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EFFECT OF DRIP IRRIGATION ON GROWTH, FLOWERING AND YIELD OF 'LOBO' APPLE

ABSTRACT. The effect of drip irrigation on the biology of 'Lobo' apple trees grafted on M 9 and trained in the form of a superspindle was investigated. Despite a great variability of rainfall during the experiment, in each year there was a drought period requiring additional irrigation. The obtained results show a high effectiveness of drip irrigation of apple trees. Over 5 years of the experiment a total yield from irrigated trees was 22.3 % higher and mean fruit weight 21.5 % higher than from unirrigated trees.

Key words: apple tree, irrigation, superspindle

INTRODUCTION. Seasonal deficiencies of rainfall affect the growth and fruit yield of apple trees (Pacholak, 1986; Treder and Mika, 1996a,b). It has been reported that drought reduces an active surface of root system and in consequence weakens water and mineral salts uptake (Evans and Proebsting, 1985). The effect is especially pronounced in trees grafted on dwarf rootstocks commonly used in modern orchards. High density planting causes the disproportion between potential evapotranspiration of

the trees and root system capable of water uptake. Thus, in dense planted orchards even short periods without rain can cause drought in the active root zone. This work aimed to establish the influence of drip irrigation on the biology of 'Lobo' apple trees grafted on M 9 rootstock and planted at a high density.

MATERIAL AND METHODS. The experiment was set up in the Pomological Orchard of the Research Institute of Pomology and Floriculture, Skierniewice. The object were 'Lobo' apple trees grafted on M 9, planted in autumn of 1990 at the distances of 3.5 x 0.5 m (5714 trees/ha) on grey-brown podzolic soil with loamy subsoil. Soil in the rows was kept clean of vegetation with herbicides and in the interrows the sod was maintained. Trees were trained in the form of a superspindle. Irrigation started in 1992. Control trees were not irrigated.

The experiment was set in a block design with 4 replicates consisted of 20 trees each. Irrigating pipes were equipped with emitters spaced at 0.6 m intervals and water delivery rate was 1.75 l/h.

The following observations and measurements were taken:

- in autumn every year trunk thickness at 30 cm above ground;
- in spring of 1992, 1993 and 1994, flower buds on each tree were counted;
- every year, a total fruit yield from 20 trees was measured and mean yield per plot was calculated;
- every year a mean weight and diameter was calculated from 100 randomly picked fruits.

Data were statistically elaborated with an analysis of variance. Student's "t" test was employed to calculate the significance of differences at P=0.05 and P=0.01. To evaluate the influence of bloom intensity in previous year (x) on the abundance of flowering in the following (y) seasons, a linear correlation was used. Trunk cross section area is presented graphically with standard error (SE).

RESULTS. Mean air temperature, precipitation and volume of water delivered to irrigated trees from May to October in 1992-1996 are presented in Table 1.

Table 1. Mean air temperature, total rainfall and water delivered with irrigation in 1992-1996 (May - September)

Parameter	Years				
	1992	1993	1994	1995	1996
Mean air temp. (°C)	15.72	14.97	14.22	15.87	15.14
∑ rainfall [mm]	196.1	237.4	312.4	300.9	444.2
Irrigation [mm]	81.2	19.5	18.9	94.0	34.3

The above data show great variability between years. Season 1992 was very warm and dry, with total rainfall amounted only to 196.1 mm. The last season of the experiment (1996) was very wet - from May to the end of September total precipitation reached 444.2 mm. However, in every season there were dry periods requiring irrigation. Watering amounts varied considerably between the years.

Irrigation had significantly affected tree growth. In the autumn of 1992, trunk cross-section area (TCA) of irrigated trees was significantly larger than that of the control and the difference increased with years (Fig. 1).

