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DRIP IRRIGATION OF APPLES AT A MODERATE CONTINENTAL CLIMATE

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Abstract - Establishing irrigation scheduling of apples grown in soil and weather conditions of the Sofia region in the period 2001-2005 research was conducted with drip irrigation. Tested the watering - full of satisfying the daily needs of the culture of water to irrigation reduced by 20% and 40% irrigation norms.

Established irrigation schedulings of apples - number irrigations, irrigations depths, irrigation rate and yields of apples of the Sofia plant. At high yields are obtained at 100% irrigation is rate- 2087kg / da. The reduced irrigation depths with 20% resulted in rather small drops in yields by 7%. This irrigation scheduling can be applied in conditions of water deficit.

Key Words: apple sort "Florina", drip irrigation, Republic of Bulgaria

1. INTRODUCTION

Apple occupies the first place in the Republic of Bulgaria by area and fruit production compared to other fruit crops. The economic and economic efficiency of apple production in our climatic conditions is largely determined by the application of rational irrigation regimes and appropriate irrigation techniques.

Micro-irrigation is one of the most perceptual ways of irrigating fruit crops, mainly due to the great water economy and the possibilities for complete automation of the irrigation process.

Along with all the benefits of drip irrigation in physiological and technological terms, the most important of which is the obtaining of biologically optimal yield of high quality fruits with significant water savings compared to traditional irrigation methods (Dochev, 1983), he proposes Best prerequisites for implementing the so-called An irrigated regime by reducing the size of irrigation regulations (Lazarov et al., 1982).

The optimal irrigation and irrigation norms mentioned in the literature range widely (Dochev, 1983) due to the dependence of these parameters on the soil-climatic conditions, the age period, the vegetative development of the trees, the applied cultivation technology.

Research in Bulgaria on the irrigation regime of an apple tree in a fruit-plantation in the Plovdiv region shows that irrigation rates vary from 140mm to 300.0mm (Dochev, Gospodinova, 1987).

Doichev (1994) pointed out that intensive apple plantations, sparged by droplets, should be created from high-yielding and quality fruit varieties. It recommends the MM 106 substrate and a irrigation regime with a irrigation rate of 100% ET and a water shortage reduced to 60% ET. The application of this irrigation method to the apple harvest, which is of great economic significance, requires a detailed identification of the irrigation parameters of the irrigation regime in our country

For grassland treatment and plant protection spraying, tractors can be used Bulgarian family tractors for small farms (Bojkov, Sn., et al., 2009). In the Republic Bulgaria was development and research a new theoretical method for extraction of saplings apples trees from nurseries was made.(Stefanov, Bojkov, Mortev, Dimitrova 2017)..

MATERIALS AND METHODS

The studies to establish the irrigation regime of apples sort "Florina" on a MM-106 substrate variety at drip irrigation were performed at practice ground in experiment field at the Institute of Soil Science, Agro technologies and Plant Protection - Chelopechene (42°73' 23" N, 23° 47' 32" E and 550 m. Altitude) around the Sofia capital during period 2001-2005.

The following variants were tested:

Pre irrigation moisture - 80% of limit field moisture capacity LFMC

1. Non irrigation.
2. 100% realized rate of water application.
3. 80% realized rate of water application.
4. 60% realized rate of water application.

The trees are planted at 4.5 m inter-row spacing and 2.5 m inter-row spacing or 125 trees per decar.(1da = 0,1ha) Each row of the orchard consisting of 30 trees represents a four-replicate of six trees in repetition with an area of each repetition of 67.5m2 (2.5mx4.5m= 11.25m^2 area per one wood). Irrigation was carried out by surface dripping with drippers KP - 4.6, perforated hose over 0.60 m.
Values of rate of water application and irrigation rate
The irrigated standards are calculated according to the formula:

$m = [10H.\alpha.(\delta\tau \text{ LFMC} - \delta\tau \text{ pr. m.})].K.K_1$
where,
m –rate of water application in mm;
α – soil volume density in gr/cm^3;
H – depth of active soil layer in m (in this experiment H = 1,00 m);
δτ LFMC /limit field moisture capacity/ – limit field moisture capacity in % with respect to the absolutely dry weight of soil;
δτ pr. m /preirrigation moisture/ – preirrigation moisture of soil in % with respect to the absolutely dry weight of soil;
K – coefficient of rate of water application reduction taking into account the area cropped with plants in 1 dka.

