CLIMATIC FACTORS AFFECTING DEVELOPMENT AND YIELDING OF GRAPEVINE IN CENTRAL POLAND

Jerzy Lisek

Research Institute of Pomology and Floriculture
Pomologiczna 18, 96-100 Skierniewice, POLAND
e-mail: jlisek@insad.pl

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A B S T R A C T

The most important factor limiting the vineyard development in central Poland is climate. The main threats pose: minimum winter temperatures lower than -30°C (registered at least once a decade),spring frosts, temperature unsuitable for grapevines and irregular precipitation.

Of all the climatic changes noticed in the past several dozen years the most favourable for grapevine growing, is increased annual air temperature during the growing season, expressed as the so-called sum of active temperatures (SAT). This consists of the daily temperature averages above 10°C. Average SAT for Skierniewice (central Poland) in 1981-2000 came up only to 2500°C. In 2003 SAT exceeded 2700°C, and in the unusually hot year 2006 even 2900°C.

The yielding of the grapevines registered in the cultivar collection and in the cultivar evaluation experiment during 1986-2007 proves that climatic fluctuations noticed in the last decades are favourable to vine growing in central Poland. On average, beginning of the phenological stages such as bud swelling, blooming and fruit ripening of seven grapevine cultivars ('Perl of Csaba', 'Seneca', 'Aurora', 'Swenson Red', 'Edelweiss', 'Chasselas Dore', 'Steuben') in the years 2005-2007 on average occurred 12 days earlier than in the period 1987-1989.

Climate fluctuations, especially increase of temperature during the growing season, has presented in the past few years new issues concerning plant protection against pests and diseases. Some of the most important problems are more and more frequent grapevine infections with the fungus *Unicunula necator* responsible for powdery mildew, fungus *Phomopsis viticola*, causal agent of excoriose, and the appearance of grape leafhopper (*Empoasca vitis*) that has not been recorded in central Poland before 2006 year. New threats pose solar injuries of grapevine leaves and fruit caused by thermal (infrared) and ultraviolet (UV-B) radiation.

Developing a technology of grapevine growing that would be suitable for Polish conditions requires extensive studies on interactions between genotypes, environment and agrotechnical practices.

Key words: grapevine, cultivars, climate, phenology

INTRODUCTION

The area of vineyards in Poland is estimated at 250-300 ha. The grapevine is also commonly grown in home gardens. The increased interest in cultivating grapevines is related to warm springs and summers in the last decades, biological progress in the breeding of new cultivars, as well as economic and cultural transformations and changes in legal regulations concerning the production of wine. According to Plocher and Parke (2001); Caprio and Quamme (2002); Jones (2005) and Selley (2008), global climatic changes shift the viticulture zone northward – for example to Washington and Oregon in the USA, British Columbia in Canada and Great Britain, Netherlands and Denmark in Europe. Climate warming causes problems for traditional wine-producing regions, and necessitates changes in the selection of cultivars, agrotechnical and enological practices which sometimes took centuries to evolve, (Schultz, 2000).

The response of the grapevine cultivars and clones to the changing climatic conditions and their suitability for cultivation in Poland are preliminary assessed in the collection of grapevines at the Institute of Pomology and Floriculture in Skierniewice, which at present consists of 227 genotypes. The subject of the assessment in the collection were utility traits of the cultivars, primarily yielding and tolerance of the bushes to frost and pathogenic organisms. Collection gives the chance to compare far bigger number of genotypes than in the cultivar evaluation experiments, which have been carried out in Poland (Lisek et al., 1992/93; Lisek, 2005, 2007).

The purpose of the work was to describe the climate limitations in vine growing in Poland as well as the influence of weather factors on the development, condition and health of the bushes. The role of the climatic changes was pointed out by comparing the course of the phenological stages and some of the fruit quality features of selected seven cultivars in the years 1987-1989 and 2005-2007. Another aspect of the work was the assessment of suitability for the cultivation of prospective vine genotypes with various fruit destination/usability.

