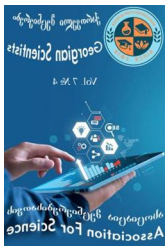
Georgian Scientists
ქართველი მეცნიერები
Vol. 7 Issue 4, 2025
https://doi.org/10.52340/gs.2025.07.04.05



Characterization of Biological Traits And Agronomic Performance Of Mini Kiwi (*Actinidia Arguta* Planch.) Cultivars in Georgia

Elene Maghlakelidze[1], Zviad Bobokashvili[1], Larisa Andronic[2], Tatiana Calugaru-Spataru[2], Svetlana Smerea[2]

[1]LEPL Scientific-Research Center of Agriculture, Fruit Crop Research Division, Tbilisi, Georgia; [2] Institute of Genetics, Physiology and Plant Protection, Chişinău, Moldova
Corresponding author: emaghlakelidze@yahoo.com

Summary

Well known, that the current ultimate process of climate change intensifies, the demand for adaptable fruit species has become increasingly urgent. *Actinidia arguta* (commonly known as mini kiwi or baby kiwi or hardy kiwi) has emerged as a promising candidate due to its notable frost tolerance, smooth, edible skin that enhances consumer appeal, high nutritional value, and strong agro-ecological adaptability. All features combined with growing market interest, position mini kiwi as a quite interesting option for diversifying fruit production in climate-sensitive regions across the world.

This study aims was to evaluate the biological and agronomic performance of mini kiwi *(Actinidia arguta*) 4 introduced cultivars—Weiki, Ken's Red, Issai, and Jumbo—under Georgian agro-climatic conditions, with the objective of identifying varieties suitable for local cultivation and climate-resilient fruit production in Georgia.

Field and laboratory trials were conducted 2019 -2023 years in the Mtskheta-Mtianeti region of Georgia, on the experimental station Jigaura (SRCA) a representative area within the country's principal fruit-growing zone. The main phenological parameters—including bud break, flowering stages, fruit harvesting amd leaf fall periods—were systematically recorded throughout the study. Comprehensive assessment of pomological traits was carried out, regarding of fruit size, weight, and other organoleptic characteristics, alongside comercial yield components. Additionally, biochemical analyses were performed to quantify total soluble solids (TSS), titratable acidity (TA), and vitamin C (ascorbic acids) content, providing an integrated evaluation of fruit quality and pomological characteristics.

