Available online: www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not Bot Horti Agrobo, 2018, 46(1):213-222. DOI:10.15835/nbha46110771

Original Article

The Bases of Peach Tree Irrigation in the Fruit-Growing Basin from Oradea and the Use of the Microsprinkler System

Cristian G. DOMUȚA[1]*, Cornel Domuța[2], Manuel A. GÎTEA[1],
Ioana M. BORZA[1], Ana C. PEREȘ[2], Ionuț PANTIȘ[3],
Nicolae CENUȘA[2], Radu P. BREJEA[2]

*[1]University of Oradea, Faculty of Environmental Protection, Department of Agriculture and Horticulture, 26 Gen. Magheru St., 410048, Oradea, Romania; cristian_domuța@yahoo.com (*corresponding author); giteamanuel@yahoo.com; borzaioanamaria@yahoo.com*
[2]University of Oradea, Faculty of Environmental Protection, Department of Environmental Engineering, 26 Gen. Magheru St., 410048, Oradea, Romania; peresana35@yahoo.com; cenusa.nicolae@yahoo.com; rbrejea@yahoo.com
[3]University of Agricultural Sciences and Veterinary Medicine, Calea Mănăștur 3-5, Cluj-Napoca, Romania; pantis_ionut@yahoo.com

Abstract

The paper presents the results obtained on preluvo-soil in Sâniob, Oradea, during 2007-2015. In order to maintain the soil water content between easily available water content and field capacity, the irrigation rate used was between 60 mm/ha and 470 mm/ha. Irrigation determined an increase of the total water consumption by 53% (712 mm/ha vs. 466 mm/ha). For the non-irrigated variant (71%) and for the irrigated one (46%), the rainfalls registered between 15 March-1 October yearly represented the main source of supplying the total water consumption, while irrigation supplied 40% of the total water consumption (with a variation range 11%-61%). The microsprinkler irrigation system led to a 30.6% yield gain, with a variation range of 15.8%-58.7%. It also determined a higher size index in comparison with the non-irrigated variant and a smaller percentage of kernels. All differences were statistically very significant. Several correlations were quantified in the soil-water-plant-atmosphere system. The parameters of the system were: pedological drought, strong pedological drought and water consumption. All correlations were statistically very significant; the best mathematical expression was the polynomial function. Four methods (Penman Monteith, Pan, Piche and Thornthwaite evaporimeter methods) were studied to determine the reference evapotranspiration (ETo) in comparison with the optimal water consumption of the peach tree. As it was cheaper and easier to use, the Pan evaporation method was recommended in the irrigation scheduling, although the Penman Monteith method could have given more accurate results in assessing the optimal water consumption.

Keywords: correlations, pedological drought, strong pedological drought, water consumption, yield, yield gain

Introduction

The peach tree is one of the very important crops in Romania. The peach tree basin from Oradea is the second largest peach tree basin in Romania after the one from Dobrogea. Before 1990, Bihor County ranked second in the country in terms of the amount of exported peaches. There is no consistent irrigation in the area, and the locations where peach tree orchards have very small surfaces that are irrigated (Șandor *et al.*, 2010).

Șcheau (2005) conducted the first research on the crop coefficient for the peach tree irrigated by microsprinkler and drip irrigation systems in the area, followed by other studies on the subject (Domuța *et al.*, 2007; 2009; 2013; Șcheau *et al.*, 2006). These studies also referred to: the influence of irrigation on the growth of the peach tree, the optimal water regime, the soil water distribution on a 0-100 cm depth, the influence of irrigation on the microclimate, supply sources for water consumption, the influence of irrigation on the yield quantity and quality and the water use efficiency, offering a complex approach of the study. All results were obtained in Oradea, thus in the same area and with similar climacteric conditions as the current study.

Knowing a plant's water consumption is very important for establishing the irrigation design (Grumeza and Kleps, 2005). Even the best methods of determining the reference evapotranspiration do not give similar results of a plant's

Received: 13 Mar 2017. Received in revised form: 11 Sep 2017. Accepted: 14 Sep 2017. Published online: 19 Sep 2017.

water consumption (Doorembos and Pruitt, 1992; Domuța, 1995; 2003; 2005). Therefore, it is necessary to determine the crop coefficients (Kc) used to convert the reference evapotranspiration in the optimal water consumption for the plant. Irrigation scheduling is very important in order to obtain the best yield in regard with quantity and quality (Doorembos and Pruit, 1992; Johnson, 2008).

For analysing crop evapotranspiration, Allen *et al.* (1998) used irrigation scheduling based on soil water balance (SWB) calculations, as the most common method, in establishing the soil moisture status, which is estimated by using the water balance approach. The crop coefficient approach of the FAO (Food and Agriculture Organization of the United Nations) irrigation and drainage Paper 56 (FAO-56) estimates the potential crop evapotranspiration ETc by multiplying the reference evapotranspiration ETo with a crop-specific, empirically determined crop coefficient (Kc factor). ETc is defined as the amount of water required by a crop for optimal growth.