MATERIAL AND METHODS

The grapevine field collection is located in Skierniewice, Central Poland, on a podsolic soil, slightly acidic (pH 6.3) and containing 1.3% of organic matter. Grapevine genotypes

were collected at the Institute of Fruit and Ornamental Plant Research since 1970s, but the collection on the present site was established in 1992. Each of the genotypes is represented by three vines, planted at a spacing of 2.5 m × 1 m and trained according to the "low-head" method. One to three trunks, 20 cm in height, were formed on each plant. After winter pruning, 6 - 8 evenly spaced canes, each with 2-3 buds, were left on the vine (spur pruning). The following traits have been: phenology, yielding, weight of clusters and berries, fruit soluble solids content and taste, winter hardiness and tolerance to fungal diseases – downy and powdery mildew, grey mould and excoriose. The climatic data: temperature, precipitation, humidity, isolation, wind direction and velocity were also recorded.

Seven grapevine cultivars: 'Perl of Csaba' and 'Chasselas Dore' (*V. vinifera*); 'Seneca', 'Aurora', 'Swenson Red', 'Edelweiss' and 'Steuben' (interspecific hybrids of *V. labruscana*, *V. riparia*, *V. rupestris* and *V. vinifera*); were selected from the collection for the sake of evaluation within this project. Data concerning the beginning of growing season (bud swelling), flowering, fruit maturity, weight of clusters and berries, fruit soluble solids content in the years 1987-1989 and 2005-2007 were compared. The results from the 1980s came from the cultivar evaluation experiment carried out in the same location as the collection, in which the bushes were planted in the spring of 1979 and were trained in the low stem, double Guyot system.

RESULTS

The most significant climate variation favourable for the grapevine cultivation which has become obvious in the last twenty years is the increase of the average air temperature during the vegetative period expressed as the sum of active temperatures (SAT). SAT is the sum of average daily temperatures above 10°C. In the years 1981-2000, the multiyear average SAT for Skierniewice (central Poland) was just under 2500°C and during the years 1987-1989 it was 2480°C. In 2003, SAT exceeded 2700°C, in 2005 came to 2550°C, in 2006, the warmest year on the record, reached as much as 2900°C and in 2007 nearly 2590°C. Average monthly air temperatures from June to September were higher in the years 2005-2007 than in 1987-1989 (Tab. 1).

Other factors affecting the cultivation of grapevines in central Poland include: minimum winter temperatures below -30°C (at least once every 10 years); spring frosts (serious damages were noticed on average twice every 10 years); weather fluctuations – air temperature below or above the optimum for grapevines, and irregular precipitation.

In 2007 two waves of spring frost were registered. They damaged up to 80% of the early started bushes. The culmination of the first one reached its peak on April 22nd (-3.5°C) and the second on May 2nd (-4.5°C) as registered in the meteorological cage at a height of 2 m. The fluctuations of the climate in recent years, connected with higher air temperature during

Table 1. Average air temperatures at Skierniewice

Year	Averege monthly temperature [°C]												Annual average
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1987	-12.0	-0.8	-2.3	7.1	14.8	16.6	18.0	15.3	13.2	8.5	4.2	0.9	6.6
1988	1.1	1.0	1.2	7.0	11.8	15.9	19.4	17.6	13.6	7.8	0.4	1.3	8.5
1989	2.2	4.0	5.4	8.8	14.8	16.4	18.4	18.2	14.2	10.5	1.8	1.4	9.7
Mean for 1987-1989	**-8.7**	**1.4**	**1.4**	**7.6**	**13.8**	**16.3**	**18.6**	**17.0**	**13.7**	**8.9**	**2.1**	**1.2**	**8.3**
2005	0.7	-3.4	-0.3	8.3	12.8	15.4	19.3	16.6	14.7	8.6	2.7	-0.6	7.9
2006	-9.0	-3.2	-1.4	-2.1	13.1	17.0	22.3	17.1	15.3	10.4	5.7	3.8	7.4
2007	3.3	-0.7	6.2	8.8	14.4	18.1	18.2	18.2	12.5	7.4	1.5	-0.1	8.7
Mean for 2005-2007	**-5.0**	**-2.4**	**1.5**	**5.0**	**13.4**	**16.8**	**19.9**	**17.3**	**14.2**	**8.8**	**3.3**	**1.0**	**8.0**
Mean for 1921-1970	**-2.9**	**-2.4**	**1.4**	**7.5**	**13.0**	**16.2**	**18.0**	**17.0**	**13.3**	**8.2**	**3.1**	**-1.2**	**7.6**

