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

Stanisław Rolbiecki, Piotr Piszczek
UTP University of Science and Technology in Bydgoszcz

Abstract

The aim of the present research has been an attempt at estimating the water requirements of sweet cherry tree in 2016-2050 in the Bydgoszcz region drawing on the forecast temperature changes. 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 sweet cherry 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 temperature change scenarios, one can expect an increase in the water requirements of the sweet cherry tree. Determined with the Kemmer and Schulz method, the required annual (January-December) optimal total precipitation will increase for the sweet cherry tree from 532 mm to 746 mm (by 214 mm, which accounts for 40%). The optimal precipitation trend equations show that in the reference period (1981-2015), calculated with the Kemmer and Schulz number, the optimal annual precipitation was increasing in the sweet cherry tree in each pentad by 2.4-3.0 mm. In the forecast period (2016-2050) the water requirements will increase, however, in each pentad within a much greater range, from 13.0 to 14.5 mm. In the summer period (May through September) determined by Kemmer and Schulz, the total precipitation optimal for the sweet cherry tree, expressing the water requirements, in 2016-2050 will increase by 107 mm.

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

INTRODUCTION

The water requirements of fruit trees vary (Słowik 1973, Dzieżyc 1988, Rzekanowski 2009, Treder, Pacholak 2006). Sweet cherry trees represent a group of plants with indirect water requirements (Słowik 1973, Dzieżyc 1988, Rozpara 2005, Rzekanowski 2009).

Orchards in the Bydgoszcz region account for more than 40% of the horticultural crops acreage, and the production effects are not always satisfactory, which is due to a considerable (over 1/3) share of light soils and, present here and a high variation of weather conditions in the vegetation period. To ensure high yielding, orchard plants should receive, additionally, besides the natural precipitation, from 100 to 200 mm of water in a form of supplemental irrigation (Rzekanowski et al. 2001).

The temperature and precipitation change scenarios developed for Poland differ significantly for the summer period (June-August) (Łabędzki 2009). All the models forecast an increase in temperature and only some – increased precipitation, whereas others – even a decrease in precipitation (Łabędzki 2009). It is estimated that the forecasted climate change can result in an increase in the water requirements of plants (Łabędzki 2009).

The aim of the present research has been an attempt at estimating the water requirements of sweet cherry tree in 2016-2050 in the Bydgoszcz region drawing on the forecast temperature changes.

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 sweet cherry 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 sweet cherry 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 sweet cherry-tree-optimal precipitation time variation in successive 35 years (n=35) or 7 five-year periods (n=7). Excel spreadsheet was used.

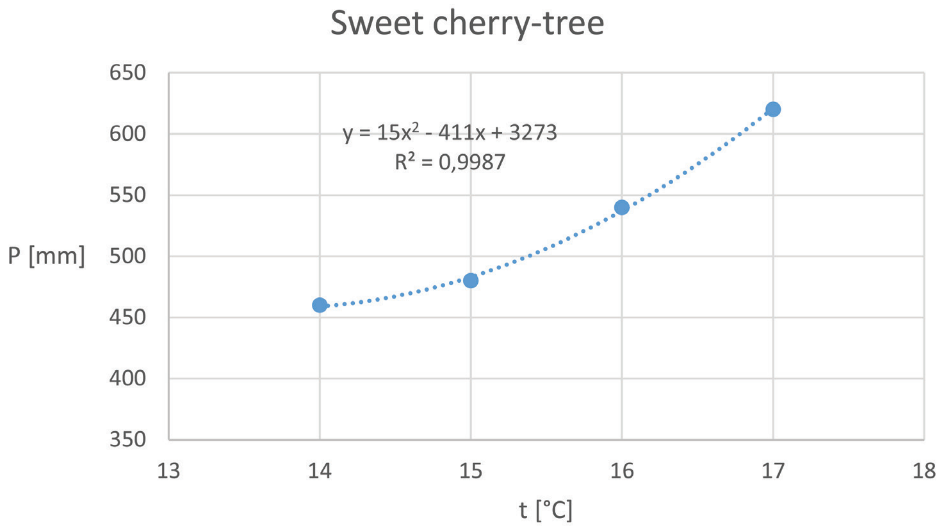

Figure 1. Relation between the mean temperature in summer (May-September) and optimal annual precipitation for sweet cherry-trees according to Kemmer and Schulz in a soil of average compaction. The own elaboration on the base of the table values for the sweet cherry tree provided by Dzieżyc (1988)