Forey *et al.* (2016) studied the effect of soil water deficit on the peach tree in the first two years following plantation, on net photosynthesis, on final leaf number count and on the tree height; the authors concluded that net photosynthesis was more intensely reduced in the first year following plantation compared to the second year when net photosynthesis was not reduced during moderate soil water deficit. The study was carried on three variants: variant 1 – fully irrigated (C); variant 2 – moderate water deficit (RDI); variant 3 – moderate water deficit associated with grass on the entire orchard floor (RDI+G). Statistically speaking, moderate water deficit had a significant negative impact both on the shoot growth (1st and 2nd order) and on the final growth. The soil water deficit associated with grass on the entire orchard level had a negative impact on the height of the young peach trees due to water competition between the tress and the grass.

Moderate soil water deficit was studied by other authors as well in order to preserve water resources in pear tree orchards, apple tree orchards and peach tree orchards as a strategy set up to determine planting density and to provide optimal light for increased fruit productions (Li *et al.*, 1989; Zegbe *et al.*, 2007; Cheng *et al.*, 2012).

Determining the time for the most efficient irrigation, based on moderate water stress, consists in applying irrigation according to the crop requirements at that time as noted by Fereres and Soriano (2006). It is a strategy that was first designed to control density per unit area to allow light penetration and hence increase fruit production and fruit quality during water stress (Chalmers *et al.*, 1981; Glenn *et al.*, 1996).

Two main hypotheses were responsible for the success of moderate water deficit (RDI). It was followed the production level in different crops during water deficit. Moderate water deficit in different growth stages of the tree and of the fruit was determined at several species of fruit trees where fruit formation was less sensitive to water deficit (Johnson and Handley, 2000).

In a study on the influence of irrigation scheduling using thermometry on the yield and quality of the peach tree irrigated by three irrigation systems, Huihui *et al.* (2017), after having analysed the influence of water deficit on the yield and quality of the peach tree, concluded that the values of mid-day water reserve for the well-irrigated variants were maintained at a range of 0.5 to 1.2 MPa, while for the variants with soil water deficit, values were lower. The number of fruits and the weight of the fruits from the variants with postharvest water deficit were lower than from the well-irrigated variants (Wang and Gartung, 2010). However, no statistically significant reduction in fruit size or quality ($p < 0.05$ level) was found either for the trees irrigated by drip and micro-spray irrigation systems or for the trees with water deficit.

The IRT method provided valuable information in taking irrigation management decisions regarding the peach tree cultivation. Huihui *et al.* (2017) found the implementation of this method efficient and necessary.

Girona *et al.* (2005) analysed the vegetative growth and the fruit production of the peach trees that either benefited of optimal irrigation conditions or were subjected to water supplies that were lower than water demands in stage II of fruit development and/or during postharvest. The study showed that deficit irrigation in stage II and/or during postharvest significantly reduced the vegetative growth of the peach tree. Fruit production was not affected by any of the irrigation regimes until the 4th year, when the fruit set slightly decreased due to deficit irrigation. Overall, the authors considered that deficit irrigation could be successfully used on the growth of the peach tree on watering depth.

The research results presented hereby were obtained at Sâniob, 20 km away from Oradea. The following parameters were determined: pedological drought, water consumption, peach yield, fruit size index and percentage of kernels. The water consumption for the non-irrigated and irrigated peach trees was also determined. Supplying water sources were analysed as well.

Materials and Methods

Biological material

The peach variety used in the research was 'Superbă de toamnă', with a reversed pyramid crown and high yields, that ripe in the first 20 days of September. The fruit is big and the pulp is white.

Description of the study

The paper presents researches carried out during the period 2007-2015 on the preluvo-soil located in the village of Sâniob in the fruit-growing basin from Oradea, in North-Western Romania. Its complex and varied surrounding relief, part of the great Pannonian Basin, includes hilly formations and terraces. The information on the climate was provided by the Weather Station in Oradea: average annual temperature 10.1 °C; hottest month July, average temperature 20.5 °C; coldest month January, average temperature -2.1 °C; number of frosty days 92.5 per year; late spring frost common in March, rare in April and very rare in May; annual average rainfall 615.7 mm; highest amount of rainfall in June, lowest amount of precipitations in January and February; most frequent winds from South, south-West and North.

Research soil was preluvo-soil and the parent material was clay. Ground water was located at a depth of 10 m. Soil texture was medium with a clay content of 28.5% at the depth of 0-24 cm and of 34.1% at a depth of 0-150 cm. Soil bulk density (BD) was 1.46 g/cm^3 at a depth of 0-24 cm and 1.59 g/cm^3 at the depth of the soil water balance. Therefore, the total porosity (PT) at these depths was 45%, respectively 41%, and the hydraulic conductivity (K) was 1.3 mm/h, i.e. 22%. Field capacity (FC) was 23%, respectively 23.3%; wilting point (WP) was 10.0%, respectively 12.0%; the easily available water content (Wea) was established at 2/3 of the easily available water content and was of 18.6% at a depth of 0-24 cm and of 19.5% at a depth of 0-150 cm (Table 1).

The determined chemical properties indicated a slightly acidic soil, 16.6% at a depth horizon of 0-24 cm, and slightly alkaline at the following horizons. The humus level was low at the first depth horizon (2.8%) and decreased at depths of 24-43 cm (1.06%) and of 34-60 cm (0.91%). The phosphorus level was high (39 ppm) at the first depth horizon and low at the others. The potassium level was low at all depth horizons (Samuel *et al*., 2011; Domuța, 2016) (Table 2).

