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# Some morphological and biological features of 'Bingo' – a new hardy kiwifruit cultivar from Warsaw University of Life Sciences (WULS) in Poland

Wybrane cechy morfologiczne i biologiczne nowej odmiany aktinidii 'Bingo', wyselekcjonowanej w Szkole Głównej Gospodarstwa Wiejskiego w Warszawie

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Abstract: Hardy kiwifruit (*Actinidia arguta*) is a relatively new crop, and new cultivars suitable for commercial production are still needed. This paper outlines the results of research on the morphological and biological features of 'Bingo', a new cultivar of hardy kiwifruit obtained in the breeding programme conducted at Warsaw University of Life Sciences (WULS), Poland. The research was conducted in 2008 and 2009. 'Bingo' is a F1 hybrid between *A. purpurea* 'Purpurna Sadova' and *A. arguta*. Its fruit is dominated by the characteristics of *A. arguta*. The fruits of 'Bingo' are elliptical and laterally flattened, with an average weight of 8.1 g (max. 14.4 g). Ripe fruit have a smooth yellow-green skin with a strong rose-red blush. Fruiting potential (88.2 fruit/1m of fruiting arm) is lower than that of 'Ananasnaya' but greater than that of 'Jumbo'. Ripe fruit of 'Bingo' is rich in vitamin C, has pleasant sensory characteristics and good consumer acceptance. The plants can be successfully cultivated in central Poland's climate.

**Key words:** *Actinidia arguta*, *Actinidia purpurea*, Bower actinidia, kiwiberry, selection

## Introduction

The genus *Actinidia* Lindl. belongs to the Actinidiaceæ family. The systematics of *Actinidia* are not straightforward, and taxonomists are not in agreement over the number of existing species, but according to recent research there are 55 (Li et al. 2009). All *Actinidia* come from the Asian continent, and for the majority the range is within China.

*Actinidia* is most known around the world thanks to the kiwifruit (*A. deliciosa* (A. Chev) C.F. Liang et A.R. Ferguson), the commercial cultivation of which developed in the second half of the Twentieth Century. The plant is cultivated in countries with a warm climate, mainly New Zealand, USA, Chile and Italy. This unusual fruit is one of the most identifiable 'new' products available on the fruit market. Kiwifruit is not only popular thanks to their unusual look and successful marketing, but also because of their taste and health value. They stand out because of high levels of vitamin C, but also because they are rich in phenolics, carotenoids and folic acid. Their health benefits established during *in vitro* research (Jung et al. 2005) were also confirmed during *in vivo* (Duttaroy, Jørgensen 2004). In 2000 kiwi fruit was recognised as the most nutritional of the 27 most commonly eaten fruits (California Kiwifruit Commision 2000), as a result they became known as the 'healthy fruit'.

In countries with a moderate climate, research and selection work on cold resistant species of *Actinidia* has been conducted. In Poland even before the Second World War work was carried out on *Actinidia arguta* (Siebold et Zucc.) Planch. ex Miq., recognising many benefits of its fruit (Muszyński 1939). Unfortunately the Second World War interrupted this research. After the war, many cultivars of *A. kolomikta* (Maxim. et Rupr.) Maxim. were obtained in Lithuania (Pranckietis, Pranckietiene 2000,

Chesoniene 2000). In Ukraine's Kiev Botanical Garden, selection of cultivars of *A. arguta* and its hybrids with *A. purpurea* Rehder have been conducted for many years, as a result of which many cultivars have been developed and registered (Skripchenko, Moroz 2002). In the middle of the Twentieth Century interest also grew in China, where plants were selected from the wild (Xiao 1999), as well as in some Central and Southern European countries, and also in South Korea, breeding programs were conducted (Jo et al. 2007, Latocha, Krupa 2007, Stănică, Zuccherelli 2007). In New Zealand three cultivars of *A. arguta* were selected and registered – 'Hortgem Wha', 'Hortgem Tahi' and 'Hortgem Toru', which were introduced into commercial production at the start of the Twenty First Century (Williams et al. 2003). In the 1990's the first commercial plantations were established in the USA, Chile and Japan, and also in Europe (Italy, Belgium, France, Switzerland and Germany). More recently field research has been carried out in Poland, and the first commercial plantations were established (Werner 2002, Kawecki, Bieniek 2008, Latocha 2008, Marosz 2009). The breeding and selection of hardy clones of *Actinidia* have also been carried out at Warsaw University of Life Sciences (WULS), as a result of which there are some promising selections.

The aim of this article is to present the morphological characteristics and fruiting potential of the new cultivar 'Bingo', the best form selected after many years of selection at WULS, Poland.

