STUDY CONCERNING WATER REQUIREMENTS IN APPLE TREE AND HYDRIC DEFICIT IN THE CONDITIONS OF TIMISOARA (2000-2010)

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Abstract: *This paper presents a study of water consumption in apple tree in the conditions of Timisoara, between 2000 and 2010, and of water deficit during apple tree vegetation period. Well knowing water requirements of a fruit tree species is of importance in determining irrigation requirements if we wish to obtain large high-quality productions. Literature shows that water requirements vary depending on the different biological, meteorological, soil, and technological factors. This explains largely the different results mentioned in literature concerning annual, monthly and daily water requirements in apple tree in different geographical areas. The theme has direct applicability in practice, particularly for the farmers. Research was carried out on the fruit tree plantation of the Didactic Station of the Banat University of Agricultural Science and Veterinary Medicine of Timisoara, Romania, within a trial organised in an intensive apple tree plantation. The apple tree cultivar we studied, Jonathan, is precocious, very productive, and moderately pretentious as far as climate and soil are concerned, resistant to apple scab, codling moth or apple root aphid. The soil is a cambic chernozem, poorly gleyed, with low salinisation and alkalinisation below 100 cm, meso lime, on fine medium loessoid deposits, medium loamy clay. The value of hydrophysic indices show that the soil has a high capacity of retaining water since it has a natural fertility favourable to apple tree and is suitable for drip irrigation. The studied area is within the moderate temperate continental climate area, with a mean multiannual temperature of 10.8^{0}C and atmospheric precipitations reaching a mean multiannual value of 631.0 mm. Water consumption was calculated with the Thornthwaite formula, the most suited taking into account that it best correlates with research field results. Thus, we calculated monthly, daily total and mean water consumption during the vegetation period (April 1 – October 1) for all the studied years between 2000 and 2010, and then we compared these consumption levels with the coverage degree from precipitations during the same period of time, obtaining hydric deficits, i.e. the necessity of covering them through irrigation. The highest hydric deficits were in 2000 and 2009 (447.12 mm and 355.76 mm, respectively), but there has been hydric deficit that coincided with maximum consumption periods in apple tree (June, July and August).We also need to supplement these hydric deficits through drip irrigation, the method with the lowest water consumption, compared to classical irrigation methods.*

Keywords: *water requirement, apple tree, hydric deficit*

INTRODUCTION

Apple tree moisture requirements are, generally, high, depending on cultivar, on mother/father plant, and on water "critical" phases the tree crosses. Maximum water consumption takes place in the intense shoot and fruit growth phase and it is followed by a decrease of the water consumption upon maturation of the same organs, shoots, and fruit (GHENA N, 2004).

Apple tree culture has favourable conditions in areas where mean annual temperature is between 7.5 and 11^{0}C for a precipitation regime of about 650-700 mm annually, evenly distributed during the year, and where soils are fertile, deep, aerated, with loamy clay and pH 6.5-7.3 (DRĂGĂNESCU E, 2002).

Irrigation in apple tree is necessary in areas with precipitations below 550-600 mm, as well as in moister areas when there are frequent periods of hydric deficits during critical phenophases (GONDA I., 2003).

Literature shows that water requirements vary depending on different biological factors (species, cultivar, mother/father plant, age, size of canopy, root volume, vegetation phase, yield size), meteorological factors solar radiation, air temperature, atmospheric precipitations, air currents), soil factors (soil moisture, layering, depth of soil profile, slope, exposition, etc.) and technological factors (maintenance system of the plantation).

From an economic point of view, apple tree culture is a profitable business: it is considered the most profitable culture together with strawberry, peach tree and pear tree.

Total water consumption in apple tree depends on soil features, on water supply, on the water storage capacity, on water availability, and on mineral salts availability.

Water loses through evaporation intensify when solar radiation is intense, under frequent circulation of air currents, and when it rains abundantly. High temperatures determine higher water consumption, except for extreme temperature values that hinder plant transpiration (ONU, 1988).

Well knowing water consumption specific to apple tree is the main element in determining the species irrigation requirements (ONCIA, 2009).

In the conditions of the Romanian Western Plain, because of the ongoing aridisation process, apple tree cultivation suits drip irrigation very well: in this watering method, water consumption is 20-40% lower than in classical irrigation methods, and energy consumption is 50% lower than in classical irrigation methods (IENCIU A., 2005)

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MATERIAL AND METHODS

Research was carried out between 2000 and 2010 at the Didactic Station of the Banat University of Agricultural Science and Veterinary Medicine of Timisoara, Romania, within a trial organised in an intensive apple tree plantation located in a fruit tree and grapevine plantation.

