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THE GROWTH AND YIELDING OF PEACH TREES CULTIVATED IN RIDGES IN IRRIGATION CONDITIONS

Ewelina Gudarowska, Adam Szewczuk, Marta Czaplicka-Pędzich
Wroclaw University of Environmental and Life Sciences

Abstract

The aim of the research conducted in the conditions of Lower Silesia in the years 2012-2016 was to evaluate the growth and yielding of young peach trees cultivated in ridges with drip irrigation. The experiment concerned the flat-fruit peach trees, cultivar Saturn on the Manchurian peach tree seedling, planted in the spring of 2012 in the spacing 4.0 x 1.5 m.

In each year the shortage of rainfall was observed, as compared to the years 1997-2000. During the vegetation period, the deficiencies were from – 7.3 mm up to – 221.7 mm. The insufficient amount of rainfall was accompanied by the rise of the mean air temperature in the vegetation period by 0.5 – 1.7°C.

In the orchard, the drip irrigation in the form of stippling tape T-Tape TSX515-50-380 was applied, with the emitters every 50 cm and the expenditure of 3.8 l per metre in 1 hour. The humidity measurements were being taken from the beginning of May until the end of July with the use of Watermark probes, testing the sucking power of soil at the depth of 20 cm. The irrigation started when the water potential of soil was 30 kPa.

During the 4 years, the total yield per hectare from the irrigated trees was by 5 t bigger than in the case of the trees that had not been irrigated. The irrigated trees cultivated in ridges had a tendency to more intensive radial growth. As far as the radial increase is concerned, statistically significant differences were noticed between the autumn of 2012 and the autumn of 2016. The application of irrigation also stimulated the elongation but only in the first two years of cultivation. The mean rate of proliferacy for the 4 years of fruiting was higher in the case of irrigated trees.

Key words: peach trees, irrigation, ridges, yield, growth.

INTRODUCTION

The climatic conditions in Poland are unfavourable for the production of peaches in terms of agricultural commodities. Yet, the cultivation area for this species has been the same for years (2400 ha) and the scale of production remains on the same level, with the greatest number of peach orchards in Greater Poland and Lower Silesia (Nosecka, 2016). Even in those regions where the cultivation is possible, there is a great risk of flower damage because of spring frost. That is why in some orchards there are rain gun systems installed for frost protection. In the periods of rainfall shortage or with no rainfall at all, they are an additional source of water, necessary for trees to grow and yield (Treder, 2009). In spite of the above-mentioned advantages of a rain gun system, in peach orchards drip irrigation is applied. In the surveys conducted by Treder *et al*. (2011), drip irrigation makes 80% of all the irrigation systems used in peach production. In the experiments of Bryla *et al*. (2003) drip irrigation, both on the surface of soil and beneath, is most recommended in peach trees cultivation.

A peach tree demands less water than other fruit tree species cultivated in Poland. However, in the conditions of rainfall deficiency, and also to ensure high quality of fruit, the irrigation of peach trees becomes an essential agro-technical procedure (Podsiadło *et al*., 2005, Rzekanowski, 2009). Peach trees are most susceptible to drought in the periods of blooming, shoot growth and fruit ripening. The cultivation of peach trees in warm and dry climate requires irrigation not only in the vegetation period, but also after cropping, until the leaves start falling down (Dichio *et al*., 2007).

What is more, the necessity of applying irrigation in peach trees cultivation results from the way of planting the trees. In Lower Silesian conditions planting and cultivating apple trees and peach trees in ridges enhances the growth and yielding of the trees (Szewczuk and Gudarowska, 2006, Szewczuk *et al*., 2011). Besides, in the case of peach trees, such method of planting shortens the production cycle of the nursery material and increases the quality parameters of the obtained maiden trees (Gudarowska *et al*., 2015). It seems that orchard plants cultivated in ridges get warmer faster and develop more roots, and consequently grow better and produce higher yield. In the research conducted by Szewczuk *et al.* (2009) ridges increased the mass of the roots with a diameter < 1 mm, developed in the arable soil layer. However, introducing this kind of cultivation requires the optimal amount of rainfall or the regulation of soil humidity by means of irrigation.

The aim of the conducted research was to evaluate the growth and yielding of young peach trees cultivated in ridges with drip irrigation.

