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CAN KIWIFRUIT GROW IN ROMANIA? RESULTS OF THE ROMANIAN BREEDING PROGRAM AFTER 25 YEARS OF RESEARCH ON *Actinidia* spp.

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Abstract

In Romania, kiwi is a new fruit specie and the creation, testing and introduction of winter hardy genotypes, adapted to the local harsh climate conditions represent a priority. The first kiwifruit orchards with A. deliciosa and A. arguta were planted in Romania in 1993, at Ostrov (Constanța County), on the border of the Danube River. In the same year, a common Italian-Romanian kiwifruit breeding program was initiated at the Faculty of Horticulture within the University of Agronomic Sciences and Veterinary Medicine of Bucharest. Since 1993, research has been carried out to determine the best methods of propagation, growing and kiwifruit orchard management. Genotypes phenology was studied every year in comparison with the climatic data. In parallel, physical and biochemical fruit characteristics were evaluated after ripening and during the storage. After some years of observations and tests, three kiwiberry elites were selected: 'Vip Green' (R8P23), 'Vip Red' (R8P20) and 'Green Delight' (R8P1). Other intra and interspecific crossings using A. deliciosa and A. chinensis were made and from the initial hybrids, some selected genotypes as R0P13, R1P9, R1P8 and R1P12, have good fruit characteristics and yield. The new selections have to be registered as cultivars and can be successfully cultivated on commercial orchards and in private gardens. This paper presents few results of the Actinidia spp. Romanian breeding program. Some fruit quality characteristics of the new kiwi selections and hybrids as average weight, fruit shape index, soluble solids content, dry matter, acidity and ascorbic acid are detailed. After more than two decades of research, it was demonstrated that A. deliciosa and A. chinensis can be grown in Romania in peach favorable areas, while A. arguta (kiwiberry or baby kiwi) can cover larger areas, suitable for plum cultivation.

***Key words**: A. arguta, A. chinensis, A. deliciosa, fruit characteristics, selection.*

INTRODUCTION

Actinidia species have been domesticated from wild populations located on Yangtze River basin (Ferguson, 1990; Young et al., 1995) and almost all the *Actinidia* species are widely distributed in Asia (Huang & Ferguson, 2007). Kiwifruit represent a recently developed crop, only within the last century started to be commercialized (Barboni et al., 2010; Ferguson & Bollard, 1990; Huang & Ferguson, 2007; Sui et al., 2013; Warrington 1990; Young et al., 1995), and it is recognized as highly nutritious and low calories fruit with the potential to deliver a range of health benefits (Burdon et al., 2004; Cangi, 2011; Drummond, 2013; Harker et al., 2007; Huang et al., 2004; Iwasawa et al., 2011; Mohammed et al., 2017; Namestnikov et al., 1989; Plekhanova, 1940; Samadi-Maybodi & Shariat, 2003; Stonehouse et al., 2013; Testolin et al., 2016; Vasile Scăețeanu et al., 2019; Yang, 2010).
Cultivation of kiwifruit spread from China in the early 20th century to New Zealand (Biao et. al., 2018; Huang et al., 2007; Meena et al., 2018). The kiwifruit history started in 1904, when Isabel Fraser, brought the first seeds from China to New Zealand (Ferguson & Bollard, 1990; Huang et al., 2007; Warrington 1990; Young et al., 1995). In 1910, Hayward Wright, obtained the first kiwi plants in New Zealand and in 1930, was selected and cultivated the first cultivar - 'Hayward' (Biao et al., 2018; Stănică et al., 2007; Stănică, 2009; Stănică & Zuccherelli, 2009). According Huang (2016) and Zhang et al. (2010), the current commercial

cultivation is almost entirely based on *A. deliciosa* and *A. chinensis* species, that are naturally distributed between 25° and 45° in both northern and southern hemispheres. *A. arguta* commercial potential started to be recognized in the last years, especially in colder regions, this specie being lesser extent (Ferguson and Huang, 2007).

In Romania, *Actinidia* is a new fruit specie and the creation, testing and introduction of winter hardy kiwifruit genotypes, adapted to the local harsh climate conditions represent a priority in the national fruit growing programs (Iliescu et al., 2019a; 2019b; 2019c; Stănică et al., 2007; Stănică, 2009; Stănică & Zuccherelli, 2009).

The first kiwifruit orchards with *A. deliciosa* and *A. arguta* were planted in Romania in 1993, at Ostrov (Constanța County), on the border of the Danube River (Iliescu et al., 2019a; 2019b; 2019c; Peticilă et al., 2002; Stănică & Cepoiu, 1996a; Stănică, 2009; Zuccherelli, 1994). In the same year, a common Italian-Romanian kiwifruit breeding program was initiated between Vitroplant, Cesena and Faculty of Horticulture within the University of Agronomic Sciences and Veterinary Medicine of Bucharest (Iliescu et al., 2019a; 2019b; 2019c; Iliescu & Stănică, 2022; Iliescu et al., 2022; Stănică et al., 2003a; 2004; Stănică & Zuccherelli, 2007; Stănică et al., 2022a, 2022b).

