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Assesment of climatic conditions for *Actinidia arguta* cultivation in north-eastern Poland

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Abstract

This study analysed the effects of weather conditions on the growth and yield of five cultivars of *Actinidia arguta*, also called hardy kiwifruit, kiwiberry cultivated during 2005–2014 in the Experimental Garden of the University of Warmia and Mazury in Olsztyn, north-eastern Poland. The following cultivars were studied: ‘Figurnaja’, ‘Kijevskaja Gibrydnaja’, ‘Kijevskaja Krupnoplodnaja’, ‘Purpurovaja Sadovaja’ and ‘Sientiabrskaja’. For each cultivar, the following were determined: yielding and the beginning dates of the following phenophases: bud-swelling, flowering, fruit setting, fruit maturity and the plant growth stages. For the phenophases, the following values were calculated: mean daily temperature (°C), sum of effective temperatures (>5°C and >10°C) and sum of precipitation (mm). Individual phenophases of the analysed cultivars of hardy kiwifruit started in a given year almost on the same dates and demonstrated high year-on-year variety. The largest differences (in four weeks) between the extreme dates were recorded for the fruit maturity of the *Actinidia arguta*. The differences between the extreme dates of other phases averaged two weeks. Simulated data satisfying the assumptions of the assumed climate change scenarios (GISS model E) were used in order to obtain information about future climatic conditions in which kiwiberry could be cultivated in the region of north-eastern Poland. Using the weather generator WGENK, 300 probable variants of weather sequences were generated in annual periods, which made it possible to examine the probable diversity of future weather conditions. Comparative characteristics of climatic indicators determined on the basis of the data from the 2005–2014 years and the generated data demonstrated that the climatic conditions of the area of north-eastern Poland could be subject to significant change, particularly in thermal resources. Spring frosts, which in the future could be more intense and could emerge much later than now, continue to pose an element of risk related to *Actinidia arguta* cultivation.

Key words: *Actinidia arguta*, phenophases, precipitation, temperature, yielding.

Introduction

Due to climatic conditions, the range of species that can be introduced to commercial cultivation in the countries of north-eastern Europe is limited. Producers in those regions are interested in growing plants that are resistant to frost and spring ground frosts. The species with fruits containing many bioactive substances are particularly highly valued. Consumers prefer tasty, natural food produced in an unpolluted environment (Bieniek, 2013). Plants satisfying such criteria include oriental species, especially hardy kiwifruit (*Actinidia arguta* (Siebold et Zucc.) Planch. ex. Miq.) and super hardy kiwifruit (*Actinidia kolomikta* Maxim.) (Leontowicz et al., 2016). In Lithuania, the cultivation of *Actinidia kolomikta* (Pranckietis et al., 2009; Česonienė et al., 2013; Paulauskienė et al., 2015) is developing intensively, while in Poland in recent years, the production of *Actinidia arguta* has been rapidly expanding (Kawecki, Bieniek, 2008; Latocha, 2008; 2010; Bieniek, 2013). As results from the research and field experiments concerning morphological, physiological and phenological features in the conditions of growth, pollination, cultivation and storage of hardy kiwifruit carried out so far in Europe, this plant has good prospects for development (Cossio et al., 2015).

Kiwiberry is a relatively young orchard plant. Depending on the country, the fruits are offered under the name of mini-kiwi, kiwiberry, hardy kiwifruit or kiwai. They are popular because of their taste and health-promoting properties. They contain significant amounts of flavonoids which have health-promoting effects (Krupa et al., 2011). Studies of the content of mineral composition of fruits of *Actinidia arguta* showed that they are a rich source of K, Fe, Cu and Mg (Bieniek, 2012 b; Bieniek, Dragańska, 2013; Latocha et al., 2015). The chemical composition of fruit depends not only on the cultivar, but also on the geographical and climatic conditions, as well as on the cultivation methods (Leontowicz et al., 2016). It was found in preliminary observations that cultivars bred in Ukraine and in Russia on the basis of those species provide the possibility of producing fruits that are not inferior in terms of quality to those obtained from *Actinidia deliciosa* (kiwifruit). They can be eaten raw, dried or canned. They can also be used in herbal medicine. Consumers highly appreciate the taste of the hardy kiwifruits and producers can grow these vines in an environmentally-friendly way (Latocha, 2010; Bieniek, 2013).