Experimental procedures

An experiment was conducted in 2004 in 4 stages according to the Latin rectangle method, using 48 trees in each stage. Research variants: V_1 – non-irrigated; V_2 – irrigated, using microsprinkler irrigation and maintaining the water between the easily available water content and field capacity at a depth of 0 -75 cm.

Underground water was used for irrigation. Chemical determinations indicated that the water was suitable for irrigation thanks to its pH (7.2), low sodium content (12.9%) and fixed residue (0.4 g/l) below the permitted level (0.8-1.0 g/l). The alkalinisation potential was low (-1.1); according to Florea's classification, irrigation water belonged to group II "very good water for irrigation". Air temperature increased by 17%, rainfall decreased by 4% and air humidity decreased by 7% in the studied period compared to the data gathered from 1931 to the start of the study. Table 3 shows the main climate parameters of the period included in the research.

Results

The results of the experiment indicated the pedological drought, the optimal water regime for peach tree, the water consumption, the peach yield, as well as several quality parameters for fruit yield.

Pedological drought for the growth of the non-irrigated peach tree

Two indicators were used to quantify the pedological drought: pedological drought and strong pedological drought. Pedological drought is the period with soil water content on watering depth below the easily available water

Table 1. Hydrophysical properties of the research soil

Depth	Clay	TP	K	BD	FC	WP	Wea
- cm -	%	%	mm/h	g/cm^3	%	%	%
0-24	28.5	45	1.3	1.46	23.0	10.0	18.6
24-34	28.8	44	2.1	1.49	23.1	10.1	18.6
34-60	31.3	43	2.3	1.51	23.2	11.0	19.0
60-95	23.0	42	2.5	1.53	22.6	11.8	17.7
0-150	34.2	41	2.2	1.50	23.3	12.02	19.5

Table 2. Chemical properties of the research soil

Depth	pH	Humus	P_{AL}	K_{AL}
- cm -	(H_2O)	%	ppm	
0-24	6.60	2.80	39	116
24-34	7.35	1.06	13	120
34-60	7.45	0.91	7	110
60-95	7.85	-	-	-

Table 3. Climate parameters, Oradea 2007 – 2015 (according to the Weather Station in Oradea)

Specification	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average/Total
Air temperature													
2007 - 2015	11.4	7.3	2.0	1.1	1.7	6.6	12.3	17.0	23.1	22.9	22.5	16.7	11.9
1931 - 2006	10.6	5.3	0.6	-2.3	0.3	5.0	10.5	15.8	19.1	20.8	20.0	16.2	10.2
Rainfall (mm)													
2007 - 2015	55.9	50.7	42.8	36.5	31.3	39.2	33.6	64.9	66.3	69.9	55.6	47.4	594.0
1931 - 2006	39.7	48.7	50.4	34.3	38.7	34.6	46.1	61.1	84.9	70.9	58.7	45.3	613.7
Air humidity (%)													
2007 - 2015	78	83	87	86	82	70	64	67	66	63	66	68	73
1931 - 2006	79	84	88	85	86	77	72	72	73	69	71	75	78

content. Within the current research, the watering depth was of 0.75 cm. According to Domuța (1995), strong pedological drought is defined as the period with soil water content on watering depth below the wilting point. The author determined these indicators according to the graphs of the dynamics of the soil water content at watering depth. Such graphs were set up based on the decadal determinations of the soil moisture (Grumeza and Klepş, 2005).

During the research period, the number of days with pedological drought, in descending order, was as follows: 114 days in 2007, 108 days in 2009, 102 days in 2012, 96 days in 2008 and 2013, 90 days in 2014, 72 days in 2015, 50 days in 2011 and 16 days in 2010. In 2011, 2013, 2014 and 2015 the soil water content at the depth of 0-75 cm did not drop below the level of the easily available water content. The number of days with strong pedological drought was of: 28 in 2009, 18 in 2010 and 2012, 17 in 2013, 8 in 2007, 6 in 2008, 4 in 2014, 3 in 2015 and 0 in 2011 (Table 4).

The optimal irrigation regime for peach tree

The highest irrigation rate used (470 mm/ha) and the highest number of waterings (10) were recorded in 2009. The following years, regarding the number of waterings needed, were 2008 with 355 mm/ha and 8 waterings; 2011 and 2014 with 290 mm/ha and 8 waterings, 2012, 2013 and 2015 with 285 mm/ha, 280 mm/ha and 270 mm/ha and 7 waterings each. The lowest irrigation rate was of 60 mm/ha. In general, July and August were the months with the highest water consumption. In 5 years (2007, 2009, 2011, 2014 and 2015) irrigation had to be carried out even in April (Table 5).

The influence of irrigation on water consumption

On average, irrigation led to a 53% increase in total water consumption, with a variation range between 11% (in 2010) and 81% (in 2009). The main source for supplying total water consumption was the rainfalls recorded between March 15 and October 1, both for the irrigated (46%) and for the non-irrigated peach trees (71%). Irrigation supplied between 11% (in 2010) and 61% (in 2009) of the total water consumption (Table 6).

The influence of irrigation on the yield quantity

On average, during the studied period, irrigation led to a 30.6% yield increase (49.1 t/ha compared to 376 t/ha). Over the period, the relative differences were between 15.8% and 58.7%. Statistically speaking, all differences were very significant (Table 7).