Worldwide, the most *A. deliciosa* or *A. chinensis* cultivars were initially selected directly from the wild population (Atak et al., 2015; Ferguson, 1997; Huang et al., 1999). In time, in their breeding programs, researchers have tried to get new cultivars with different fruit characteristics, such as flesh colour, hairless skins, early maturity, better taste, high yield, long storage life, through different intraspecific and interspecific crosses techniques (Atak et al., 2015; Muggleston et al., 1998; Nicotra et al., 1999; Testolin & Ferguson, 2009; Xiao, 1999).

The aim of this paper is to present the results of the *Actinidia* spp. Romanian breeding program, after 25 years of research. Some fruit quality characteristics of the new kiwi selections and hybrids as average weight, fruit shape index, soluble solids content, dry matter, acidity and ascorbic acid are also detailed.

Romania's position is 43°37'-48°15' northern latitude, and 20°15'-29°41' eastern longitude. The climate is temperate-continental, with 8-11°C annual average temperature and 450-800 mm annual rainfall (Stănică et al., 2022a).

After more than two decades of observations, studding different morpho-productive characteristics of kiwi plants - as the main phenological stages according to the BBCH scale, plant resistance to deep frost, pest and diseases, for the most important *Actinidia* species was establish the fruit growing favorable areas where they can be cultivated with success (Stănică, 2009; Stănică & Zuccherelli, 2009; Stănică et al., 2022a; 2022b), especially due to the soil diversity (Mihalache et al., 2015; Popa et al., 2016) and quality (Schmidt et al., 2017; Vizitiu et al., 2017), and also climate condition (Bucur & Dejeu, 2016) from our country.

MATERIALS AND METHODS

Romanian breeding program objectives focused on fruit quality parameters as size, shape; fruit hairs and skin; fruit and pulp colour; maturation period and ripening indicators; fruit texture; aroma; composition in nutrients and vitamins. Plant resistance to deep frost, pest and diseases are also studied (Stănică, 2009; Stănică et al., 2022a).

Experience location and plantation description

The trial plants with kiwifruit hybrid genotypes, was established on preluvosoil in the Romanian plain, using some hybrid seedlings (Stănică & Cepoiu, 1996a; Zuccherelli, 1994). Some varieties - Hayward, Bruno etc. were also planted. Planting system used for the most trials was 4 m between the rows and 2 m between the plants. The experimental field within the Faculty of Horticulture, Bucharest - 44.4708° N and 26.0662° E (Asănică et al., 2017), was established in 1993. The climate is temperate continental, with 10.5-12°C annual average temperature and 550-600 mm annual amount rainfall, with a maximum recorded between May and July (Bălan et al., 2015). Almost 178-205 frost-free days and the vegetation period of 245 days are registered every year (Bălan et al., 2015). Air circulation is dominant from the east and north east during winter and west for the rest of the year, and the maximum wind speed is 3.5-4 m/sec (Bălan et al., 2015).

Most of the observations and analysis took place in the research orchard and laboratories of the Faculty of Horticulture and at the Research Center for Studies of Food Quality and Agricultural Products, within the University of Agronomic Sciences and Veterinary Medicine of Bucharest.

The plants were grown under an organic orchard management, on a T-bar trellis system, represented in Figure 1. The inter row surface was covered with a mixture of perennial grasses and mowed mechanically, and along the row, the soil was kept clean (Stănică et al., 2022a). Drip irrigation and micro spray irrigation system was provided (Stănică et al., 2022a).

Figure 1. T-bar trellis system
on *A. arguta* experimental field
(Source: original, photo credit Lavinia Mihaela Iliescu)

Selection criteria for kiwifruit hybrids for all three species - *A. deliciosa*, *A. chinensis* and *A. arguta*

In order to decide if kiwifruit can grow in Romania the following selection criteria for kiwifruit hybrids, were studied:

- **different morpho-productive characteristics of kiwi plants** (habitus; the main phenological stages according to the BBCH scale and the optimal harvesting period; drought and frost resistance; resistance to water excess; plants productivity; behavior to pests and diseases; studies of polyploidy);
- flowering period, pollen viability and germination percentage were analysed, for the **hybrid male selections**;
- **some physical and chemical quality parameters of the fruits** at harvest and at consumption maturity (productivity index; average fruit weight; fruit shape index; length of the fruit peduncle; fruit flesh firmness; soluble solids content - Brix %; total dry matter content - %; fructose and glucose content - %; malic acid and citric acid content - mg/100 g; ascorbic acid content - mg/100 g), **fruits storage capacity,** initial analyzes (after harvest) and monthly analyzes in dynamics (physical and chemical fruits parameters as fruit flesh firmness; percent of fruits losses; soluble solids content - Brix %; total dry matter content - %; fructose and glucose content - %; malic acid and citric acid content - mg/100 g; ascorbic acid content - mg/100 g; polyphenol content; antioxidant capacity), **consumers perception** regarding different characteristics of the fruits (shape and size, taste, flavor and pulp colour), were analysed, for the **hybrid female selections**;
- **different fruits consumption possibilities** (fresh or processed).

