

**THE GENESIS AND CURRENT STATE  
OF *ACTINIDIA* COLLECTION IN M.M. GRISHKO  
NATIONAL BOTANICAL GARDEN IN UKRAINE**

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**Key words:** kiwiberry, kiwifruit, mini kiwi, selection, morphology, yield.

**Abstract**

The genus *Actinidia* was established by LINDLEY in 1836. The most recent systematic revision of *Actinidia* distinguish about 54 different species 52 of which occur naturally in China (44 of it are endemic). Recently *Actinidia* fruit has become famous for its nutritious, especially high content of vitamin C, and is evaluated as a healthy fruit. The results from the introduction of *Actinidia* species in M. M. Grishko National Botanical Garden of National Academy of Sciences of Ukraine (Kiev) are presented. These collections of *Actinidia* are the largest in Ukraine and includes 6 species and over 300 different cultivars and forms. This collection provides valuable material for further selective work with *Actinidia* in Forest-Steppe of Ukraine. The most promising for hybridization are *Actinidia arguta* and *A. arguta* var. *purpurea*. The result of the selection work are at least 15 cultivars established and registered in Ukraine. This paper describe the history and current status of kiwiberry selection work made in Botaical Garden in Kiev, Ukraine.

**HISTORIA I STAN OBECNY KOLEKCJI AKTINIDII  
W NARODOWYM OGRODZIE BOTANICZNYM IM. M.M. GRISZKO NA UKRAINIE**

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## A b s t r a k t

Rodzaj aktinidia utworzył LINDLEY w 1836 roku. Według najnowszej rewizji rodzaju wyróżnia się około 54 gatunki, z czego 52 naturalnie występują w Chinach (z tego 44 są endemitami). W ostatnim czasie owoce aktinidii stały się bardzo popularne z powodu swoich dużych wartości odżywczych, głównie wysokiej zawartości witaminy C i są uważane za owoce zdrowia.

W pracy przedstawiono wyniki introdukcji aktinidii do Narodowego Ogrodu Botanicznego im. M.M. Griszko w Kijowie na Ukrainie. Znajdująca się tu kolekcja aktinidii jest największą na Ukrainie i liczy 6 gatunków oraz ponad 300 odmian i form. Zbiór ten stanowi cenny materiał do dalszej pracy hodowlanej aktinidii na leśno-stepowym obszarze Ukrainy. Najbardziej obiecujące dla hybrydyzacji są *Actinidia arguta* i *A. arguta* var. *purpurea*. Efektem prac selekcyjnych jest ponad 15 odmian, które zarejestrowano na Ukrainie. W artykule przedstawiono historię i stan obecny prac hodowlanych prowadzonych w Narodowym Ogrodzie Botanicznym UAN w Kijowie na Ukrainie.

## Introduction

The intensive introduction into the culture of new uncommon plants is related with the increasing demand for medical-dietary qualities in gardening products, because many of the uncommon fruit and berry plants contains an abundant amount of biologically active substances. Additionally, these plants possess a high level of resistance to pests and diseases; they practically needn't chemical protection. One of these uncommon genus is *Actinidia* Lindl. It is a relatively new crop. Its commercial cultivation dates back to last century and is associated mainly with *A. deliciosa* and *A. chinensis*, which is more commonly known as kiwifruit. Nowadays, kiwiberry (*Actinidia arguta*) is a new product on the market with growing worldwide consumer acceptance. *A. arguta* in contrast to kiwifruit are small grape-sized fruit, with thin, edible predominantly green skin. The fruit have high sensory quality, is very aromatic with a sweet, intense flavour that has been compared to blackcurrant, pineapple, ripe strawberry, pear, banana, melon and other tropical flavours and is highly accepted by the consumers (LATOCHA and JANKOWSKI 2011, LATOCHA et al. 2011). Its great advantage is not only pleasant taste but also rich chemical composition having significant antioxidant activity (LATOCHA et al. 2010, BIENIEK 2012a, LATOCHA et al. 2013). Currently, kiwiberry is treated as one of the most nutrient dense fruit and are usually referred to as "healthy fruit". A great kiwiberry advantage is its delicate, edible skin containing up to 15 times more antioxidants than fruit pulp (KIM et al. 2009, LATOCHA et al. 2015). This paper describe the history and current status of kiwiberry selection work made in Botanical Garden in Kiev, Ukraine.