The influence of irrigation on several yield quality indexes

On average, during the studied period, the peach size index of the irrigated peach tree was 68 mm vs. 55.8 mm of the non-irritated one. The relative difference between the peach size of the irrigated peach trees and the peach size of the non-irrigated trees was between 7% (in 2011) and 69% (in 2009). Statistically speaking, all differences were very significant (Table 8).

Fig. 1. Peach from the non-irrigated variant

Fig. 2. Peach from the irrigated variant

Table 4. Pedological and strong pedological drought for the non-irrigated peach tree (days)

Specification	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pedological drought	114	96	108	16	50	102	96	90	72
Strong pedological drought	8	6	28	18	0	18	17	4	3

Table 5. Optimal irrigation regime used for peach tree (2007-2015)

No	Year	Irrigation regime										Total	
		April		May		June		July		August			
		∑m	n	∑m	n	∑m	n	∑m	n	∑m	n	∑m	n
1	2007	25	1	40	1	70	2	100	2	60	2	295	8
2	2008	-	-	90	2	100	2	100	2	65	2	355	7
3	2009	76	1	-	2	50	1	120	3	130	3	376	10
4	2010	-	-	-	-	-	-	-	-	60	1	60	1
5	2011	30	1	50	1	30	1	80	2	100	3	290	8
6	2012	-	-	40	2	70	2	70	2	120	3	300	9
7	2013	-	-	-	-	30	1	120	3	110	3	260	7
8	2014	30	1	30	1	70	2	60	2	100	2	290	8
9	2015	30	1	30	1	60	2	70	2	95	2	285	8

∑m = irrigation rate; n = number of rate

Table 6. Total water consumption and water supplying sources for the irrigated and non-irrigated peach trees (2007 - 2015)

Year	Variant	Total water consumption		Supplying sources					
				Soil water content		Rainfall during the vegetation period		Irrigation	
		mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%
0	1	2	3	4	5	6	7	8	9
2007	Non-irrigated	461	100	83	18	378	82	-	-
	Irrigated	718	156	65	9	378	51	295	40
2008	Non-irrigated	488	100	186	38	302	62	-	-
	Irrigated	809	166	152	19	302	37	355	44
2009	Non-irrigated	427	100	173	41	254	59	-	-
	Irrigated	774	181	50.0	6	254	33	470	61
2010	Non-irrigated	510	100	34.0	7	476	93	-	-
	Irrigated	566	111	30.0	5	476	84	60	11
2011	Non-irrigated	490	100	120.0	24	270	55	-	-
	Irrigated	700	143	90.0	12	270	39	290	49
2012	Non-irrigated	439	100	134.0	30	305	69	-	-
	Irrigated	683	156	98.0	14	305	45	280	41
2013	Non-irrigated	431	100	247.0	57	290	67	-	-
	Irrigated	740	172	180.0	24	290	39	270	37
2014	Non-irrigated	502	100	232.0	46	370	74	-	-
	Irrigated	716	143	130.0	18	370	52	290	30
2015	Non-irrigated	442	100	102.0	23	340	77	-	-
	Irrigated	705	159	80.0	11	340	48	285	41
2007-2015	Non-irrigated	466	100	134	29	332	71	-	-
	Irrigated	710	152	92	14	332	46	288	40

Table 7. The influence of the microsprinkler irrigation on peach yield

Year	Variant	Yield		Val. of the limit standard deviation	Statistical significance
		t/ha	%		
2007	Non-irrigated	33.2	100	LSD 5% = 1.7	***
	Irrigated	48.3	145.5	LSD 1%= 2.5 LSD 0.1% = 4.7	
2008	Non-irrigated	32.6	100	LSD 5% = 4.5	***
	Irrigated	45.8	140.5	LSD 1%= 6.4 LSD 0.1% = 8.6	
2009	Non-irrigated	30.0	100	LSD 5% = 3.8	***
	Irrigated	47.6	158.7	LSD 1%= 5.7 LSD 0.1% = 7.6	
2010	Non-irrigated	37.0	100	LSD 5% = 3.8	***
	Irrigated	49.5	133.8	LSD 1%= 5.6 LSD 0.1% = 9.8	
2011	Non-irrigated	43.6	100	LSD 5% = 3.2	***
	Irrigated	50.5	115.8	LSD 1%= 5.3 LSD 0.1% = 8.9	
2012	Non-irrigated	40.1	100	LSD 5% = 2.9	***
	Irrigated	50.3	125.4	LSD 1%= 4.2 LSD 0.1% = 6.7	
2013	Non-irrigated	38.9	100	LSD 5% = 3.1	***
	Irrigated	49.6	127.5	LSD 1%= 4.7 LSD 0.1% = 7.9	
2014	Non-irrigated	43.2	100	LSD 5% = 2.9	***
	Irrigated	51.6	119.4	LSD 1%= 4.5 LSD 0.1% = 7.7	
2015	Non-irrigated	39.6	100	LSD 5% = 3.8	***
	Irrigated	48.3	122.0	LSD 1%= 5.7 LSD 0.1% = 8.9	
Average	Non-irrigated	37.6	100	LSD 5% = 3.1	***
	Irrigated	49.1	130.6	LSD 1%= 5.4 LSD 0.1% = 7.8	

Table 8. The influence of the microsprinkler irrigation on the peach size index (%)

