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ATTEMPT AT A COMPARISON OF THE GRAPEVINE WATER REQUIREMENTS IN THE REGIONS OF BYDGOSZCZ AND WROCŁAW

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Abstract

The aim of the present research was to compare the water requirements of grapevine in the regions of Bydgoszcz and Wrocław in the forty-year period between 1976 and 2015. In the research the authors used the mean monthly temperature values (°C) and monthly precipitation (mm) for the May-September period in the years 1976-2015. The meteorological data for the Bydgoszcz region was derived from standard meteorological measurements performed at the Experiment Station at Mochełek, and analysed at the Department of Land Reclamation and Agrometeorology of the UTP University of Science and Technology in Bydgoszcz. The meteorological data for the Wrocław region were provided by the Swojec experiment station of the Wrocław University of Environmental and Life Sciences. The grapevine water requirements were determined as optimal precipitation assumed by Kemmer and Schulz. It has been found that the grapevine water requirements in 1976-2015, expressed as the optimal annual precipitation according to Kemmer and Schulz, were higher in the Wrocław region than in the Bydgoszcz region and they amounted to 469.3 mm and 435.8 mm, respectively. The grapevine water requirements in both regions in the forty-year period under study showed a growing tendency. A larger increase in grapevine water requirements (27.5-28.0 mm per decade) occurred in the Wrocław region. The estimates show that during the forty-year period (1976-2015) the precipitation

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deficits in grapevine growing in the May-September period occurred in 11 years in the Bydgoszcz region and in 9 years in the Wrocław region.

Key words: grapevine, water requirements, optimal precipitation, Bydgoszcz region, Wrocław region

INTRODUCTION

Even though Poland has never been considered a grapevine-growing country, over the last few years there has been a clearly growing interest in grapevine (Pink 2015). Our country reports on a regular increase in the number of vineyards; as reported by the Agricultural Market Agency, in the 2009/2010 economic year only 26 vineyards were registered in Poland, whereas in 2015/2016 – as many as 103 vineyards with the wine marketing licence (Adamczewska-Sowińska *et al.* 2016). These data indicate that during just 6 years the number of vineyards increased almost four times. At the same time the acreage increased more than five-fold – from 37.1 to 194.2 ha (Adamczewska-Sowińska *et al.* 2016).

However, the real number of vineyards in Poland is much higher; it is estimated that in total in Poland almost 500 vineyards are already operating (Adamczewska-Sowińska *et al.* 2016). All that shows that new vineyards have been emerging and only about 20% of them are recorded in the register as vineyards with a wine selling licence. Today the web portal where vineyard owners can report their plantations themselves (winogrodnicy.org) covers 386 vineyards all across Poland. Most vineyards are located in the south-eastern, south-western and southern provinces with the most favourable climate conditions pattern for grapevine growing (Adamczewska-Sowińska *et al*. 2016, Bokwa and Klimek 2009, Kopeć 2009, Myśliwiec 2013). Despite less favourable climate conditions new vineyards are also set up in eastern and central Poland (Adamczewska-Sowińska *et al.* 2016). Interestingly, since 1 May 2004, the territory of Poland has been considered, similarly to e.g. north-eastern federal states of Germany, Great Britain and Denmark, grapevine growing zone A – the regions hardly favourable to growing this species (Lisek 2011, Kapłan 2013).

The increase in grapevine growing, observed in Poland, can result from advancement in growing new cultivars with a low susceptibility to fungal pathogens and frost damage, as well as from a gradual climate warming in Poland, which enhances grapevine growing (Lisek 2011, Kapłan 2013, Myśliwiec 2013, Łabędzki 2009, Kopeć 2009, Woś 1999, Szymanowski and Smaza 2007).

Precipitation is the basic water source for grapevine (Myśliwiec 2013). It is assumed that the mean precipitation value in the areas applicable for grapevine growing is 500-800 mm (Myśliwiec 2013, Adamczewska-Sowińska *et al.* 2016).

According to Dzieżyc (1988), the annual precipitation required for grapevine ranges from 380 to 500 mm.

The aim of the present research was to compare the water requirements of grapevine in the regions of Bydgoszcz and Wrocław in the forty-year period between 1976 and 2015.