## Materials and Methods

**Selection work**

Work on selecting attractive cultivars of hardy kiwifruit, have been carried out at WULS since the beginning of the 1990's. The aim of this work was to obtain cultivars with good fertility and fruit attractive in size, colour and taste. Seed was collected in 1995 from fruit of the cultivar 'Purpurna Sadova' (*A. purpurea*) pollinated by *A. arguta*. After stratification the seed was sown in the spring of 1996. The first plants flowered 2-3 years after being planted out. Selection was carried out successively, as the plants fruited. The best individuals were propagated vegetatively and observation continued, and their fruit was also analysed chemically and sensorially. The best one was a female selection with breeding code D14, which in 2010 was submitted for registering at the Polish Official Variety Testing (COBORU) under the name 'Bingo'. Currently this variety is undergoing further field research, at a commercial plantation in central Poland.

**Plant morphology**

The plant's growth rate and the observation of frost resistance was conducted several years from the beginning of cultivation. Morphological measurements of plants were conducted in 2008 and 2009 on 5 mature (6 year old) plants growing in the experimental field of the Environment Protection Department, WULS, Poland (N 52°13'; E 21°00'). Shrubs were planted in rows with 3 m spacing and trained to a 2 m high T-bar support.

Young sprouts in May and mature shoots in Winter were described. The leaves, flower, and fruit analyses were carried out on 60, 30 and 30 pieces respectively, taken randomly from all the plants. Leaves were taken from the middle part of long shoots, at the end of July, when they had a target size without any deformation. Fully open 'king' flowers were studied. The studied fruit were well-shaped, typical in size and without any deformation or damage. The number of seeds in each fruit were calculated and 500 pieces were weighed.

The methodology of morphology of flowering and fruiting potential was developed on the basis of Jie and Thorp (1986), Giorgio et al. (1990) and Chesoniene (2000), and described in detail by Latocha (2010). The morphological research on flowering was conducted on whole plants, and separately on short and long shoots. The number was analysed on individual flower types (triple, double and single) and their location on shoots.

For the fruiting potential, 10 long and 10 short fruiting arms were identified on each shrub in winter. Their length was measured, and the number of buds was counted on each of them. In the autumn on each of these shoots the number and mass of fruit was recorded. The fruiting potential was calculated as a number or a mass of fruit on 1m fruiting arms, separately for both types of arm.

## Results and discussion

**Growth, phenology and frost resistance**

The strong growth of 'Bingo' is comparable to the growth of *A. arguta* and *A. purpurea*. Once planted out, two year old plants give off strong shoots. The plant begins to fruit 3-4 years after planting. Full fruiting occurs after 5-7 years. Current observations show that it is sufficiently resistant to cold in central Poland, as is *A. arguta.* However, further observation is needed in colder regions of the country. Taking into consideration the fact that both of the parents are successfully grown in the region of Olsztyn (Kawecki, Bieniek 2008) and in the Ukraine (Skripchenko, Moroz 2002) suggests that the cultivar 'Bingo' should also be suited to similar conditions. In central Poland the plant begins it's growth very early, often in April, like 'Jumbo' (a very popular in Poland cultivar with the largest fruit) and 'Ananasnaya' – most commonly grown worldwide, which is treated as the standard (Strik, Hummer 2005). 'Bingo' flowers at the beginning of June, a few days earlier than 'Ananasnaya', and a few days later than 'Jumbo', and it lasts, depending on the weather, 7-10(11) days. Depending on annual weather conditions, the fruit begins to ripen between the end of September and the beginning of October, about a week earlier than the fruit of 'Ananasnaya', and at a similar time to 'Jumbo' when grown in similar conditions. Harvesting of ripe fruit requires cutting them off the stalk, otherwise the fruit may be damaged. However, the harvesting of fruit at harvest maturity (firm fruit with min. 8% soluble solid content – SSC) does not require cutting.

**Plant morphology**

Young, vigorous shoots (the current year's growth) of 'Bingo' in May become suddenly cherry-red at the top of the plant (fig. 1). On 'Ananasnaya' and 'Jumbo' the young

shoots are covered in fine woolly hairs. On 'Jumbo' they are completely green, and on 'Ananasnaya' pinkish. The ripe shoots of 'Bingo' become cherry-brown in winter and have dense, rounded lenticels (fig. 2). 'Ananasnaya' has browner year old shoots, whereas those of 'Jumbo' are lighter in colour. The leaves of 'Bingo' are elliptical or obovate, green above and light green below. The leaf tip is long-pointed, whereas it's base is truncate or broadly cuneate. The leaves of 'Ananasnaya' have a more wedge shaped base, whereas those of 'Jumbo' are more cordate and the leaf is wider (fig. 3). Leaves are roughly 10 cm long and 6 cm wide. The serration of the leaf margins is fine and regular, but clearly pointing towards the leaf tip. The underside of the leaf is glabrous. The average length of the petioles is 32.8 mm and they are clearly red, as in 'Ananasnaya'. Whereas those of 'Jumbo' are lighter, with a pale pink petiole. In autumn the leaves become an intensive yellow.

