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The influence of irrigation on growth and yield of plum trees cv. Valor grafted on Myrobalan and Wangenheim Prune

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Summary

The climate of Poland is characterized by a high variability, especially regarding the sum of precipitation and its distribution in the season. Dry years occur periodically. Repeated negative climatic water balance for vegetative season is insufficient for proper growth and development of plants. In this experiment we studied the effectiveness of drip irrigation in plum tree cultivation. The study was carried out since 1990 to 1998 in the orchard of the Institute of Pomology and Floriculture in Skierniewice. Trees of plum cv. Valor, grafted on Myrobalan and Wangenheim Prune seedlings were planted in the spring 1990 at a distance 4,2 m x 2,9 m. Influence of drip irrigation on trees growth changes, yield and fruit quality depended on weather conditions in the individual years. Generally, drip irrigation significantly increased the tree growth, yield and fruit quality. Higher positive effect of irrigation was obtained for plums grafted on Wangenheim Prune seedlings than on Myrobalan seedlings. Drought conditions clearly decreases the average weight of the fruit of the trees grafted on Wangenheim Prune. The rootstocks had no effect on fruit size.

Keywords: plum, irrigation effect, drip irrigation

INTRODUCTION

The climate of Poland varies, especially if the sum of precipitation and its distribution in the season is concerned. High negative climatic water balance (deficit more then 100 mm) characterizes 24 % of area of Poland (Bac, 1980). Yield and quality of fruits are limited by quantity of precipitation. It has been reported that drought reduces the active surface of root system and in consequence weakens water and mineral salts uptake (Evans and Proebsting 1985). Treder (1996) shows that irrigation significantly increases growth and yield of apples, cherries, peaches and other fruit crops in Polish conditions. The main purpose of the experiment was the study the long term effect of drip irrigation on yield, fruit quality, and growth of plum trees grafted on two rootstocks.

MATERIAL AND METHODS

The experiment was set up in the experimental orchard at the Research Institute of Pomology and Floriculture, Skierniewice. The orchard was planted with plum trees (*Prunus domestica* L. cv. Valor) grafted on Wangenheim Prune seedlings and Myrobalan seedlings (*Prunus cerasifera* L.). The trees were planted in the spring of 1990 year at the distance of 4,2 x 2,9 m (821 trees/ha). The experiment was set in a factorial design 2 x 2, where trees grafted on two rootstocks were drip irrigated or no irrigated (6 replications, one tree consisted a replication). On line the PC drippers (4 Lh^{-1}) were located 0,35 m from the both sites of tree trunk. Plants were irrigated to maintain the soil moisture at the level of -0,02 MPa of water potential controlled by tensiometers. The following observation and measurements were taken every year:

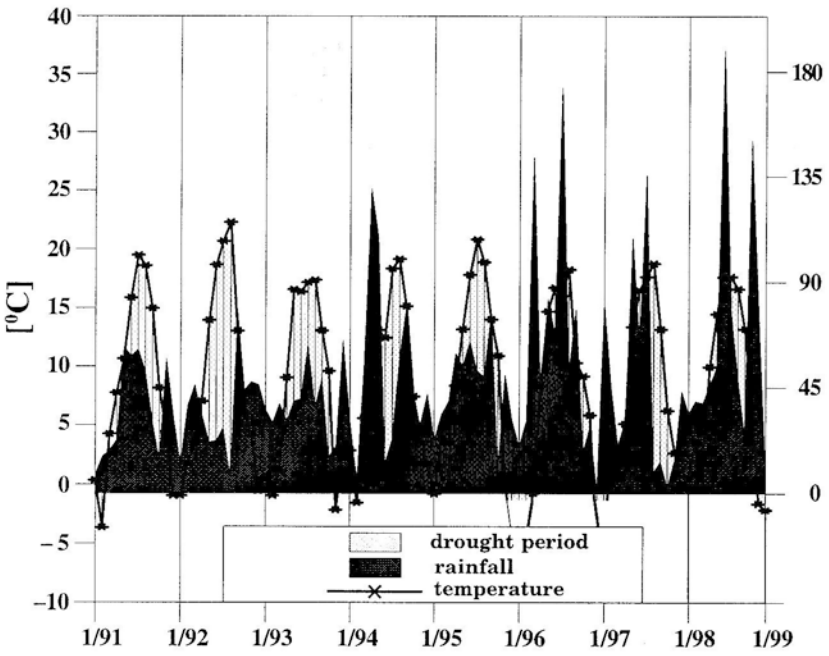
- trunk thickness at 30 cm above the grafting point (in autumn),
- annual shoot length in the years 1991, 1992, 1993,
- yield and mean fruit weight.

