INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr IV/4/2016, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 1811–1819
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2016.4.4.135

EFFECT OF THE FORECAST CLIMATE CHANGE ON THE PEAR 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 pear 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 pear 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 the period 2016-2050 in the Bydgoszcz region, in the light of the temperature change scenarios made, one should expect an increase in the water requirements of the pear tree. Determined with the Kemmer and Schulz method, the required optimal annual (January-December) precipitation will increase for the pear tree from 624 mm to 771 mm (by 147 mm, namely by 24 %). The optimal precipitation trend equations show that in the reference period (1981-2015), calculated with the Kemmer and Schulz numbers, the optimal annual precipitation was increasing in the pear tree in each pentad by 5.1-5.5 mm. In the forecast period (2016-2050) the water requirements will increase, on the other hand, in each pentad within a much greater

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range (7.5-8.4 mm). In, determined by Kemmer and Schulz, summer period (May-September), the total precipitation, expressing water requirements, optimal for the pear tree in 2016-2050 will increase by 73 mm.

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

INTRODUCTION

The pear tree is a fruit tree representing a group of plants with average water requirements (Słowik 1973, Dzieżyc 1988, Rzekanowski 2009, Mika 2010). According to Treder and Pacholak (2006), the pear tree water requirements are slightly lower than in the apple tree and range from 600 to 750 mm of annual precipitation. The authors cited estimate that in key orchard-growing regions, located in the central, western and south-western Poland, precipitation deficits for the pear tree, on average, range from 120 to 180 mm annually.

Rzekanowski et al. (2001), on the other hand, estimate that in the Bydgoszcz region, to ensure the optimal soil moisture conditions, one should provide, on average, from 117 to 192 mm of water to fruit trees in the vegetation period, in a form of supplemental irrigation. In another paper by Rzekanowski (2009), the greatest water deficits occur in the central Poland's belt (the Great Valleys Region) and for the pear tree the deficit falls within the range from 50 to 81 mm in the vegetation period.

Developed in the recent years for Poland, quite numerous scenarios of changes in temperature and natural precipitation differ significantly, as compared with the summer period (June-August) (Łabędzki 2009). All the models forecast an increase in temperature and only few – an increase in precipitation, while others – even a decrease in precipitation (Łabędzki 2009). Bąk and Łabędzki (2014) report on the highest increase in temperature in 2011-2050 being forecast for July and August. Such increase, as compared with the reference period (1971-2000), respectively for those months, will be 1.5°C and 1.2°C.

Specialists evaluate that the forecasted climate change can increase the water requirements of plants (Łabędzki 2009, Rzekanowski et al. 2011).

The present research has been an attempt at evaluating the water requirements of the pear tree in 2016-2050 in the Bydgoszcz region based 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 pear 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 pear tree provided by Dzieżyc (1988), the regression equation was determined (Figure 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 pear-tree-optimal precipitation time variation in successive 35 years (n=35) or 7 five-year periods (n=7). Excel spreadsheet was used.

