INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr IV/4/2016, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 1847–1856
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2016.4.4.138

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

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Abstract

The present research has aimed at estimating the water requirements of grapevine in 2016-2050 in the Bydgoszcz region based on the anticipated 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 grapevine 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 2016-2050 period in the Bydgoszcz region, in the light of the anticipated temperature change scenarios, one can expect increased grapevine water requirements. Determined with the Kemmer and Schulz method, the required optimal annual (January-December) precipitation will increase for the grapevine from 440 mm to 576 mm (by 136 mm, namely by 31 %). The optimal precipitation trend equations demonstrate that in the reference period (1981-2015), calculated with the Kemmer and Schulz, the optimal annual precipitation was increasing in grapevine in each pentad by 2.2-2.6 mm. In the forecast period (2016-2050) the water requirements will increase, however, in each pentad in a much greater range (8.0-8.9 mm). In the summer period (May-September) determined by Kemmer and Schulz, the total precipitation optimal for the grapevine, expressing the water requirements, in 2016-2050 will increase by 68 mm.

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

INTRODUCTION

Grapevine growing in Poland enjoys a very long tradition already as it reached our country with Christianity (Myśliwiec 2013). Already about a thousand years ago on Polish soil such warm-loving plants as grapevines were cultivated with much success (Szymanowski, Smaza 2007). Even though most grapevine plantations used to be located in Silesia and in Zielona Góra, it was still grown a lot also in the vicinity of Poznań, Płock, Włocławek and Toruń and even further, in the area between Toruń and Bydgoszcz, which is seen from the map provided in the monograph by Myśliwiec (2013). Grapevine growing was facilitated especially by higher temperature since, as reported by Woś (1999), the eleventh century, most probably, showed the temperature higher than the mean many-century and in total with the twelfth and thirteenth century formed a period considered warmest in our history. Today in Poland can be observed a greater and greater interest in grapevine growing and new vineyards are very frequently set up in the regions they had already existed in (Myśliwiec 2013). Since 1 May 2004 the territory of Poland has been considered, similarly as e.g. north-eastern federal states of Germany, Great Britain and Denmark, grapevine growing zone A; the regions hardly favorable to growing this species (Lisek 2011, Kapłan 2013).

Today grapevine growing in Poland is of little economic importance, however, it is accompanied by a high social interest and fast increase in grapevine acreage (Kapłan 2013). A clearly increasing interest in grapevine growing in Poland comes, on top of others, from important reasons, e.g. advancement in growing new cultivars with a low susceptibility to fungal pathogens and frost damage; due to a gradual climate warming in Poland, which enhances grapevine growing (Lisek 2011, Kapłan 2013, Myśliwiec 2013, Łabędzki 2009). According to Łabędzki (2009), in Poland one can expect an increase in temperature by about 2-4°C. However, with different models applied, the temperature and precipitation change scenarios in Poland (in 2020, 2050 and 2080) differ significantly for the summer period (June-August). And so all the models forecast an increase in temperature, however, an increase in precipitation – only some; there are also models which predict decreased precipitation (Łabędzki 2009). It is considered e.g. very likely that the July and August temperature (except for the coast) will exceed 25°C. Interestingly, most scenarios for Poland do not expect an increased total precipitation throughout the year.

Precipitation is the basic source of water for grapevine which shows considerable water requirements (Myśliwiec 2013). Dzieżyc (1988), after Kemmer and Schulz, reports on the required annual precipitation for grapevine, respectively for the temperature range from 14.0°C to 17.0°C, falling from 380 to 500 mm.

The water deficits, recorded during drought, result in a poor grapevine and fruit growth, premature shoots drying-off and leaf yellowing (Myśliwiec 2013). The highest grapevine water requirements occur at the stage of intensive grapevine growth as well as at berries growth (from mid May through mid August). At the flowering stage (June) grapevine requires moderate soil moisture and minimal air humidity. Both precipitation deficit and surplus decrease the effectiveness of flowering, whereas fruit ripening and grapevine turning woody are enhanced by no-rainfall weather. Rainfall surplus at fruit ripening (September) results in fruit cracking and getting rotten.

The present research has aimed at estimating the water requirements of grapevine in 2016-2050 in the Bydgoszcz region based on the anticipated 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 grapevine 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 and grapevine 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 grapevine 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 grapevine-optimal precipitation time variation in successive 35 years (n=35) or 7 five-year periods (n=7). Excel spreadsheet was used.