## Systematics of the genus *Actinidia*

The genus *Actinidia* was established by LINDLEY (1836) based on the specimens WALLICH no. 6634 collected from Nepal in 1821. Taxonomy of the genus *Actinidia* was firstly proposed by GILG (1893). The author distinguished only eight species and based on inflorescences has divided it into two groups, *Monanthae* (with solitary flower) and *Pleianthae* (with cymes). The first comprehensive taxonomic revision of the genus was published in 1911 by DUNN (1911). He recognized 24 species and almost 40 varieties and forms worldwide and established four sections *Vestitae*, *Maculate*, *Ampulliferae* and *Leiocarpae* based mainly on the shape of the ovary and the degree of pubescence. The next major revision made by LI (1952) listed 36 species and 14 varieties. Based on the structure of leaf hairs he divided the section *Vestitatae* into two sections *Stellatae* (with stellate hairs) and *Strigosae* (with simple hairs). The section *Ampulliferae* was merged into section *Leiocarpae*. The revision by LIANG (1984) significantly increased the number of taxa to a total of 51 species and 35 varieties and six forms. Many of them were found in China. One of the most important taxonomical changes was including *A. purpurea* into *A. arguta* variability (as varieties of *A. arguta*) based on fruit colour and leaf serration. Finally, the last systematic revision made by LI et al. (2007) distinguish 54 species and 21 varieties (52 of which occur naturally in China and 44 are endemic). He concluded that fruit colour of *A. arguta* var. *purpurea* is not consistently correlated with leaf serration and is not useful as diagnostic feature. The variety was therefore merged with *A. arguta* var. *arguta*. Regardless of these systematic revisions some authors described different number of *Actinidia* species. SENETA (1991) mention 30–40 species, SENETA and DOLATOWSKI (2012) – about 40 species, HUANG et al. (2003) – 66 species and 118 taxa and FERGUSON and HUANG (2007) describe 76 species and 125 taxa. As genus *Actinidia* is very diverse and many natural hybrids occur, the list of species will probably change many times.

Some *Actinidia* species are successfully cultivated in M.M. Grishko National Botanical Garden (NBG) of National Academy of Sciences of Ukraine. The garden, located in Kyiv (N 50°27'; E 30°31'), has one of the largest scientific and practical Ukrainian centers for the introduction and acclimatization of uncommon fruit species, selection and spreading of new cultivars, which may be successfully cultivated on commercial plantations and private gardens as well. The most attention is paid to frost resistance species such as *A. arguta* and *A. kolomikta*.

## Botanical garden environmental characteristics

The botanical garden is located on the border of two climatic zones – the wooded district and forest-steppe in the southeastern part of the city on the slopes of Pechersk hills near Dnipro river. The main type of soil is dark-gray podzolic. Due to the crossing of locality, the soil is rather washed-out and characterized by low humus content. The climate of the area is moderately continental with an average annual temperature of 7.6°C; the average temperature in January is -5.5°C and in June 20.4°C. The winter in Kyiv is softened by periodic changes of Atlantic air masses. The frost-free period in Kyiv is 165–180 days on average. According to long-term data the sum of active temperatures in Kiev is 2000–2500°C. The average annual amount of precipitation in Kyiv is 550–650 mm, relative humidity is 73–76%. The duration of frost free period, the temperature conditions, rainfall during the active growing season create suitable possibilities for successful cultivation of different fruit plants from regions with similar and sometimes more mild climate conditions. The whole collection of the Department of Fruit Plants Acclimatization of NBG has more than 150 species and 2000 cultivars. Among them an exclusive place belongs to the genus *Actinidia* (KLIMENKO and SKRYPCHENKO 2013).