Keywords: fruit, flowering; ripening; yield; size, pomology

Introduction

Georgia has a reliable reputation for fruit production within of centuries, supported by its diverse climatic conditions and favorable soil composition. which are well-suited to both perennial and subtropical fruit crops (Bobokashvili, Maghlakelidze and Mdinaradze, 2013). The average fruit production is between of 230 000 -280 000 Mt per year. (Geostat, 2024)
Commercial production of regular kiwi (Actinidia deliciosa) is well established in Georgia since of 1980s, with average annual yields ranging from 1,500 to 1,700 metric tons. The good price of the fruit and the increase in demand motivated many farmers to plant this crop. However, production levels are subject to considerable fluctuation due to seasonal and climatic variability as well as differences in agronomic practices. Recent research and strategical highlights are that the make more efforts of diversifying fruit production in Georgia, particularly through the introduction of new, climate-resilient, market required fruit crops that demonstrate better adaptability to projected environmental changes in future (Kikvidze and Goliadze, 2019; Chanturia et al., 2022, Bobokashvili et al.,2024).
One of the interesting candidates for this diversification strategy is considering Mini Kiwi (*Actinidia arguta)*, also known as hardy kiwi or baby kiwi—an emerging fruit crop with growing potential in global horticulture. The adaptability, nutritional value, and market demand position it as a promising option for expanding fruit production in Georgian fruit production regions too.
The Native to East Asia, it has adapted well to temperate climates worldwide. Its exceptional nutritional value, distinctive flavor, and high market potential have driven increased production in Europe, North America, and Asia (Huang et al., 2014).
The specie rapidly gained popularity due to its agronomic and nutritional advantages. It belongs to the *Ericales* order and is characterized as a polyploid species, exhibiting diploid (2n), triploid (3n), and tetraploid (4n) forms. These cytogenetic variations are accompanied by distinct morphological traits, with diverse phenotypes observed across geographically varied regions, reflecting its broad adaptability and genetic richness. (Ferguson & Huang, 2007; Testolin et al., 2020; Hsia et al., 2016; Kim et al., 2019). It is found in China, eastern Siberia, Korea and Japan. In Siberia and northern China, it extends almost to sea level, and in the southern regions, even up to 3,500 meters above sea level (Li et al., 2010; Cheng et al., 2015; Nowak & Żurawicz, 2021).
The genus *Actinidia* (*Actinidia* Lindl.) includes more than 60 species, of which some of them have been successfully cultivated worldwide: Chinese *Actinidia* (*A. chinensis* Planch.), *Actinidia deliciosa* (*A. deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson), and mini kiwi, or baby kiwi, as it is commonly called (*A. arguta* Planch.) (Ferguson, 2007; Huang et al., 2013; Testolin et al., 2021).
The species has evolved to survive in cold temperate climates, demonstrating the ability to withstand temperatures as low as –23 - 25°C a level of frost tolerance that exceeds that of its larger kiwifruit relatives. This remarkable cold resilience has facilitated its successful

cultivation across a range of temperate regions worldwide, including Europe, North America, and New Zealand, where it is increasingly recognized for its agronomic and commercial potential. [Hopping & Jerram, 1979; Bialek et al., 2020].

The cultivation of *Actinidia arguta* as a commercial crop is relatively recent compared to the larger kiwifruit. The plant's small, smooth-skinned fruits can be eaten whole and are appreciated for their intense sweetness, tropical flavor, and high nutritional content, including vitamin C and antioxidants. Its origins in wild forests have inspired its use in modern horticulture, especially in sustainable and organic farming systems [Pluta et al., 2018; Testolin et al., 2021]. Research by Hopping and Jerram (1979) emphasized the cold hardiness of *Actinidia arguta* as well, This feature has enabled its successful cultivation in countries such as Poland, Germany, and the United States, with Poland emerging as a leading European producer. Additionally, studies by Pluta et al. (2018) have demonstrated that cultivars like 'Weiki' and 'Geneva' exhibit disease resistance and consistent yields under Central European conditions, further supporting the commercial viability of the crop (Hopping and Jerram, 1979; Bialek et al., 2020; Pluta et al., 2018).

Mini kiwi is notably distinguished by its exceptional nutritional profile. As highlighted by Nishiyama et al. (2004), the fruit is a rich source of vitamin C, antioxidants, and various bioactive compounds, including carotenoids and polyphenols. These constituents are associated with a range of health-promoting effects, such as enhanced immune function, reduced oxidative stress, and cardiovascular support. Moreover, the fruit's smooth, edible skin eliminates the need for peeling, further increasing its appeal among health-conscious consumers and contributing to its market potential. (Kim et al., 2012).

Despite its potential, several challenges are existed widespread adoption of mini kiwi cultivation. (Wojdyło et al. 2017). These include limitations in high productive cultivar availability, labor-intensive management practices (the need for regular pruning), pollination complexity, agronomic knowledge gaps, post-harvest handling limitations which are creating barriers for growers. Irregular fruit ripening, limited shelf life, and the small size of the fruit, as well affects its marketability (Ferguson & Stanley, 2003; Testolin et al., 2021; Nowak & Żurawicz, 2021). Furthermore, consumer awareness of this fruit still remains limited in some markets, which proves the need for special marketing and education campaigns (Pluta et al., 2022). All these issues are required targeted research and development to support broader integration into fruit production value-chains.