Besides selection of male and female hybrids adapted to the local climate, since 1993, research has been carried out to determine the best methods of propagation, growing and kiwifruit orchard management.

RESULTS AND DISCUSSIONS

Study of morpho-productive characteristics of kiwi plants

The main phenological stages according to the BBCH scale and the optimal harvesting period, were studied every year, in comparison with the climatic data (Iliescu & Stănică, 2020).

The bud break mostly took place in the beginning to mid-March, when the temperature was higher than 3.5°C, while the flowering started in first decade of May, for Bruno, and male selections (R2P8 and R3P9).

The female selections (R0P13, R1P8, R1P9, R1P12) started to bloom in the second decade of May. The flowering period finished in the first or second decade of June (Iliescu & Stănică, 2020; Stănică et al., 2022a).

Regarding the harvesting period, this started with 'Bruno', R0P13, R1P8 and R1P12, in the third decade of October and continued with 'Hayward' and R1P9 in the first decade of November (Iliescu & Stănică, 2020; Stănică et al., 2022a).

The phenological enlargement of kiwifruit could improve the quality of fruits by providing information about evolution of the varieties and local hybrids under the environmental conditions of Southern Romanian (Iliescu & Stănică, 2020).

An accurate understanding of kiwifruit plant phenological stages it is essential for an appropriate orchard management (Iliescu & Stănică, 2020). Through this study, one proposal of principal kiwifruit phenological growth stages adapted according to the BBCH scale, was described, for all the three species – *A. deliciosa*, *A. chinensis* and *A. arguta* (Figure 2).

Figure 2. Principal kiwifruit phenological growth stages adapted according to the BBCH scale for the main *Actinidia* species
(Source: Iliescu & Stănică, 2020)

Plants productivity represents an important criterion in the selection of elites, so in every year production per plant and per hectare were studied and calculated for some hybrid, and over the time was published in different papers (Iliescu et al., 2019a; Stănică et al., 1998).

Intraspecific and interspecific crosses are frequently used in the breeding process and the genetic morphological characterization of the hybrid descendants represents an important task (Iliescu & Stănică, 2022). Because, *Actinidia* species have different numbers of chromosomes, after interspecific crosses, the new hybrids can have the same number of chromosomes as the parents or a different number. Flow cytometry has proved to be an efficient means of estimating genome size and associated ploidy level for some interspecific hybrids obtained over the years (Cotruț et al., 2013a). On the study "*Actinidia* species under microscope", the results showed how different morphological characters are influenced and defined by different species and was concluded that most of the kiwifruit interspecific hybrid genotypes *A. deliciosa* × *A. chinensis* showed similar characters to *A. deliciosa*, while the *A. chinensis* × *A. arguta* ones, to *A. arguta* (Iliescu & Stănică, 2022).

Study of kiwi hybrid genotypes for pollinator selection

No matter specie, pollination is a very important component regarding a regular and consistent production in a number of fruit crops (Costa et al., 1993; Hopping et al., 1982; Jovanovic-Cvetkovic et al., 2016; Petrisor et al., 2012; Underwood, 2001). The viability, tube growth and morphological homogeneity related to pollen quality are the most important properties in fruit plants (Iliescu et al, 2022; Petrisor et al., 2012). These properties are useful for plant breeders, geneticists, and growers (Bolat and Pirlak, 1999). Relationships between viability and pollen germination have been studied and a positive correlation between them was reported (Pearson & Harney, 1984).

After more than two decades of research, several hybrid genotypes were obtained and introduced to be tested through the Romanian breeding program (Cotruț et al., 2014; Iliescu et al., 2022; Stănică & Cepoiu, 1996b). For pollinator (male) kiwi plants, breeding programs involve the selection of elites with high pollen germination capacity and long flowering period (Cotruț et al., 2014; Iliescu et al., 2022; Stănică & Cepoiu, 1996b). In previous research (Cotruț et al., 2014) germination rate of few Romanian kiwi genotypes (*Actinidia* spp.) was evaluated after 3, 6 and 9 hours in a culture medium containing 20% sucrose, 5 ppm boric acid (H_3BO_3) and 1% agar. The results showed that in all kiwi genotypes the germination rate and pollen tube growth varied according to the incubation period and most of the studied genotypes appear to be suitable pollinators (Cotruț et al., 2014).