Table 2. Time (day, month) of the bud burst and of the beginning of flowering

Cultivar	Bud burst		Flowering	
	mean in years			
	1987-1989	2005-2007	1987-1989	2005-2007
Perl of Csaba	6.05	21.04	28.06	19.06
Seneca	4.05	16.04	26.06	14.06
Aurora	3.05	16.04	26.06	14.06
Swenson Red	2.05	15.04	25.06	13.06
Edelweiss	4.05	16.04	24.06	12.06
Chasselas Dore	8.05	22.04	30.06	20.06
Steuben	5.05	17.04	27.06	15.06

vegetation period, has brought about new problems in plant protection, for example the appearance of grape leafhopper (*Empoasca vitis*) and solar injuries of berries and leaves caused by infrared and ultraviolet (UV-B) radiation, that has not been recorded in central Poland before the year 2006. Temperature and air humidity fluctuations registered since the end of May to July were responsible for the solar injuries in 2007. On May 25th, the maximum temperature came to 31.1^{o}C, after a cold night (8,4^{o}C).– From July 8th to 13th the weather was chilly (minimum temperatures even about 8.6^{o}C) and humid (with the average humidity from 80.5 to 98.5%), whereas during July 15-17th there were heats exceeding 30^{o}C (maximum temperature came to 35.5 ^{o}C). At the same time the average air humidity fell to 64.7%. The interspecific hybrids (‘Bath’, ‘Canadice’, Zala Gyongye’, ‘Agat Donski’) proved to be more prone to solar injuries than the *V. Vinifera* cultivars. Infections of the vines with the fungus *Unicunula necator* responsible for powdery mildew, and the fungus *Phomopsis viticola*, causal agent of excoriose, were noticed on all the cultivars tested more frequently in the last few years than in 1980s and 1990s

On average, beginning of all the phenological stages in the years 2005-2007 occurred earlier than in 1987-1989. Growing season (bud swelling) in 2005-2007 would start from 15 (‘Perl of Csaba’) to 18 (‘Seneca’, ‘Edelweiss’, ‘Steuben’) days earlier than in 1987-1989 (Tab. 2). Bushes started blooming from 9 (‘Perl of Csaba’) to 12 (‘Seneca’, ‘Aurora’, ‘Swenson Red’, ‘Edelweiss’, ‘Steuben’) days earlier (Tab. 2) and ripening time occurred from 2 (‘Aurora’) to 17 (‘Chasselas Dore’) days earlier (Tab. 3). The clusters and berries of the seven cultivars studied and the fruit extract content were higher during 2005-2007 than in the 1980s (Tab. 3). Increase in the weight of clusters and berries was more noticeable in the ‘Perl of Csaba’ and ‘Chasselas Dore’ cultivars belonging to *V. vinifera* than in the hybrids (Tab. 4). The berry weight of

Table 3. Time (day, month) of berry ripening and content of soluble solids

Cultivar	Berry ripening date		Soluble solids content [%]	
	mean in years			
	1987-1989	2005-2007	1987-1989	2005-2007
Perl of Csaba	29.08	20.08	16.0* c	18.0 c
Seneca	11.09	2.09	17.5 d	17.8 c
Aurora	16.09	14.09	15.5 bc	18.9 d
Swenson Red	28.09	22.09	15.0 bc	18.1 c
Edelweiss	5.10.	19.09	14.0 b	18.0 c
Chasselas Dore	9.10	22.09	13.5 a	16.9 b
Steuben	12.10	6.10	13.0 a	16.1 a

*The averages were compared separately for each evaluation time. Means followed by the same letter do not differ at p = 0.05

Table 4. Weight of grape cluster and berries

Cultivar	Weight of cluster [g]		Weight of 100 berries [g]	
	mean in years			
	1987-1989	2005-2007	1987-1989	2005-2007
Perl of Csaba	30.9 a*	127.3 ab	145.0 a	280,7 bc
Seneca	63.9 b	115.7 ab	219.5 d	316.3 d
Aurora	77.4 c	93.7 a	162.8 b	181.7 a
Swenson Red	72.4 bc	116.3 ab	205.5 c	318.7 d
Edelweiss	66.9 b	112.7 ab	252.5 e	261.3 b
Chasselas Dore	68.9 b	178.7 c	170.5 b	298.7 cd
Steuben	112.4 d	133.3 b	272.0 f	305.7 c

*Explanation, see Table 3

'Pearl of Csaba' in 1987-1989 was considerably lesser than of the other cultivars studied, while in 2005-2007 it was lesser only in comparison with berries of 'Chasselas Dore', which were significantly the biggest among all of the seven genotypes compared.