MATERIAL AND METHODS

In the research the authors used the mean monthly temperature values (°C) and monthly precipitation (mm) for the May-September period in the years 1976-2015. The meteorological data for the Bydgoszcz region were derived from standard meteorological measurements performed at the Experiment Station at Mochełek, and analysed at the Department of Land Reclamation and Agrometeorology of the UTP University of Science and Technology in Bydgoszcz. The meteorological data for the Wrocław region were provided by the Swojec experimental station of the Wrocław University of Environmental and Life Sciences.

The grapevine water requirements were determined as optimal precipitation postulated by Kemmer and Schulz (Słowik 1973, Dzieżyc 1988, Treder and Pacholak 2006). According to the above mentioned authors, the optimal annual precipitation (January-December) for grapevine in mid-compact soil can be determined with the mean temperature in the summer period (May-September). However, it is assumed that at least 50% of the optimal precipitation determined in that way coincides with the period from 1 May to 30 September (Słowik 1973, Treder and Pacholak 2006). The January-December grapevine water requirements were determined by applying the equation provided by Rolbiecki and Piszczek (2016), and derived with the Kemmer and Schulz numbers and reported by Dzieżyc (1988). Precipitation deficits or surpluses in the May-September period were calculated from the difference between grapevine water requirements, expressed as optimal precipitation for that period (50% of the optimal annual precipitation according to Kemmer and Schulz) and the total precipitation recorded in that period.

The results were statistically verified by determining the values of mean, median, maximum and minimum, standard deviation as well as the coefficient of variation. An attempt was also made to define potential trends of changes in the indicators of grapevine water requirements in both regions with the analysis of linear regression. The calculations involved the use of an Excel spreadsheet.

RESULTS AND DISCUSSION

Grapevine water requirements, expressed as the optimal annual precipitation according to Kemmer and Schulz, were higher in the Wrocław region than

in the Bydgoszcz region (Table 1) – the average values for the period 1976-2015 amounted to 469.3 mm and 435.8 mm, respectively. In the Wrocław region the grapevine water requirements showed higher values of the standard deviation and the coefficient of variation.

Table 1. Statistical characteristics of the grapevine-optimal annual precipitation according to Kemmer and Schulz in 1976-2015

Specification	Region	
	Bydgoszcz	Wrocław
Minimum (mm)	380.0	385.3
Maximum (mm)	586.9	569.9
Median (mm)	433.9	466.9
Average (mm)	435.8	469.3
Standard deviation (mm)	39.7	49.2
Variation coefficient (%)	9.1	10.5

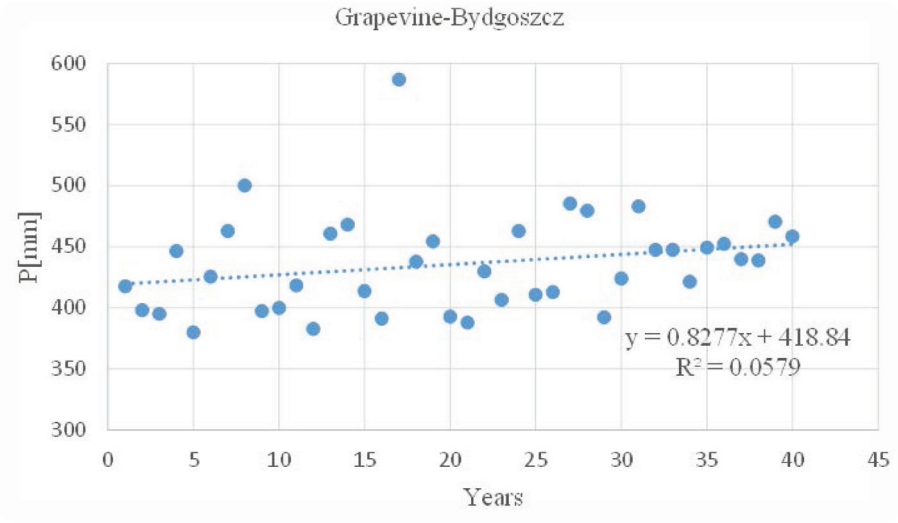

Figure 1. Temporal variability of the grapevine-optimal annual precipitation in consecutive years of the period 1976-2015 in the Bydgoszcz region