RESULTS AND DISCUSSION

The total annual precipitation optimal for the sweet cherry tree, according to Kemmer and Schulz, showed a greater variation in 2016-2050 than in the reference period 1981-2015 (Table 1). The calculated (based on the temperature) precipitation indispensable for the sweet cherry tree, respectively for those periods, ranged from 505 to 1168 mm and from 462 to 759 mm. A high variation in total precipitation optimal for the sweet cherry tree in 2016-2050 resulted from, on the one hand, the forecast of an increase in temperature in the summer period (May-September), and on the other hand, from the pattern of, based on the Kemmer and Schulz number, function making the precipitation optimal for the sweet cherry tree dependent on temperature (Figure 1). Interestingly, temperature in the Bydgoszcz region, according to the forecast of its pattern in respective months (Bąk, Łabędzki 2014), May through September, will be higher than 19°C in five years (2018, 2024, 2025, 2034, 2045), and in three years (2036, 2048 and 2049) it will exceed even 20°C. The pattern of the function describing the dependence of the annual precipitation optimal for the sweet cherry tree, on the other hand, determines clearly higher precipitation at higher temperature. For example, an increase in temperature May through September from 14.0°C to 15.0°C (by 1°C) increases the annual precipitation optimal for the sweet cherry tree by 20 mm (from 460 mm to 480 mm). Whereas when temperature increases in the same range (namely by 1.0°C), however from 16.0°C to 17.0°C, then the required optimal annual precipitation increases, according to Kemmer and Schulz, by as much as 80 mm (from 540 mm to 620 mm) (Dzieżyc 1988).

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

Specification	Period	
	1981-2015	2016-2050
Minimum (mm)	462	505
Maximum (mm)	759	1168
Median (mm)	528	720
Average (mm)	532	746
Standard deviation (mm)	57,9	174,7
Variation coefficient (%)	10,9	23,4

From the sweet-cherry-tree-optimal precipitation trend equations (Table 2, Figure 2, Figure 3) one can see that in the reference period (1981-2015) the optimal annual precipitation was increasing in each five-year period by 2.4 mm, whereas in the forecast period (2016-2050) it will increase for the same period in a much greater range; as much as by 14.5 mm.

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

Period	Equations of the trend	R^2	Tendency of the sweet cherry-tree-optimal annual precipitation ($mm \cdot pentad^{-1}$)
1981-2015	$y = 0.4881x + 523.45$	0.0075	2.4
2016-2050	$y = 2.9002x + 693.39$	0.0289	14.5

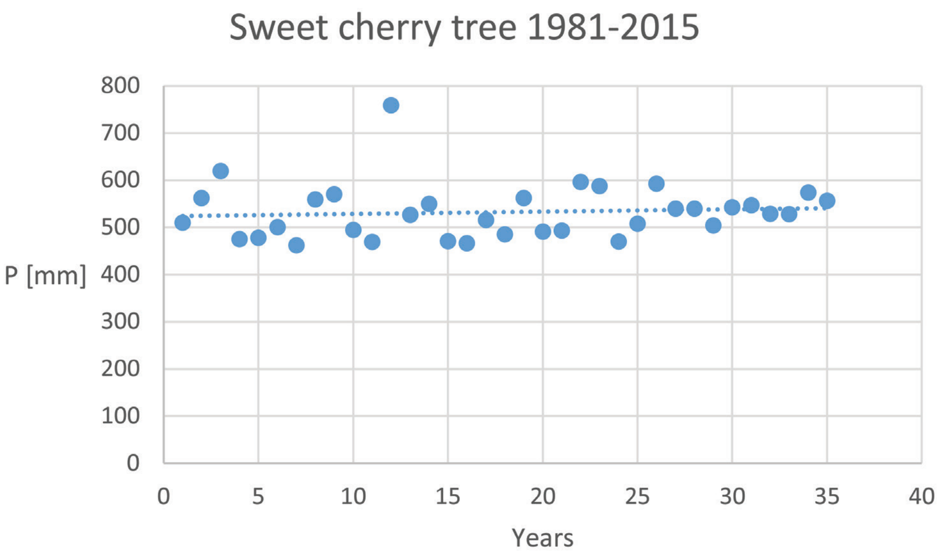

Figure 2. Temporal variability of the sweet cherry-tree-optimal annual precipitation in consecutive years of the reference period 1981-2015