## Description of *Actinidia* species and cultivars from the collection

In Ukraine, the introductory work with *Actinidia* species was initiated by academician N. Kaschenko in Acclimatization Garden (Kyiv) in the 20s and 30s of the 20<sup>th</sup> century. His investigations with *A. kolomikta* and *A. arguta* demonstrated the possibility of its cultivation under climatic conditions of forest-steppe of Ukraine (SHAJTAN et al. 1983). In NBG the first seedlings of *A. kolomikta*, *A. arguta* and *A. polygama* were obtained by researcher Y. HOTSYSK from seeds collected during an expedition to Far East of Russia in 1949 (HOTSYSK 1955), which were later transferred to the geographical area 'Far East' in the Garden. Systematic creation of collection and selection work of *Actinidia* was carried out by well-known breeders I. SHAITAN and R. KLEYEVA since 1958 (SHAJTAN et al. 1983). Now the NBG collection of *Actinidia* is the largest in Ukraine – it includes 6 species and over 300 different forms and cultivars of *Actinidia* (SKRYPCHENKO and MOROZ 2002, KLIMENKO and SKRYPCHENKO 2013, SKRYPCHENKO 2016). The collection is constantly supplemented through exchanges with various botanical institutions and through breeding work focused on creating high-performance cultivars, which are adapted to the conditions of forest-steppe of Ukraine. The principal



*Actinidia* species with which we work with in Kyiv are described below (SKRYPCHENKO and MOROZ 2002, KLIMENKO and SKRYPCHENKO 2013).

*Actinidia kolomikta* (Rupr et Maxim.) Maxim. (Figure 1). The length of the vines in nature reaches (if supported) 15 m. Annual wooden shoots are smooth, reddish-chestnut in color with numerous white lenticels of elliptical oblong shape. Leaves have rounded-elliptical or ovoid form with linearly-lanceting tip and reddish hair on the veins. The upper leaf surface is green, matt, but the reverse side is lighter. During the growing season some of the leaves change colour several times – the whitening of the tip of the leaf or the whole leaf is observed during leaf formation; 8–15 days later (before flowering period) the leaves become partially crimson. After flowering leaf colour fades but is preserved till the end of vegetation. Some leaves remain green without colour changes. This phenomenon is most prevalent in male plants, which are located under direct sunlight.



Fig. 1. *Actinidia kolomikta*: a – female flower; b – bud; c – fruit

*A. kolomikta* flowers are white with wide ovoid petals and have a strong odour. The male flowers mainly are in inflorescences (up to three) and have up to 30 stamens per one flower with a rather large yellow anthers. Female flowers are mainly alone, the diameter of flower is up to 2 cm. There is a large flower ovary in the center, which is surrounded by stamens. *A. kolomikta* fruits are oblong elliptical and have emerald green smooth surface. The beginning of fruit ripening season occurs in Kyiv in the second half of July. Ripe berries weigh about 3–5 g, are soft and sweet with pineapple flavour. The ripening is not simultaneous and ripe fruit fall off, but peduncles remain on the shoots for a long time.

*Actinidia arguta* (Siebold et Zucc.) Planch. ex Miq. (Figure 2). The seeds of *A. arguta* were obtained from China (Beijing) in 1958. In native location *A. arguta* is a liana, climbings up to 25 m. The shoots are mainly gray-brown with large number of longitudinal small lenticels. The buds are fully covered by

stem bark. Leaves have elongated-ovoid or elliptical form up to 15 cm in length and up to 10 cm in width. The leaf is dark green, leathery with light veins. The flowers are about 2–2.5 cm in diameter, white to light cream colored with gray anthers and a slight odour; the male flowers are gathered to 5–10 in an inflorescence, but the female ones are usually singlet or triplet (seldom up to 7). Petals are ovoid, sepals are light green.