Studies of the male plants flowering period, pollen germination rate (Iliescu et al, 2022) and also the shape and surface of pollen grains (Iliescu & Stănică, 2022) were achieved to identify the most suitable pollinators for kiwi female selections released from the Romanian breeding program. The aim of the study was to evaluate the pollen grains quality of fifteen kiwifruit hybrids express by: shape index of viable and dead pollen grains, viability percentage (%), germination rate (%) and pollen tubes length (µm) after 4, 8, 12 and 24 hours (Iliescu et al., 2022). Regarding the study of male plants flowering period, it can be mentioned that most kiwi hybrids bloomed between the first decade of May and the first decade of June (Iliescu & Stănică, 2020; Iliescu et al, 2022). The R0P7 hybrid ensued the BBCH 60 stage in the last decade of April, with the earliest development and the longest flowering period was recorded for the R2P8 hybrid (Iliescu et al., 2022). Results showed that in all kiwi genotypes the germination rate and pollen tube growth varied according to the incubation period (Iliescu et al., 2022), confirming the previous studies accomplished in 2014 (Cotruț et al., 2014). The highest percentage of germination (93%) was recorded after 24 hours of incubation for R2P8 and R3P9 (Iliescu et al, 2022). Because the evaluation of pollen germination rate is an essential criterion for kiwi pollinator's characterization, four genotypes - R0P3, R0P6, R2P8 and R3P9 (which recorded over 90% germinability rate after 24 hours), have been selected for further field tests (Iliescu et al., 2022).

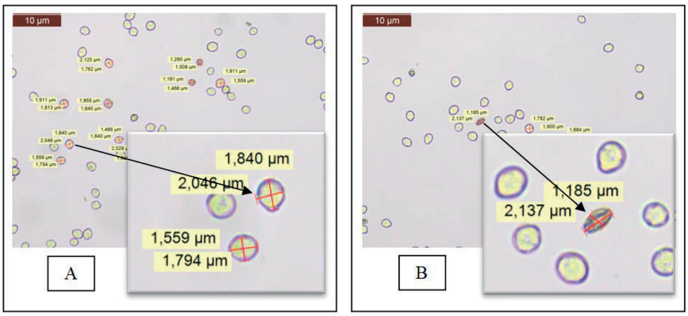

Figure 3. Viable (A) and dead (B) pollen grains of R0P7 male kiwifruit hybrid, after immerging in a 15% sucrose solution
(Source: Iliescu et al., 2022)

Study of some physical and chemical quality parameters of the fruits, at harvest and at consumption maturity, for some kiwi hybrid genotypes (*Actinidia* spp.)

Productivity index, average fruit weight, fruit shape index, length of the fruit peduncle, fruit flesh firmness, content in soluble solids (Brix %), total dry matter content (%), fructose and glucose content (%), malic acid and citric acid content (mg/100 g) and ascorbic acid content (mg/100 g), were determined on 20 fruits samples for some kiwifruit hybrids (Iliescu et al., 2019a; 2019c; Stănică et al., 2022a; 2022b; Vasile Scăețeanu et al., 2019).

Study regarding the fruit's storage capacity, initial analyzes (after harvest) and monthly analyzes in dynamics

Fruit behaviour in cold storage was evaluated in normal conditions (3°C and 95% relative humidity) and in three controlled atmosphere conditions, with 1.5% O_2, 2.0 and 5.0% CO_2, at 1-2 °C and 95% relative humidity (Cotruț et al., 2016; Iliescu et al., 2019 b; Stănică et al., 2007; Stănică et al., 2022 a, b). At harvest and then monthly, during the storage, some physical and chemical fruits parameters as fruit flesh firmness, percent of fruits losses, soluble solids content (Brix %), total dry matter content (%), fructose and glucose content (%); malic acid and citric acid content (mg/100g), ascorbic acid content (mg/100g), polyphenol content, antioxidant capacity, were determined (Cotruț et al., 2016; Iliescu et al., 2019 b; Stănică et al., 2007; Stănică et al., 2022 a, b).

Figure 4. Kiwifruits harvesting and storage possibilities (normal and controlled atmosphere conditions)
(Source: original, photo credit Lavinia Mihaela Iliescu)

Consumers perception regarding different characteristics of the fruits (shape and size, taste, flavor and pulp colour), for the hybrid female selections

Sensorial assessment was carried out in a sensorial testing laboratory by consumer panelists of different age, gender and origin (Iliescu et al., 2019c). Fruit quality was evaluated by appearance and taste (fruit size and shape, fruit pulp colour, taste and flavor) and for the results it was used a 1-5 rating Hedonic scale (Iliescu et al., 2019 c; Stănică et al., 2022a; 2022b).