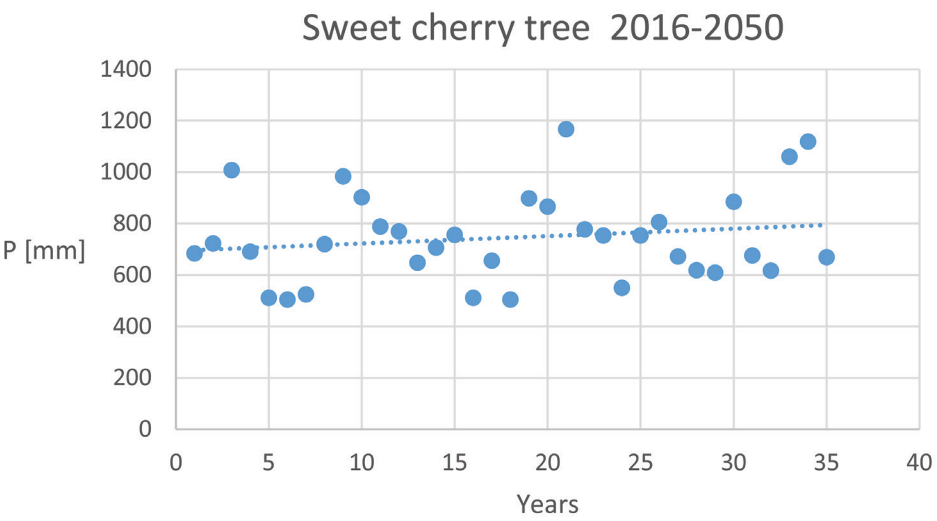

Figure 3. Temporal variability of the sweet cherry-tree-optimal annual precipitation in consecutive years of the forecasted period 2016-2050

Table 3 additionally includes annual precipitation, average for successive pentads in the 35-year periods. The analysis of the data shows that the optimal mean annual precipitation was higher in each pentad of the 2016-2050 period, as compared with the reference period (1981-2015). The highest precipitation (547 mm for the 2011-2015 pentad) was lower than the lowest value for 2016-2050 (688 mm for the 2031-2035 pentad).

Table 3. The sweet cherry-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	529	2016-2020	723
1986-1990	517	2021-2025	727
1991-1995	555	2026-2030	734
1996-2000	504	2031-2035	688
2001-2005	531	2036-2040	800
2006-2010	544	2041-2045	718
2011-2015	547	2046-2050	829
Average for 1981-2015	532	Average for 2016-2050	746

A comparison of the sweet-cherry-optimal precipitation trend equations in successive pentads (Table 4, Figure 4, Figure 5) shows that in the reference period (1981-2015) the optimal annual precipitation in each five-year period was increasing by 3.0 mm. In comparison to the reference period, the optimal annual precipitation in the forecast period (2016-2050) will increase more than 4-fold (in each pentad as much as by 13.0 mm).

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

Period	Equations of the trend	R^2	Tendency of the sweet cherry-tree-optimal annual precipitation ($mm \cdot pentad^{-1}$)
1981-2015	$y = 2.9671x + 520.36$	0.1297	3.0
2016-2050	$y = 13.039x + 693.44$	0.3179	13.0

A comparison of the mean annual precipitation optimal for the sweet cherry tree in the many-year periods demonstrates that it will increase from 532 mm to 746 mm (Table 5). Such increase will be 214 mm, which accounts for 40%.

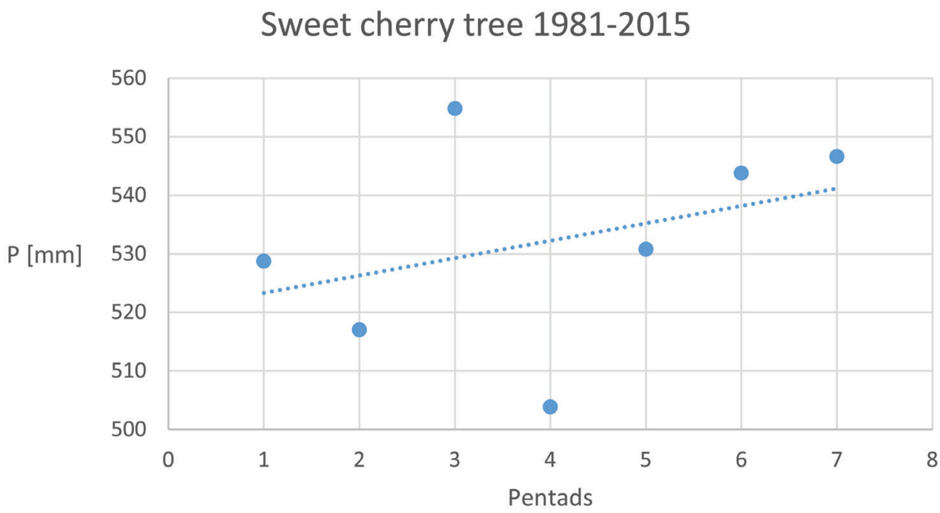

Figure 4. Temporal variability of the sweet cherry-tree-optimal annual precipitation in consecutive pentads of the reference period 1981-2015