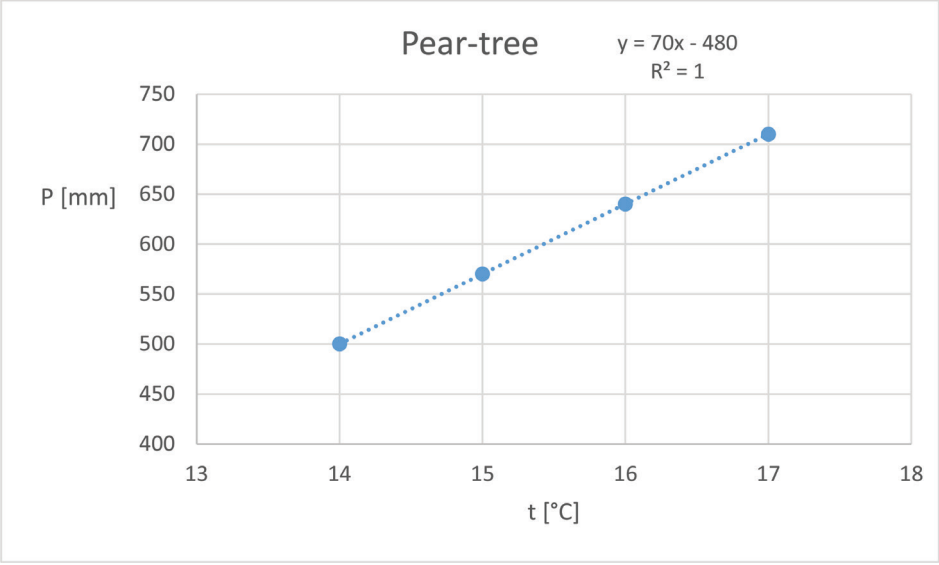

Figure 1. Relation between the mean temperature in summer (May-September) and optimal annual precipitation for pear-trees according to Kemmer and Schulz in a soil of average compaction. The own elaboration on the base of the table values for the pear tree provided by Dzieżyc (1988)

RESULTS AND DISCUSSION

Determined, based on the forecast temperature values and drawing on the assumptions by Kemmer and Schulz, optimal total precipitation in 2016-2050 showed a higher variation than calculated for the reference period, namely 1981-2015 (Table 1). The range of precipitation variation, respectively for the 35-year periods, was 604-961 mm and 515-793 mm.

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

Specification	Period	
	1981-2015	2016-2050
Minimum (mm)	515	604
Maximum (mm)	793	961
Median (mm)	630	772
Average (mm)	624	771
Standard deviation (mm)	59.3	96.3
Variation coefficient (%)	9.5	12.5

The optimal precipitation trend equations determined for the pear tree (Table 2, Figure 2, Figure 3) show that in the reference period (1981-2015) the optimal annual precipitation was increasing in each pentad by 5.1 mm, whereas in the forecast period (2016-2050) it will be increasing in an even greater range by 8.4 mm, respectively.

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

Period	Equations of the trend	R^2	Tendency of the pear-tree-optimal annual precipitation (mm·pentad^{-1})
1981-2015	y = 1.0243x + 605.28	0.0313	5.1
2016-2050	y = 1.6812x + 740.38	0.032	8.4

A breakdown of optimal mean (for successive pentads) annual precipitation in the 35-year periods reveals that the mean values are higher in each pentad of the 2016-2050 period, as compared with the reference period (1981-2015) (Table 3). The lowest mean annual precipitation of 730 mm (the 2031-2035 pentad) of the forecast period (2016-2050) is higher than the highest (649 mm) mean precipitation (the 2011-2015 pentad) of the reference period (1981-2015).

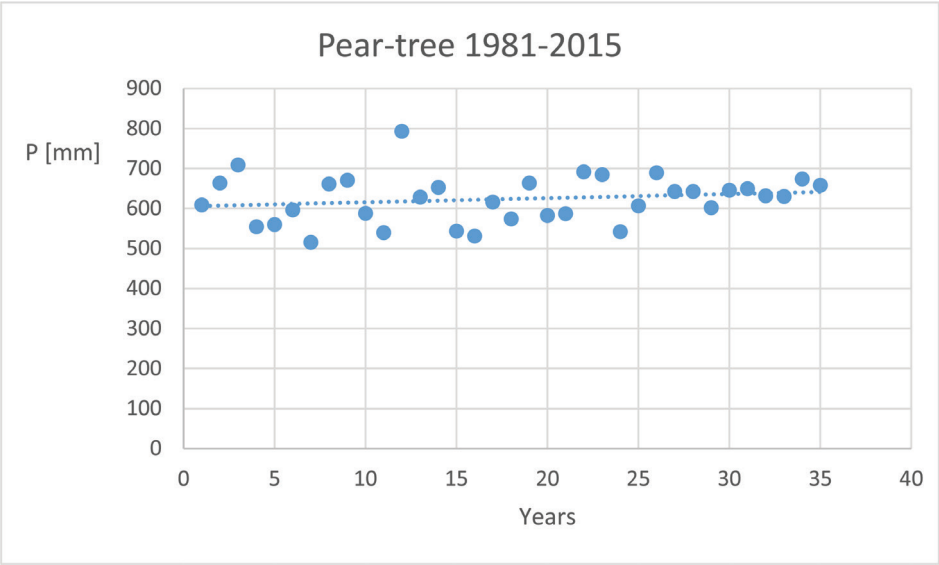

Figure 2. Temporal variability of the pear-tree-optimal annual precipitation in consecutive years of the reference period 1981-2015