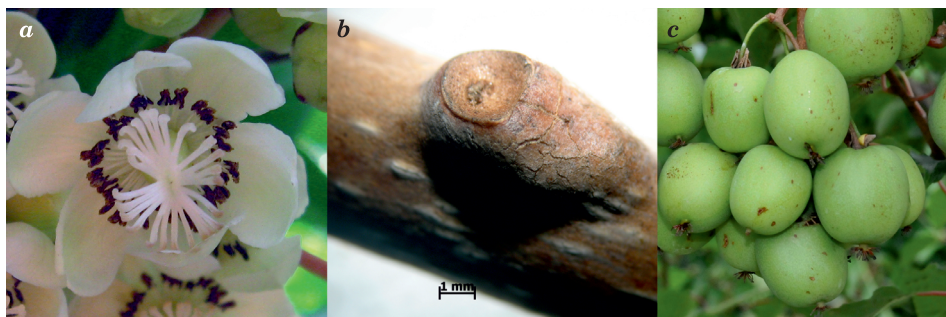


Fig. 2. *Actinidia arguta*: a – female flower; b – bud; c – fruit

Fruits of *A. arguta* are elliptical, almost spherical or elongated, with weight of 5–20 g. The berries are sweet and sour, with a specific delicate aroma. Their surface is smooth, dark or light green with or without blush. Berries begins to ripen in the Garden at mid-September. Ripe berries do not fall off and remain on stems until the first frost.

*A. arguta* var. *purpurea* (Rehder) C.F. Liang ex Q.Q. Chang (Figure 3). According to most recent taxonomy revision (LI et al. 2007) this variety is included in the variability of the *A. arguta* but for a long time it was considered a separate species. Seeds of this *Actinidia* were obtained from Beijing in 1958. This is a vigorous vine with shoots covered by numerous brown lenticels and leaves more elongated than in most *A. arguta* – with crimson petioles 3–5 cm in length. Flowers are white 2–2.5 cm in diameter, with five-six petals, on long thin peduncles, in female plants mostly two-three in a inflorescence. The male flowers are up to ten in inflorescence. The oblong-cylindrical, dark purple berries weigh 6–12 g. They ripen in Kyiv by the end of September or by the beginning of October and do not fall off after ripening. The last two species were used to produce many highly productive *Actinidia* hybrid cultivars, selected in NBG.

*Actinidia polygama* (Siebold et Zucc.) – Figure 4. As noted above, *A. polygama* was introduced to Ukraine in 1949 from seeds collected by an expedition to the Far East of Russia (Primorsky Krai). *A. polygama* is a liana growing up to 6 m. The bark on its stems is dark brown with furrow-like white

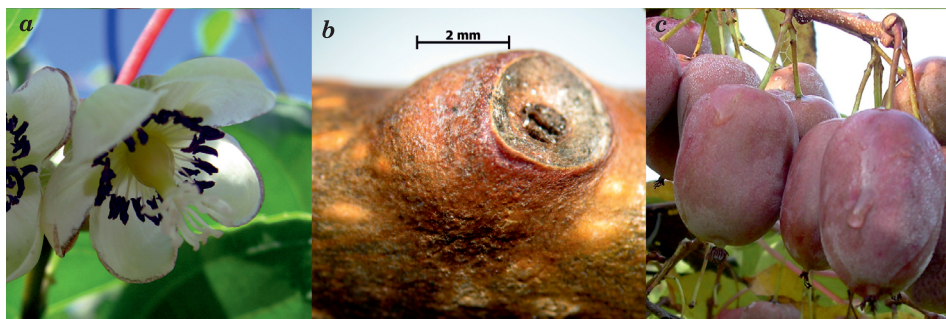


Fig. 3. *A. arguta* var. *purpurea*: a – female flower; b – bud; c – fruit

lenticels. The stem core is solid, unlike the previous species. The buds are not fully covered by stem bark, with apices well visible at the bases of petioles. The leaves are alternate, broadly ovate to oblong-elliptical, with light green petioles. During leaf formation, some leaves change color to silvery white, sometimes remaining till the end of the summer. The flowers of *A. polygama* are white with a strong pleasant odour. Flowers are 2–3 cm in diameter. The male flowers are a bit larger than female. Fruits of *A. polygama* are orange, matte and smooth with oblong lighter streaks. The shape is cylindrical with thin tips; sepals remain until the full fruit maturation. Fruits ripen in the first decade of September and taste like hot or sweet peppers.