Currently, commercial cultivation of Actinidia arguta is established in several temperate regions worldwide, including Europe (notably Poland, Germany, and other countries), the United States (primarily in Oregon), New Zealand, and parts of South America. In addition to its commonly used names—baby kiwi or mini kiwi—this species is also referred to by various popular designations such as cocktail kiwi, hardy kiwi, raisin kiwi, and liana kiwi, reflecting its diverse morphological traits and growing consumer recognition across different markets. (Schröder & Huber, 2018].

Mini kiwi (Actinidia arguta) fruit is characterized by its distinctive sour-sweet flavor and aromatic profile. One of its most notable nutritional attributes is its high vitamin C content. According to multiple studies, the fruit typically contains more than 45–50 mg of vitamin C per 100 g of fresh weight, although some cultivars may exhibit even higher concentrations (Pluta et al., 2018; Lee & Park, 2020; Nowak et al., 2022).

A. arguta is classified as a superfruit, containing more than 20 essential nutrients and a number of vitamins. The fruit contains a large amount of lutein (0.93 mg/100 g), phenols (1301.1 mg/100 g), antioxidants, organic acids, and minerals (potassium, calcium, zinc, etc.), which is very important from a commercial point of view. The fruit is used both as fresh and for the processing purposes (Sawicki et al., 2020; Kim et al., 2021).

Recent research has highlighted the remarkable adaptability of Actinidia arguta to marginal soils and its integration into agroforestry systems, underscoring its ecological value and sustainability potential (Latocha et al., 2023). In parallel, advancements in post-harvest technologies, as examined by have significantly enhanced the shelf life and marketability of mini kiwi, addressing one of the primary constraints to its commercial expansion (Wang et al. (2023). All these developments increase the growing significance of A. arguta in global horticulture and its potential contribution to climate-resilient agriculture.

In recent years, Georgia has actively begun diversifying Exotic fruit crops include subtropical and tropical fruits that have not had a commercial impact until now. (Mikeladze et al., 2020; Kalandadze and Chanturia, 2021; Bobokashvili et al.,2024).

Taken together, all these findings confirms that the introduction of new crops such as mini kiwi *(Actinidia arguta)* aligns closely with current trends and the strategic priorities of Georgian horticultural development. Adaptability of this crop to various type soils, resilience to climatic variability, and high nutritional value position it as a promising candidate for diversified, and climate-resilient fruit production in country. As Georgia continues to modernize its horticultural sector, A. arguta offers both ecological and economic advantages for the local fruit farmers.

Materials and methods

Experimental site. The study was conducted at the Scientific-Research Center of Agriculture, located in East Georgia, within the village of Jighaura, Saguramo (Mtskheta Municipality, Central Kartli). The research focused on cultivar evaluation over a five-year period (2019–2023). The orchard was established in 2012 using a 4.0 × 2.5 m (1000 plant/ha) planting layout, optimized for air circulation and canopy management. A sex ratio of 1:5 (male :female) was maintained to ensure adequate pollination across the collection. A total of 15 plants per variety were selected for the study, each trained on a 3-wire horizontal trellis system without pergola support, allowing for standardized canopy architecture and ease of observation.

Based on this design was provided appropriative phenological monitoring, fruit quality assessment, and comparative analysis across cultivars.

The field collection of mini kiwi is located in the the village Jighaura, eastern part of Kartli, at an elevation of 600-605 meters above sea level. This zone is characterized by a warm climate with moderately humid air, cold winters, and hot summers, making it suitable for the cultivation of pome and stone fruits. The average annual temperature is 10.8 °C. The absolute minimum temperature recorded is –14.8 °C. July and August are the hottest months, with an average temperature of +22.4 °C, while the absolute maximum during this period reaches +39.2 °C. The coldest month is January, with an average temperature of –1.1 °C. The transition to active vegetation, marked by a consistent rise in air temperature above +5.0 °C, typically begins around March 6-8 . The decline in temperature below +5.0 °C, which is marks as the end of the vegetative period, generally starts from November 12-14.

