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EFFECT OF THE FORECAST CLIMATE CHANGE ON THE PEACH TREE WATER REQUIREMENTS IN THE BYDGOSZCZ REGION

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Abstract

The aim of the present research has been an attempt at evaluating the water requirements of peach trees over 2016-2050 in the Bydgoszcz region drawing on the forecast changes in temperature. The paper draws on the forecasting of mean monthly temperature for the Bydgoszcz region in 2011-2050 according to the climate change scenario for Poland SRES: A1B (Bąk, Łabędzki 2014). The water requirements of the peach tree have been determined based on the indispensable precipitation determined by Kemmer and Schulz. The water requirements were calculated for the period January through December and May through September for each year in the 35-year period (2016-2050). The reference period was made up by a 35-year period immediately preceding it (1981-2015). In 2016-2050 in the Bydgoszcz region, in the light of the forecast scenarios of changes in temperature, one should expect an increase in water requirements of the peach tree. Determined according to the Kemmer and Schulz method, the required optimal annual (January-December) precipitation will increase for peach from 486 mm to 612 mm (by 126 mm, which accounts for 26%). The optimal precipitation time variation trend equations show that in the reference period (1981-2015), calculated based on the Kemmer and Schulz number, the optimal annual precipitation was increasing in the peach tree in each pentad by 4.4-4.8 mm. In the forecast period (2016-2050) the water requirements of the peach tree will be increasing in each pentad in a greater range – from 6.4 to 7.2 mm. In the summer period (May-September) determined by Kemmer and Schulz, expressing water requirements, the total precipitation optimal for the peach tree in 2016-2050 will increase by 63 mm.

Key words: peach tree, water requirements, optimal precipitation, forecast climate change, Bydgoszcz region

INTRODUCTION

In the applicable literature which covers water requirements of fruit trees, peach trees represent a group of plants with average water requirements (Słowik 1973, Dzieżyc 1988, Rzekanowski 2009).

It is estimated that in the Bydgoszcz region, a recognized fruit production center in Poland, to ensure optimal soil moisture conditions, one should provide fruit trees in the vegetation period with a form of supplemental irrigation, on average from 117 to 192 mm of water (Rzekanowski et al. 2001).

Quite numerous, developed in the recent years for Poland, scenarios of changes in temperature and natural precipitation differ from one another significantly for the summer season (June-August) (Łabędzki 2009). All the models forecast an increase in temperature and only few – an increase in precipitation, whereas others – even a precipitation drop (Łabędzki 2009). According to specialists, the forecasted climate change can result in an increase in the water requirements of plants (Łabędzki 2009, Rzekanowski et al. 2011).

The aim of the present research has been an attempt at evaluating the water requirements of peach trees over 2016-2050 in the Bydgoszcz region drawing on the forecast changes in temperature.

MATERIAL AND METHODS

The paper draws on the forecasting of mean monthly temperature for the Bydgoszcz region in 2011-2050 according to the climate change scenario for Poland SRES: A1B (Bąk, Łabędzki 2014). The water requirements of the peach tree have been determined based on the indispensable precipitation determined by Kemmer and Schulz (Słowik 1973, Dzieżyc 1988). The authors have considered the optimal annual (January-December) precipitation for fruit trees in average soil (of average compaction) to depend on mean temperature in summer (May-September), yet assuming that at least 50% of precipitation coincides with the period from 1 May to 30 September (Treder, Pacholak 2006). With the table values for the peach tree provided by Dzieżyc (1988), the regression equation was determined (Fig. 1). Then the water requirements were calculated for the period January through December and May through September for each year in the 35-year period (2016-2050). The reference period was made up by a 35-year period immediately preceding it (1981-2015). Each of the two 35-year periods was divided into seven pentads for which optimal mean total precipitation values were determined. There were also defined trends for the peach-tree-optimal precipitation time variation in successive 35 years (n=35) or 7 five-year periods (n=7). Excel spreadsheet was used.