Apple tree culture was re-established in 1996 as an intensive plantation system, on an area of 3.49 ha, together with pear tree and peach tree. The fruit trees are planted at a distance of 4 m between the rows and 2 m between the trees in a row, i.e. 1250 plants/ha.

The cultivar we studied, Jonathan, is precocious, very productive, and moderately pretentious as far as climate and soil are concerned, and resistant to apple scab şi codling moth or apple root aphid.

The characterisation of the genetic type of soil and of the physical and of its hydrophysic indices was done based on the analysis of a main soil type representative for the studied area. Soil sample analysis was done by O.S.P.A. Timisoara, through usual laboratory methods.

In order to characterise the micro-zonal climate and to establish the annual hydro climate balance, we processed and interpreted meteorological data recorded at the Meteorological Station in Timisoara.

The studied area is part of the moderate temperate continental climate; it is located at the crossroads between the climate province sector with Mediterranean influence and the sector of province with ocean influences.

The representative soil is a cambic chernozem poorly gleyed with low salinisation and alkalinisation below 100 m, on fine medium loessoid deposits, medium loamy clay, of the Ap-Am-AB-Bv-BC-CK-CKGo type profile. The soil has a fine, loamy clay texture along the entire soil profile. The value of hydrophysic indices (table 1) shows that the soil has a high water storing capacity.

The soil with a high water storing capacity and also an excessively large edaphic volume and a natural fertility is favourable to apple tree cultivation and fit for drip irrigation (VOICULESCU N, 2001).

Table 1.

Hydrophysic indices of the poorly gleyed, feebly decarbonated cambic chernozem in Timişoara

Horizon	Depth (cm)	CH (% ms)	CO (% ms)	CC (% ms)	CT (% ms)	CU (% ms)	K (% ms)
Ap	0-20	9.2	13.8	26.6	37.5	12.8	2.9
Am	20-37	8.8	13.2	26.0	35.3	12.8	3.0
A/B	37-63	9.0	13.5	27.2	38.0	13.7	2.8
Bv	63-75	9.2	13.8	27.5	35.3	13.7	2.5
BC	75-98	9.2	13.8	27.1	35.6	13.3	2.5
Ck	98-120	9.0	13.5	26.6	34.0	13.1	2.8
CkG_0	120-180	8.6	12.9	26.8	34.0	13.9	3.0

Water consumption in apple tree was calculated with Thornthwaite, the best suited formula taking into account the fact that consumption thus calculated best correlates with research field results.

The Thornthwaite method takes into account mean air temperature using the following formula:

$$ETP = 16\left(\frac{10 \cdot tn}{I}\right)^{a} \cdot K \text{ *kp}$$

where:

ETP - monthly potential evaporation (mm);

tn - monthly mean temperature for which we calculate monthly potential evaporation in ^{0}C;

I - area thermal index (the sum of monthly thermal indices);

$$I = \sum_{n=1}^{12} i_n$$

$$i_n = \left(\frac{t_n}{5}\right)^{1,514}$$

t - multiannual mean temperature;

a - exponent depending on I;

a - 0.0000006751 I^3- 0.00007711 I^2 + 0.0179211 I +0.49239;

I_n - monthly thermal index

K - latitude coefficient specific to the area;

kp - coefficient depending on the culture.

RESULTS AND DISCUSSION

The studied area is part of the moderate temperate continental climate, at the interference between the sector of climate province with Mediterranean influence and the sector of province with ocean influences. Mean multiannual temperature is 10.8^{0}C. Atmospheric precipitations have a mean multiannual value of 631.0 mm.

Annual hydro climatic balance is not excessive, showing a slight deficit (-67.0 mm), with a hydro climatic index of 9.40 and with an aridity index "de Martonne" of 30.30.

Water climatic balance with no phreatic supply points out a moisture surplus in winter and spring months and a moisture deficit during summer and at the beginning of fall.

Research shows total water consumption during vegetation (April 1 – October 1) between 504.62 and 619.76 mm. The highest water consumption levels were in 2009 and 2000, tightly correlated with high temperatures and with precipitations during this period.

The evolution of total water consumptions in apple tree in the conditions of Timisoara during the period analysed is shown in the graph below.