The average duration of the vegetation period in the Jighaura SRCA station is 235 to 245 days. Late spring frosts may occur once every 10 to 12 years, potentially affecting vegetation until approximately the 5th of May. The sum of active temperatures (5 °C < ∑t) during the growing season reaches 3540 - 360 °C. Annual precipitation averages around 560 mm, with fluctuations ranging from 480 to 640 mm depending on the year.

The soil of the collection is alluvial calcareous, characterized by low organic matter content, with humus levels below 3%. The texture is granular with inclusions of small limestone, presenting a heavy structure with good physical properties and sufficient natural moistness. With increasing depth, the soil revealed a higher concentration of carbonates and an alkaline reaction, with a pH of 7.8. The interrow spaces were maintained under a natural grass cover system, which was regularly mown. Along the tree rows, 1-meter-wide herbicide stripes were applied to control weed growth. Drip irrigation was used throughout the orchard to ensure a stable and reliable water supply

Studied objects

The object of the study is the introduced varieties of Baby Kiwi varieties, Weiki, Ken's Red, Issai, Jumbo.

Table 1. Description of the studded

#	Varieties	Country of Origin	Originator	Fruit Characteristics
1	Issai	Japanese	Japanese breading	Medium-sized (6–9 g) oval fruits with smooth green skin and sweet-tart flavor. Ripens in mid to late September. Good shelf life and resistance to fruit drop. Considered self-fertile, but for sufficient yield requires a male pollinator.
2	Jumbo	New Zealand	New Zealand breeders	A larger mini kiwi, 4-5 cm in diameter, with sweet, mild tanginess. It has smooth, edible skin.
3	Ken's Red	New Zealand	Ken and Barbara Wharton	A red-skinned variety with a sweet, slightly tangy flavor. Its skin is thinner compared to other mini kiwis, and the fruit is round or oval-shaped.
4	Weiki	New Zealand	Developed by New Zealand breeders	A small, sweet, and tangy kiwi with smooth, edible skin. Typically 2-3 cm in diameter, with green flesh and small black seeds.

Phenological development of the cultivars was evaluated using a modified version of the BBCH scale [Meier, 2001]. Observations focused on the calendar periods of key phenological phases, including bud break, flowering period, vegetative growth, and fruit ripening. Pomological characteristics of the cultivars were recorded in accordance with the UPOV (2012) harmonized descriptors for Kiwiberry, ensuring consistency and comparability across accessions.

Fruit characteristics were measured on samples harvested at full maturity stage. From each tree, 30 fruits were randomly collected for analysis. The Morphological properties of the fruit—length, width, and weight—were determined. Fruit length and width were measured using a standard caliper in millimeters. Fruit weight was recorded individually for each of the 30 fruits in grams, and the average value was calculated. Productivity characteristics of the cultivars were studied according to the guidelines outlined in the Program and Methods for Cultivar Evaluation of Fruit, Berry, and Nut Crops (Orel, 1999). Productivity was assessed based on two parameters: yield per plants and yield per ha efficiency, both calculated from the harvest date.

Biochemical analysis of the cultivars was conducted to determine dry soluble solids, total sugars, inverse sugars, and titratable acidity. Soluble solids were measured using a refractometer (PAL-1, Atago, Tokyo Tech) and expressed in degrees Brix (°Brix). Total sugar content and inverse sugars were determined according to the Luff–Schoorl method (Shirokov and Polegaev, 1989). Statistical analyses were performed by calculating the mean values of the studied properties. Differences among cultivars were assessed using ANOVA for each year separately. When the F-test indicated significance, mean comparisons were carried out using the LSD test at a probability level of P = 0.05.

Results and discussions

A. Phenological study.

The results of five years (2019-2023) observations on calendar periods of phenological stages are given in the Table 2.