Consumers education regarding local kiwi fruits production and the recommended consumption maturity

Consumer's request is focused more and more on high quality, safe and environment friendly products, as well as having a transparent traceability (Nicolae et al., 2016). In this context, Romanian consumers are more interested to consume local kiwifruits. In the framework of numerous events and fairs organized within the University of Agronomic Sciences and Veterinary Medicine of Bucharest and not only, a lot of consumers have the opportunity to test the kiwifruits produce in Romania. The purpose of this fruits testings are the educations of the Romanian consumers regarding the local production, the taste and flavor of the fruits, and also the recommended consumption maturity.

Different fruits consumption possibilities (fresh or processed)

Kiwifruits are mostly eaten fresh, although some kiwifruits are also processed into juices, alcoholic beverages (cider, liqueur, brandy), purees, candied fruit and bars, jam and marmalade, dehydrated and lyophilized products, cakes or pastries, kiwifruit leathers (Cassano et al., 2007; Guine et al., 2017; Stan et al., 2021). In the last years fruits processing starts to be more appreciate in the same way, by the consumers and also by the producers (Catană et al., 2018). The new tendency is to use local fruits and also to find innovative products using fruits waste (Catană et al., 2018).

Figure 5. Different products obtained from kiwi fruits and waste
(Source: original, photo credit Lavinia Mihaela Iliescu)

Kiwifruit propagation research in the last 25 years

According with Hartmann et al. (2011), Stănică et al. (1995), Stănică (2004) and Tanimoto (1994), the common methods of kiwifruit propagation are grafting, cuttings and micropropagation. Since 1993, Romanian researchers has been carried out a lot of studies to determine the best methods of propagation (Table 1), for all three species - *A. deliciosa*, *A. chinensis* and *A. arguta*. During the time, numerous studies have been carried out on the multiplication by grafting (Iliescu et al., 2021) or over grafting (Stănică et al., 2001), cuttings (Peticilă et al, 2015; Peticilă et al., 2016; Stănică et al., 1995; Stănică et al., 1997; Stănică et al., 2003b; 2003c) and micropropagation (Peticilă et al., 2012; Stănică et al, 1995; Stănică, 1998; Stănică & Armeanu, 2004; Stănică et al., 2004 Stănică et al., 2005). Stănică et al. (2002), in the study "Synthesis of researches regarding the kiwifruit (*Actinidia* sp.) propagation" concluded that: for **grafting** - the bark grafting method gave very good results with a rate of success between 75.7%-98.5%, waxed scions preservation at 3-4°C gave excellent result in terms of viability and aseptically and the best binding material for the grafting point was the black self-adhesive tape named Bendaflex; for **cutting** - the optimal period was between the end of January and mid-February (for *A. deliciosa* and *A. chinensis*) and beginning of August (for *A. arguta*), for obtaining a high rooting percentage a basal heating at 22-24°C and lower atmospheric temperature (15-18°C) were essential, the best results were obtained when perlite on wood compost and perlite on wood flour were used; for **micropropagation** - the best stage for the *in vitro* culture initiation is when the new shoots reach 5-10 cm length, the proper sterilization of the material was made with 0.1% mercuric chloride ($HgCl_2$), for 15 minutes for *Actinidia deliciosa* and 10 minutes for *A. arguta*, S 2,5 medium was the best for the multiplication phase with 4 weeks duration, acclimatization of rooted explants can be made in tap water (viability 92%) or in peat + perlite substrate under mist conditions.

Latest results regarding the kiwifruit breeding

Considering that the consumers global trends are increase regarding food safety and natural products (Lelieveld, 2015); the agricultural sector is sensitive to climate change (Bucur & Dejeu, 2016; Pickering et al., 2014); the farmers started convert their cultivating methods to organic, taking into consideration the environmental protection (Koufiotis et al., 2016) and conservation agriculture without affecting crop yields, especially on soils with high initial fertility (Rusu et al., 2015); the number of trees in urban agriculture are increasing and also the diversification of species and varieties of trees and shrubs grown (Bălan et al., 2015) and farmers' desire to cultivate profitable species increased (Asănică et al., 2016), the cultivation of the *Actinidia* in Romania, can be a solution for all of this tendencies.

In time, several hybrid genotypes were obtained by free and controlled crossings between different cultivars of *A. arguta*: Francesca, Rosana, Jumbo, AA2, AA5, AA 6, AA 8 and the male ARM (Stănică et al., 2003 a; Stănică & Zuccherelli, 2007). The first flowers and fruits from *A. arguta* hybrid plants were produced in 2001 and selection has continued since then (Stănică et al., 2003a; Stănică & Zuccherelli, 2007; Stănică & Zuccherelli, 2009). After some years of observations and tests, eight elite female plant with interesting fruit characteristics were chosen for propagation and testing under commercial orchard conditions (Stănică et al., 2003a; Stănică & Zuccherelli, 2007; Stănică et al., 2007; Stănică & Zuccherelli, 2009; Stănică et al., 2022b). From this, three kiwiberry selections were registered: 'Vip Green' (R8P23), 'Vip Red' (R8P20) and 'Green Delight' (R8P1), and for male selection was proposed R9P16 (Stănică et al., 2022b).