Commercial production of these species can be an interesting alternative for producers, provided that the plant yields well. The cultivars recommended for growing in plantations should demonstrate a high productivity factor and frost resistance, as well as produce relatively attractive, large and tasty fruit for many years (Bieniek, 2012 a). At present, there are dozens of kiwiberry cultivars known in the world. Some of the examined Ukrainian cultivars ('Kijevskaja Krupnoplodnaja', 'Purpurovaja Sadovaja' and 'Sientiabrskaja') are also cultivated in central Poland but more extensive research is necessary before they can be recommended for commercial cultivation.

In developing a method for cultivation of those species, knowledge of their seasonal development in specific climatic conditions is of significant importance (Skripczenko, Moroz, 2002; Latocha, 2010; Bieniek, 2013). Climate changes are of a global nature and in various ways affect (and will affect in the future) plant production in different parts of the world. Currently, various models specifying the scenarios of climate change are applied, usually based on global climatic models simulations with reference to CO_2 emission scenarios, describing different social and economic futures (Christensen, Christensen, 2007; Christensen et al., 2007; Climate Change, 2007).

The aim of the study was to determine the effect of weather conditions on the development and yielding of kiwiberry – *Actinidia arguta* (Siebold et Zucc.) Planch. ex Miq., *Actinidia arguta* var. *purpurea* (Rehd.) C. F. Liang) and their hybrid cultivars grown in north-eastern Poland in 2005–2014.

Materials and methods

The research was conducted in 2005–2014 on five cultivars of kiwiberry (*Actinidia arguta* (Siebold et Zucc.) Planch. ex. Miq., *Actinidia arguta* var. *purpurea* (Rehd.) C. F. Liang) and their hybrids bred in Ukraine and grown in the Experimental Garden of the University of Warmia and Mazury in Olsztyn, north-eastern Poland (latitude: 53°50′ N, 20°31′ E). The tested cultivars included 'Figurnaja', 'Kijevskaja Gibrydnaja', 'Kijevskaja Krupnoplodnaja', 'Purpurovaja Sadovaja' and 'Sientiabrskaja'. Five vines of the cv. 'Weiki' were used as pollinators for those cultivars. In the autumn of 1996, annual plants of these cultivars were planted in two rows, spaced at 1.5 × 2 m, in five replications, and each plant constituted a replication. Vines were planted at A-shaped metal support structures. The supports were 4 m high. The plants were grown on typical loamy sand through the entire profile, classified as *Haplic Cambisol* (*Eutric*) according to WRB (2014). Soil pH ranged from 6.2 to 6.8 and the soil was characterized by a medium content of nutrients.

In the experimental years, a 10-cm thick bedding of bark of coniferous trees was spread around the plants. From the establishment of the experiment until the end of 2014, the plants did not require fertilization or chemical protection against diseases and pests or additional irrigation.

Detailed observations of plants of each cultivar carried out every year during their vegetation period in 2005–2014 concerned the yielding and the dates when the following phenophases occurred: 1) bud-swelling, 2) beginning of flowering, 3) fruit setting and 4) fruit maturity.

On this basis, the earliest, latest and average dates of the occurrence of phenophases were determined along with the number of days of individual development periods: bud-swelling–beginning of flowering (1–2), beginning of flowering–fruit setting (2–3), fruit setting–fruit maturity (3–4) and bud-swelling–fruit maturity (1–4). The characteristics of weather conditions prevailing in 2005–2014 were based on daily meteorological data originating from the station of the Institute of Meteorology and Water Management in Olsztyn, Poland. The following values were determined for the established development periods of A*ctinidia arguta*: average daily temperature (°C), sum of effective temperatures (>5°C and >10°C) and sum of precipitation (mm).

In determining potential climate change, the GISS (Goddard Institute for Space Studies) scenario model E for Central Europe was adopted. This scenario assumed an increase in the air temperature of 2.8°C per year, 3.2°C in the winter period and by 2°C in summer period, and a 10% increase of the annual sum of precipitation, maintaining the current level during the summer period. The assumptions of the scenario were defined for the conditions of a doubling of CO_2 concentration in the atmosphere (Kuchar, 2004; Christensen et al., 2007; Ruosteenoja et al., 2007).