The 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. Annual shoot length, trunk cross section area and mean fruit weight are presented graphically including standard errors (SE).

RESULTS AND DISCUSSION

Rainfall distribution and monthly temperature are shown on climatic graph (figure 1).

Fig. 1. Climatic graf Skierniewice 1991-1998



This graph shows mean monthly temperatures and monthly precipitation in the ratio 1°C: 4,5 mm of rainfall according to the scheme worked out by Walter and Lietha (1970). This method allows to estimate climatic periods of drought. The data show great variability between years. During the course of research there were two dry seasons: 1992, 1994, and three semi wet seasons: 1996, 1997, 1998. However, in every season there were dry periods requiring irrigation. Total annual supply of water is presented in table 1.

Table 1.

Total water supply [mm/year]

1990	1991	1992	1993	1994	1995	1996	1997	1998
4	10	53	10	86	105	56	40	21

Fig. 2. Influence of drip irrigation on sum of annual shoot length [m] of plum trees cv. Valor grafted on two rootstocks.

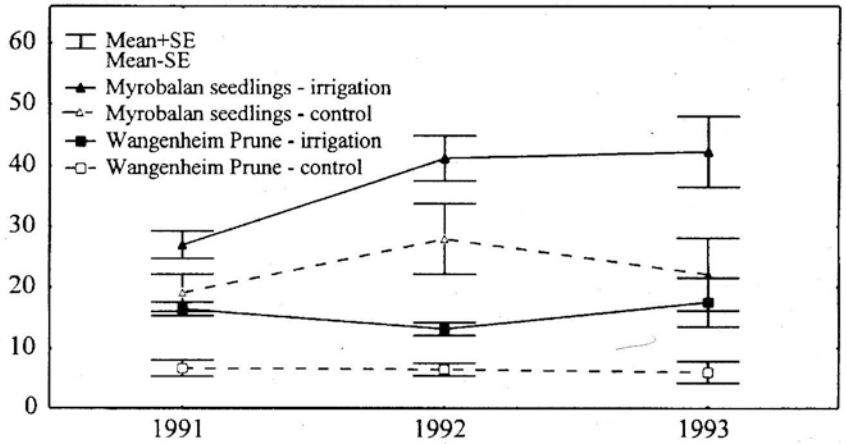
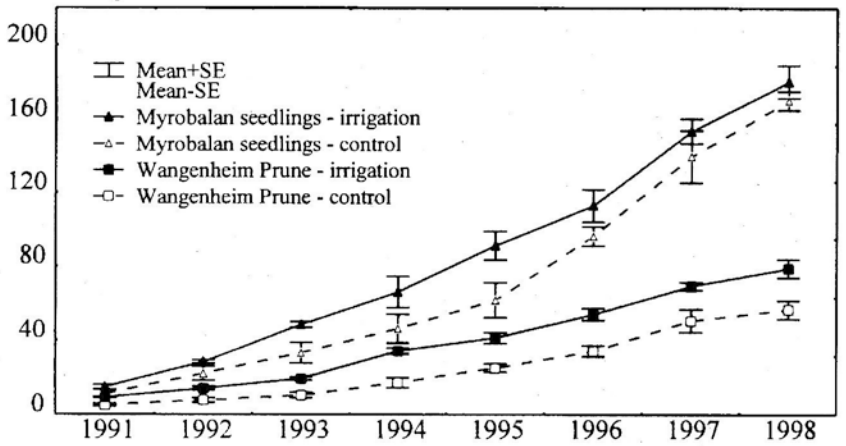


Fig. 3. Influence of drip irrigation on trunk cross sectional area [cm²] of plum trees cv. Valor grafted on two rootstocks.



Generally, the trees on Wangenheim Prune grew less vigorously than those on Myrobalan seedlings (figure 2, 3).