Other intra and interspecific crossings using *A. deliciosa* and *A. chinensis* were made and from the initial hybrids, some selected genotypes as R0P13, R1P9, R1P8 and R1P12, have good fruit characteristics and yield (Iliescu et al., 2019a, 2019c; Stănică et al., 1998; Stănică et al., 2022a), good storage capacity (Cotruț et al., 2016; Iliescu et al., 2019b; Stănică et al., 2007b; Stănică et al., 2022a; 2022b) and positive appreciation from consumers (Iliescu et al., 2019c; Stănică et al., 2022a). For male selections was proposed R2P8. This hybrid selections are under the registration process as new cultivars by ISTIS (Romanian institute for testing and registration of new varieties).

Table 1. Kiwifruit propagation results in the last 25 years

Species	Propagation methods	Materials and methods	Results and conclusions	References
Actinidia spp. and hybrids	grafting	**Rootstocks:** 'Z1 Vitroplant'; **Grafted method:** whip and tongue; **Time and temperature**: April, in a cold greenhouse, where the temperature varied between 20-24°C; **Materials:** Flexiband, Arborinn.	Grafting success rate varied between 45-90%.	Iliescu et al., 2021
	cuttings	**Substrate:** sand and perlite (1:1, volumetric ratio); **Experimental variants:** V1 - control; V2 - Radistim; V3 - NAA 2000 ppm (NAA = naphthyl acetic acid); V4 - IBA 2000 ppm (IBA = beta-indolyl butyric acid); V5 - NAA + IBA 1000 ppm.	For rooting stimulation, it is recommended treatment NAA+IBA 1000 ppm.	Peticilă et al., 2016
		Treatments: alpha naphthyls acetic acid (2,000 - 3,000 ppm); **Substrates:** double layers and mixed, with: wood flour + perlite; wood compost + perlite; cotton waste + perlite; **Temperature**: at the cutting's base was maintained constantly at 22-25°C, while in the air, at 15-18°C.	The rooting percentage and the quality of formed roots were strongly influenced by specie, variety, cutting moment, substrate type used and basal and atmospheric temperature. The optimal period for cutting was between the end of January and mid-February. The best results were obtained when pearlite on wood compost and pearlite on wood flour were used. On double layer variants the root's length was higher than in one-layer variants, but the root's number per cutting was lower.	Stănică et al., 2003 b
	micropropagation	**Explant types**: roots fragments of 2 cm length; shoots' internodes; petioles; leaf blades; **Culture media:** callogenetic medium MS, supplemented with 1.0 mg/l zeatine and 0.02 mg/l ANA; organogenetic medium MS, supplemented with 0.2 mg/l ANA and 2.0 mg/l BAP.	The greatest callus production was accomplished by the petiole and leaf blade. The pH value of the culture medium radically influenced the callogenesis and indirect organogenesis processes, the best results being registered for all explant types at pH 7. The callus growing (callogenesis) alternates with the formation of a big number of shoots on that callus (indirect organogenesis).	Stănică & Armeanu, 2004
A. deliciosa	cuttings	**Substrates**: 50% manure + 20% peat + 20% fallow soil + 10% sand; 40% manure + 50% fallow soil + 10% sand.	The obtained results regarding N, P, K accumulation in kiwi leaves recommend the cultivation of Hayward cultivar on substrate based on 50% manure + 20% peat + 20% fallow soil + 10% sand, this system offering the best release of available forms of nutritive elements for plants, with not significant differences given by the fertilization system, excepting N accumulation.	Peticilă et al, 2015
A. arguta	micropropagation	**Growing media**: classic MS with unchanged components; modified MS medium with a double quantity of ammonium nitrate (2N); modified MS medium with a triple quantity of ammonium nitrate (3N).	To initiate the culture of *A. arguta*, the most successful medium for the male plant (86.6%) was MS 2N and for the female plant (66.6%) were classic MS and MS 2N.	Peticilă et al., 2012