The flowers have on average a diameter of 24mm and have 5-6 cream coloured petals, which during flowering are gently curled in to the middle of the flower (fig. 4 and 5). The anthers are clearly purple-black, similar to those of 'Ananasnaya', but different from those of 'Jumbo', on which the anthers are brown. The sepals of 'Bingo' are usually a strong red. After flowering and once the fruit is formed they quickly drop. Fruit primordia are flattened and gently stretched and have characteristic light red styles. This is similar in 'Ananasnaya'. However, in 'Jumbo' there is no red colouring (fig. 6).

Ryc. 1. Młoda latorośl 'Bingo' (fot. P. Latocha).

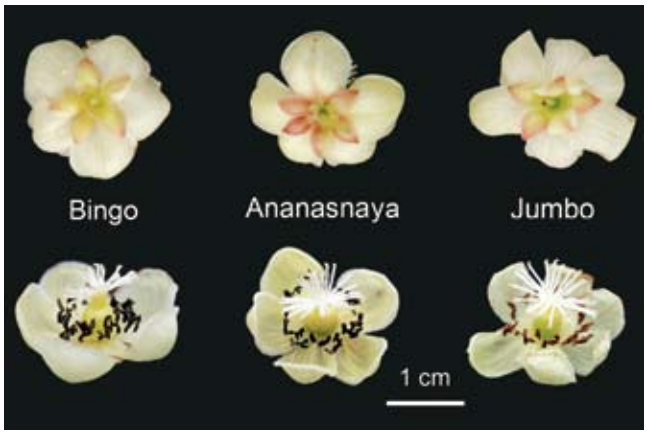
Fig. 1. Young summer shoot of 'Bingo' (photo P. Latocha).


Ryc. 2. Roczne pędy 'Bingo' w porównaniu do innych popularnych odmian (fot. P. Latocha).

Fig. 2. Annual shoot of 'Bingo' in comparison to other popular cultivars (photo P. Latocha).


Ryc. 3. Liście 'Bingo' w porównaniu do innych popularnych odmian (fot. P. Latocha).

Fig. 3. Leaves of 'Bingo' in comparison to other popular cultivars (photo P. Latocha).

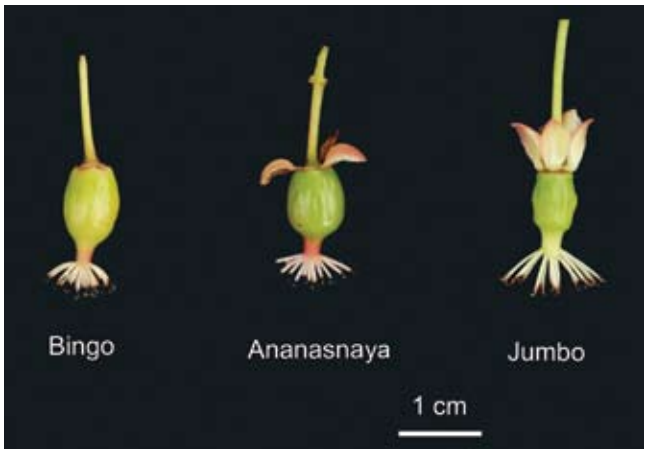



Ryc. 4. Kwiaty ‘Bingo’ w porównaniu do innych popularnych odmian (foto P. Latocha).

Fig. 4. Flowers of ‘Bingo’ in comparison to other popular cultivars (photo P. Latocha).