Similar results for different plum cultivars got Rozpara and Grzyb (1994). The growth of shoots of no-irrigated trees grafted on Wangenheim Prune and Myrobalan seedlings was the poorest in the three years of experiment. Drought limited the growth of shoots of the trees grafted on both rootstocks on the similar level. In the experiment published by Treder at al (1999) the influence of irrigation on the vigour of shoots of trees cv. Bluefree grafted on Myrobalan seedlings was considerably poorer compared with the trees grafted on Wangenheim Prune. During the whole period of the experiment (1991 - 1998) the irrigated trees grafted on Wangenheim Prune had their TCA bigger than that of control trees. In the case of the trees grafted on Myrobalan seedlings significant differences were observed in the years 1991 – 1996. In the next years (1997 – 1998) very heavy rainfall caused a rapid growth of the control trees grafted on Myrobalan seedlings, which now show no differences compared with the irrigated ones. From the second year after planting (1992) irrigated and control trees grafted on Wangenheim Prune had a considerable smaller trunk cross sectional area compared irrigated and no irrigated trees grafted on Myrobalan seedlings.

Because of the less vigorous growth, Rozpara and Grzyb (1994) suggest that plum trees on Wangenheim Prune seedlings are suitable for intensive orchards, which has been confirm by our results. However in Polish weather conditions trees grafted on Wangenheim Prune are expected to be sensitive to water stress. Therefore there is a need for irrigation. The total (per hectare) TCA of irrigated trees grafted on Myrobalan seedlings was 14,79 m^2/ha in 1998 and the total TCA of irrigated trees grafted on Wangenheim Prune was 6,45 m^2/ha. Both data compared gives a proportion of 1:0,44. TCA is strictly related to the capacity of tree growth and the area of its leaves which result in productivity. Therefore the total TCA can be used as a parameter helpful to determine the density of planting. In order to make the total TCA similar for both rootstocks, 821 trees/ hectare of plums grafted on Myrobalan seedlings must equal 1866 trees grafted on Wangenheim Prune. Such a density of planting plum trees might significantly improve the yield of plums per hectare. Investigations carried on plum tree cv. Bluefre confirm these observation (Treder et al., 1999). Plum trees grafted on Wangenheim Prune being of smaller size make it possible to plant more trees per hectare. Influence of the investigated factors on the yield varied in the years of experiment. Taking into account the lack of interaction between the factors (except for the year 1994), Table 2 shows statistical significance and mean values of yielding only for the main treatments. Yielding in the years of experiment and the average crop are shown in Table 2. Plum trees grafted on Myrobalan seedlings gave the biggest crops. Only in years 1992, 1995, 1998 there were no differences in yielding of the trees grafted on the both investigated rootstocks. Irrigation significantly influenced both the yielding in the years 1991, 1993, 1994, 1995. The 1994 was the only year in which the interaction between the investigated factors was observed. It was caused by a prolonged and severe summer drought which especially affected trees grafted on Wangenheim Prune (with a shallow and weak root system). Trees grafted on Myrobalan seedlings survived that period in a considerably better condition. The average yield of plums depended on the both investigated factors.Total yield from irrigated trees was significantly higher compared to not irrigated control trees (table 3). Trees grafted on *Prunus cerasifera* seedlings had significantly higher cumulative yield

per tree than trees on Wangenheim Prune which was caused by the bigger capacity of the crowns. Treder et al. (1999) obtained similar results with plum trees cv. Bluefre.

Table 2

Influence of rootstocks and drip irrigation on yield [kg/tree] of plums cv. Valor.

Year	Significance		Yield [kg/tree]			
	Rootstocks	Irrigation	Wangenheim Prune	Myrobalan seedlings	Irrigation	Control
1991	NS	*	0.15	0.11	0.04	0.22
1992	NS	NS	2.57	2.24	2.11	2.7
1993	**	**	17.66	28.44	27.25	18.85
1994	**	**	8.63	25.35	21.17	12.82
1995	NS	**	6.64	6.97	8.14	5.48
1996	**	NS	19.85	25.96	24.05	21.76
1997	**	NS	11.16	18	15.73	13.43
1998	NS	NS	11.13	14.5	14.13	11.5
Average	**	**	9.61	15.18	13.96	10.83

* Statistical analysis was carried out separately for each year.