Simulated data satisfying the assumptions of the adopted climate change scenarios were used to obtain information about future climatic conditions in which *Actinidia arguta* could be cultivated near Olsztyn. Using the weather generator WGENK (Kuchar, 2004; 2005), 300 probable variants of weather sequences were generated in annual periods, which made it possible to analyse the possible diversity of future weather conditions. In the applied model, data generation consisted of creating sequences of daily observations of total radiation, minimum and maximum temperatures and precipitation consistent with the climatic characteristics of the location for which the data were generated.

Statistical analysis. The data was processed using computer software *STATISTICA 7* (Hill, Levicki, 2005).

Results and discussion

The area of north-eastern Poland is regarded as the least favourable in terms of agroclimatic conditions. Thermal resources constitute less than 90% of the average resources in Poland with high variability of effective sums of temperature exceeding the threshold of 5°C (Żmudzka, 2012). The mean annual air temperature in 1981–2010 was 7.6°C. The vegetation period starts, on average, on 9 April and ends on 3 November and its average duration is 208 days. The average date when the active growth of plants begins is 30 April and the end date is 4 October (average duration is 157 days). The unfavourable phenomena in this region include late spring frosts, particularly ground frosts – which are observed even in mid-June (Suchecki et al., 2011). The average annual air temperature in the period of research covering the years 2005–2014 was higher than the multi-year average and amounted to 8°C. In the spring of 2007 and 2014, intensive ground frosts occurring in May (−5.9°C and −7.9°C, respectively) severely damaged young shoots, leaves and flower buds and resulted in no yield. Since scarce fruit appeared only on shoots of the cvs. 'Purpurovaja Sadovaja' and 'Kijevskaja Gibrydnaja', it can be assumed that these cultivars are most resistant to spring frosts (Kawecki, Bieniek, 2008). Under the climatic conditions of Lithuania, Pranckietis et al. (2009) and Česonienė et al. (2013) found that the main critical factor in *A. arguta* cultivation was subzero temperatures occurring in May. In a study on *A. kolomikta* cultivars, Česonienė et al. (2013) found that they were characterized by various resistance to late spring frosts, as well as by various intensity of regeneration, which depended on the genotype.

Under conditions of north-eastern Poland, the individual phenophases of the analysed cultivars of hardy and kiwifruit and their hybrids in a given year started almost on the same dates, although they demonstrated a high year-on-year diversity in this regard (Table 1). Bud-swelling was recorded on average on the first days of May: for cvs. 'Figurnaja', 'Purpurovaja Sadovaja' and 'Sientiabrskaja' on 3 May, and for cvs. 'Kijevskaja Gibrydnaja' 'Kijevskaja Krupnoplodnaja' on 4 May. These phenophases occurred one month later than under the conditions in Ukraine. Skripczenko and Moroz (2002) demonstrated that in the conditions of Ukraine, *A. arguta* started vegetation (sap rising) from 23 March to 2 April. Bud-swelling occurred almost one month earlier than under the conditions of north-eastern Poland, i.e. on 4–6 April, the beginning of blossoming occurred between 3 and 6 June, and the beginning of fruit ripening was between 28 August and 4 September. A large diversity was also observed as regards the dates of beginning of phenophases in the territory of Poland. Marosz (2009) presented data for cvs. 'Issai', 'Jumbo' and 'Kens Red', for which under the conditions of central Poland, the earliest bud bursting occurred on 11 March, while in the experiment presented in this study, the earliest date of beginning of that phenophase was recorded on 24 April (Table 1). Unfortunately, there are no experiments comparing the same cultivars of *Actinidia*.

Table 1. Average and extreme dates of the beginning of phenophases of the examined cultivars of *Actinidia arguta* grown in north-eastern Poland in 2005–2014

Phenophase	Date of beginning	Cultivar				
		'Figurnaja'	'Kijevskaja Gibrydnaja'	'Kijevskaja Krupnoplodnaja'	'Purpurovaja Sadovaja'	'Sientiabrskaja'
Bud-swelling	average	03.05	04.05	04.05	03.05	03.05
	earliest	24.04	24.04	26.04	24.04	24.04
	latest	10.05	10.05	10.05	10.05	10.05
Beginning of flowering	average	10.06	10.06	11.06	09.06	10.06
	earliest	04.06	04.06	05.06	04.06	04.06
	latest	18.06	18.06	18.06	16.06	18.06
Fruit setting	average	06.07	07.07	08.07	06.07	06.07
	earliest	27.06	27.06	30.06	27.06	27.06
	latest	11.07	11.07	13.07	11.07	11.07
Fruit maturity	average	26.09	27.09	30.09	23.09	23.09
	earliest	14.09	16.09	21.09	14.09	14.09
	latest	07.10	07.10	10.10	03.10	03.10

The largest differences between the extreme dates of beginning of a specific phenophase were observed for fruit maturity The earliest fruit maturity was noted on 14 September, while the latest was almost four weeks later. The differences between the occurrences of extreme dates of other phases amounted, on average, to two weeks (Table 1).