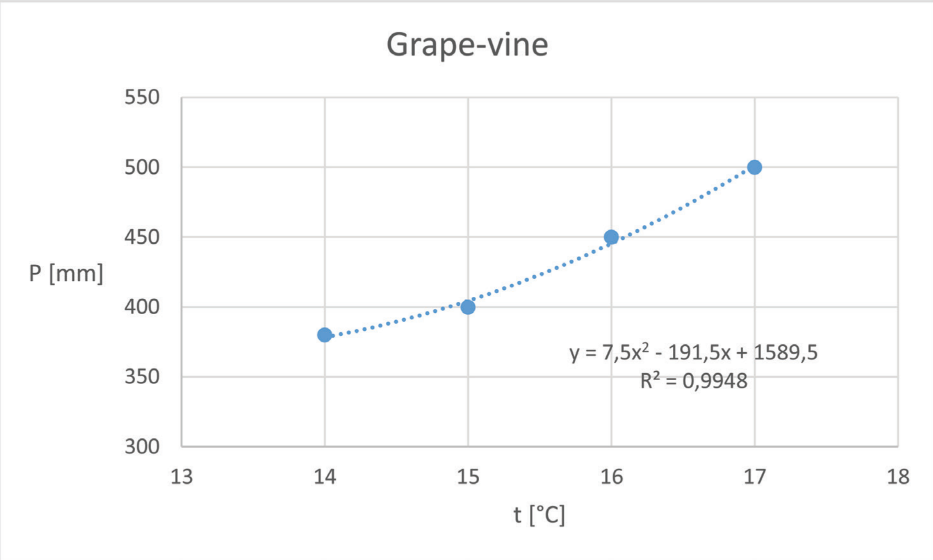

Figure 1. Relation between the mean temperature in summer (May-September) and optimal annual precipitation for grapevine according to Kemmer and Schulz in a soil of average compaction. The own elaboration on the base of the table values for the grapevine provided by Dzieżyc (1988)

RESULTS AND DISCUSSION

Grapevine water requirements, expressed as the optimal annual precipitation according to Kemmer and Schulz, based on the forecast 2016-2050 temperature values, show a greater variation, as compared with the reference period (1981-2015) (Table 1). The precipitation variation range, respectively for the 35-year periods, was 422-825 mm and 383-587 mm, and the coefficient of variation – 18.4% and 9.2%.

In the reference period (1981-2015) the optimal annual precipitation was increasing in each pentad by 2.2 mm, however, in 2016-2050 it will be increasing in an even greater range, by 8.9 mm, respectively (Table 2, Figure 2, Figure 3).

The optimal mean annual precipitation is 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 539 mm (the 2031-2035 pentad) of the forecast period (2016-2050) is higher than the highest mean total (452 mm) reported in the 2011-2015 pentad of the reference period (1981-2015).

Table 1. Statistical characteristics of the grapevine-optimal annual precipitation

Specification	Period	
	1981-2015	2016-2050
Minimum (mm)	383	422
Maximum (mm)	587	825
Median (mm)	439	563
Average (mm)	440	576
Standard deviation (mm)	40.5	106.3
Variation coefficient (%)	9.2	18.4

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

Period	Equations of the trend	R^2	Tendency of the grapevine-optimal annual precipitation ($mm \cdot pentad^{-1}$)
1981-2015	$y = 0.4489x + 431.78$	0.0129	2.2
2016-2050	$y = 1.7864x + 543.77$	0.0296	8.9

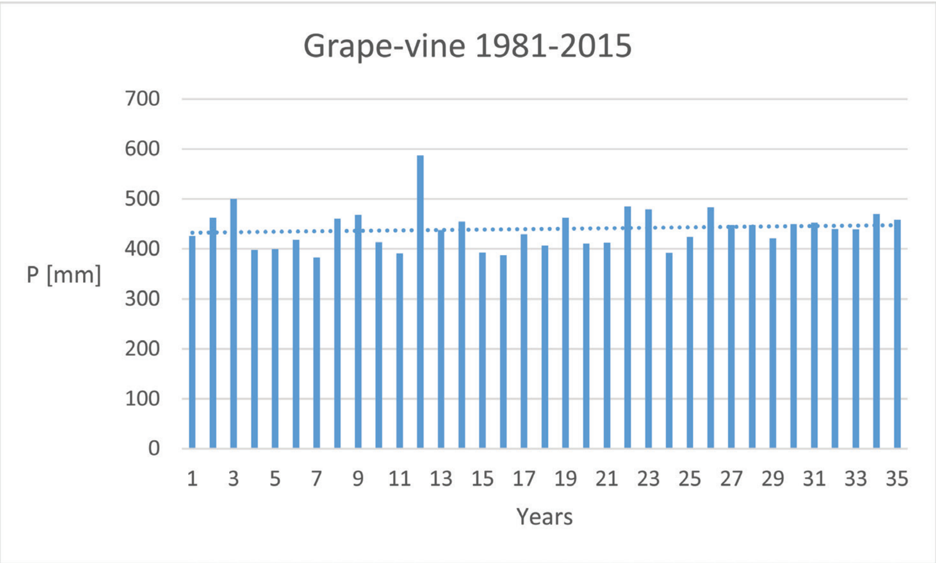

Figure 2. Temporal variability of the grapevine-optimal annual precipitation in consecutive years of the reference period 1981-2015