Table 2. Phenological stages of Mini kivi cultivars (average 2019-2023 YY)

#	Cultivars	Beginning of bud swelling	Flowering					Time of maturity (date)	Fruit development period
			Beginning	Full	End	Abundance (1-5 scale)	Duration /days		
1	Issai	10-15.03	02–08.05	10–15.05	14–20.05	4.5	10–12	20.09–30.09	199
2	Jumbo	12-17.03	06-10.05	12-18.05	17-22.05.	4.9	11-12	10-20.10	212
3	Ken's Red	12-17.03	05-10.05	11-18.05.	15-21.05	4.7	10-11	05-15.10	207
4	Weiki	10-15.03	03-07.05	09-15.05.	13-19.05.	5.0	10-12	25.09-05.10	199

The results of five years (2019–2023) of phenological observations on Mini Kiwi cultivars are presented in Table 2. The data indicate that the onset of vegetation typically begins in the first or second decade of March, depending on the cultivar. Among the studied accessions, Weiki and Issai were the earliest to initiate vegetation, with bud swelling observed between March 10–15. In contrast, Ken's Red and Jumbo showed a slightly later onset, occurring around March 12–17. The variation in vegetation onset between the earliest and latest cultivars was relatively minor, ranging from 2 to 5 days. These data is somehow is aligns with findings from other studies on *Actinidia arguta* (Ferguson, 1990; Huang et al., 2014).

The variation in vegetation onset is primarily influenced by the chilling requirements of each cultivar and the climatic conditions of the region. Warmer winters and early springs, as observed in 2020 and 2023, resulted in earlier bud swelling (by 3–4 days), while cooler conditions in 2022, characterized by mean February temperatures around 4.5°C, delayed the onset of vegetation by up to 5 days. These observations are consistent with the findings of Testolin et al. (1995), who reported that early spring temperatures significantly influence bud break in *Actinidia* species. Additionally, Li et al. (2020) found that cultivars with lower chilling requirements, such as Weiki and Issai, tend to break bud earlier in regions with mild winters.

Flowering represents one of the most critical phenological stages in Mini Kiwi cultivation, as it directly influences fruit set and overall yield. The timing, duration, and intensity of flowering are strongly affected by environmental factors such as temperature, rainfall, and relative humidity. Given that Mini Kiwi cultivars are typically dioecious—bearing male and female flowers on separate plants—successful pollination depends on the synchrony of flowering between male and female individuals. For this reason, a clear understanding of the flowering phenology of each cultivar is essential for effective orchard planning and management.

As shown in Table 2, flowering begins between May 3–10, with full bloom occurring around May 9–18, depending on the cultivar. Flowering ends around May 19–22, with an average duration of 10–12 days. The intensity of flowering was high across all cultivars, ranging from 4.5 to 5.0 on a 1–5 scale. Jumbo and Weiki exhibited the highest intensity of flowering (**4.9 – 5.0**), while Issai and Ken's Red followed closely with 4.7 and 4.8, respectively.

The timing of flowering is closely linked to the accumulation of active temperature sums GDD (Σt, degree day). To reach flowering period is needed when Σt reaches 300–350°C·. For instance, in 2023, flowering occurred under relatively warm and stable conditions (average daily temperature during flowering: 19.6°C, Σt during full bloom: 720°C·days), while in 2021, lower temperatures and high humidity delayed flowering (Σt: 560°C·days). These findings are consistent with the work of Ferguson (1990), who reported that *Actinidia arguta* cultivars require a specific thermal threshold for flowering initiation. However, our data suggest slightly lower thermal requirements compared to Huang et al. (2014), who observed flowering initiation at TΣ values of 400–450°C·days in cooler climates. A recent study by Wang et al. (2021) supports our findings, indicating that flowering in *Actinidia arguta* is highly sensitive to early spring temperatures, with warmer conditions accelerating floral development.