Fig. 4. *Actinidia polygama*: a – female flower; b – bud; c – fruit

*A. macrosperma* C.F. Liang (Figure 5). This species grows in the homeland in damp areas of mixed forests in eastern Chinese provinces. Seeds of this species were introduced to Ukraine in 2007; since 2013 the plants began fruiting. Leaves are small, 3–6 × 1.7–3.5 cm, with serrate margins and lightly pubescent petioles. Flowers are white with two or three ovate bared sepals and 5–12 ovoid petals. Fruits ripen in late September and are round, up to 4 cm in

diameter and mature with yellow-orange skin and pulp. Ripe fruit taste bitter. This species is promising for further hybridization because of beautiful fruit appearance (as mandarins).

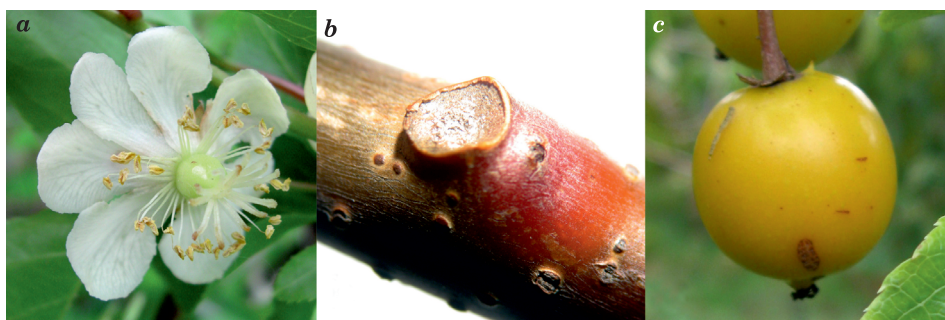


Fig. 5. *Actinidia macrosperma*: a – female flower; b – bud; c – fruit

*Actinidia deliciosa* (A. Chev) C.F. Liang et A.R. Ferguson (Figure 6). This species was firstly introduced in NBG in the 1970s (under the name *A. chinensis*) from Batumi and the first plants were male. In the 1990s, seedlings from kiwifruits from Italy were obtained but unfortunately most of these seedlings died due to the low winter temperatures. Only the most winter-hardy of our plants, which were able to withstand winter temperatures up to  $-19^{\circ}\text{C}$  have survived. *A. deliciosa* is a strong woody vine, growing up to 8 m in height, with vigorous shoot growth. Young shoots are green-brown or red-brown and densely pubescent with relatively large hairs. The buds are covered with stem bark. The leaves are well-rounded to elliptical, with pubescent mostly red petioles. Leaves are dark green with smooth topside and a densely hairy underside (stellate hairs).



Fig. 6. *Actinidia deliciosa*: a – female flower; b – bud; c – fruit



Flowers of *A. deliciosa* are large, up to 5 cm in diameter, white; at the end of flowering they are yellow-orange with ovoid petals and three-four sepals on a long peduncle. At the center of female flowers there is a pistil with ray-like stigmas, surrounded by a lot of stamens with yellow anthers. The fruits are very fragrant, spherical to ellipsoid, weigh 45–60 g with sweet-sour taste. The fruit skin is tick, light brown and densely covered by hairs. In forest-steppe conditions, fruits of *A. deliciosa* do not ripen until the first frost, but are harvested before first frost occurs. They mature during storage and acquire the desired taste.

As the results of the selection work based on the above presented *Actinidia* collection new cultivars such as ‘Sentiabrskaya’ (*A. arguta*), ‘Purpurnaya Sadovaya’ (*A. arguta* var. *purpurea*) and ‘Pomarancheva’ (*A. polygama*) were obtained (Table 1). These cultivars were received as the results of interspecific and intervarietal hybridization. Despite of information given in the Table 1, they are characterized by a stable annual crop, abundant biochemical fruit composition and good frost resistance (SKRYPCHENKO 2016). Among these cultivars ‘Kievskaya Krupnoplodnaya’, ‘Figurnaya’, ‘Karavaievskaya Urozhainaya’, ‘Nadiya’, ‘Zagadkova’, ‘Rubinovaya’, ‘Originalnaya’ are most promising. Afterwards new winter-hardy cultivars ‘Lasunka’, ‘Perlyna Sadu’, ‘Krasunia’, ‘Juvileyna’, ‘Smaragdova’ were selected. All these cultivars were registered in Ukraine State Register. The male cultivar ‘Don Juan’ as a pollinator for all female cultivars was selected. But for further research work other species of *Actinidia* are of great interest: *A. polygama* and *A. kolomikta* as they are a source of high amount of biologically active substances in fruits, *A. macrosperma* due to its original fruit and *A. deliciosa* as a species with well-known fruits.