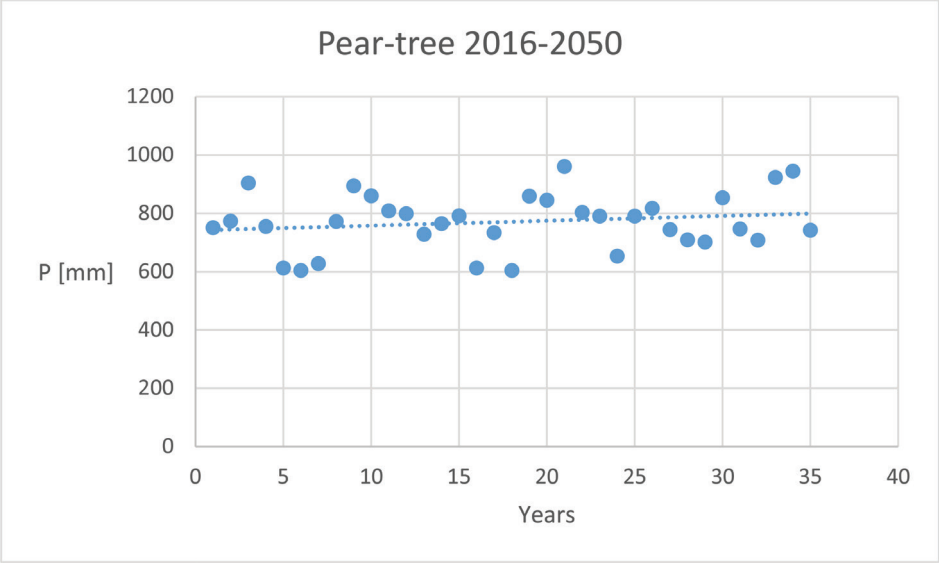

Figure 3. Temporal variability of the pear-tree-optimal annual precipitation in consecutive years of the forecasted period 2016-2050

Table 3. The pear-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	619	2016-2020	759
1986-1990	606	2021-2025	751
1991-1995	631	2026-2030	778
1996-2000	594	2031-2035	730
2001-2005	622	2036-2040	799
2006-2010	644	2041-2045	765
2011-2015	649	2046-2050	812
Average for 1981-2015	624	Average for 2016-2050	771

A comparison of pear-tree-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 was increasing in each pentad by 5.5 mm, whereas in the forecast period (2016-2050) it will increase in each pentad by 7.5 mm.

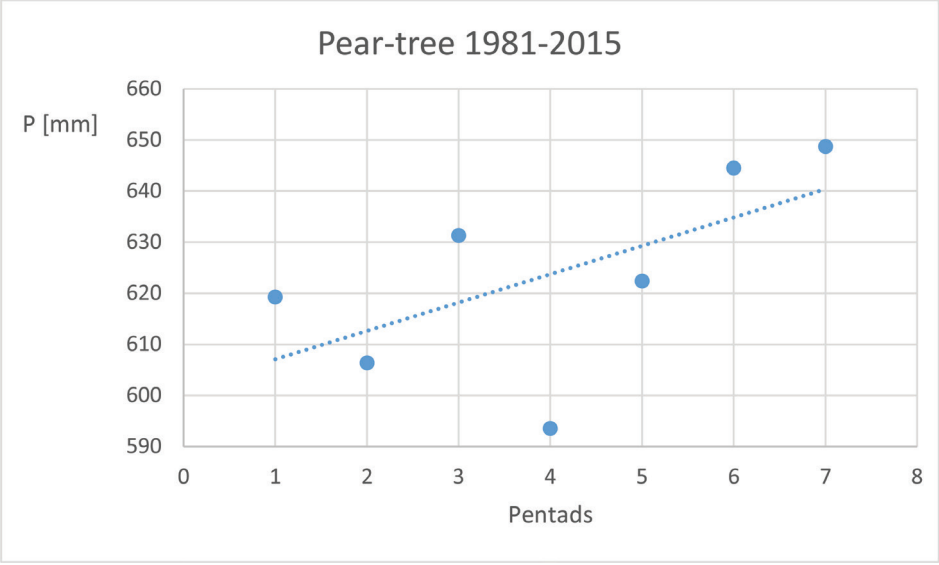

Figure 4. Temporal variability of the pear-tree-optimal annual precipitation in consecutive pentads of the reference period 1981-2015