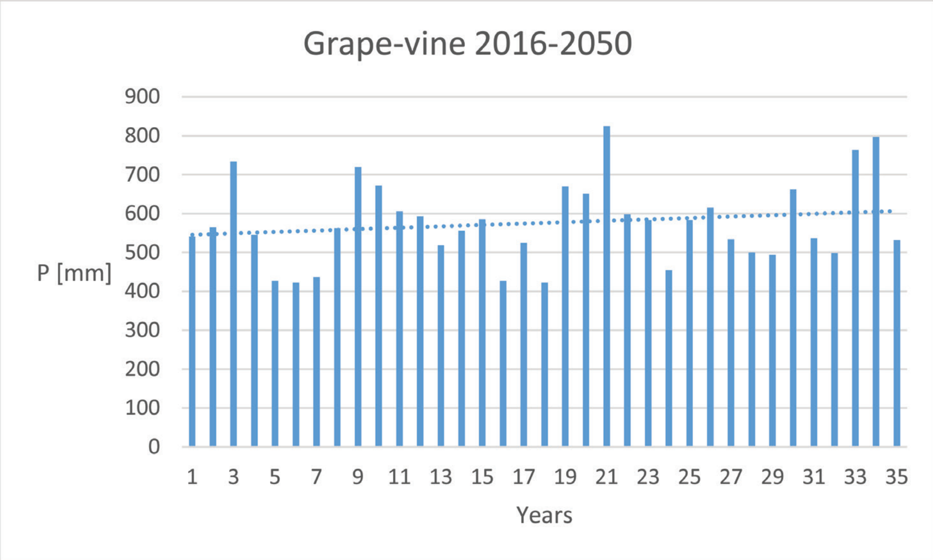

Figure 3. Temporal variability of the grapevine-optimal annual precipitation in consecutive years of the forecast period 2016-2050

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

Reference period 1981-2015		Forecast period 2016-2050	
Pentad	P (mm)	Pentad	P (mm)
1981-1985	437	2016-2020	562
1986-1990	429	2021-2025	563
1991-1995	453	2026-2030	572
1996-2000	420	2031-2035	539
2001-2005	439	2036-2040	609
2006-2010	450	2041-2045	561
2011-2015	452	2046-2050	626
Average for 1981-2015	440	Average for 2016-2050	576

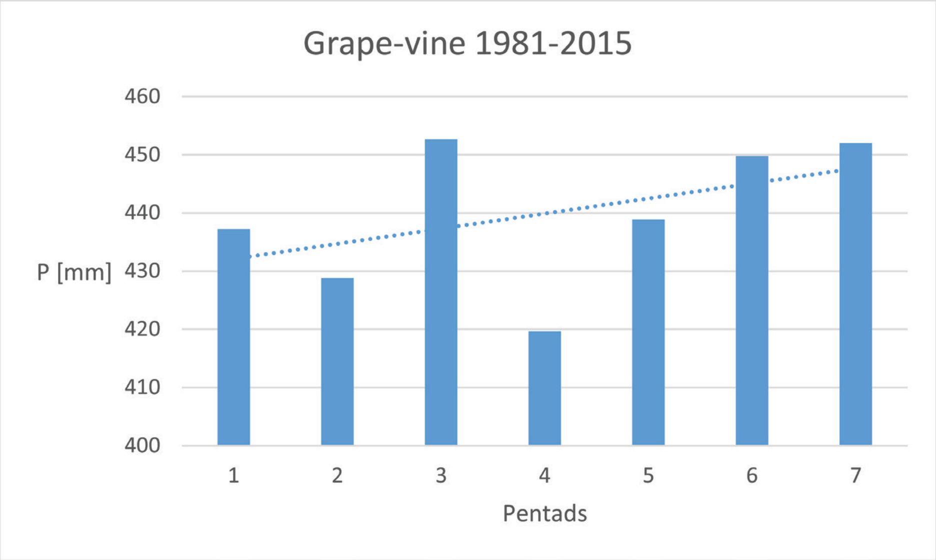

Figure 4. Temporal variability of the grapevine-optimal annual precipitation in consecutive pentads of the reference period 1981-2015