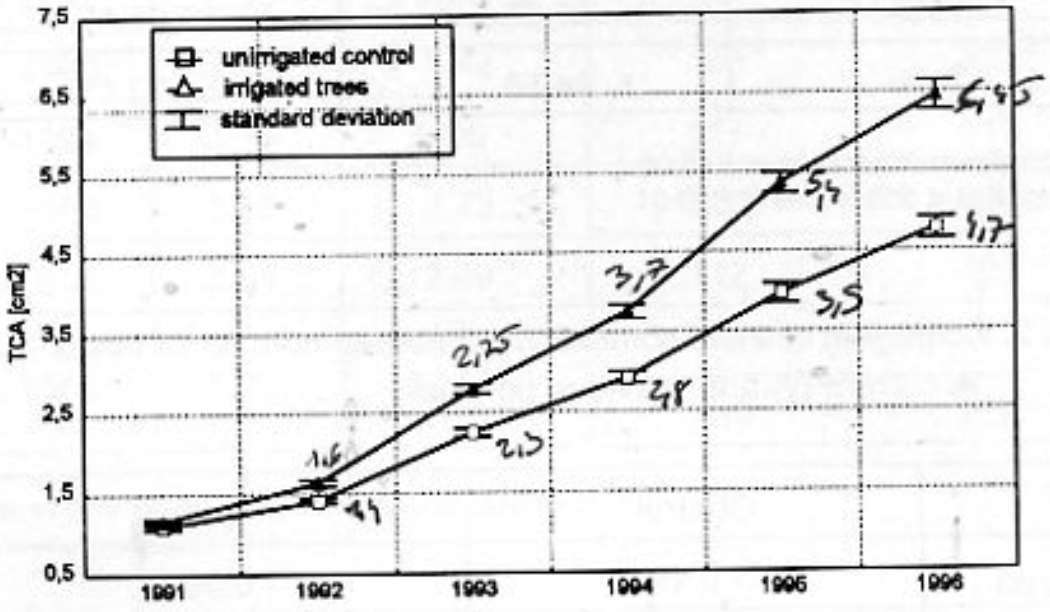

Fig. 1. Trunk cross-section area [cm²]

Flowering intensity showed great variability (Tab. 2). Generally, in the period 1992-1994 irrigated trees bloomed more intensely than the control. However, biennial flowering was observed when after abundant flowering in 1992 (second year after planting) there was considerably less flowers in the following year. The reverse effect was observed on unirrigated trees where reletively week flowering in 1992 was followed by abundant blooming in 1993. Statistical analysis showed the significance of linear correlation coefficient r_{xy} between the number of flower buds in current (y) and preceeding (x) year (Tab. 3). In both combinations these coefficients had negative values. It proves that in a young orchard flowering intensity is inversely correlated with blooming in the preceeding season.

Table 2. Number of flower buds per tree in 1992-1994

Year	Treatment	
	control	irrigated
1992	5.49	7.98 **
1993	7.86 **	4.7
1994	31.23	39.05 **
Total	44.58	51.73 **

* - significant differences at P=0.05
** - significant differences at P=0.01

Table 3. Coefficient of linear correlation r_{xy} between number of flower buds in current (y) and previous (x) year

	Control	Irrigated
$r_{92/93}$	- 0.49 *	- 0.49 *
$r_{93/94}$	- 0.58 *	- 0.66 *

* - significant difference at P=0.05

In the first year of fruiting (1992) irrigated trees yielded better and bore larger fruit than the control (Tab. 4). Crop harvested in the following year was similar in both combinations, however fruits from irrigated trees were larger. In the next season (1994) irrigation had increased yield, but had no effect on fruit size. Then, in 1995 watered trees gave a very low yield (though, the difference was not significant by Student's t- test) but fruit size was significantly larger than in the control. In 1996 yield and fruit size were similar in both combinations. Total fruit yield from irrigated trees during five years of fruiting amounted to 22.33 kg/tree (127.6 t/ha) and was significantly higher than yield from the control (17.7 kg/tree; 101 t/ha). The mean weight of fruits from irrigated trees was also significantly higher as compared to the control. Productivity index (We), expressed as a yield increase in t/ha per 10 mm of applied water (Pacholak, 1994), amounted to 1.07. It is a convincing evidence of the effectiveness of intensive orchard irrigation.

Table 4. Fruit yield and mean fruit weight of Lobo apple in 1992-1996

Year	Yield [kg/tree]		Mean fruit weight [g]	
	control	irrigated	control	irrigated
1992	0.56	1.03 *	147	168 *
1993	1.42	1.42	198	243 *
1994	3.16	5.06 *	117	119
1995	3.55	2.73	123	190 *
1996	9.01	12.09	112	125
Total	17.7	22.33*	Mean	
			139	169 *

Means differences were calculated separately for each year
* Means significant at P=0.05

In 1992, 1994 and 1995, the percentage of apples with a diameter exceeding 7 cm was significanly higher in irrigated trees (Tab. 5).

Table 5. Percentage of apples with diameter above 7 cm

Year	Control	Irrigated
1992	79.1	95.0 *
1993	100	100
1994	65.9	93.5 *
1995	76.1	97.4 *
1996	72.8	84.7
Mean	78.8	94.1 *

DISCUSSION. Our results confirm the effectiveness of drip irrigation of apples previously reported by other authors (Assaf et al., 1984; Pacholak, 1986; Rzekanowski, 1988). The yield increase due to irrigation of apple trees trained as a superspindle was similar to that obtained in our earlier experiments (Treder and Mika, 1996a,b). Beneficial effect of irrigation on fruit size increase was also previously observed (Assaf et al., 1984; Evans and Proebsting, 1985; Treder and Mika, 1996 b). However, productivity index was not affected because a higher yield was connected with trunk cross-section area increase. Similar results on plum trees were obtained by Treder et al. (1995).

CONCLUSIONS

1. Drip irrigation significantly affected growth vigour, flowering and yield of apple trees.
2. Irrigated trees yielded larger fruit as compared to unirrigated control.

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