Long-term (10–15 years) phenological observations of *Actinidia* species showed that their vegetation in Kyiv begins on average in the third week of March, with intense weeping. The growth of *Actinidia* shoots begins in the second week of April. There are significant differences in the biology of flowering and fruiting in the introduced species mostly due to their origin. Plants of *A. kolomikta* are the first to flower (middle-late May), whereas *A. arguta*, *A. arguta* var. *purpurea*, and *A. deliciosa* begin to flower several days later. The last to flower are *A. polygama* and *A. macrosperma* (first or the second week of June). The male plants usually start growing at Spring and flowers one-three days earlier than the female ones. Duration of the flowering of the studied *Actinidia* species is 6–19 days, depending on the weather conditions. As an example comparing differences in the phenological development of different *Actinidia* species, the results of the observation from 2014 are shown (Figure 7).

Table 1  
Fruit characteristics and yield of actinidia cultivars from NBG selection (fruit weight for the year 2015 as average of 100 fruit  $\pm$  standard deviation; yield as long-term average)

Cultivar	Origin	Fruit skin colour	Fruit weight [g]	Average yield [kg per plant]
‘Purpurnaya Sadovaya’	<i>A. arguta</i> var. <i>purpurea</i>	purple	11.7 $\pm$ 1.4	20–35
‘Sentiabrskaya’	<i>A. arguta</i>	green	10.3 $\pm$ 1.8	9–12
‘Krasunia’	<i>A. arguta</i>	green	13.3 $\pm$ 1.2	9–12
‘Kievskaya Gibrinaya’	<i>A. arguta</i> $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green	10.6 $\pm$ 1.8	10–18
‘Kievskaya Krupnoplodnaya’	<i>A. arguta</i> $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green	18.5 $\pm$ 2.4	20–25
‘Figurnaya’	<i>A. arguta</i> $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green	8.6 $\pm$ 1.4	20–25
‘Rima’	‘Sentiabrskaya’ $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green	6.8 $\pm$ 1.5	15–20
‘Zagadkova’	‘Sentiabrskaya’ $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green with purple blush	9.3 $\pm$ 1.6	15–20
‘Originalnaya’	‘Sentiabrskaya’ $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green	10.4 $\pm$ 1.9	15–20
‘Lasunka’	‘Sentiabrskaya’ $\times$ <i>A. arguta</i> var. <i>purpurea</i>	green with purple blush	9.3 $\pm$ 1.3	10–11
‘Karavaievskaya Urozhainaya’	‘Purpurnaya Sadovaya’ $\times$ <i>A. arguta</i>	purple	6.6 $\pm$ 1.1	10–12
‘Nadiya’	‘Purpurnaya Sadovaya’ $\times$ <i>A. arguta</i>	purple	9.0 $\pm$ 1.4	15–20
‘Rubinovaya’	‘Purpurnaya Sadovaya’ $\times$ <i>A. arguta</i>	purple	6.1 $\pm$ 1.0	10–13
‘Perlyna Sadu’	‘Purpurnaya Sadovaya’ $\times$ <i>A. arguta</i>	green	8.2 $\pm$ 1.1	12–15
‘Juvileyna’	(‘Kievskaya Krupnoplodnaya’ $\times$ ‘Purpurnaya Sadovaya’ $\times$ <i>A. arguta</i> )	brown-purple	14.8 $\pm$ 2.1	12–15
‘Smaragdova’	‘Sentiabrskaya’ $\times$ ‘Don Juan’*	dark green	10.2 $\pm$ 1.8	12–15
‘Pomarancheva’	<i>A. polygama</i>	orange	6.5 $\pm$ 1.0	3–5

\* – ‘Don Juan’ – male cultivar (pollinator)