Year	Variant	Size index		Val. of the limit standard deviation	Statistical significance
		mm	%		
2007	Non-irrigated	60.5	100	LSD 5% = 2.9	***
	Irrigated	69.6	115.0	LSD 1%= 3.7 LSD 0.1% = 5.8	
2008	Non-irrigated	60.3	100	LSD 5% = 1.8	***
	Irrigated	68.4	113.4	LSD 1%= 3.6 LSD 0.1% = 5.1	
2009	Non-irrigated	39.6	100	LSD 5% = 2.2	***
	Irrigated	66.9	169.0	LSD 1%= 4.3 LSD 0.1% = 7.7	
2010	Non-irrigated	43.5	100	LSD 5% = 6.0	***
	Irrigated	63.2	145.2	LSD 1%= 9.1 LSD 0.1% = 12.3	
2011	Non-irrigated	65.5	100	LSD 5% = 1.1	***
	Irrigated	70.1	107.0	LSD 1%= 2.7 LSD 0.1% = 4.1	
2012	Non-irrigated	57.6	100	LSD 5% = 5.8	***
	Irrigated	68.7	119.3	LSD 1%= 7.3 LSD 0.1% = 9.6	
2013	Non-irrigated	51.8	100	LSD 5% = 3.7	***
	Irrigated	65.8	127	LSD 1%= 5.1 LSD 0.1% = 7.4	
2014	Non-irrigated	61.0	100	LSD 5% = 2.6	***
	Irrigated	69.8	114.4	LSD 1%= 4.1 LSD 0.1% = 6.2	
2015	Non-irrigated	62.0	100	LSD 5% = 4.8	***
	Irrigated	69.8	112.6	LSD 1%= 6.6 LSD 0.1% = 9.9	
Average	Non-irrigated	55.8	100	LSD 5% = 4.9	***
	Irrigated	68.0	124.8	LSD 1%= 6.2 LSD 0.1% = 9.1	

Figs. 1 and 2 show different aspects regarding the size of the peaches from non-irrigated peach trees and from irrigated peach trees with the microsprinkler method.

The influence of irrigation on the percentage of kernels

Irrigation led to a decrease of the percentage of kernels, on average and every year of the studied period. Statistically speaking, all differences were very significant (Table 9).

Correlations in the soil-water-plant-atmosphere system

There was a reverse correlation between the pedological drought and the peach yield and size, and a direct correlation between the pedological drought and the percentage of kernels (Fig. 3).

The same type of correlations regarding the strong pedological drought were determined, but with a higher correlation coefficient (Fig. 4).

In terms of total water consumption, a direct correlation was determined between the yield and size index, as well as a reverse correlation in terms of kernel percentage (Fig. 5).

Irrigation scheduling by using the soil-water balance method and crop coefficient "Kc"

Irrigation scheduling is very important in order to obtain the best yields and to use irrigation water rationally so as to be economically efficient. In addition, an appropriate irrigation scheduling ensures the protection of the soil. Indirect methods of irrigation scheduling are used in order to set up direct methods of irrigation scheduling (the tensiometric methods are the most popular ones). The former ones are based on the soil water balance and on the conversion of the reference evapotranspiration (ETo) into optimal water consumption. The Penman-Monteith method of determining the reference evapotranspiration is the most accurate of all methods as it uses the highest number of climate elements. The Pan evaporation method is a widespread method of determining the reference evapotranspiration (ETo) and it consists of calculating the daily Pan evaporation. Both methods were used in the research. Even more, Thornthwaite method and and the Piche method were also applied, being widely used in Romania for the design of the irrigation systems, and widespread in France respectively. The climate elements needed to calculate the Thornthwaite and the Penman Monteith reference evapotranspiration (ETo) were provided by the Weather Station in Oradea. Three evaporimeters, placed near the research plot, were used to calculate the Pan evaporation. The Piche evaporation was calculated using evaporimeters placed in the meteorological shelter, close to the location of the Pan evaporimeters.

Table 9. The influence of the microsprinkler irrigation on the peach kernel (%)

Year	Variant	Kernel		Val. of the limit standard deviation	Statistical significance
		%	%		
2007	Non-irrigated	5.3	100	LSD 5% = 0.1 LSD 1%= 0.5 LSD 0.1% = 0.6	***
	Irrigated	4.6	86.8		
2008	Non-irrigated	5.1	100	LSD 5% = 0.1 LSD 1%= 0.3 LSD 0.1% = 0.5	***
	Irrigated	4.5	88.2		
2009	Non-irrigated	5.0	100	LSD 5% = 0.09 LSD 1%= 0.13 LSD 0.1% = 0.35	***
	Irrigated	4.5	90		
2010	Non-irrigated	4.9	100	LSD 5% = 0.1 LSD 1%= 0.29 LSD 0.1% = 0.45	***
	Irrigated	4.2	85.7		
2011	Non-irrigated	4.6	100	LSD 5% = 0.07 LSD 1%= 0.1 LSD 0.1% = 0.35	***
	Irrigated	4.3	93.5		
2012	Non-irrigated	5.1	100	LSD 5% = 0.11 LSD 1%= 0.19 LSD 0.1% = 0.38	***
	Irrigated	4.6	90.19		
2013	Non-irrigated	5.0	100	LSD 5% = 0.11 LSD 1%= 0.21 LSD 0.1% = 0.35	***
	Irrigated	4.5	90		
2014	Non-irrigated	4.7	100	LSD 5% = 0.06 LSD 1%= 0.17 LSD 0.1% = 0.29	***
	Irrigated	4.3	91.5		
2015	Non-irrigated	4.8	100	LSD 5% = 0.08 LSD 1%= 0.13 LSD 0.1% = 0.21	***
	Irrigated	4.4	91.7		
Average	Non-irrigated	4.9	100	LSD 5% = 0.12 LSD 1%= 0.22 LSD 0.1% = 0.39	***
	Irrigated	4.4	89.8		