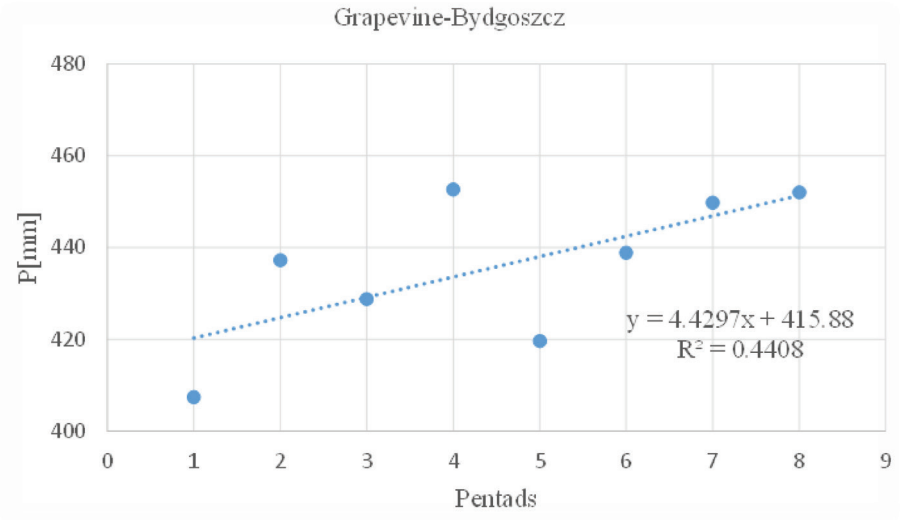

Figure 2. Temporal variability of the grapevine-optimal annual precipitation in consecutive pentads of the period 1976-2015 in the Bydgoszcz region

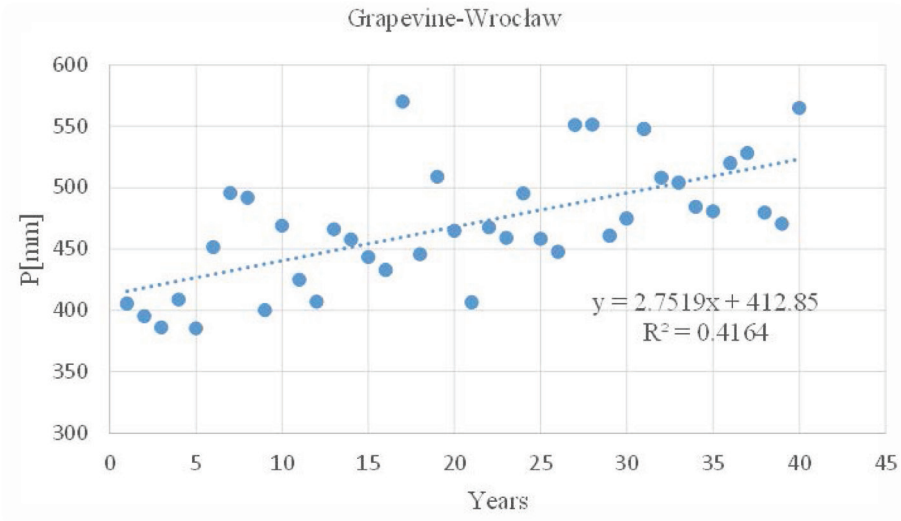

Figure 3. Temporal variability of the grapevine-optimal annual precipitation in consecutive years of the period 1976-2015 in the Wrocław region

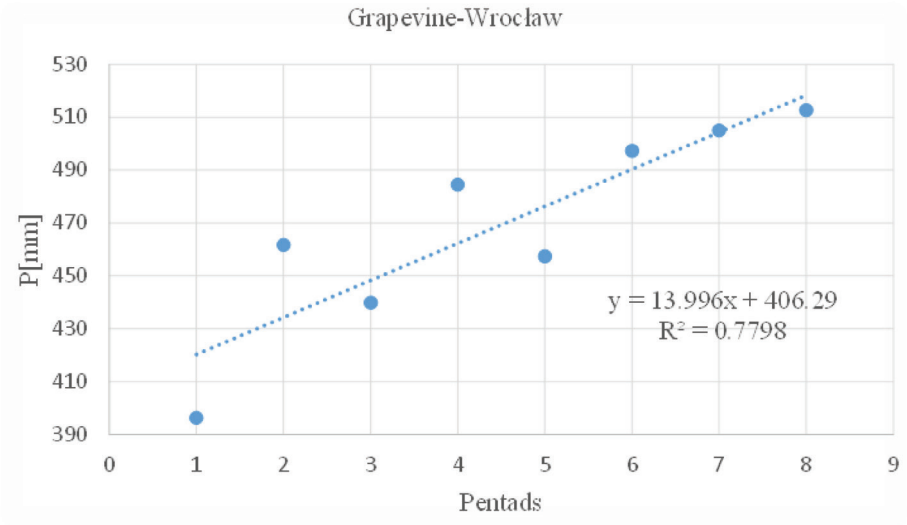

Figure 4. Temporal variability of the grapevine-optimal annual precipitation in consecutive pentads of the period 1976-2015 in the Wrocław region

