the unirrigated is unsignificant statistically. Unsignificant statistically in comparison with daily water consumption of the unirrigated peach-tree are the values of the reference evapotranspiration determined by Thornthwaite, pan evaporimeter and Penman-Monteith methods; using the Piche evaporimeter the values obtained is bigger and the difference a very significant statistically. In the irrigation variant the same situation was registered but the difference obtained using the Thornttwaite method is statistically assured too. (table 1)

Table 1

Daily water consumption in peach-tree and the reference evapotranspiration (ET_o) in April, Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Real evapotranspiration (unirrigated variant)	2.49	100	93
2.	Optimum real evapotranspiration (drip irrigation)	2.68	107	100
3.	ET_o Thornthwaite	1.93	78	72
4.	ET_o Pan evaporimeter	2.63	106	99
5.	ET_o Piche evaporimeter	3.70	149	138
6.	ET_o Penman-Monteith	2.59	104	97
		$LSD_{5\%}$	23	18
		$LSD_{1\%}$	31	29
		$LSD_{0.1\%}$	47	37

Situation from May

The use of the irrigation determined the increase of the peach-tree water consumption with 13%, significant statistically. In comparison with peach-tree water consumption from unirrigated variant, the difference of the reference evapotranspiration determined by pan evaporimeter and Penman-Monteith method are significant statistically, too; the difference obtained using the Thornthwaite method is unsignificant statistically and using the Piche evaporimeter method is very significant statistically. (table 2)

Table 2

Daily water consumption in peach-tree and the reference evapotranspiration (ET_o) in May, Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Peach-tree unirrigated	3.62	100^{Ct}	88^{o}
2.	Peach-tree, drip irrigated	4.10	113^{*}	100^{Ct}
3.	ET_o Thornthwaite	3.89	109^{-}	95^{-}
4.	ET_o Pan evaporimeter	4.21	116^{*}	103^{-}
5.	ET_o Piche evaporimeter	5.32	147^{***}	129^{***}
6.	ET_o Penman-Monteith	4.16	115^{*}	99^{-}
		$LSD_{5\%}$	11	10
		$LSD_{1\%}$	18	17
		$LSD_{0.1\%}$	29	27

In comparison with optimum water consumption obtained using the drip irrigation, the reference evapotranspiration determined by Piche evaporimeter is bigger and very significant statistically. Using the Penman-Monteith method, pan evaporimeter method and Thornthwaite method, the differences are insignificant statistically.

Situation from June

In comparison with peach-tree water consumption in the unirrigated variant, the peach-tree water consumption in the irrigated variant (4.24 mm/day) increased significant statistically; significant statistically are the differences obtained using the pan evaporation method and Penman-Monteith method; the difference obtained using the Thornthwaite method is distingue significant; the difference obtained using the Piche evaporimeter is very significant statistically. In comparison with peach-tree water consumption of the irrigated variant, the use of the Penman-Monteith method and pan evaporation method detrmined the unsignificant differences; using the Thornthwaite method, the difference is

significant statistically bigger and using the Piche evaporation method, the difference obtained is very significant statistically. (table 3)

Table 3

Daily water consumption in peach-tree and the reference evapotranspiration (ET_o) in June, Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Peach-tree unirrigated	3.67	100^{Ct}	87^{o}
2.	Peach-tree, drip irrigated	4.24	116^{*}	100^{Ct}
3.	ET_o Thornthwaite	4.70	128^{**}	111^{*}
4.	ET_o Pan evaporimeter	4.29	116^{*}	102^{-}
5.	ET_o Piche evaporimeter	5.46	147^{***}	129^{***}
6.	ET_o Penman-Monteith	4.19	115^{*}	99^{-}
		$LSD_{5\%}$	10	9
		$LSD_{1\%}$	17	15
		$LSD_{0.1\%}$	26	23

Situation from July

In unirrigated conditions, the biggest value of the daily water consumption was determined in June (3.67 mm/ha) in irrigated variant the biggest value (5.24 mm/day) was determined in July; the difference between the peach-tree water consumption of the irrigated variant and peach-tree water consumption of the unirrigated variant (48%) is very significant statistically. The differences of the reference evapotranspiration (40% in Thornthwaite method, 46% in pan evaporimeter method, 52% in Penman-Monteith method, 95% in Piche evaporimeter method) are very significant, too. In comparison with optimum water consumption of the irrigated peach-tree the differences are unsignificant statistically in Thornthwaite, pan evaporimeter and penman/Monteith methods and very significant statistically in Piche evaporimeter using. (table 4)