Similar dates of the beginning of phenophases caused that durations of separate periods were at a similar level in all cultivars under analysis (Table 2). The average duration of the period from the beginning of vegetation to the beginning of blossoming was 37–38 days, with a standard deviation of 10 and 8 days, respectively. The longest duration of this period was 52 days and the shortest was 25–30 days. The average duration of the period from the beginning of blossoming to fruit setting was 27 days with a deviation of 5 days. The average duration of the period from the beginning of vegetation to fruit harvesting was from 143 days for cv. 'Sientiabrskaja' to 149 days for cv. 'Kijevskaja Krupnoplodnaja'. The longest recorded duration of this period was 162 days for cv. 'Kijevskaja Krupnoplodnaja' in 2006, 158 days for cvs. 'Figurnaja', 'Purpurovaja Sadovaja' and 'Sientiabrskaja' and 156 days for cv. 'Kijevskaja Gibrydnaja' which was observed in 2005. According to Marosz (2009), the period of growth for *A. arguta* under the conditions of central Poland amounts to 198 days, and for *A. kolomikta* to 186 days. In Ukraine, the number of days from the beginning of vegetation to the beginning of fruit maturity for *A. kolomikta* is 144, for *A. arguta* – 151, for *A. purpurea* – 167 and for *A. polygama* – 156 days (Skripczenko, Moroz, 2002).

Because of the small differences in the dates of the beginning and in the duration of phenophases of *A. arguta*, the values of mean temperature, the sums of temperatures and precipitation in individual phenophases were characterized by low diversity (Table 3). Precipitation demonstrated a high variability in time. The highest variability of precipitation was recorded for the first two periods. From the beginning of vegetation to the beginning of blossoming, the variability of this element ranged at the level of almost 53%, while in the period from the beginning of blossoming to fruit setting it averaged 65%.

Table 2. Descriptive statistics of the durations of phenophases of the examined cultivars of *Actinidia arguta* grown in north-eastern Poland in 2005–2014

Phenophase	Number of days	Cultivar				
		'Figurnaja'	'Kijevskaja Gibrydnaja'	'Kijevskaja Krupnoplodnaja'	'Purpurovaja Sadovaja'	'Sientiabrskaja'
Bud-swelling–beginning of flowering (1–2)	average	38	37	38	37	38
	max	52	52	52	52	52
	min	26	26	30	26	26
	SD	10	9	8	9	9
	CV	25	25	21	25	25
Beginning of flowering–fruit setting (2–3)	average	26	27	27	27	26
	max	33	32	33	32	32
	min	18	20	20	20	20
	SD	5	5	5	5	5
	CV	20	17	20	18	17
Fruit setting–fruit maturity (3–4)	average	82	82	84	80	79
	max	93	94	95	90	90
	min	72	71	72	71	71
	SD	8	8	10	7	6
	CV	10	10	11	9	8
Bud-swelling–fruit maturity (1–4)	average	146	146	149	144	143
	max	158	156	162	158	158
	min	137	133	136	133	133
	SD	8	8	9	8	8
	CV	5	6	6	5	5

SD – standard deviation, CV – coefficient of variation

Table 3. Characteristics of thermal and precipitation conditions in individual phenophases of the examined cultivars of *Actinidia arguta* grown in north-eastern Poland in 2005–2014

Phenophase	Descriptive statistics	Average daily temperature °C	Sum of effective temperatures		Sum of precipitation mm
			>5°C	>10°C	
Bud-swelling–beginning of flowering (1–2)	average	13.6	330.4	142.5	84.7
	max	16.5	487.8	227.8	168.6
	min	12.2	225.0	68.8	6.7
	SD	1.4	86.5	58.6	44.5
	CV	10.0	26.0	41	52.6
Beginning of flowering–fruit setting (2–3)	average	17.2	325.9	189.7	73.1
	max	18.3	420.2	261.0	175.9
	min	15.8	213.9	68.9	7.8
	SD	0.7	68.0	48.3	47.9
	CV	4.0	20.9	25.0	65.5
Fruit setting –fruit maturity (3–4)	average	16.8	970.7	557.8	195.5
	max	18.5	1154.6	679.6	264.1
	min	15.1	896.4	462.8	121.0
	SD	0.8	55.0	40.3	48.7
	CV	5.0	5.4	7.0	25.0
Bud-swelling–fruit maturity (1–4)	average	16.1	1618.0	890.0	353.2
	max	18.4	1839.0	1029.0	474.4
	min	14.8	1454.0	694.0	198.1
	SD	0.6	72.1	68.3	84.8
	CV	3.8	4.5	8.0	24.0