Table 10. Comparison between the daily water consumption (ETRopt) of the peach tree irrigated by the microsprinkler method and the reference evapotranspiration (ETo) (2007 – 2015)

N₀	Variant	April		May		June		July		August		September		TOTAL	
		mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%	mm/ha	%
1	ETRopt (microsprinkler)	2.9	100	4.1	100	4.2	100	5.2	100	4.0	100	2.1	100	710.0	100
2	ETo Thornthwaite	1.9	66	3.8	93	4.7	112	4.8	92	4.5	112	2.6	123	662.8	93
3	ETo Pan evaporimeter	2.6	90	4.4	107	4.4	105	5.0	96	4.9	122	2.7	129	722.6	102
4	ETo Piche evaporimeter	3.7	128	5.5	134	5.7	136	6.6	127	6.5	162	3.7	176	963.9	136
5	ETo Penman Monteith	2.7	93	4.2	102	4.3	102	5.3	102	4.2	105	2.3	110	711.2	101

LSD 5% 23 11 10 16 14 13 15; LSD 1% 31 18 17 22 23 21 22; LSD 0.1% 47 29 26 31 34 39 34

Table 11. Crop coefficient (Kc) of the peach tree irrigated by the microsprinkler method

N₀	Variant	April	May	June	July	August	September
		Val	Val	Val	Val	Val	Val
1	ETo Thornthwaite	1.53	1.08	0.89	1.08	0.89	0.81
2	ETo Pan evaporimeter	1.12	0.93	0.95	1.04	0.82	0.78
3	ETo Piche evaporimeter	0.78	0.75	0.74	0.79	0.62	0.57
4	ETo Penman Monteith	1.07	0.98	0.98	0.98	0.95	0.91