Table 4

Daily water consumption in peach-tree and the reference evapotranspiration (ET_o) in July, Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Peach-tree unirrigated	3.41	100^{Ct}	68^{ooo}
2.	Peach-tree, drip irrigated	5.24	148^{***}	100^{Ct}
3.	ET_o Thornthwaite	4.85	140^{***}	95^{-}
4.	ET_o Pan evaporimeter	4.96	146^{***}	99^{-}
5.	ET_o Piche evaporimeter	6.62	195^{***}	132^{***}
6.	ET_o Penman-Monteith	5.18	152^{***}	111^{-}
		$LSD_{5\%}$	16	15
		$LSD_{1\%}$	22	22
		$LSD_{0.1\%}$	31	31

Situation from August

Optimum water consumption of the peach-tree was bigger than water consumption of the unirrigated peach-tree; the difference (125%) was very significant statistically. Very significant statistically were the differences obtained in all 4 method used for reference evapotranspiration determination. In comparison with optimum water consumption the value of the Piche evaporation is very significant bigger; the pan evapotranspiration is distingue significant and the reference evapotranspiration Thornthwaite is significant statistically bigger than optimum water consumption of the peach-tree; the difference determined using the Penman-Monteith method is unsignificant statistically. (table 5)

Table 5

Daily water consumption in peach-tree and the reference evapotranspiration (ET_o) in August, Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Peach-tree unirrigated	1.71	100^{Ct}	45^{ooo}
2.	Peach-tree, drip irrigated	3.84	225^{***}	100^{Ct}
3.	ET_oThornthwaite	4.60	258^{***}	115^{*}
4.	ET_o Pan evaporimeter	4.30	287^{***}	128^{**}
5.	ET_o Piche evaporimeter	6.53	382^{***}	170^{***}
6.	ET_o Penman-Monteith	4.20	246^{***}	109^{-}
		$LSD_{5\%}$	14	13
		$LSD_{1\%}$	23	22
		$LSD_{0.1\%}$	34	33

Situation from September

The irrigation determined a bigger values of the peach-tree water consumption, but distingue significant, only; in the all 4 methods for the reference evapotranspiration, the differences are very significant statistically. In comparison with the optimum water consumption of the peach-tree, the values of the reference evapotranspiration are bigger and the differences are very significant statistically. (table 6)

Table 6

Daily water consumption in peach-tree and the reference evapotranspiration (ET_0) in September, Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Peach-tree unirrigated	1.18	100^{Ct}	73^{oo}
2.	Peach-tree, drip irrigated	1.62	137^{**}	100^{Ct}
3.	ET_o Thornthwaite	2.60	220^{***}	160^{***}
4.	ET_o Pan evaporimeter	2.20	186^{***}	136^{***}
5.	ET_o Piche evaporimeter	3.66	310^{***}	226^{***}
6.	ET_o Penman-Monteith	2.30	195^{***}	142^{***}
		$LSD_{5\%}$	13	12
		$LSD_{1\%}$	21	20
		$LSD_{0.1\%}$	39	31

Peach-tree water consumption, covering sources and a comparison with the reference evapotranspiration

Total water consumption of the unirrigated peach-tree has an average value for period 2000-2013 of 490.4 mm/ha; 65.0% (320.3 mm/ha) was covered by rainfall registered during April-September and 35% (170.1 mm/ha) was covered by the water from soil reserve. The use of the irrigation (maintaining the soil water reserve on 0-100 cm between easily available water content and field capacity) determined the increase of the total water consumtion with 43%, very significant statistically; rainfall registered during April-September covered 49%, the irrigation covered 33% and the soil water reserve covered 18% from irrigated peach-tree. Irrigated peach-tree determined to use a smaller quantity of water (125.0 mm) from soil water reserve in comparison with unirrigated peach-tree.