SD – standard deviation, CV – coefficient of variation

Skripczenko and Moroz (2002) demonstrated that each cultivar of *A. arguta* under conditions of Ukraine had its own seasonal rhythm. Česonienė et al. (2013), analysing the seasonal development of *A. kolomikta*, found that the rhythm of growth and development during the vegetation period corresponded to the climatic conditions in Lithuania. However, the research concerning the climatic conditions of *A. arguta* cultivars is very inadequate. Skripczenko and Moroz (2002) characterized the phenophases of several species of *A. arguta* under the conditions of Ukraine on the basis of sums of effective temperatures. The researchers found that the sums of effective temperatures above 5°C from sap rising to the beginning of blossoming for *A. arguta* were 543°C, for *A. purpurea* – 524°C, for *A. kolomikta* – only 377°C and for *A. polygama* – 710°C. In the period from the beginning of vegetation to the beginning of fruit maturity, this sum amounted to 1350°C for *A. kolomikta*, to 1809°C for *A. arguta*, to 1953°C for *A. purpurea* and to 1969°C for *A. polygama*. Under conditions of the experiment conducted in Olsztyn, the sum of effective temperatures in the phenophase from bud-swelling to the beginning of blossoming for the examined cultivars of *A. arguta* averaged 225°C, over the entire period of development to 1618°C.

The analyzed cultivars of *A. arguta* yielded at very different levels. The mean yield ranged from 0.62 to 8.8 kg per plant (Table 4). The highest yield (with the lowest coefficient of variance in the study) was recorded for the cv. 'Purpurovaja Sadovaja'. The lowest productivity and a higher coefficient of yielding variability (amounting to 160%) were recorded for the cv. 'Sientiabrskaja'. The present study confirmed the yielding stability of cv. 'Purpurovaja Sadovaja', and the lowest yielding and lower suitability for cultivation in the north – eastern region of Poland of the cv. 'Sientiabrskaja' reported by Bieniek (2012 a).

No statistically significant relationships were found between the yielding of *A. arguta* and thermal and precipitation conditions prevailing in identified developmental periods. The short period of the experiment and the high variability of weather conditions year-on-year most probably did not permit establishing clear relationships between the variables under analysis. Determination of those relations requires conducting further observations.

Highly differentiated data are provided as regards the yielding of *A. arguta*. According to Latocha (2010), high differentiation in yielding is conditioned by genetic features, as well as the method of plant management, i.e. plant spacing, type of the supportive structure and the pruning method. In the second year after planting, the plants can give the first moderate yield and they enter their full fructification period after 5–7 years. The above author, examining several cultivars and genotypes of hardy kiwifruit in Warsaw, Poland in 2007–2009, obtained the highest yield in the last year of research, amounting to 3.59–6.91 kg berries per plant. The data presented in literature (Latocha, 2010; Bieniek, 2013) suggest that vines planted on T-shaped structures give a yield that is several times higher than that of vines planted on A-shape structures. According to Latocha (2010), plants managed on the T-shape support are less exposed to ground frosts, their fruits are better protected against strong winds and burns caused by strong insolation and higher yields can be expected: 10–15 t per ha as compared to 8–10 t per ha from the lane. Cossio et al. (2015) indicate that the yield from plantations established on T-shaped structures amounts at least to 15–20 t per ha, and in New Zealand the recorded harvest was 30 t per ha.