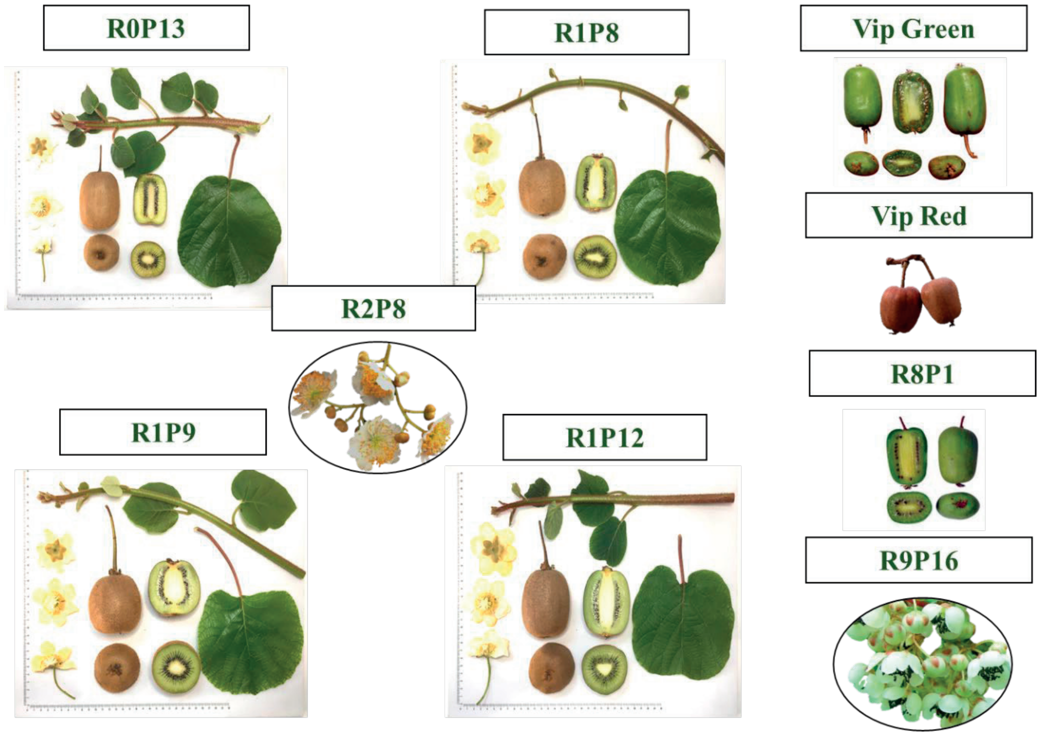

Figure 6. New released kiwifruit genotypes
(Source: original, photo credit Lavinia Mihaela Iliescu)

Actinidia arguta **Vip Green (R8P23)** CPVO: n. 2017/2828 (Figure 6) **-** it is a climbing plant of medium vigour, yielding specially on long and medium branches with determined growth; the cultivar is unisex, female with medium blooming period; the fruit is large (15.6 g), long of approximately 5.2 cm, cylindrical shape, flat dorso-ventral, with a diameter of 3.8 cm and one of 2.7 cm, olive green peel colour, shining green pulp, juicy, accentuated sweet taste, with very fine specific flavor (Stănică et al., 2022b). Contains about 14.2% dry soluble solids, balanced acidity, and 67.32 mg ascorbic acid at 100 g/fresh fruit (Stănică et al., 2022b). It starts bearing fruits in the 2^{nd}-3^{rd} year after planting and has a production capacity between 4.9-6.0 kg/plant (Stănică et al., 2022b).

Actinidia arguta **Vip Red (R9P20)** CPVO: n. 2017/2829 (Figure 6) **-** it is a climbing plant of medium vigour, yielding specially on long and medium branches with determined growth; the cultivar is unisex, female; with medium blooming period; the fruit is small to medium large (9.1 g), long of approximately 2.7 cm, truncated cone shape, with the largest diameter of 2.4 cm, dark red, shining red pulp, juicy, accentuated sweet taste, with very fine specific flavor (Stănică et al., 2022b). Contains about 16.65% dry soluble solids, low acidity, 76.7 mg ascorbic acid at 100 g/fresh fruit (Stănică et al., 2022 b). It starts bearing fruits in the 2^{nd}-3^{rd} year after planting and has a production capacity between 4.7-5.0 kg/plant (Stănică et al., 2022b).

Actinidia arguta **Green Delight (R8P1)** represented in Figure 6 – it is a climbing plant of medium vigour, yielding specially on long and medium branches with determined growth; the cultivar is unisex, female; with medium blooming period; the fruit is medium large (12-13 g), long of approximately 4 cm, cylindrical shape, flat dorso-ventral, olive green, shining green pulp, juicy, accentuated sweet taste, with very fine specific flavor (Stănică et al., 2022b).

Contains about 13.71% dry soluble solids, balanced acidity, 70.15 mg ascorbic acid 100 g/fresh fruit (Stănică et al., 2022b). It starts bearing fruits in the 2nd-3rd year after planting and has a production capacity between 4.7-5.4 kg/plant (Stănică et al., 2022b). The plants are resistant to *Pseudomonas syringae* pv. *Actinidiae* (Cotruț et al., 2013b).

For good pollination, two selected pollinators: **R9P16**, **R9P18** are recommended to be planted in the orchard in a 1:5 ratio.