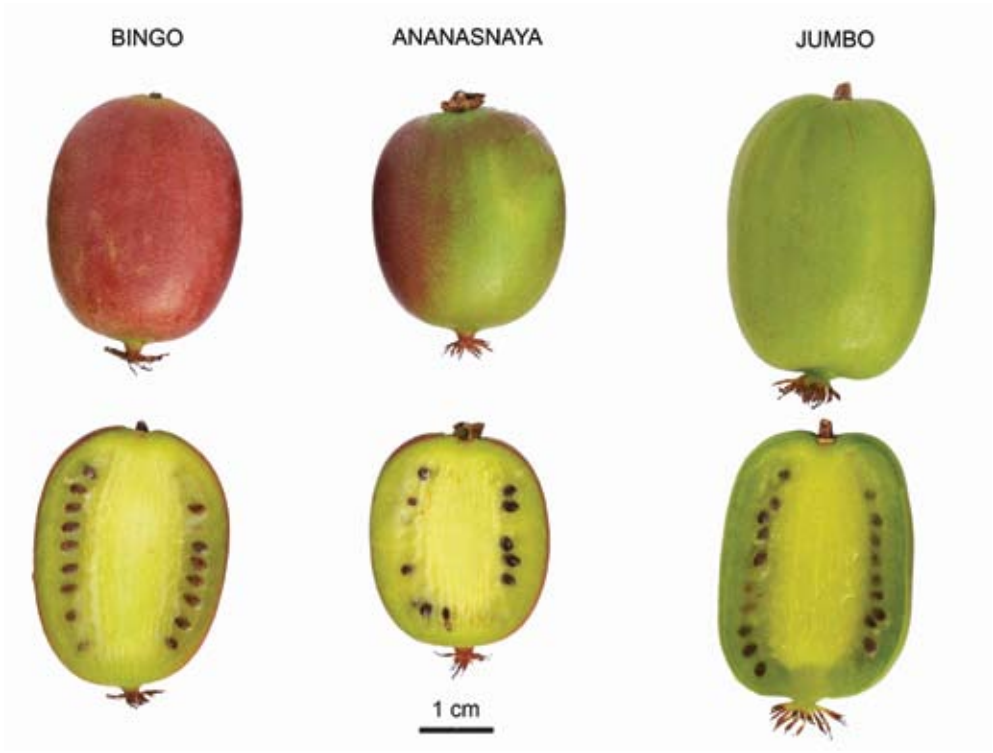
Ryc. 5. Kwitnący pęd odmiany ‘Bingo’ (foto P. Latocha).

Fig. 5. Flowering twig of ‘Bingo’ (photo P. Latocha).




Ryc. 6. Zawiązki owoców ‘Bingo’ w porównaniu do innych popularnych odmian (foto P. Latocha).

Fig. 6. ‘Bingo’ fruit primordia in comparison to other popular cultivars (photo P. Latocha).




Ryc. 7. Owoce ‘Bingo’ w porównaniu do innych popularnych odmian (foto P. Latocha).

Fig. 7. ‘Bingo’ fruit in comparison to other popular cultivars (photo P. Latocha).

Ryc. 8. Dojrzałe owoce 'Bingo' na krzewie (foto P. Latocha).
Fig. 8. Ripe 'Bingo' fruit on the plant (photo P. Latocha).

The fruit is cylindrical and clearly flattened at the sides (fig. 7 and 8). On average they grow to 31.3×24.4×20.5mm and have a mass of 9.5g (max 14.4g). 'Jumbo' has larger fruit (on average 12.7g), and 'Ananasnaya' has smaller fruit (av. 8.5g) (Latocha 2010). The colouring of the skin is original and not seen in any other cultivar. The base colour is light green, almost yellow, and it has a blush often covering most of the surface of the fruit which is reddish-pink. 'Ananasnaya' has fruit of a similar size, but they are less flattened, and their base colour is dark green and the blush is cherry--red. In turn the fruit of 'Jumbo' are clearly longer, strongly flattened and completely green, with no blush. Unlike the fruit of 'Ananasnaya', 'Bingo' depends less on exposure to light, which means that fruit that get less light still colour. The fruit of 'Bingo' on average have 175.7 yellow-brown seeds. The average mass of 500 seeds is 0.568g and is nearly half of the weight of those of 'Ananasnaya' (0.978g) or 'Jumbo (0.883g) (Latocha 2010).

**Morphology of flowering**

Research has shown that on 'Bingo's long shoots 49.8% of the buds started to grow and 67.8% of young shoots are fertile. 64% of the new growth are lateral shoots which quickly end their growth. Analogously results for *A. arguta* grown in New Zealand (Snowball 1997) and the USA (Tiyayon, Strik 2003), which shows that this is a feature for the species and is less dependant on the conditions of cultivation. On short shoots 30.4% of buds appear on the shoots of which 68.8% are fertile. As much as 96.5% of shoots are those short shoots quickly ending their growth. This suggests that the majority of the yield is produced on short shoots. Similar results for *A. kolomikta* were found by Chesoniene (2000) in research conducted in Lithuania. In *Actinidia* flowers are usually found in (ones) twos and threes. In the cultivar 'Bingo' individual flowers tend to be found on short shoots, whereas 3 flowered inflorescences tend to dominate on strong, long shoots. On the current year's long shoots flowers are found lower down on the shoot, on average between the 6$^{th}$ and 10$^{th}$ leaves, while on short shoots, on average between the 5$^{th}$ and 11$^{th}$ leaves.