Table 4. Average yield (kg plant^{-1}) of the examined cultivars of *Actinidia arguta* grown in north-eastern Poland in 2005–2014

Yield	Cultivar				
	'Figurnaja'	'Kijevskaja Gibrydnaja'	'Kijevskaja Krupnoplodnaja'	'Purpurovaja Sadovaja'	'Sientiabrskaja'
Average	6.35	5.14	4.06	8.80	0.62
max	11.00	13.00	9.67	14.67	2.67
min	1.95	1.04	1.00	2.83	0.01
SD	3.62	3.52	2.91	3.89	1.00
CV	57.1	68.5	71.7	44.1	160.4

SD – standard deviation, CV – coefficient of variation

The results obtained to date require further research and observations, particularly in the aspect of climate changes. Climate changes observed so far under conditions of Poland concern, first of all, a growing trend in air temperature. The research demonstrated that the mean annual air temperature in the 20th century increased by about 0.9°C, with a clear increase in the rate of those changes in the last twenty years of the 20th century and at the beginning of the 21st century (Żmudzka, 2009). These trends also concern the thermal conditions of north-eastern Poland. In 1966–2005, an increase in temperature was recorded at the average rate of 0.026°C per year (Suchecki et al., 2011). In 1966–1990, the rate of growth of the mean annual air temperature was 0.013°C per year, while in 1991–2005, it was as high as 0.044°C per year (Szwejkowski et al., 2009). An increase in temperature leads, in consequence, to an increase in thermal resources of the area (Juszczak et al., 2010). For precipitation, no clear change trends were found year-on-year, while a decrease in the value of sums of precipitation in the vegetation period was observed (Szwejkowski et al., 2009; Suchecki et al., 2011). Already observed and forecasted further climate changes allow us to presume that the agroclimatic conditions of the north-eastern area of Poland will be subject to a significant change. The generated data, which took into account the assumptions of the climate change scenario, demonstrate that the duration of the vegetation period and the period of active growth of plants can be prolonged, on average, by 20 days, starting 2–3 weeks earlier and ending about 2 weeks later than in 2005–2014, which in consequence, will lead to changes in thermal and precipitation conditions (Fig.).

Since previous observations demonstrated that the period from *A. arguta* bud-swelling to fruit maturity as close to the duration of the active growth period of plants, the weather conditions prevailing in the period of active growth of plants were considered to be representative for the period of *A. arguta* growth and development. Comparative characteristics of climatic indicators established on the basis of data from the years of the experiment and the generated data indicate that the climatic conditions of the north-eastern area of Poland are subject to significant changes, particularly in thermal resources. The sums of effective temperatures above 5°C

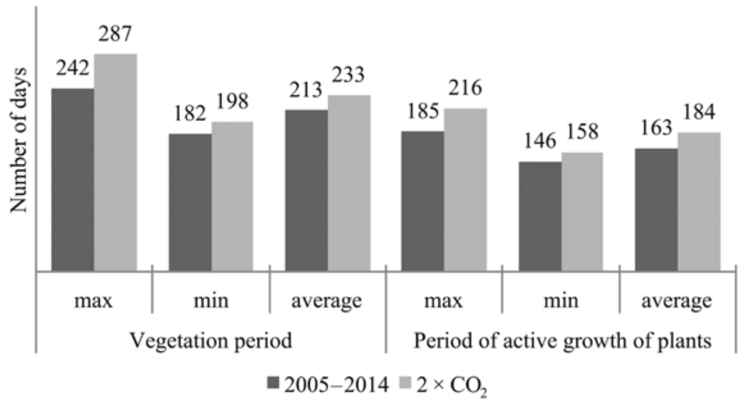

Figure. Duration of the period of vegetation (period with average daily temperature >5°C) and active growth of plants (period with average daily temperature >10°C) in north-eastern Poland in 2005–2014 and designated on the basis of data generated for the conditions 2 × CO_2

in the period of *A. arguta* growth in 2005–2014 ranged from 1454°C to 1839°C (the mean of 1617°C) while in the future they may range from 1720°C to 2175°C, which corresponds to the values currently recorded by Skripczenko and Moroz (2002) in Ukraine. Precipitation in the future may demonstrate higher variability than that recorded so far. According to the generated data, the lowest sums of precipitation in this period amount to only 175 mm. Spring frosts will continue to be an element of risk related to *A. arguta* cultivation and their significance in the future can even increase, since the predicted last spring frosts can be more intensive and can emerge much later than at present (Table 5).