MATERIAL AND METHODS

The research was conducted in Samotwór, in the Experimental Station of Wroclaw University of Environmental and Life Sciences. The experiment concerned young peach trees, the cultivar Saturn on the Manchurian seedling. The trees were planted in the spring of 2012 in the form of a rootstock with a sleeping bud, directly in the spacing 4.0 x 1.5 m, typical for orchard trees. The nursery material was planted in ridges of 30-centimetre height. Strongly branched maiden trees were obtained as soon as in autumn in the year of planting and the first yield occurred in 2013.

Table 1. The amount of rainfall and its distribution in the Experimental Station in Samotwór in the years 2012-2016, as compared to the years 1971-2000 [mm]

Month/year	2012	2013	2014	2015	2016	1971-2000
January	45,6	33	24,8	34,6	26,4	28,2
February	32,6	20,8	2,6	5,3	35,6	24,1
March	11,8	24,6	30,8	15,7	50,4	30,5
April	25,4	35,3	27,8	6,4	41	36,9
May	26,2	97,6	103,6	25	22,8	57,1
June	79,4	98	25,4	59,2	64,2	78,7
July	82,7	28,8	40,8	67,3	89,6	90,8
August	51,2	49,4	53,0	3,3	25	64,0
September	34,4	93,4	56,4	18,5	106	50,6
October	28,6	10,2	47,4	29,4	40,2	37,9
November	23,6	23,9	10,6	42,0	40,6	36,6
December	10,2	11,6	15,4	21,8	35,9	33,3
Total rainfall in a year	451,7	526,6	438,6	328,5	577,2	569,0
Total rainfall in the period March – October	339,7	437,3	385,2	224,8	439,2	446,5

Table 2. Rainfall deficiencies in the Experimental Station in Samotwór in the vegetation period (March – October) in the years 2012-2016, as compared to the rainfall in the years 1971-2000 [mm].

Month/year	2012	2013	2014	2015	2016
March	-18,7	-5,9	+0,3	-14,8	+19,9
April	-11,5	-1,6	-9,1	-30,5	+4,1
May	-30,9	+40,5	+46,5	-32,1	-34,3
June	+0,7	+19,3	-53,3	-19,5	-14,5
July	-8,1	-62	-50	-23,5	-1,2
August	-12,8	-14,6	-11	-60,7	-39
September	-16,2	+42,8	+5,8	-32,1	+56,6
October	-9,3	-27,7	+9,5	-8,5	+2,3
Total rainfall deficiency in the vegetation period March – October	-106,8	-9,2	-61,3	-221,7	-7,3
Total rainfall deficiency in a year	-117,3	-42,4	-130,4	-240,5	+8,2

From the very beginning the drip irrigation in the form of stippling tape T-Tape TSX515-50-380 was applied, with the emitters every 50 cm and the expenditure of 3.8 l per metre in 1 hour. The humidity measurements were being taken from the beginning of May until the end of August with the use of Watermark probes, testing the sucking power of soil at the depth of 20 cm. The irrigation started when the water potential of soil was 30 kPa.

Table.3. The amount of irrigation in May-August, by the water potential of soil 30 kPa and single rate 22,8 mm.

Month / year	2012	2013	2014	2015	2016
May	2	0	0	2	2
June	0	0	2	1	0
July	1	3	2	2	0
August	1	1	0	4	2
The amount of water [mm]	91,2	91,2	91,2	205,2	91,2

The single dose of irrigation was 22.8 mm. The amount of irrigation ranged from 4 to 9 in May-August (Tab. 3). The trees were led in the form of a spindle crown with pruning in mid-April. The inter-rows were covered with grass and in the rows there was herbicide fallow.

In the period 2012-2016, favourable conditions for the growth and yielding of peach trees occurred only in the year 2013. Disadvantageous weather in the spring of 2014 and 2016 caused the damage of 90% flowers and thus the lack of fruiting, whereas in 2015 fruit were damaged by hail that appeared in mid-July. In each year the shortage of rainfall was observed at the Station, as compared to the years 1997-2000 (Tab.1 and 2). During the vegetation period, the deficiencies were from from – 7.3 mm up to – 221.7 mm (Tab.2). The insufficient amount of rainfall was accompanied by the rise of the mean air temperature in the vegetation period by 0.5 – 1.7°C, as compared to the years 1997-2000 (Tab.4).

Table 4. Mean monthly temperatures in the Experimental Station in Samotwór in the vegetation period (March – October) in the years 2012-2016, as compared to the data from the years 1971-2000 [°C].