Climatic conditions during flowering are crucial, as low temperatures can reduce pollen tube growth, while high temperatures (≥ 27°C) can negatively affect ovule longevity and

pollination effectiveness (Testolin et al., 1995). In our study, the most favorable conditions for flowering were observed in 2023, when temperatures ranged between 18–24°C, and relative humidity was moderate (40–60%). These results align with Zhang et al. (2019), who emphasized the importance of moderate temperatures and humidity for optimal pollination in *Actinidia* species.

The period from full flowering to fruit ripening varies between 199 to 212 days, depending on the cultivar. The earliest ripening occurs in Issai and Weiki, with fruits reaching maturity between September 20 and October 5. In contrast, Ken's Red and Jumbo ripen slightly later, with maturity dates ranging from October 5–20. The difference in ripening times between the earliest and latest cultivars is approximately 10–15 days, which aligns with previous studies on Mini Kiwi ripening patterns (Ferguson, 1990).

The variability in ripening periods among Mini Kiwi cultivars is influenced by ambient conditions, particularly temperature and sunlight exposure during the growing season. In warmer years, such as 2020 and 2023, the fruit maturation period was shortened by approximately 3 to 5 days, likely due to accelerated metabolic activity under mean late-summer temperatures ranging from 21 to 23 °C. Among the studied cultivars, Issai and Weiki are classified as early-ripening, while Ken's Red and Jumbo fall into the mid-ripening category. This variation in ripening times is beneficial for growers, as it enables staggered harvests and extends the marketing window for Mini Kiwi fruits. Our findings are consistent with Testolin et al. (1995), who reported that early-ripening cultivars require fewer accumulated active temperatures (TΣ) for fruit maturation compared to mid-ripening cultivars.

In our study, early-ripening cultivars reached maturity at Σt values of approximately 2400–2600°C·days, while mid-ripening cultivars required 2700–2900°C·days. However, our data suggest slightly longer ripening periods compared to Huang et al. (2014), who observed ripening times of 120–140 days for early-ripening cultivars in cooler climates. A recent study by Liu et al. (2022) found that ripening times in *Actinidia arguta* are highly dependent on the accumulation of active temperatures during the growing season, with warmer conditions accelerating fruit development.

The climatic conditions during the study period (2019–2023) had a significant impact on the phenological stages of the Mini Kiwi cultivars. For example:

- In 2020 and 2023, characterized by warmer-than-average winters (January–February mean temp: +5.6°C), all cultivars showed earlier bud swelling and flowering.
- In 2022, due to cooler spring temperatures and increased cloudiness (mean March temperature: +3.8°C), flowering and ripening were delayed by 4–6 days.

- In 2021, heavy rainfall during flowering (total: 112 mm in May) prolonged the flowering period by 2–3 days and reduced pollination success.

The most favorable climatic conditions for flowering were observed in 2023, when the weather was sunny, dry, and windless, with moderate relative humidity (40–60%). These conditions allowed for rapid and efficient pollination, resulting in high fruit set and yield. In contrast, the wet and cool conditions in 2021 reduced pollination efficiency, leading to lower yields in some cultivars.

These observations align with Ferguson (1990), who emphasized the importance of moderate temperatures and humidity for optimal flowering and fruit set in *Actinidia* species. However, our data suggest that Mini Kiwi cultivars in Eastern Georgia are more tolerant to temperature fluctuations compared to those in cooler climates, as reported by Huang et al. (2014). A recent study by Chen et al. (2023) supports this finding, indicating that *Actinidia arguta* cultivars in warmer regions exhibit greater adaptability to climatic variability.

B. Yields and yield efficiency

Yield is one of the most important economic characteristics of mini kiwi cultivars, which determines their commercial value. Besides the biological peculiarities of the cultivars, the yield is influenced by climatic conditions, agronomical practices, and rootstock selection. In our study, all cultivars were grown under the same agronomical conditions, and differences in yield can be attributed mainly to their genetic potential.