Table 5. Selected climatic characteristics of the period of active growth of plants (period with average daily temperature >10°C) in north-eastern Poland in 2005–2014 and designated on the basis of data generated for the conditions 2 × CO_2

Period	Date of beginning		Date of end		Date of last spring frost	Sum of effective temperatures				Sum of precipitation mm	
						>5°C		>10°C			
	earliest	latest	earliest	latest		max	min	max	min	max	min
2005–2014	19.04	5.05	14.09	20.10	20.05	1835	1454	1029	694	460	212
2 × CO_2	22.03	2.05	28.09	6.11	4.06	2174	1720	1634	1013	512	175

Consideration of the effect of climate conditions on yielding and quality of fruit will gain particular importance as it will permit proper regionalization of the cultivation and choice of cultivars adapted to the diversified environmental conditions of the north-eastern European production space.

Conclusions

1. According to the annual observations of the phenophases of the *Actinidia arguta* in the vegetation periods of 2005–2014 under the conditions of north-eastern Poland, the bud-swelling phase started on 24 April – 10 May; the beginning of flowering phase on 4–18 June; the fruit setting phase on 27 June – 13 July, and the fruit maturity phase on 14 September – 10 October. The largest differences (in four weeks) between the extreme dates were recorded for the fruit maturity of the *A. arguta*. The average of the differences between the occurrences of the extreme dates of other phases was two weeks. The cultivar 'Kijevskaja Krupnoplodnaja' was clearly different from the others, and its above-mentioned phenophases began at the earliest time.

2. The mean yield of the examined cultivars of *A. arguta* in 2005–2014 ranged from 0.62 kg per plant for cv. 'Sientiabrskaja' up to 8.8 kg for the cv. 'Purpurovaja Sadovaja', which was characterized by the highest yielding stability over the examined period.

3. The sums of effective temperatures in the phenophases of *A. arguta* in 2005–2014 ranged from 1454°C to 1839°C, while in the future they may range from 1720°C to 2175°C, which corresponds to the values currently recorded in Ukraine. The forecasted frosts may be more intense and could occur much later than in the past, which is a significant element of risk related to the cultivation of varieties of *A. arguta* in the region of north-eastern Poland.

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Smailialapės aktinidijos augimo galimybės Šiaurės Rytų Lenkijos klimato sąlygomis

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Santrauka

Siekiant ištirti klimato sąlygų įtaką smailialapės aktinidijos (*Actinidia arguta* (Siebold et Zucc.) Planch. ex Miq.) augimui ir derėjimui, 2005–2014 m. buvo atliktas tyrimas Šiaurės Rytų Lenkijoje, Varmijos ir Mozūrijos universiteto eksperimentiniame sode. Tirtos šios veislės: ‘Figurnaja’, ‘Kijevskaja Gibrydnaja’, ‘Kijevskaja Krupnoplodnaja’, ‘Purpurovaja Sadovaja’ ir ‘Sientiabrskaja’. Kasmet buvo nustatomas derlius ir stebimas augalų augimas bei vystymasis – pumpurų brinkimas, žydėjimas, derliaus formavimasis. Atskiri vystymosi tarpsniai buvo siejami su vidutine paros temperatūra, efektyvių (>5°C) bei aktyvių (>10°C) temperatūrų sumomis ir kritulių kiekiu (mm). Daugiamečiai smailialapės aktinidijos įvairių veislių stebėjimai parodė, kad tais pačiais metais skirtingų veislių augalai vystosi beveik vienodai, tačiau labai skiriasi, lyginant atskirus metus. Stebint atskirus vystymosi tarpsnius, labiausiai (iki keturių savaičių) skyrėsi derliaus nuėmimo laikas, o kiti tarpsniai skirdavosi vidutiniškai maždaug dviem savaitėmis.
GISS modeliu E imituojant klimato kaitos scenarijus galima daryti prielaidą, kad ateityje smailialapes aktinidijas bus galima auginti Lenkijos Šiaurės Rytų regione. Duomenų generatoriumi WGENK buvo sukurta 300 įvairių galimų metinių tarpsnių orų kaitos variantų, kurie leido įvertinti galimą ateities orų įvairovę. Klimato indikatorių lyginamoji charakteristika ir daugiamečių tyrimų duomenys rodo, kad Šiaurės Rytų Lenkijos klimatas gali esmingai keistis, ypač temperatūrinis režimas. Ateityje pavasarinės šalnos gali būti vėlyvesnės bei intensyvesnės ir kelti didesnę smailialapių aktinidijų auginimo riziką.

Reikšminiai žodžiai: *Actinidia arguta*, derėjimas, krituliai, tarpsniai, temperatūra.

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