The grapevine water requirements defined in this research fell within the range determined by Dzieżyc (1988). According to that author (who made use of the assumptions by Kemmer and Schulz), the annual precipitation required for grapevine, for temperature varying from 14.0°C to 17.0°C, ranges from 380 to 500 mm, respectively. The latest publications (Myśliwiec 2013, Adamczewska-Sowińska *et al.* 2016) report on higher precipitation – it is claimed that between 500 and 800 mm of precipitation is required to produce a satisfactory fruit yield in the areas applicable for grapevine production in Poland.

Grapevine water requirements in both regions in the forty-year period showed a growing tendency, with a higher grapevine water requirements increase for the Wrocław region. The linear regression equations demonstrate that the grapevine water requirements in each decade were growing in the Bydgoszcz region from 8.3 to 8.9 mm (Figures 1-2), and in the Wrocław region – as much as by 27.5-28.0 mm (Figures 3-4).

The results of calculations reveal that in the forty-year period (1976-2015) the precipitation deficits for grapevine growing, from May through September, occurred in 11 years in the Bydgoszcz region and in 9 years in the Wrocław region (Figure 5 and 6, Table 2). In the research period, the average deficits were 52.6 and 36.0 mm, respectively, ranging from 4.1 to 167.1 mm in the Bydgoszcz region, and from 3.5 to 85.1 mm in the Wrocław region.

Table 2. Comparison of the rainfall deficits for grapevine growing in 1976-2015

Region	Period	The number of years with rainfall deficits	Average amount of the rainfall deficit (mm)	Range of the rainfall deficit (mm)
Bydgoszcz	V-IX	11	52.6	4.1 ÷ 167.1
Wrocław	V-IX	9	36.0	3.5 ÷ 85.1

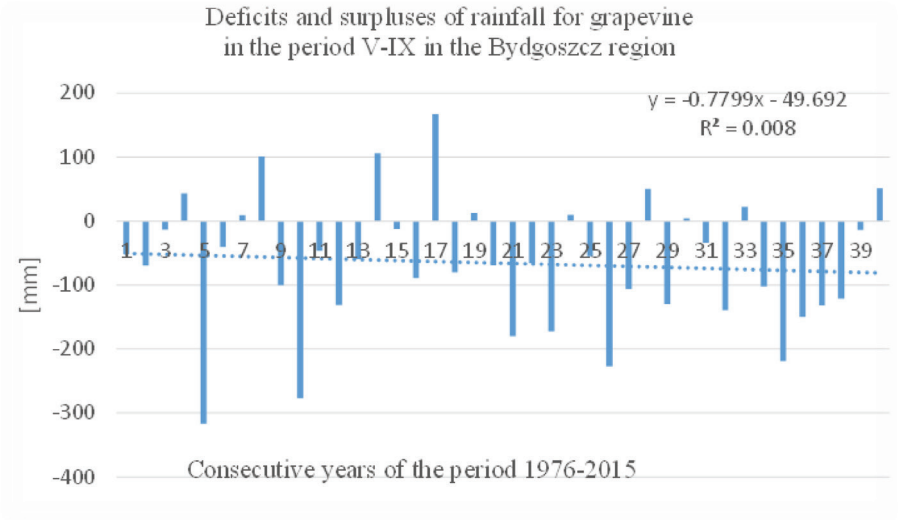

Figure 5. Temporal variability of water conditions for grapevine growing in the period V-IX in 1976-2015 in the Bydgoszcz region

On the other hand, in the forty-year period, precipitation surpluses in grapevine growing, from May through September, occurred in the Bydgoszcz region in 29 years and in the Wrocław region in 31 years (Table 3). In the research period, the average surpluses were 110.6 and 141.0 mm, respectively, ranging from 12.1 to 317.0 mm in the Bydgoszcz region, and from 7.8 to 318.9 mm in the Wrocław region.