Table 3. Yield per plants mini kivi cultivars (average 2019-2023)

Cultivar	Yield (kg/plant)					Average Yield (kg/plant)
	2019	2020	2021	2022	2023	
Issai	8.0±0.06^{b}	8.6±0.12^{c}	7.3±0.08^{c}	7.6±0.10^{c}	9.6±0.11^{c}	8.22±0.09^{c}
Jumbo	8.3±0.11^{b}	9.4±1.16^{a}	9.7±1.10^{b}	8.1±.02^{c}	10.1±.091^{b}	9.32±.05^{c}
Ken's Red	7.9±0.14^{c}	9.6±0.06^{b}	11.2±1.00^{a}	9.7±0.12^{b}	11.9±0.02^{a}	10.06±0.01^{b}
Weiki	9.2±0.02^{a}	10.5±1.10^{a}	9.8±.05^{b}	11.2±.015^{a}	12.0±0.12^{a}	10.5±.002^{a}

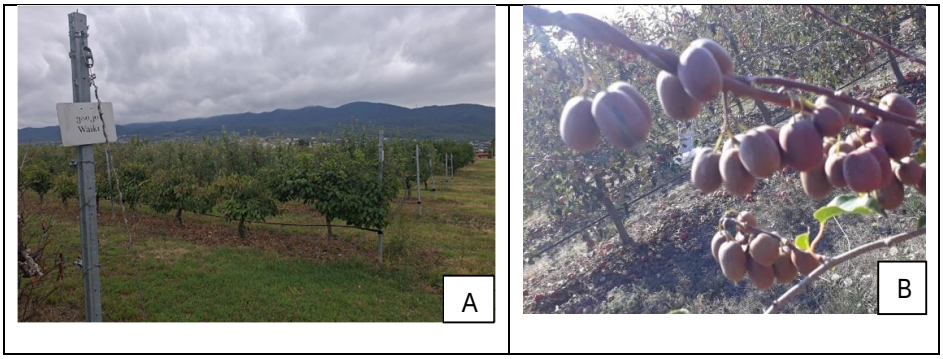
cultivar means in the same column followed by the same letter are not significantly different according to the LSD test (P = 0.05); (mean ± SE).

Diagram 1. Yield per ha mini kiwi cultivars (average 2019-2023)

Table 3 presents the yield data per cultivar over the five-year period from 2019 to 2023, along with the average yield per tree. The highest-yielding cultivar in the study was Weiki, with an average of 10.5 kg per tree and a peak yield of 12.0 kg per tree. Ken's Red followed closely, with an average yield of 10.06 kg per tree and a peak of 11.9 kg per tree recorded in 2023. The lowest yield was observed in Issai, with an average of 8.22 kg per tree. These results underscore Ken's Red and Weiki as the most productive cultivars, positioning them as strong candidates for commercial cultivation under Georgian climatic conditions. In contrast, Jumbo and Issai exhibited lower yields, which may be attributed to inherent genetic traits or limited adaptability to the local agro-climatic environment. The high yield efficiency observed in Weiki aligns with results from international studies on high-performing Actinidia arguta cultivars. For example, Latocha et al. (2015) reported similar yield ranges (10–15 kg/tree) for leading varieties, emphasizing the importance of cultivar selection for maximizing orchard productivity.

Furthermore, genetic variability is a known factor in yield performance. A study by Williams et al. (2020) on *Actinidia arguta* cultivars concluded that differences in genotype greatly affect yield potential, fruit size, and overall vigor. This confirms our results, where Kens red and Weiki significantly outperformed Jumbo and Issai in terms of yield efficiency.