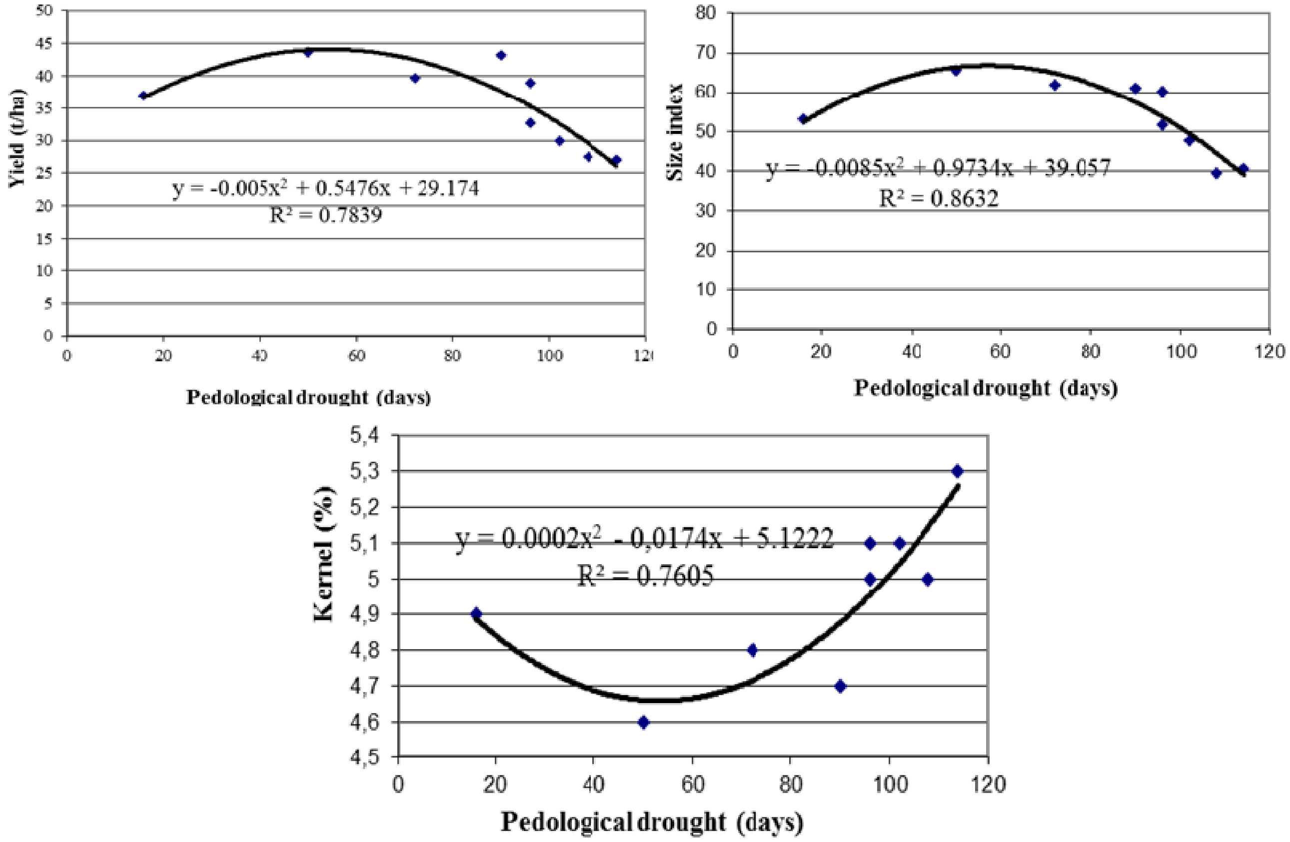

Fig. 3. Correlations of the pedological drought in the non-irrigated peach tree

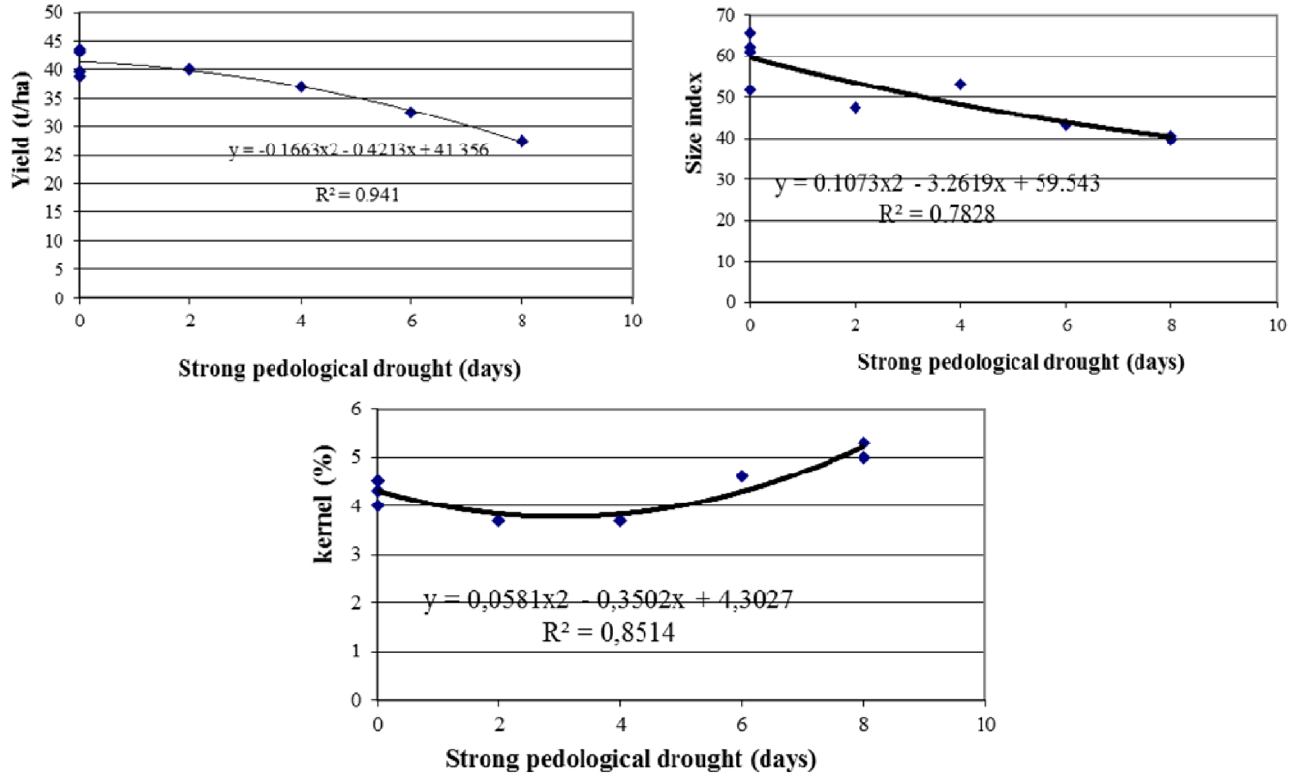

Fig. 4. Correlations of the strong pedological drought in the non-irrigated peach tree