The values of the total reference evapotranspiration are bigger than the values of the total water consumption of the peach-tree, unsignificant statistically using the pan evaporimeter method (688.9 mm/ha), the Penman-Monteith method (689.9 mm/ha) and the Thornthwaite method (700.7 mm/ha) and very significant statistically (954.3 mm/ha) using the Piche evaporimeter method. (table 7, 8)

Table 7

Total water consumption [∑(e+t)] in peach-tree in comparison with the reference evapotranspiration (ET_o), Oradea 2000-2013

No.	Variant	Value		
		mm/ha	%	%
1.	Peach-tree unirrigated	490.4	100^{Ct}	75^{oo}
2.	Peach-tree, drip irrigated	662.2	135^{***}	100^{Ct}
3.	ET_o Thornthwaite	700.7	143^{***}	106^{-}
4.	ET_o Pan evaporimeter	688.9	141^{***}	104^{-}
5.	ET_o Piche evaporimeter	954.3	195^{***}	144^{***}
6.	ET_o Penman-Monteith	689.9	141^{***}	104^{-}
		$LSD_{5\%}$	13	14
		$LSD_{1\%}$	23	26
		$LSD_{0.1\%}$	31	37

Table 8

Total water consumption [∑(e+t)] in peach-tree, unirrigated and drip irrigated, Oradea 2000-2013

No.	Variant	∑(e+t)]		Covering sources					
		mm/ha	%	Soil water reserve		Rainfall		Irrigation	
1.	Peach-tree unirrigated	490.4	100	170.1	35	320.3	65	-	-
2.	Peach-tree, drip irrigated	662.2	136	125.9	18	320.3	49	216.0	33

The crop coefficient "Kc" used in irrigation scheduling of the peach-tree

The irrigation scheduling by indirect method use is based on the soil water balance and the use of the crop coefficients "Kc". These crop coefficients "Kc" are specifical for every crop and month or stage of the vegetation period. The crop coefficients "Kc" are established in the research field using a specifical methodology. Crop coefficients "Kc" represents the value of the report between optimum water consumption of the peach-tree obtained for every month and the value of the reference evapotranspiration measured by pan evaporimeter and Piche evaporimeter or calculated by Thornthwaite and Penman-Monteith. For optimum supply of the peach-tree, the soil moisture was determined ten to ten days and the irrigation was used when the soil water reserve on 0-100 cm depth decrease at the easily available water content. The values of the crop coefficients are specifically for every month and for every determination method of the reference evapotranspiration. (table 9)

Table 9

The crop coefficients "kc" for transformation the reference evapotranspiration in optimum water consumption drip irrigated, Oradea 2000-2013

No.	The reference evapotranspiration	Kc					
		April	May	June	July	August	September
1.	Thornthwaite	0.86	0.95	1.10	0.93	1.20	1.60
2.	Pan evaporimeter	0.98	1.03	1.01	0.95	1.12	1.36
3.	Piche evaporimeter	1.38	1.30	1.29	1.26	1.69	2.26
4.	Penman-Monteith	0.97	1.02	0.99	0.99	1.09	1.42

CONCLUSIONS

Irrigation scheduling is very important for obtaining a high yield with good quality and finaly the best economical results and the research carried out during 2000-2013 in the Research and Development Station for Fruit Tree Oradea had the aim the establish the best indirect method for irrigation scheduling in peach-tree in the condition of the drip irrigation method. The indirect methods are based on the reference evapotranspiration (ET_o) and crop coefficient "Kc" use. The most known the reference evapotranspiration (pan evaporation, Penman-Monteith, Piche evaporation and Thornthwaite) were studied and the conclusions of the research results are presented:

- the optimum water consumption obtained in the conditions when the soil water reserve on 0-100 cm was maintained between easily available water content and field capacity and had the specifical values for every month of the vegetation period (April-September);
- there were the differences using the reference evapotranspiration measured by pan evaporimeter and Piche evaporimeter methods or calculated by Penman-Monteith and Thornthwaite method in comparison with the monthly optimum water consumption of the peach-tree. The smallest differences were obtained using the pan evaporimeter and Penman-Monteith methods;
- the average value for period 2000-2013 of the total water consumption in peach-tree irrigated by drip method was of 662.2 mm/ha. The closest values of the reference evapotranspiration were obtained using the pan evaporimeter and Penman-Monteith methods: 688.9 mm/ha and 689.9 mm/ha; the biggest value (954.3 mm/ha) was obtained using the Piche evaporimeter method;
- crop coefficients "Kc" have the specifical value for every method and month. For pan evaporimeter the following values were obtained: 0.98 for April, 1.03 for May, 1.01 for June, 0.05 for July, 1.12 for August and 1.36 in September.

Both the results research obtained for a long period and the simple method for utilization recomand the pan evaporimeter for irrigation scheduling in peach-tree irrigated by drip method.

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