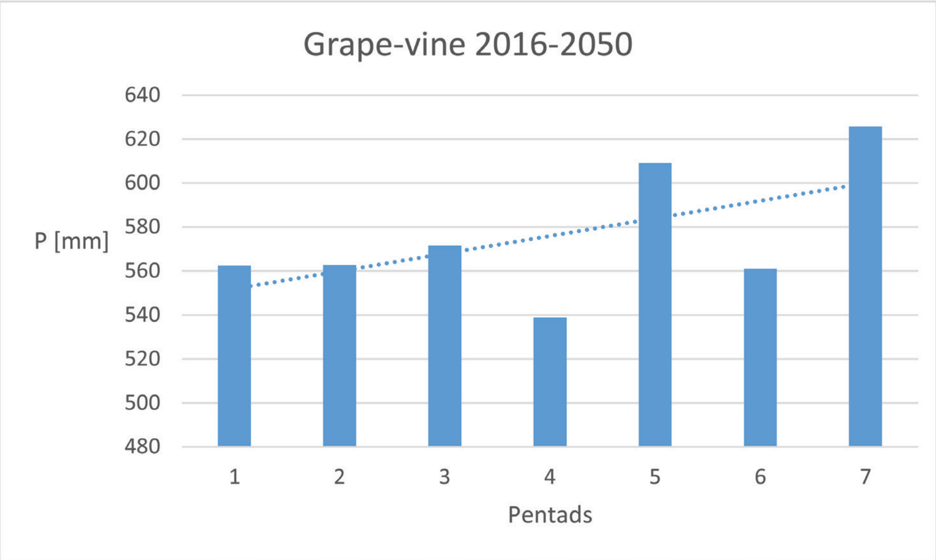

Figure 5. Temporal variability of the grapevine-optimal annual precipitation in consecutive pentads of the forecast period 2016-2050

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

Period	Equations of the trend	R^2	Tendency of the grapevine-optimal annual precipitation ($mm \cdot pentad^{-1}$)
1981-2015	y = 2.5936x + 429.49	0.1981	2.6
2016-2050	y = 8.0136x + 543.87	0.3241	8.0

The optimal precipitation trend equations determined for grapevine in successive pentads (Table 4, Figure 4, Figure 5) demonstrate that in the reference period (1981-2015) the optimal annual precipitation was increasing in each pentad by 2.6 mm, while in the forecast period (2016-2050) the plant water requirements indicator value will be increasing in each pentad by 8.0 mm.

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

Period	January-December	May-September
1981-2015	440	220
2016-2050	576	288
(2016-2050) – (1981-2015)	+136	+68
Change (%)	+31	

Compliant with the forecast temperature changes, the grapevine water requirements will increase from 440 mm to 576 mm (Table 5). It means that the grapevine water requirements, expressed with the optimal annual precipitation according to Kemmer and Schulz, will increase by 136 mm, namely by 31 %. According to the assumptions by Kemmer and Schulz, the grapevine water requirements from May through September will increase by 68 mm, respectively.

May through September the water requirements of the grapevine will increase up to 288 mm. According to Myśliwiec (2013), the total summer precipitation in Poland is sufficient for the grapevine. However, the precipitation distribution in respective months is unfavorable since droughts often occur in May while in June, the grapevine flowering period, excessive precipitation is frequent.

Dzieżyc (1988), drawing on the data reported by Kemmer and Schulz, states that the precipitation requirements (the optimal annual precipitation) of the grapevine for temperatures from May through September of 15°C and 17°C are 400 mm and 500 mm, respectively.

RECAPITULATION AND CONCLUSIONS

With the assumptions (temperature change forecast by other authors) as well as 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 anticipated temperature change scenarios, one can expect increased grapevine water requirements. Determined with the Kemmer and Schulz method, the required optimal annual (January-December) precipitation will increase for the grapevine from 440 mm to 576 mm (by 136 mm, namely by 31 %).
2. The optimal precipitation trend equations demonstrate that in the reference period (1981-2015), calculated with the Kemmer and Schulz, the optimal annual precipitation was increasing in grapevine in each pentad by 2.2-2.6 mm. In the forecast period (2016-2050) the water requirements will increase, however, in each pentad in a much greater range (8.0-8.9 mm).
3. In the summer period (May-September) determined by Kemmer and Schulz, the total precipitation optimal for the grapevine, expressing the water requirements, in 2016-2050 will increase by 68 mm.

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Received: 19.11.2016
Accepted: 02.12.2016