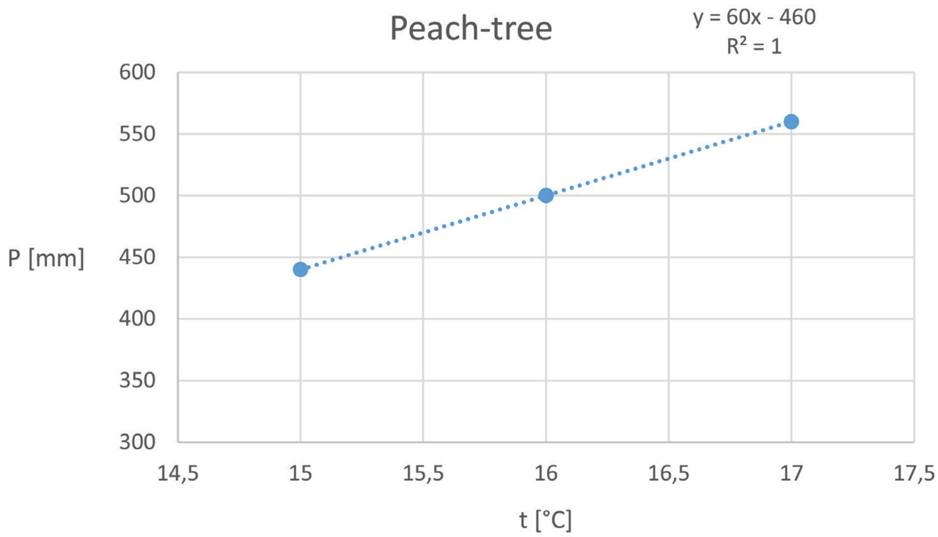

Figure 1. Relation between the mean temperature in summer (May-September) and optimal annual precipitation for peach-trees according to Kemmer and Schulz in a soil of average compaction. The own elaboration on the base of the table values for the peach tree provided by Dzieżyc (1988)

RESULTS AND DISCUSSION

Determined with the forecast 2016-2050 mean monthly temperature, the annual precipitation optimal for the peach tree, according to Kemmer and Schulz, demonstrated a higher variation than calculated for the reference period of 1981-2015 (Table 1). The optimal annual precipitation for the peach tree, respectively for those periods, ranged from 469 to 775 mm and from 393 to 631 mm. A greater variation in the total precipitation optimal for the peach tree in 2016-2050 mostly resulted from the forecast of an increase in temperature in summer (May-September) (Bąk, Łabędzki 2014).

Table 1. Statistical characteristics of the peach-tree-optimal annual precipitation

Specification	Period	
	1981-2015	2016-2050
Minimum (mm)	393	469
Maximum (mm)	631	775
Median (mm)	492	613
Average (mm)	486	612
Standard deviation (mm)	50,8	82,5
Variation coefficient (%)	10,5	13,5

Table 2. Equations of the trend of the peach-tree-optimal annual precipitation in consecutive years

Period	Equations of the trend	R^2	Tendency of the peach-tree-optimal annual precipitation (mm·pentad^{-1})
1981-2015	y = 0.878x + 470.24	0.0313	4.4
2016-2050	y = 1.441x + 586.04	0.032	7.2

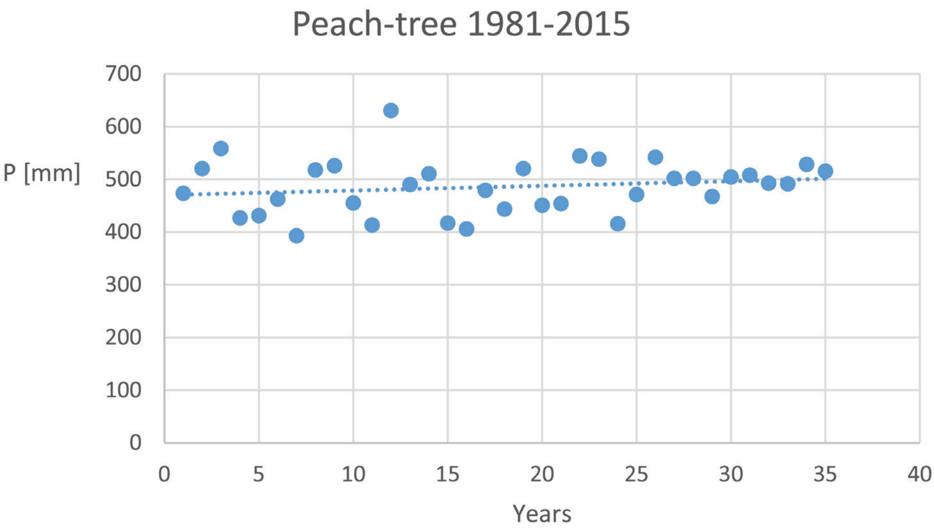

Figure 2. Temporal variability of the peach-tree-optimal annual precipitation in consecutive years of the reference period 1981-2015