DISCUSSION

The earlier occurring phenological stages as well higher quality of grapes in 2005-2007 in comparison with the years 1987-1989 are can be explained by weather changes since plant age, agrotechnical treatments and protection were roughly the same during those two compared periods. According to previous findings, different way of plant training in the collection and in the cultivar evaluation experiment was of a little importance for the features that were examined (Lisek, 2005). Noticeable differences in the onset of most of phonological stages observed can be explained partially by increased average air temperature from May to September and higher minimum temperature during winter. The minimum temperature in 1987-1989 was registered in January of 1987

(–37.4°C). In 2005-2007 the minimum temperature of –31.6°C was registered on January 21st of 2006. Taking into account relatively short time of examination and a high number of factors and their interactions, it is hard to determine which one of the weather components – such as minimum and maximum temperatures, average daily temperature similar to active temperature, precipitation or solar exposure – is the most responsible for changes in the development and yielding of grapes. Jones (2005), examining influence of the climate on the viticulture in the western part of the United States, where the average annual temperature during the vegetative period has increased by 1.7°C in the last 50 years, assessed the importance of 11 temperature parameters, such as the averages, minimum and maximum temperatures during the growing season and dormancy, heat accumulation etc.

Nevertheless, the climatic fluctuations, which occurred in a relatively short time, considerably affected Polish viticulture increasing its chances to succeed. Still, it should be taken into account that vine growing can be unreliable due to frost injuries and extreme temperatures which are far from optimal. What should be noticed is that climatic changes cannot be the only reason for increasing the acreage of vineyard in Poland. The scope of further changes is unknown and the Polish climate is characterized by variability. Further adaptation of viticulture to the climatic changes will be possible thanks to the proper regionalization of vineyards, optimal selection of cultivars as well changes in the means of vine growing and protection against pathogens.

Most of inerspecific hybrids are more tolerant to frosty Polish winters than the *V. vinifera* cultivars (Lisek, 2007). However, growing of *V. vinifera* is more and more effective. In the regions of relatively cool climate – such as British Columbia – the cultivation area of hybrids shrinks for the sake of *V. Vinifera* cultivars, characterized by a higher quality of fruit and wine (Caprio and Quamme, 2002). For the *V. vinifera* cultivars, costly protection of vines against frosts every year is a necessary condition for their survival and development in central Poland, where winters are usually frosty. Vine growing is more perspective in the south-west part of Poland, where winters are relatively mild.

CONCLUSIONS

1. The grape cultivation in central Poland is at present more successful than twenty years ago because of climate fluctuations, among which the most important is an increase of mean air temperature from May to September.
2. As a result of climate variation, plants' phenological stages occur earlier and the quality of grapes cultivated in central Poland is higher.
3. The vines of interspecific hybrids yielded better and were more tolerant to climate of central Poland than bushes of *V. vinifera* cultivars.

4. Growing of *V. vinifera* cultivars in central Poland is more and more effective and the main obstacle is little tolerance to winter frosts.
5. Apart from further climatic changes, a significant role in vineyard maintenance in the future of in Poland will play proper selection of cultivars, agrotechnical practices and protection against pests and diseases.

REFERENCES

Caprio J.M., Quamme H.A. 2002. Weather conditions associated with grape production in the Okanagan Valley of British Columbia and potential impact of climate change. CAN. J. PLANT. SCI. 82: 755-763.

Jones G.V. 2005. Climate change in the Western United States grape growing Region. ACTA HORTIC. 689: 41-59.

Lisek J., Smolarz K., Kostusiak A., Szpunar J. 1992/93. Ocena wartości produkcyjnej siedmiu odmian winorośli. PRACE NAUKOWE ISK ser. A, 31: 99-107.