Month/year	2012	2013	2014	2015	2016	1971-2000
March	6,7	-0,2	7,4	5,6	4,8	3,9
April	9,9	9,4	10,9	10	9,1	8,2
May	15,7	14,4	13,5	13,6	14,7	13,5
June	17,2	17,2	16,8	16,7	18,9	16,3
July	20	20,2	21,3	20,5	19,7	18,1
August	19,3	18,8	15,1	22,6	18,2	17,8
September	14,9	13,1	15,8	15,5	19	13,6
October	8,9	11,1	11,2	8,8	8,9	8,9
Total mean temperature in the vegetation period March – October	14,1	13,0	14,0	14,2	14,2	12,5
Compared to the years 1971-2000	+1,6	+0,5	+1,5	+1,7	+1,7	

During the research, the growth and yielding of the trees were evaluated each year. The yield was assessed individually from each tree and the fruit quality – on the basis of the weight of 20 fruits from each tree. According to Szczepański (1987) and other authors: Bryla *et al* (2003), Dichio *et al*.(2004), plant vigour was assessed taking into account the increase in cross section area of tree trunk, the number of one-year shoots and the sum of their length. To determine the relation between trees growth and their yielding there was estimated a crop efficiency index. For all the trees the yearly increases of cross section area were calculated. The elongation was estimated having into account the number of one-year-old shoots and their total length. In 2015 the shoots were not measured as they were seriously damaged by hail.

The experiment was set using the method of random blocks in 4 repetitions. In each repetition there were 4 trees. The results regarding the growth and yielding were subjected to statistical variation analysis, with the use of t-Duncan test for significance level $\alpha=0.05$.

RESULTS AND DISCUSSION

In the conducted experiment, the growth and yielding of peach trees was affected mostly by the weather. Throughout 5 years, considerable changes of temperature and rainfall were observed during the vegetation period. The weather was unfavourable for the cultivation of peach trees (Tab.1-3). Mainly because of spring frost, rainfall deficiency and hailing.

In spite of the insufficient amount of rainfall and greater water requirements of the trees cultivated in ridges, the irrigation had no influence on yielding (Tab.5).

Table 5. The influence of irrigation on the yielding of the Saturn cultivar peach trees, cultivated in ridges [kg · tree^{-1}].

Combination	Yield kg · tree^{-1}				Total yield kg · tree^{-1}
	2013	2014	2015	2016	2013-16
control	3,3 a	0,3 a	6,4 a	0,0 a	10,1 a
irrigation	5,8 a	0,3 a	6,4 a	0,6 b	13,1 a
% change under the influence of irrigation relative to control	75	0	0	60	29

Table 6. The influence of irrigation on the mass of 1 peach fruit of the Saturn cultivar [g].

Combination	Mass of 1 fruit [g]				Mean mass [g]
	2013	2014	2015	2016	2013-16
control	39 a	71 a	38 a	-	49 a
irrigation	50 b	85 a	44 a	62	60 b
% change under the influence of irrigation relative to control	28	20	16	-	22

The differences in yielding were not statistically proved. Yet, the irrigated trees tended to yield better in the second and fifth year after planting. During the 4 years, the total yield per hectare from the irrigated trees was by 5 t bigger than in the case of the trees that had not been irrigated. The irrigation also positively influenced the size of fruit (Tab. 6).

Table 7. The influence of irrigation on the growth of the Saturn cultivar peach trees, cultivated in ridges [cm^{-2}].

Combination	Increase of Trunk Cross Section Area (TCSA) in a year [cm^{-2}]					Total increase in the period 2012-16
	2012	2013	2014	2015	2016	
Control	1,91 a	3,93 a	4,41 a	5,21 a	6,98 a	22,44 a
Irrigation	2,22 a	4,46 a	4,80 a	6,23 a	8,82 a	26,53 b
% change under the influence of irrigation relative to control	16	13	9	19	26	18

Table 8. The influence of irrigation on the elongation of the Saturn cultivar peach trees, cultivated in ridges.

Combination	Number of shoots [number · $tree^{-1}$] and total length of one-year-old shoots [cm · $tree^{-1}$]							
	2012		2013		2014		2016	
	shoot number	total length	Shoot number	total length	shoot number	total length	shoot number	total length
Control	18 a	501 a	48 a	1373 a	92 a	2849 a	299 a	6536 a
Irrigation	35 b	974 b	81 b	2280 b	93 a	2851 a	262 a	5645 a
% change under the influence of irrigation relative to control	94	94	69	66	1	0	-23	-14

In the research, the irrigated trees had a tendency to more intensive growth, shown in the increase of the cross section area of a trunk (Tab.7). Statistically significant differences were observed in the radial increase between the autumn of 2012 and the autumn of 2016. The application of irrigation also stimulated the elongation but only in the first two years of cultivation (Tab.8). In spite of intensive radial growth, the mean rate of proliferacy for the 4 years of fruiting was higher in the case of irrigated trees (Tab.9).