Actinidia spp. **R0P13** (Figure 6) **-** it is a climbing plant; the cultivar is unisex, female with medium blooming period; the fruit is medium (65.77 ± 0.013 g), long of approximately 54.95 ± 0.812 cm, elliptical shape, with a diameter of 44.50±0.766 cm, shining green pulp, juicy, accentuated sweet taste, with specific flavor (Stănică et al., 2022a). At the consumption maturity contains about 17.56% Brix, 28.45% dry soluble solids, 1.536% citric acid, and 49.23 mg ascorbic acid at 100 g/fresh fruit (Stănică et al., 2022a). Harvesting period can start at the end of October * first decade of November (Stănică et al., 2022 a). Storage capacity is about 7 months in normal condition, respectively 10 months in controlled atmosphere (Stănică et al., 2022a).

Actinidia spp. **R1P8** (Figure 6) **-** it is a climbing plant; the cultivar is unisex, female with medium blooming period; the fruit is large (118.88 ± 8.291 g), long of approximately 57.86 ± 0.887 cm, elliptical shape, with a diameter of 57.86 ± 0.887 cm (Stănică et al., 2022 a). At the consumption maturity contains about 14.37% Brix, 16.30% dry soluble solids, 1.500% citric acid, and 38.92 mg ascorbic acid at 100 g/fresh fruit (Stănică et al., 2022a). Harvesting period can start at the end of October - first decade of November (Stănică et al., 2022a). Storage capacity is about 6 months in normal condition, respectively 7-9 months in controlled atmosphere (Stănică et al., 2022a).

Actinidia spp. **R1P9** (Figure 6) **-** it is a climbing plant; the cultivar is unisex, female with medium blooming period; the fruit is large (106.88±6.640 g), long of approximately 56.85±1.954 cm, spherical shape, with a diameter of 55.86±3.143 cm (Stănică et al., 2022 a). At the consumption maturity contains about 16.50% Brix, 32.26% dry soluble solids, 1.603% citric acid, and 77.20 mg ascorbic acid at 100 g/fresh fruit (Stănică et al., 2022a). Harvesting period can start at the beginning of November until the second decade of November (Stănică et al., 2022a). Storage capacity is about 8 months in normal condition, respectively 10-11 months in controlled atmosphere (Stănică et al., 2022a).

Actinidia spp. **R1P12** (Figure 6) **-** it is a climbing plant; the cultivar is unisex, female with medium blooming period; the fruit is very large (202.39 ± 3.479 g), long of approximately 72.91 ± 1.510 cm, oblong shape, with a diameter of 60.97 ± 1.305 cm (Stănică et al., 2022a). At the consumption maturity contains about 10.18% Brix, 13.41% dry soluble solids, 1.487% citric acid, and 125.38 mg ascorbic acid at 100 g/fresh fruit (Stănică et al., 2022a). Harvesting period can start at the end of October - first decade of November (Stănică et al., 2022a). Storage capacity is about 7 months in normal condition, respectively 8-10 months in controlled atmosphere (Stănică et al., 2022a).

For good pollination, two selected pollinators: **R2P8**, **R3P9** are recommended to be planted in the orchard in a 1:5 or 1:6 ratio. **R2P8** male plant formed between 4 and 6 or 8 flowers in the dichasium inflorescence, had over 90% pollen viability and 93.35% pollen germinability (Stănică et al., 2022a). **R3P9** male selection had between 3 to 5 flowers in inflorescence, over 97% pollen viability and 93.23% pollen germinability (Stănică et al., 2022a). The main advantage of R2P8 and R3P9 pollinators is a long flowering period, which coincides with the female selections.

CONCLUSIONS

After more than 25 years of research, it was demonstrated that the main *Actinidia* species can be cultivated in Romania with success.

Regarding *A. arguta*, **'Vip Green' (R8P23)** and **'Vip Red' (R9P20)** are two new kiwiberry cultivars in the last phases of registration at CPVO Angers. The green very large fruits (over 15 g), respectively the medium red ones (around 10 g) are very appreciated by the consumers. **Green Delight (R8P1)** and **R9P16** (male), are under the registration process as new cultivars by ISTIS (Romanian institute for testing and registration of new varieties). All cultivars showed a good adaptability to the Romanian local climate and pedological conditions, and they can be tested in other areas in order to be extended in commercial orchards. Kiwiberry or baby kiwi can cover larger areas, suitable for plums cultivation.

The new intra and interspecific kiwifruit hybrids females: **R0P13**, **R1P8**, **R1P9**, **R1P12** and male: **R2P8** selections, are under registration process as new cultivars by ISTIS (Romanian institute for testing and registration of new varieties) and can be successfully cultivated on commercial orchards and private gardens. The selected elites and other *A. deliciosa* and *A. chinensis* cultivars can be cultivated in Romania in the favorability zone for peach and apricot with some special measures for the deep frost protection of young plants and for the wind protection too.

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