Lisek J. 2005. Zdrowotność, plonowanie i rozmnażanie wybranych genotypów winorośli (*Vitis* Sp. L.) w warunkach Polski. Zesz. Nauk. Inst. Sadow. Kwiac., Monografie i Rozprawy, pp. 63-70.

Lisek J. 2007. Frost damage of grapevine in Poland following the winter of 2005/2006. FOLIA HORT. 19(2): 69-78.

Plocher T.A., Parke R.J. 2001. Northern Winework. Eau Claire Printing Co., Minnesota, pp. 1-6.

Schultz H.R. 2000. Climate change and viticulture: a European perspective on climatology, carbon dioxide, and UV-B effects. AUSTRAL. J. GRAPE WINE RES. 6: 2-12.

Selley R.C. 2008. The Winelands of Britain: past, present and prospective. Petravin, Dorking, Surrey, pp. 102-115.

CZYNNIKI KLIMATYCZNE DECYDUJĄCE O ROZWOJU I PLONOWANIU WINOROŚLI W CENTRALNEJ POLSCE

Jerzy Lisek

STRESZCZENIE

Najważniejszym czynnikiem ograniczającym rozwój winnic w centralnej Polsce jest klimat. Zagrożenie stanowią:

- minimalne temperatury zimowe poniżej -30°C (notowane przynajmniej raz na 10 lat);
- przymrozki wiosenne;
- wahania pogodowe, związane z temperaturą nieodpowiednią dla winorośli oraz nieregularnym występowaniem opadów atmosferycznych.

Najbardziej istotną i sprzyjającą winorośli zmianą klimatu, widoczną w ciągu ostatnich kilkudziesięciu lat jest wzrost średniej temperatury powietrza w okresie wegetacji roślin, wyrażanej jako suma temperatur aktywnych (SAT), na którą składają się średnie dobowe temperatury powyżej 10^{o}C. Wieloletnia średnia SAT dla Skierniewic (centralna Polska), w latach 1981-2000, wynosiła niespełna 2500^{o}C. W roku 2003 STA przekroczyła 2700^{o}C, a w rekordowo ciepłym roku 2006 wynosiła aż 2900^{o}C.

Zestawienie wyników z plonowania winorośli w kolekcji odmian oraz w Doświadczeniach odmianowo-porównawczych z lat 1986-2007 świadczy, że anomalie klimatyczne związane z okresowym ociepleniem sprzyjają rozwojowi uprawy winorośli w centralnej Polsce. Średni termin rozpoczęcia faz fenologicznych, takich jak nabrzmiewanie pąków, kwitnienie i dojrzałość owoców krzewów 7 odmian winorośli (‘Perl of Csaba’, ‘Seneca’, ‘Aurora’, ‘Swenson Red’, ‘Edelweiss’, ‘Chasselas Dore’, ‘Steuben’) w latach 2005-2007 następował przeciętnie o 12 dni wcześniej niż w latach 1987-1989. Zawartość ekstraktu w owocach oraz masa gron i jagód porównywanych 7 odmian była w okresie 2005-2007 większa niż w latach 80. ubiegłego wieku.

Wahania klimatyczne, a przede wszystkim wzrost temperatury w okresie wegetacyjnym niosą ze sobą w ostatnich kilku latach nowe zagadnienia związane z ochroną roślin przed organizmami szkodliwymi oraz ich reakcją na niekorzystne czynniki środowiskowe. Do najważniejszych problemów należą coraz powszechniejsze porażenie krzewów przez grzyby: *Unicunula necator*, będącego sprawcą mączniaka prawdziwego i *Phomopsis viticola* – sprawcę nekrozy korowej winorośli oraz pojawienie się skoczka winoroślowego (*Empoasca vitis*) nie notowanego wcześniej w Polsce. Zupełnie nowe zagrożenie w naszym kraju, stanowią uszkodzenia słoneczne liści i owoców winorośli powodowane przez promieniowanie cieplne (podczerwone) oraz ultrafioletowe.

Opracowanie technologii uprawy winorośli odpowiednich do polskich warunków wymaga kompleksowych badań uwzględniających związki pomiędzy genotypem, środowiskiem i praktykami agrotechnicznymi.

Słowa kluczowe: winorośl, odmiany, klimat, fenologia