Table 9. The influence of irrigation on the value of proliferacy rate for the Saturn cultivar peach trees, cultivated in ridges [kg · cm^{-2}].

Combination	Crop efficiency index [kg · cm^{-2}]				Mean 2013-16
	2013	2014	2015	2016	
Control	0,51 a	0,03 a	0,43 a	0,00 a	0,24 a
Irrigation	0,82 b	0,03 a	0,36 a	0,03 b	0,31 b
% change under the influence of irrigation relative to control	61	0	-17	3	29

The results obtained in the experiments run in Poland and abroad regarding the influence of irrigation on the growth and yielding of peach trees are not clear. Undoubtedly, the growth and yielding of the examined trees were affected by unfavourable weather conditions. As far as yielding is concerned, the relationship was noticed by Podsiadło *et al*. (2009). The authors of the research on the irrigation of peach trees in the conditions of the Stettin Lowland showed that in a warmer and drier year, when irrigation was applied, the yield increase was lower than in a humid year (Podsiadło *et al*., 2009). In such soil conditions, having applied irrigation, Podsiadło *et al*. (2005) obtained the yield increase from 24.4% to 39.2% also in other peach tree cultivar. However, in the same experiment irrigation did not improve the fruit mass. The results from the Stettin Lowland concerned five-year-old and older trees, in their full fruiting potential. As it was shown by Szewczuk (1994), in the conditions of Lower Silesia irrigation had no influence on the yielding of four – and five-year-old peach trees but it increased the crop mass. According to this author's research, irrigation definitely stimulated the elongation of the trees. In the opinion of Bryla *et al*. (2003), the irrigation of young peach trees is very difficult because of the insufficient water supply. According to Bryla *et al*. (2003), the doses and frequency of irrigation should be increased in the vegetative growth period (100 – 100% evapotranspiration), whereas smaller amount of water is appropriate in the case of the generative growth of young peach trees. Hence, the irrigation technology should also be adjusted to the age of peach trees (Bryla *et al*., 2003). Sotiropoulos *et al*. (2010) notice that older peach trees are less dependent on the type of irrigation and the time it is applied. It is confirmed in the research by Dichio *et al*. (2007). Here, the irrigation doses were limited after cropping (57% ET_c) in the case of peach trees in their full yielding potential, and the obtained crops were appropriate in terms of size and quality, as compared to the combination with a full water dose (100 % ET_c). The authors also proved that the reaction of peach trees to water deficiency is usually the weakening of elongation, rather than the decreasing of the photosynthesis activity. Besides, varied irrigation doses had no influence on the size of the obtained fruit (Dichio, 2007).

CONCLUSIONS

In the conducted experiment, the factor that inhibited the proper growth of young peach trees was the unfavourable weather, namely rainfall deficiency, spring frost and hailing. In such conditions, the trees cultivated in ridges and irrigated had a tendency to more intensive elongation and radial growth and showed greater yielding potential. The irrigation also improved the quality of the fruit in terms of their mean mass. The obtained results show that even in unfavorable conditions for peaches, drip irrigation can affect the yield and growth of trees of this species. Despite of the peach small water requirements, irrigation in ridge, where the trees grew increased the average yield by 29% and the fruit weight in the range 16-28%. Irrigation also affected the radial growth of trees by 9-26%, and in the first years increased the growth of annual shoots at 66-94%. The weaker growth of shoots in later years can reduce the labor intensity of cutting trees. Undoubtedly, still the most important treatment in peach cultivation is the protection of flower buds against frost.

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Corresponding author: Eng. Ewelina Gudarowska, Ph.D
ewelina.gudarowska@upwr.edu.pl.
ewelina.gudarowska@up.wroc.pl

Prof.dr hab. Adan Szwczuk
adam.szewczuk@upwr.edu.pl

Eng. Marta Czaplicka –Pędzich Ph.D
marta.czaplicka-pedzich@upwr.edu.pl

Department of Horticulture
Wroclaw University of Environmental and Life Sciences
pl. Grunwaldzki 24a,
PL 50-363 Wroclaw

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