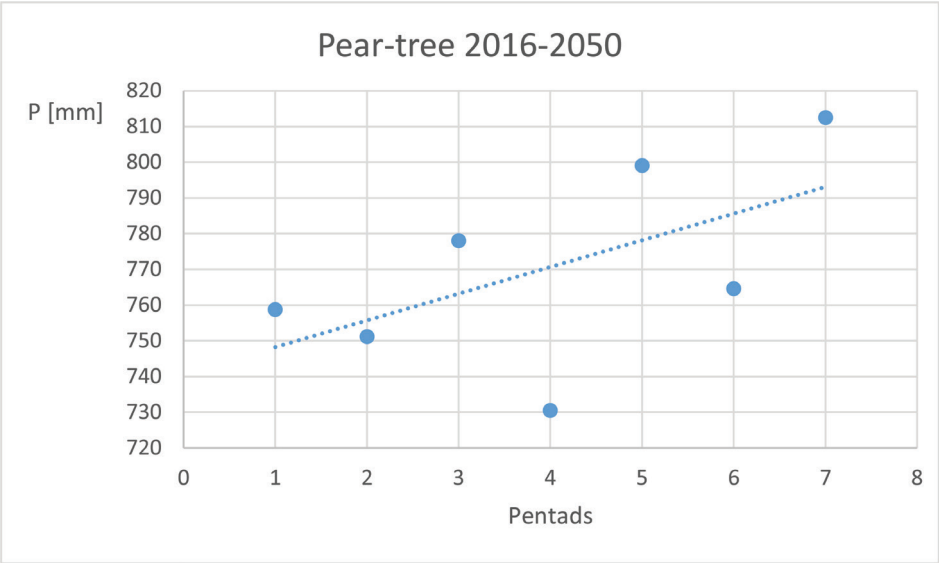

Figure 5. Temporal variability of the pear-tree-optimal annual precipitation in consecutive pentads of the forecasted period 2016-2050

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

Period	Equations of the trend	R^2	Tendency of the pear-tree-optimal annual precipitation (mm·pentad^{-1})
1981-2015	y = 5.55x + 601.52	0.3677	5.5
2016-2050	y = 7.47x + 740.76	0.3265	7.5

The comparison of mean annual precipitation optimal for the pear tree in the 35-year periods demonstrates that it will increase from 624 mm to 771 mm (Table 5). In other words, the pear tree water requirements, expressed with the optimal annual precipitation according to Kemmer and Schulz, will increase by 147 mm, namely by 24 %. Compliant with the assumptions by Kemmer and Schulz, the water requirements of the pear tree from May through September will increase by 73 mm, respectively.

Increasing pear-tree water requirements will increase irrigation requirements, which is pointed to by e.g. Łabędzki (2009) and Rzekanowski et al. (2011). Słowik (1973) demonstrates that, with insufficient precipitation, approximate

irrigation norms for the pear tree range from 170 to 200 mm. According to Dzieżyc (1988), the seasonal irrigation norm for the pear tree is 220 mm.

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

Period	January-December	May-September
1981-2015	624	312
2016-2050	771	385
(2016-2050) – (1981-2015)	+147	+73
Change (%)	+24	

RECAPITULATION AND CONCLUSIONS

With the assumptions made (temperature change forecasts) and the calculations and analyses made, the following conclusions can be developed:

1. In the 2016-2050 period in the Bydgoszcz region, in the light of the temperature change scenarios made, one should expect an increase in the water requirements of the pear tree. Determined with the Kemmer and Schulz method, the required optimal annual (January-December) precipitation will increase for the pear tree from 624 mm to 771 mm (by 147 mm, namely by 24 %).
2. The optimal precipitation trend equations show that in the reference period (1981-2015), calculated with the Kemmer and Schulz numbers, the optimal annual precipitation was increasing in the pear tree in each pentad by 5.1-5.5 mm. In the forecast period (2016-2050) the water requirements will increase, on the other hand, in each pentad within a much greater range (7.5-8.4 mm).
3. In, determined by Kemmer and Schulz, summer period (May-September), the total precipitation, expressing water requirements, optimal for the pear tree in 2016-2050 will increase by 73 mm.

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Received: 19.11.2016
Accepted: 02.12.2016