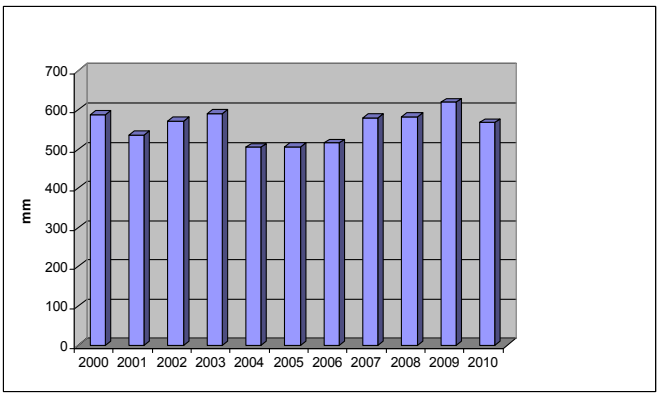

Figure 1. Evolution of total water consumptions in apple tree in the conditions of Timisoara between 2000 and 2010

Mean daily consumptions during the period analysed ranged between 2.12 and 4.0 mm/day, with maximum values in June, July and August. The highest mean daily consumptions of all studied years were 4.64 mm/day in June 2003 and 4.58 mm/day in June 2007. July also recorded high mean daily consumptions of 4.39 mm/day in 2009 (figure 2).

Figure 2. Evolution of daily water consumptions in apple tree in the conditions of Timisoara between 2000 and 2010 (mm/day)

After studying total water consumption in apple tree between 2000 and 2010, we calculated existing water deficits in each studied year and we noticed that they were rather high and overlapping the period in which apple tree has high water requirements (Figure 3). It is

obvious that in 6 of the 10 years there were significant hydric deficits in the periods of high water requirements in apple tree, i.e. irrigation water requirements of about 25.05% -76.05%.

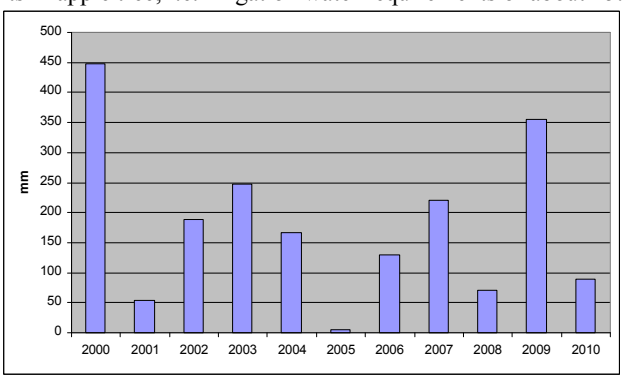

Figure 3. Evolution of hydric deficit in apple tree in the conditions of Timisoara between 2000 and 2010

In the present study, the degree of coverage of water consumption in apple tree from existing precipitations during the studied period is shown in table 2. In a single year the water requirements were covered by precipitations.

Table 2.

Sources of water to cover water requirements in apple tree in the conditions of Timisoara between 2000 and 2010

Year	Water requirements (mm)	Precipitations (mm)	Share of water requirements from precipitations (%)	Irrigation water requirements (mm)	Irrigation water requirements (%)
2000	587.92	140.8	23.95	447.12	76.05
2001	536.82	483.1	90.00	53.72	10.00
2002	571.75	384.0	67.16	187.75	32.84
2003	590.2	342.4	58.03	247.8	41.97
2004	504.62	337.8	66.94	166.82	33.06
2005	505.39	510.7	101.05	-	-
2006	515.56	386.4	74.95	129.16	25.05
2007	580.07	360.0	62.06	220.07	37.94
2008	583.27	512.2	87.81	71.07	12.85
2009	619.76	264.0	42.60	355.76	57.40
2010	567.58	478.1	84.23	89.48	15.77

CONCLUSIONS

1. Total water consumption in apple tree calculated through the Thornthwaite indirect method in the conditions of Timisoara between 2000 and 2010 ranged between 504.62 mm and 619.76 mm, with the highest water consumption levels in June, July and August in all studied years, a period that corresponds with water requirements in apple tree of 63% of the total water consumption.

2. Mean daily consumption ranged between 2.12 and 4.64 mm/day, with maximum values in June 2003 and in June and July 2007, ranging between 4.0 and 4.39 mm/day.

3. Hydric deficits during the vegetation period were in 9 years out of 10, ranging between 447.12 mm and 53.72 mm, corresponding to the period in which apple tree culture has high water requirements (May-August).

4. Taking into account apple tree water requirements in the climate conditions of Timisoara, where there is a trend to drought, apple tree water requirements during vegetation can be met only through irrigation for high-quality productions. We recommend drip irrigation since it is a modern and efficient watering technique.

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