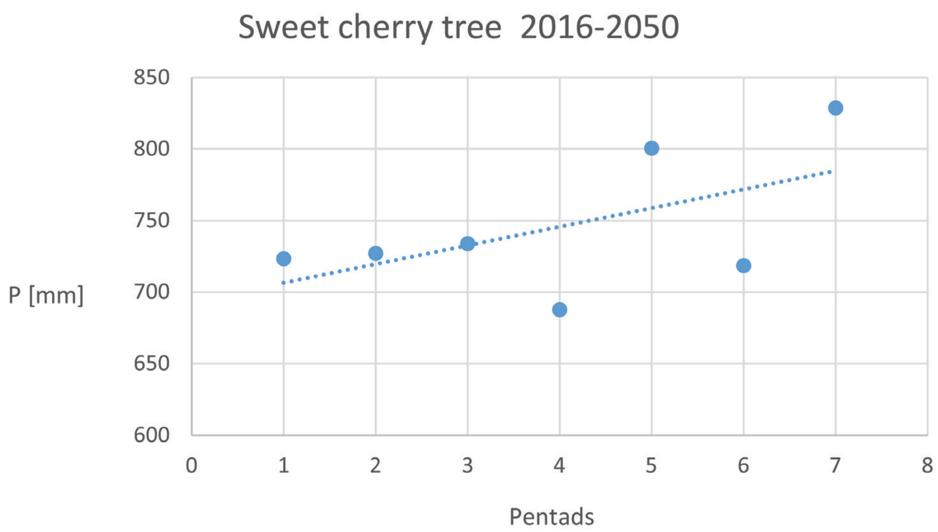

Figure 5. Temporal variability of the sweet cherry-tree-optimal annual precipitation in consecutive pentads of the forecasted period 2016-2050

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

Period	January-December	May-September
1981-2015	532	266
2016-2050	746	373
(2016-2050) – (1981-2015)	+ 214	+ 107
Change (%)	+ 40	

To compare, the annual precipitation optimal for the sweet cherry tree (according to Kemmer and Schulz), determined by Rzekanowski (1989), for the Lubostroń region (north-western ends of the Kujawy region) in 1981-1985 was from 473 mm to 539 mm (the mean of 495 mm).

Increasing the water requirements of the fruit tree species under study comes mostly from the forecast increase in temperature. As reported by Bąk and Łabędzki (2014), the greatest increase in temperature in 2011-2050 is forecast in July and August and, as compared with the reference period (1971-2000), it will be 1.5°C and 1.2°C, respectively. It is very likely that the forecast climate changes can result in, through an increase in the water requirements of plants (Łabędzki 2009), a greater development and application of water-saving irrigation systems, e.g. the drip irrigation system (Rzekanowski, Rolbiecki 2000, Rzekanowski et al. 2011).

RECAPITULATION AND CONCLUSIONS

With the assumptions (temperature changes forecast) and the calculations and analyses made, one can formulate the following conclusions:

1. In 2016-2050 in the Bydgoszcz region, in the light of the forecast temperature change scenarios, one can expect an increase in the water requirements of the sweet cherry tree. Determined with the Kemmer and Schulz method, the required annual (January-December) optimal total precipitation will increase for the sweet cherry tree from 532 mm to 746 mm (by 214 mm, which accounts for 40%),
2. The optimal precipitation trend equations show that in the reference period (1981-2015), calculated with the Kemmer and Schulz number, the optimal annual precipitation was increasing in the sweet cherry tree in each pentad by 2.4-3.0 mm. In the forecast period (2016-2050) the water requirements will increase, however, in each pentad within a much greater range, from 13.0 to 14.5 mm.

3. In the summer period (May through September) determined by Kemmer and Schulz, the total precipitation optimal for the sweet cherry tree, expressing the water requirements, in 2016-2050 will increase by 107 mm.

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Prof. dr hab. Stanisław Rolbiecki
Department of Land Melioration and Agrometeorology
UTP University of Science and Technology in Bydgoszcz
6 Bernardyńska St., 85-029 Bydgoszcz
e-mail: rolbs@utp.edu.pl

Doc. dr Piotr Piszczek
Department of Ornamental Plants and Vegetable Crops
UTP University of Science and Technology in Bydgoszcz
Bernardyńska 6, 85-029 Bydgoszcz
e-mail: ppisz@utp.edu.pl

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