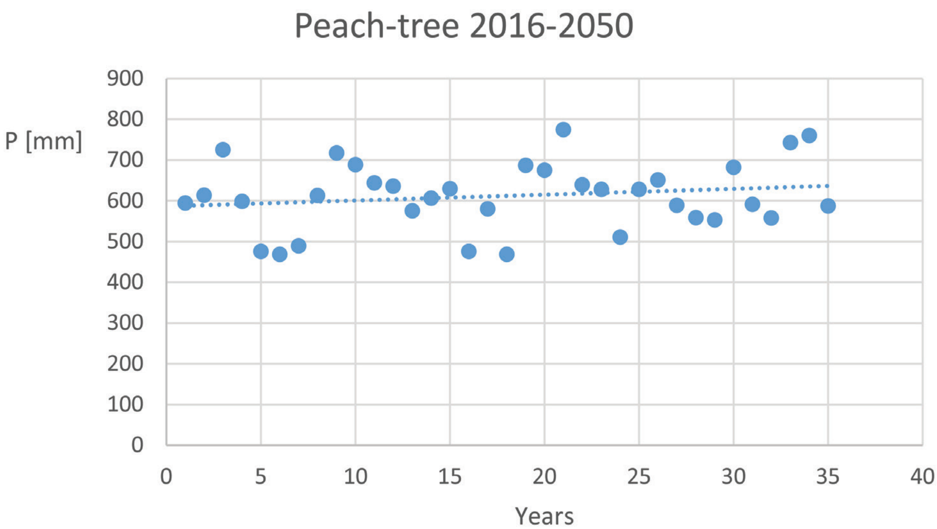

Figure 3. Temporal variability of the peach-tree-optimal annual precipitation in consecutive years of the forecasted period 2016-2050

Table 3. The peach-tree-optimal annual precipitation according to Kemmer and Schulz in consecutive pentads for the compared periods (mm)

Reference period 1981-2015		Forecasted period 2016-2050	
Pentad	P (mm)	Pentad	P (mm)
1981-1985	482	2016-2020	602
1986-1990	471	2021-2025	595
1991-1995	493	2026-2030	618
1996-2000	460	2031-2035	578
2001-2005	485	2036-2040	636
2006-2010	504	2041-2045	607
2011-2015	507	2046-2050	648
Average for 1981-2015	486	Average for 2016-2050	612

According to the forecast changes in temperature in 2016-2050, the annual precipitation optimal for the peach tree will be increasing in each 5-year period by 7.2 mm (Table 2). To compare, in the reference period (1981-2015) the optimal annual precipitation was increasing in each 5-year period by 4.4 mm, which is graphically represented by time variation trends of that indicator of peach tree water requirements in the reference period (Figure 2) and the forecast period (Figure 3).

Table 3 provides a breakdown, average for successive pentads in the 35-year periods, of optimal annual precipitation, demonstrating that it will be higher in each pentad of the 2016-2050 period in comparison to the reference period (1981-2015). The highest value of the precipitation reported (507 mm for the pentad of 2011-2015) was lower than the lowest of the forecast values of that index for 2016-2050 (578 mm for the 2031-2035 pentad).

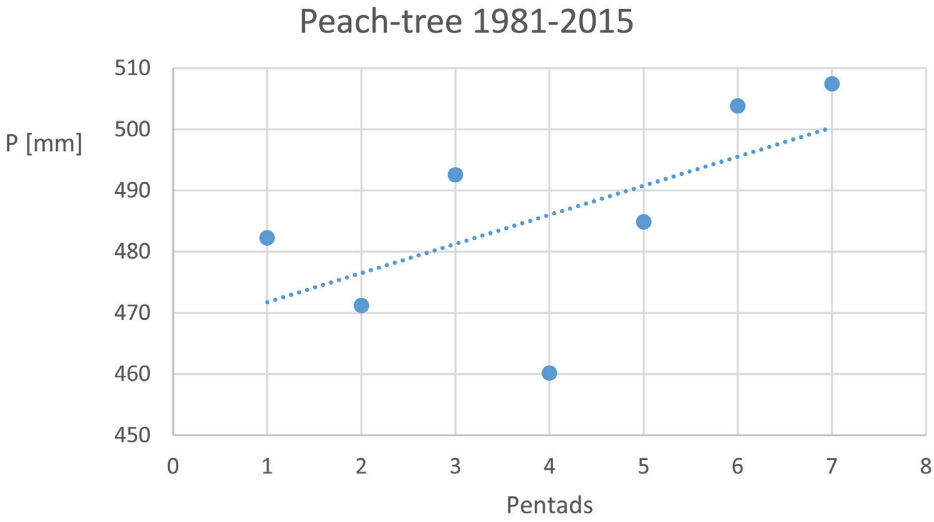

Figure 4. Temporal variability of the peach-tree-optimal annual precipitation in consecutive pentads of the reference period 1981-2015

The time variation trend equations of optimal precipitation for the peach tree in successive pentads (Table 4, Figure 4, Figure 5) show that in the reference period (1981-2015) the optimal annual precipitation was increasing in each five-year period by 4.8 mm. In comparison to the reference period, the optimal annual precipitation in the forecast period (2016-2050) will be increasing by 6.4 mm in each pentad.

The comparison of the optimal mean annual precipitation for the peach tree in the periods considered, according to the assumptions of increased temperature, shows that the index of water requirements of the peach tree will increase from 486 mm to 612 mm (Table 5). An increase in water requirements will be 126 mm, which accounts for 26%.