For the drip irrigation the amount of total rate of water application is not given as for the other methods. So reduction is required at the expense of the not irrigated area. For this purpose, the formula of Zivkov, (2013) is used taking into account the scheme of planting. After calculating the rate of water application for variant 2 with respect to its size, the standards for the other variants were established. In order to track the soil moisture dynamics, soil samples were taken from variant 2 in every seven days at depth to 1,00 m, at every 0,10 m in 3 replications; these samples were processed according to the usual gravimetric thermostatic method.

The soil is cinnamon forest leached soil, slightly sandy-clayish in its upper layer formed on the base of old talus cone made of alluvial materials. The soil is poorly supplied with nitrogen, moderately – with phosphorus, and better supplied – with potassium. At the average for the layer of 0 – 0,60 m the soil has the following water physical properties: LFMC = 22,1%, withering moisture content – 12,3% with respect to the absolutely dry weight of soil, bulk weight at LFMC – 1,47 g/cm^3. For the soil layer of 0 – 100 cm, the same indicators have the following values: LFMC – 21,8%, withering moisture content – 12,3% and bulk weight – 1,50 cm^3. The soil is suitable for cultivation of strawberry plants.

Meteorological conditions of the experiments.

Studies on irrigation norms, taking into account the water-physical characteristics of the soil type and the weather conditions in individual years, make it possible to establish such a size of watering in which the biological needs of the crops are most fully met without the possibility of large water losses .

Table - 1 Rainfall during apples vegetation period (2001–2005 years.)

Periods	Total rainfall				
Years	2001	2002	2003	2004	2005
IV – IX	358	418	329	258	765
Average multi-annual	365	365	365	365	365
VII – VIII	75	158	104	73	400
Average multi-annual	110	110	110	110	110

During the years of experience, the provision of precipitation amounts in the 50-year series characterized the vegetation period of the development of culture (April to September) as middle rainfall - 2001, 2002, and 2003, a wet -2005 year and one - 2004 was a very dry. The lowest rainfall fell in 2004 (258 mm) and most in 2005 (765 mm), and in the remaining three years the precipitation ranged from 329 to 418 mm (Table 1). Falling rainfall during the vegetation of the crop was unevenly distributed, which led to the implementation of watering and in years of experience.

RESULTS AND DISCUSSIONS

Studies on irrigation norms, taking into account the water-physical characteristics of the soil type and the weather conditions in individual years, make it possible to establish such a size of watering in which the biological needs of the crops are most fully met without the possibility of large water losses .

The results of the five-year research show that the number of irrigations and irrigation rates are determined by the weather conditions (precipitation) in individual years. The number of irrigation varies from 14 to 20 and the irrigation rate from 238 to 438 m^3/da.

Average number of irrigations with average irrigation rate of 19 mm and irrigation rate of 323 mm were submitted during the growing season (Table 2) during the vegetation period of the apples, with the highest number of irrigation being carried out during the dry year (2004), where the number of water courses reach 20 and the irrigation rate 360 mm.

Table - 2 Number irrigations, irrigations depths and irrigation rate of apples in the region near to Sofia, Chelopechene. (average 2001-2005)

Years	Average 2001-2005 year.		
Variant	Number irrigaions	Irrigation rate mm	Irrigation rate total, mm
Non irrigation	-	-	-
100% m.	17	19	323
80% m	17	15	255
60% m	17	12	204

The scheduling irrigation are implemented for the period from the beginning of May to the end of September. The intercourse periods during the vegetation of the crop are different and depend on the quantity and distribution of the rainfall, as well as the phases of the development of the culture

It has been found that apple requirements for soil moisture are greater at the beginning of flowering, fruit formation until fruit harvesting, therefore moisture in the soil during this period it is necessary to maintain 80-85% of limit field moisture capacity in %.