The fruits of *A. kolomikta* begin to ripen in late July – early August (30–40 days after petal fall) and fall down just after ripening. The fruits of *A. arguta* begin to mature in the first week of September (ripe fruits do not fall off and can remain on stems for a long time). The harvest can be done in two-three steps or once after they fully ripen. Fruits of *A. arguta* var. *purpurea* ripen in late September – early October. Berries of *A. polygama* ripen simultaneously with fruits of *A. arguta* and do not fall down after ripening due to strong short

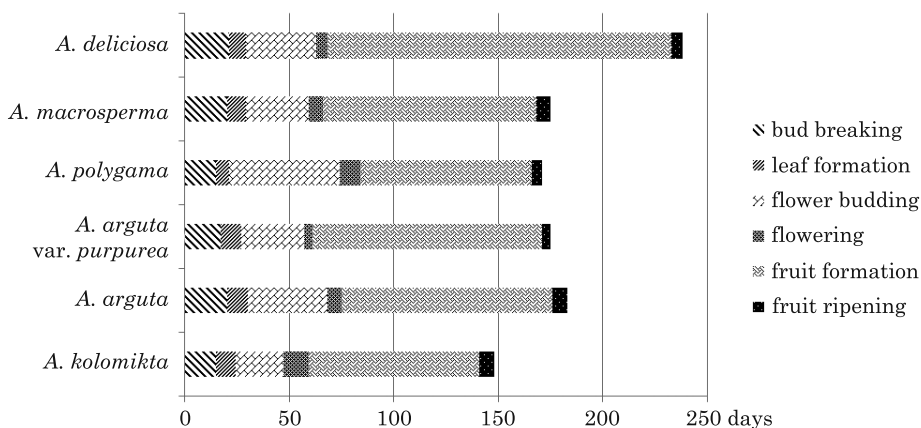


Fig. 7. Comparison of phenological spectrums of different *Actinidia* species in Kyiv. An example from the year 2014 (zero corresponds to 1<sup>st</sup> March)

peduncles. Ripe fruit can remain on a stems for up to a month. Fruits of *A. macrosperma* ripen in the middle of September. Fruits of *A. deliciosa* in our area are harvested when not fully mature before the first autumn frost occur, but they ripen during storage.

Leaves of *A. kolomikta*, *A. arguta* and *A. polygama* begin to acquire their autumn color in September, and defoliation happens in the first and the second week of October. Plants of *A. deliciosa* and *A. arguta* var. *purpurea* have green foliage at the first frost with leaves falling down after the air temperature drops below zero. Hence, vegetation periods of these species end with induced defoliation at the end of October or even the beginning of November.

With exception of *A. deliciosa* all other introduced species of *Actinidia* undergo their full circles of seasonal development hence the Forest-steppes of Ukraine climate conditions are favorable for widespread cultivation of these plants.

Some of these Ukrainian kiwiberry selections has already been introduced into North-Eastern Poland. Cultivars 'Kiyewskaya Gibridna', 'Purpurnaya Sadovaya', 'Figurnaya' and 'Kievskaya Krupnoplodnaya' were successfully cultivated in UWM Experimental Station in Olsztyn (BIENIEK 2012a,b, BIENIEK and DRAGAŃSKA 2013). Research made by Bieniek et al. (2016) shown that the sum of effective temperature (SET) during kiwiberry growing in years 2005–2014 in Olsztyn estimated between 1455 and 1839°C, on average. It was not much less than SET noted in Ukraine. Authors indicated late spring frost as the most important kiwiberry growing limitation in North-Eastern Poland.

## Conclusions

The plant collection of *Actinidia* species of M. M. Grishko NBG of NAS of Ukraine is a basis for research of anatomical, morphological and biochemical properties of the new cultivars suitable for cultivation in Forest-steppe of Ukraine. The collection is an important source for hybridization work carried out in order to obtain new highly productive cultivars of *Actinidia*, with high contents of biologically active substances. The *A. kolomikta*, *A. arguta*, *A. polygama*, and *A. macrosperma* are characterized by high introduction potential, undergo all phases of development and produce high quality seeds.

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