**Fruiting potential**

Due to limited information regarding the actual harvesting of this cultivar in various conditions, the results presented are those regarding fruiting potential. The indicator was previously counted for various cultivars of *A. deliciosa* cultivated in New Zealand (Jie, Thorp 1986) and, similarly, for cultivars of *A. kolomikta* cultivated in Lithuania (Chesoniene 2000). In calculations for 'Bingo' the fruiting potential for long shoots was 88.2 fruit/1m (0.72kg) and was lower than the analogical potential for 'Ananasnaya' (123.7 fruit/1m; 1.09kg), but higher than for 'Jumbo' (46.0 fruit/1m; 0.60kg) (Latocha 2010). In turn, the potential for the short shoots of 'Bingo' was 102.4 fruit (0.83kg)/1m. Calculating in the same way for long shoots, the fruiting potential of 9 cultivars of kiwifruit cultivated in New Zealand wavered between 16.4 and 38.4 fruit (1.40-2.50kg)/1m (Jie, Thorp 1986). 'Monty' had the highest potential, and the lowest was the popular 'Hayward'. In turn, the fruiting potential of six cultivars of *A. kolomikta* cultivated in Lithuania was from 9.2 to 39.0 fruit/1m, of which the highest potential was that of the cultivar 'VIR–1', and the lowest 'Pavlovskaya' (Chesoniene 2000).

The average harvest collected from the cultivar 'Bingo' on the experimental field at WULS in the first years of fruiting (4, 5 and 6 years after planting) came to 4.4, 6.0 and 10.0 kg per plant.

**The basic parameters of quality and taste of the fruit**

The fruit of hardy kiwifruit do not ripen on the plant evenly, which is considered by those cultivating it as its fault. The phenomenon of quick and irregular softening during ripening of the fruit has been observed in many species of *Actinidia* (White et al. 2005). However, in amateur cultivation this phenomenon can be an advantage as it lengthens the fruiting period during which fruit can be harvested. In the ripening phase the fruit of 'Bingo' reach firmness (force necessary to destroy the skin of the fruit) 2.3-2.7 Newtons (N) and the value of the dry mass 17.7-21.1% (Latocha 2010). The same author found that ripe fruit contains 15.5-17.6% dry mass at an acidity of 1.0-1.1% (expressed as anyhydrous citric acid), and the Vitamin C content in 100g of fruit was 74.4–112.8mg. Fruit harvested in a state where it is ready for consumption can be stored for about a week at room temperature, or about 2 weeks in cold storage. However, fruit for commercial production is harvested having achieved a minimum 8% SSC (Fisk et al. 2006) and can be kept in cold storage for 4-6 weeks. The fruit of 'Bingo' harvested at a SSC of 8-9% has a firmness of about 27 N, which after the first week of cold storage dramatically falls to 8 N, and after the second week to 4 N. The fruit maintains good quality in cold storage for 1-1.5 months (Krupa et al. 2011).

The taste of the fruit of 'Bingo' when ready for consumption is delicate, sweet and sour with a pleasant aroma. On the basis of the results of sensory testing (Latocha et al. 2011) the fruit's skin can be described as being soft, sour, slightly tart and irritating. The soft pulp is dominated by a sweet fruity taste, and a slightly irritating acidic wine taste. The ripe fruit is not astringent, which frequently characterises other cultivars. Consumer research has shown that the fruit is highly rated not only in taste but also in its look (Latocha, Jankowski 2011).

## Summary

'Bingo' (*A. purpurea* × *A. arguta*) the cultivar selected at Warsaw University of Life Sciences (WULS), has dominant characteristics of *A. arguta*, and its fruit differs from other cultivars on the market, mainly in its intense reddish-pink blush. The fruit of 'Bingo' is elliptical and clearly flattened. They reach a good size and an average mass of 8g (to about 14g). They have attractive tints as they are ready for harvest (8-10% SSC). The fruiting potential of 'Bingo' is lower than that of the popular cultivar 'Ananasnaya', but slightly higher than that of 'Jumbo'. The fruit has high levels of Vitamin C, and is accepted by consumers. It is suited to short term cold storage. The hardiness of 'Bingo' does not differ from that of other cultivars of *A. arguta*, and the plants can be comfortably cultivated in central Poland. Further research is required in colder parts of the country.

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