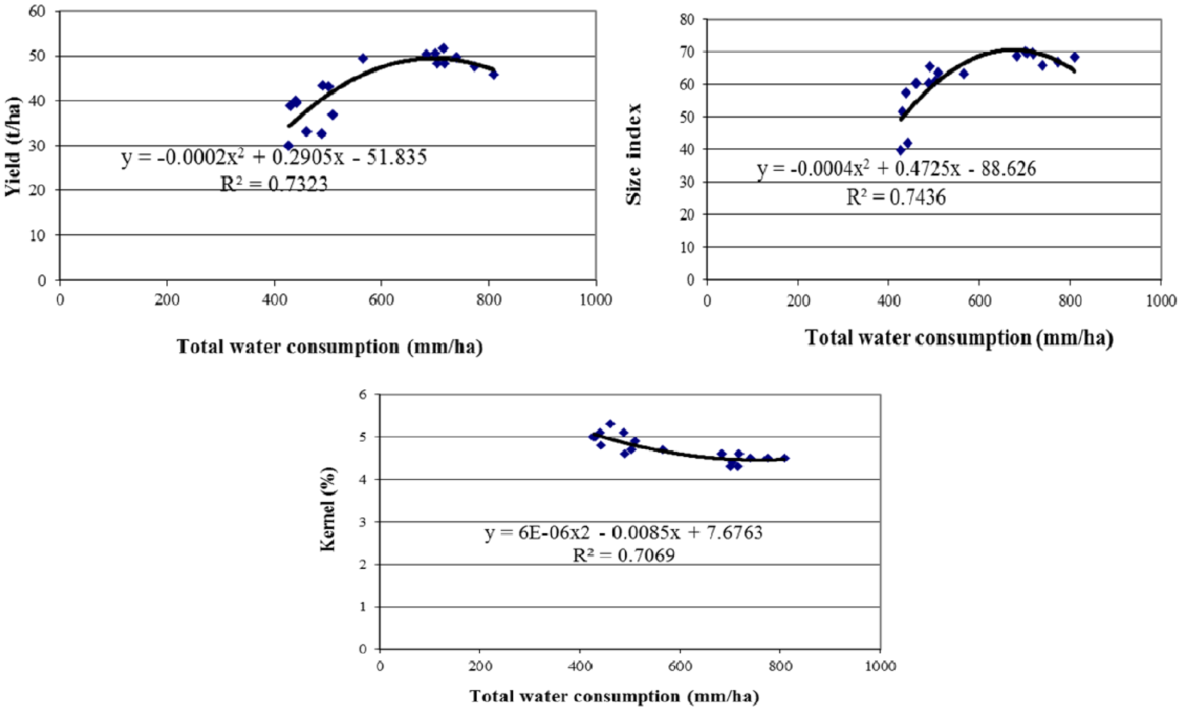

Fig. 5. Correlations of the total water consumption for the irrigated peach tree

The average data obtained during the nine years of research showed that the reference evapotranspiration determined by the four methods presented very significant statistical values, different from the water consumption of the peach trees in all six months of research (Table 10). Under these circumstances, the use of the Kc coefficients to convert the reference evapotranspiration into the optimal water consumption was a requirement. Their values are shown in Table 11. Figures showed that the smallest differences regarding the optimal water consumption of the peach tree in all six months were recorded using the Penman Monteith method.

Discussion

The objectives of the hereby researche were to determine the influence of microsprinkler irrigation on the water consumption of the peach tree and on the yield quantity and quality. In comparison to the optimal water consumption of peach tree, four methods of determining the reference evapotranspiration were studied in order to choose the best method of irrigation scheduling based on soil water balance in fruit growing basin from Oradea.

The climate conditions during the period 2007-2015 were different and relevant for the research, thus the results of the research are representative. Pedological drought occurred in each year of the research interval. The number of days with pedological drought varied from 16 days in 2010 to 114 days in 2007. Strong pedological drought varied from 0 days in 2011 to 28 days in 2009.

The irrigation rate used to maintain the soil water content between easily available water content and field capacity was between 60 mm/ha and 470 mm/ha. Irrigation led to a 53% increase of the total water consumption (712 mm/ha vs. 466 mm/ha). Both for the non-irrigated peach trees (71%) and for the irrigated ones (46%), the rainfalls recorded during 15 March-1 October yearly represented the main source in supplying the total water consumption. Irrigation covered 40% of the total water consumption (variation range 11%-61%). This comes to underline the importance of irrigation regardless the method used, because the lack of water can have severe effects on yield of crops as pointed out by Doorembos and Pruitt (1992).

The yield gain determined by the microsprinkler irrigation was of 30.6%, with a variation range between 15.8% and 58.7%. In all years studied, the differences between the yields of the irrigated peach trees and the yields of the non-irrigated ones were statistically very significant. Obtained contents are similar to those from previous studies (Chalmers *et al.*, 1981*;* Zhang *et al.*, 2017).

The study underlines that microsprinkler irrigation led to a higher size index when compared to the non-irrigated variant and to a lower percentage of kernels. All differences were very significant from a statistical point of view. This comes into debate when compared to the irrigation deficit version of irrigation. The deficit irrigation was also studied by several researchers (Girona *et al.*, 2005; Fereres and Sorian, 2006; Cheng *et al.*, 2012; Forey *et al.*, 2016).

In comparison to the optimal water consumption of the peach tree, four methods of determining the reference evapotranspiration (ETo) were studied (Penman Monteith, Pan evaporation, Piche and Thornthwaite evaporimeter methods) and Pan evaporation was recommended. Other authors such as Doorembos and Pruitt (1992), Johnson (2008) laid ground for the findings of the hereby research, and the current paper comes to add valuable data. This study highlights favourable results obtained by continuous microsprinkler irrigation in a system with optimum irrigation scheduling, thus the authors consider there is ground for further discussion and investigations.

The correlations from soil-water-plant atmosphere system, those between the pedological drought, strong pedological drought and water consumption were statistically assured. All correlations were statistically very significant, the best mathematical expression was the polynomial function, thus ensuring that the research had a solid foundation.

Conclusions

Researches focused on the necessity of irrigating peach tree due to the yearly pedological drought in the fruit growing basin from Oradea. In comparison to the optimal water consumption of the peach tree, four methods of determining the reference evapotranspiration (ETo) were studied (Penman Monteith, Pan evaporation, Piche evaporimeter and Thornthwaite evaporimeter methods), from which the Penman Monteith method reported the closest values to the optimal water consumption. However, the Pan evaporation method was chosen for irrigation scheduling thanks to its simple and easy maintenance. The data on the conversion coefficients of the reference evapotranspiration (ETo) into optimal water consumption obtained at Sâniob shall provide a good irrigation scheduling for peach tree.

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