Table 3

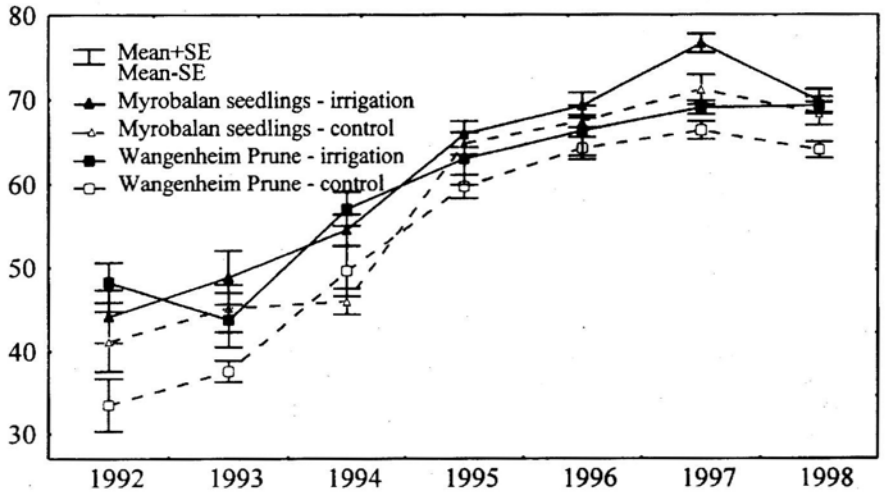
Influence of drip irrigation on cumulative yield (years 1991 – 1998) of plums cv. Valor grafted on two rootstocks

Parameter	Wangenheim Prune		Myrobalan seedlings	
	Control	Irrigation	Control	Irrigation
yield [kg/tree]	62.26 a	88.24 b	107.38 c	133.31 d
yield [T/ha]	51.12	72.45	88.16	109.45
yield increase [kg/tree]	x	25.98	x	21.29
yield increase [T/ha]	x	21.33	x	17.48
yield increase [%]	x	41.73	x	24.15

Productivity index (We), expressed as yield increase in t/ha per 10 mm of applied water for trees grafted on Wangenheim Prune achieved 0.55 and for trees grafted for Myrobalan seedlings 0.45. This result shows that irrigation is much more effective on trees grafted on Wangenheim Prune compared with those grafted on Myrobalan seedlings.

Higher yielding of irrigated plum trees was also reported by Vodyanitskaya et al. (1994), Treder et al. (1997, 1999). The average weight of fruits varied in the years of the experiment and was the lowest in the first four years after planting (figure 4). Similar results with plums cv. Bluefre were observed by Treder et al. (1999). Except for the 1994 year all non irrigated trees grafted on Wangenheim Prune produced the smallest fruits during the whole experimental period.The rootstocks had no effect on fruit size .

Fig. 4. Influence of drip irrigation on average fruit weight [g] of plum trees cv. Valor grafted on two rootstocks



CONCLUSIONS

1. Wangenheim Prune seedlings used as rootstocks drastically reduces the growth of the plum trees.
2. Irrigation positively influences the growth and yield of plum trees.
3. Plum trees grafted on Wangenheim Prune more effectively take advantage of irrigation compared to the trees grafted on Myrobalan seedlings
4. Drought conditions clearly decreases the average weight of the fruit of the trees grafted on Wangenheim Prune.

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Wpływ nawadniania kroplowego na wzrost i owocowanie śliw odmiany Valor szczepionej na siewkach ałyczy i Węgierki Wangenheima.

Streszczenie

Doświadczenie nad efektywnością nawadniania kroplowego śliw prowadzone było w Sadzie Pomologicznym ISK w Skierniewicach w latach 1990 – 1998. Materiałem doświadczalnym były śliwy odmiany Valor posadzone w rozstawie 4,2 × 2,9. Nawadnianie miało istotny wpływ na wzrost drzew. Pomimo tego, iż wpływ nawadniania na plon i jakość owoców uzależniony był od przebiegu pogody to dane wieloletnie wykazują statystycznie istotną zwyżkę plonów średnich i sumarycznych dla obu badanych odmian .Wyższą efektywność nawadniania wykazano dla drzew szczepionych na Węgierce Wangenheima.