At the beginning of the vegetation of the crop, as well as towards the end, the puddings are realized in 14 - 15 days, and in the period of active vegetation, flowering and fruiting in 5 - 6 days. In very dry years during the period of active vegetation, the pots are delivered in 3 - 4 days (Table 2).
The results obtained for the apple yield during the different humid years show the influence of drip irrigation on its size. The highest increase in yield was obtained in 2004 (dry), which is 55% more than the non-irrigated option (Table 3). The smallest increase of 667 kg/da (25%) was obtained during the wet year 2005, with an average increase of the yield for the five studied years by 821 kg/da compared to the non-irrigated option.

The irrigated regimes during the years also influenced the yields obtained. The highest yields were obtained for the variants irrigated with 100% irrigation rate of 2087 kg/da, and the lowest for irrigation variants 1266 kg/da. Lowering the irrigation rate by 20 and 40% has led to a 7% and 14% reduction in yields. On average, the reduction in yield is not drastic and such irrigation regimes can be used in the event of a water shortage. (Table 3).

Table - 3 Yield of the apples of drip-irrigation in the region near to Sofia, Chelopechene. (average 2001-2005).

Years	2001		2004	
Variant	Yeild kg/da	Relative yield %	Yeild kg/da	Relative yield %
Non irrigation	1567	100	855	100
100%M	2122	135	1866	218
80% M	2053	131	1681	196
60% M	2004	128	1459	170
Years	2005		Average 2001-2005 г.	
Variant	Yeild kg/da	Relative yield %	Yeild kg/da	Relative yield %
Non irrigation	2070	100	1266	100
100% M	2737	132	2087	161
80% M	2592	125	1952	150
60% M	2444	118	1808	134

The investigated irrigation regime has had an impact on the irrigation water productivity. It is highest in variants irrigated with the lower irrigation rate. The analysis of the obtained results showed that from each cubic meter of irrigation water on average the study period was obtained from 7.6 to 9.8 kg apples (Table 4), with the highest values reaching during the wet year to 13.4 kg per each cubic meter of water. The highest yield of irrigation water over the three years is obtained with the option of realizing 60% of the irrigation rate and amounts to 6.6 to 13.4 kg per cubic meter of water.

The results obtained for the irrigation water productivity show that the increase of the water-bearing capacity of the plants decreases the productivity of irrigation water, most pronounced in the variants irrigated with 100% irrigation norm.

Table 4 Irrigation water productivity of the apples on years.

Variant	2001 average year		2004 dry year	
	Irrigation rate mm	Water Efficiency кg/m^3	Irrigation rate mm	Water Efficiency kg/mк
100% m	340	6,1	360	5,2
80% m	275	7,5	300	6,1
60% m	217	9,3	220	6,6
Variant	2005 wet year		For average three years	
	Irrigation rate mm	Water Efficiency кg/m^3	Irrigation rate mm	Water Efficiency кg/m^3

100% m	238	11,5	313	7,6
80% m	216	12,1	255	8,6
60% m	182	13,4	218	9,8

CONCLUSIONS

The analysis of results obtained from the field experiments shows:

- During the period of active growing of the crop (April-June), 17 pots with average irrigation rate - 19,0 mm and total irrigation rate for the period - 323,0 mm were realized.
- From the tested irrigation regimes in biological terms the irrigation regime is most suitable with the implementation of a 100% irrigation norm, which is recommended under conditions of good water supply.
- The highest yields were obtained for the variants irrigated with 100% irrigation rate of 2087 kg/da, and the lowest for irrigation variants 1 266 kg/da. Lowering the irrigation rate by 20 and 40% has led to a 7% and 14% reduction in yields. On average, the reduction in yield is not drastic and such irrigation regimes can be used in the event of a water shortage.
- The highest yields were obtained for the variants irrigated with 100% irrigation rate of 2 087 kg/da and the lowest for irrigation variants 1 266 kg/da. Lowering the irrigation rate by 20 and 40% has led to a 7% and 14% reduction in yields. On average, the reduction in yield is not drastic and such irrigation regimes can be used in the event of a water shortage.
- The highest increase in yield was obtained in 2004 (dry), which is 55% more than the non-irrigated option. The smallest increase of 667 kg/da (25%) was obtained during the wet year 2005, with an average increase of the yield for the five studied years by 821 kg/da compared to the non-irrigated option.
- The irrigation water productivity of apple drip irrigation increases when the irrigation rate is reduced. Highest values reach 40% reduction in irrigation rate.

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