Interestingly, in the compared regions an opposite tendency in time variation of precipitation deficits or surpluses for grapevine growing was found. And so, in the Bydgoszcz region, the precipitation deficits showed a decreasing tendency (at the same time there was a tendency to increase precipitation surpluses) (Figure 5). However, in the Wrocław region, a trend was opposite (a deficit increased and a decrease in precipitation surpluses was observed) (Figure 6).

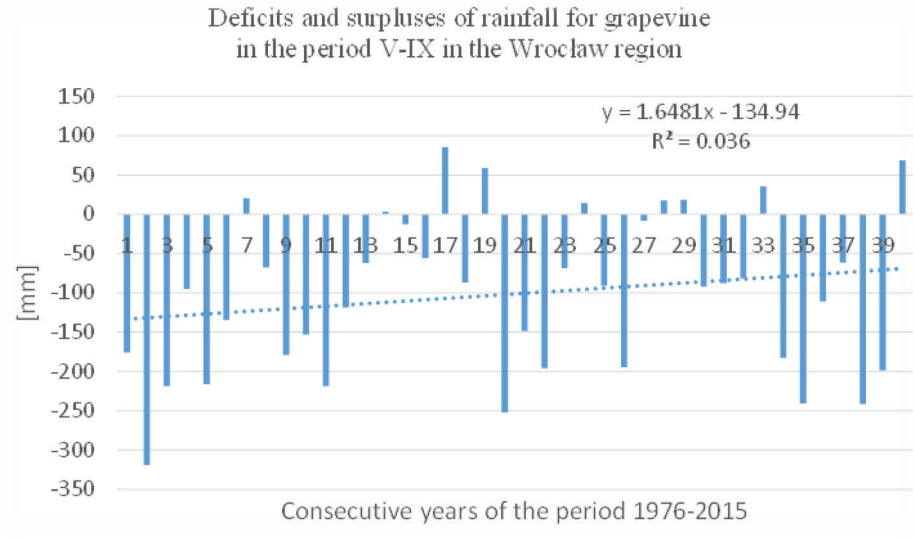

Figure 6. Temporal variability of water conditions for grapevine growing in the period V-IX in 1976-2015 in the Wrocław region

Table 3. Comparison of the rainfall surpluses for grapevine growing in 1976-2015

Region	Period	The number of years with rainfall surplus	Average amount of the rainfall surplus (mm)	Range of the rainfall surplus (mm)
Bydgoszcz	V-IX	29	110.6	12.1 ÷ 317.0
Wrocław	V-IX	31	141.0	7.8 ÷ 318.9

The applicable literature report on the highest grapevine water requirements occurring at the phase of intensive grapevine growth as well as in the period of growth of berries, namely mid-May to mid-August (Myśliwiec 2013, Adamczewska-Sowińska *et al.* 2016). In the period of drought, water deficits limit grapevine and fruit growth and cause leaf yellowing. At the flowering stage (June) grapevine requires a moderate soil moisture and minimal air humidity. Both precipitation deficit and surplus decrease the effectiveness of flowering. Fruit ripening and grapevine lignification is enhanced under no-rainfall weather. Precipitation surplus at the fruit ripening stage (September) results in fruit breaking and becoming rotten.

With the forecast scenarios of the changes in temperature for the Bydgoszcz region (Bąk and Łabędzki 2014), one should expect increased grapevine

water requirements in the 2016-2050 period (Rolbiecki and Piszczek 2016). With the method determined by Kemmer and Schulz, the required annual (January-December) optimal precipitation, for the forecast temperatures, will increase for grapevine from 440 mm (mean for 1981-2015) to 576 mm (by 136 mm, namely by 31 %).

The present research has been preliminary. Further, more detailed research is required to determine the water requirements of grapevine grown in Poland.

RECAPITULATION

In the present research it has been found that the grapevine water requirements in 1976-2015, expressed as the optimal annual precipitation according to Kemmer and Schulz, were higher in the Wrocław region than in the Bydgoszcz region and they amounted to 469.3 mm and 435.8 mm, respectively.

The grapevine water requirements in both regions in the forty-year period under study showed a growing tendency. A larger increase in grapevine water requirements (27.5-28.0 mm per decade) occurred in the Wrocław region.

The estimates show that in the forty-year period (1976-2015) the precipitation deficits in grapevine growing in the May-September period occurred in 11 years in the Bydgoszcz region and in 9 years in the Wrocław region.

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