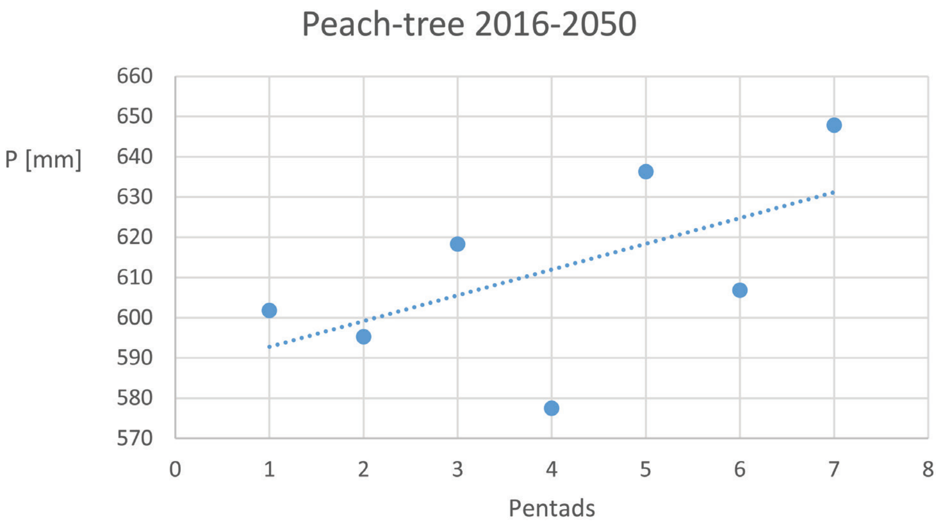

Figure 5. Temporal variability of the peach-tree-optimal annual precipitation in consecutive pentads of the forecasted period 2016-2050

Table 4. Equations of the trend of the peach-tree-optimal annual precipitation in consecutive pentads of compared periods

Period	Equations of the trend	R^2	Tendency of the peach-tree-optimal annual precipitation ($mm \cdot pentad^{-1}$)
1981-2015	y = 4.7571x + 467.02	0.3677	4.8
2016-2050	y = 6.4029x + 586.37	0.3265	6.4

Table 5. Comparison of the optimal mean precipitation for the peach tree according to Kemmer and Schulz for the compared periods (mm)

Period	January-December	May-September
1981-2015	486	243
2016-2050	612	306
(2016-2050) – (1981-2015)	+126	+63
Change (%)	+26	

To compare, according to Treder and Pacholak (2006), the annual precipitation indispensable for the peach tree grown in our climate conditions to produce a high fruit yield falls within the 530-600 mm range.

Increasing the water requirements of the peach tree comes mostly from the forecast increase in temperature. As reported by Bąk and Łabędzki (2014), the highest increase in temperature in the 2011-2050 period is forecast in July and August. As compared with the reference period (1971-2000), it will be 1.5°C and 1.2°C, respectively for those months.

The forecast climate changes (e.g. an increase in temperature) can speed up the development of modern water – and energy-saving irrigation systems in Poland, e.g. drip irrigation, recommended for orchards (Łabędzki 2009, Rzekanowski et al. 2011, Treder and Pacholak 2006). Drip irrigation enhances the growth of peach trees (Gudarowska, Szewczuk 2009, Gudarowska et al. 2015, Wojtkiewicz, Szewczuk 1990). In the experiment by Wojtkiewicz and Szewczuk (1990), drip irrigation of peach trees increased the yield of 'Jerseyland' cultivar by 19%. In the experiment performed in the Szczecin region (Podsiadło et al. 2009) "Inka" cultivar peach yielding significantly depended on the total rate of irrigation and precipitation. As a result of under-crown irrigation the peach fruit yield increased by 15% (Jaroszewska et al. 2009).

RECAPITULATION AND CONCLUSIONS

With the forecast changes in temperature and the calculations and analysis, one can formulate the following conclusions:

1. In 2016-2050 in the Bydgoszcz region, in the light of the forecast scenarios of changes in temperature, one should expect an increase in water requirements of the peach tree. Determined according to the Kemmer and Schulz method, the required optimal annual (January-December) precipitation will increase for peach from 486 mm to 612 mm (by 126 mm, which accounts for 26%).
2. The optimal precipitation time variation trend equations show that in the reference period (1981-2015), calculated based on the Kemmer and Schulz number, the optimal annual precipitation was increasing in the peach tree in each pentad by 4.4-4.8 mm. In the forecast period (2016-2050) the water requirements of the peach tree will be increasing in each pentad in a greater range – from 6.4 to 7.2 mm.
3. In the summer period (May-September) determined by Kemmer and Schulz, expressing water requirements, the total precipitation optimal for the peach tree in 2016-2050 will increase by 63 mm.

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