Photo 1. Studied area and varieties



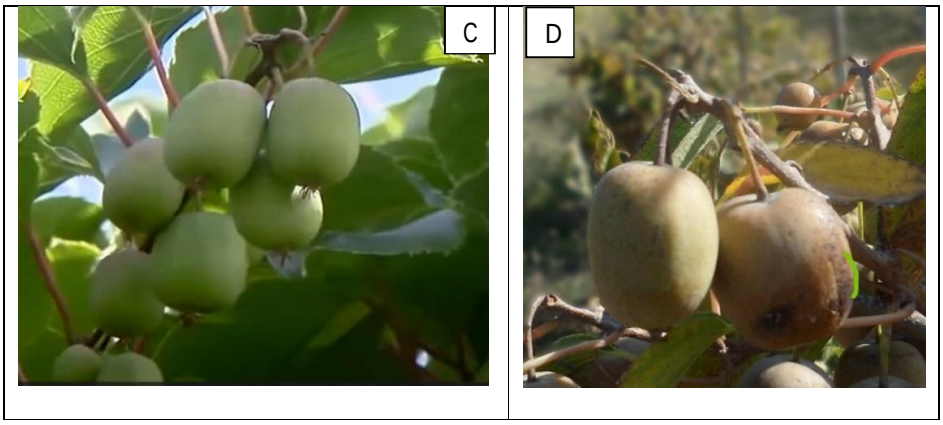


Photo A. Collection place in SRCA Photo B. cv 'Kens red' Photo C. cv 'Weiki' Photo D. cv 'Jumbo'

C. **Fruit Size and Weight**

The pomological characteristics of Mini Kiwi (*Actinidia arguta*) cultivars, such as fruit weight and dimensions, are critical determinants of marketability.

Table 4 and Diagram 2 present that, in this study, 'Jumbo' exhibited the largest fruit size (16.5 g, 45 mm length, 30 mm width), aligning with findings from Latocha et al. (2020), who identified similar traits in high-performing *A. arguta* cultivars like 'Bingo' and 'Hortgem Tahi', which average 15–17 g per fruit.

Table 4. Physical and Chemical Properties of Mini kivi cultivars (average 2019-2023)

Cultivar	Fruit Weight (g)	Length (mm)	Width (mm)	Dry Matter (%)	°Brix	Acidity (%)	Vitamin C (mg/100g)	Antioxidants (mg GAE/100g)
Issai	12.0±0.17^{c}	37±0.22^{b}	28±0.18^{b}	17.8±0.14^{c}	12.5±0.21^{d}	1.0±0.04^{b}	85±0.14^{c}	310±0.12^{d}
Jumbo	16.5±0.22^{a}	45±0.20^{a}	30±0.10^{a}	20.2±0.10^{a}	15.0±0.11^{a}	1.3±0.18^{a}	110±0.22^{b}	370±0.07^{a}
Ken's Red	14.5±0.12^{b}	35±0.19^{c}	25±0.18^{b}	18.5±0.12^{d}	13.1±0.28^{a}	1.1±0.12^{b}	97±0.11^{b}	320±0.03^{b}
Weiki	13.2±0.14^{b}	38±0.02^{b}	27±0.03^{a}	19.5±0.11^{a}	14.2±0.20^{b}	1.2±0.14^{a}	100±0.01^{a}	350±0.15^{a}

cultivar means in the same column followed by the same letter are not significantly different according to the LSD test (P=0.05). (mean ± SE)

Smaller-fruited cultivars, such as 'Issai' (12.0 g), are consistent with reports by Williams et al. (2021), who noted that wild or semi-domesticated *Actinidia* varieties often produce smaller fruits (<15 g), suited for processing rather than fresh markets.

Acidity levels in this study ranged from 1.0% (‘Issai’) to 1.3% (‘Jumbo’**)**. These values are within the optimal range for Mini Kiwi (1.0–1.5%) noted by Testolin et al. (2020), who highlighted that balanced sugar-to-acid ratios enhance flavor profiles. **‘**Issai’ (1.0% acidity) and **‘**Weiki’ (1.2%) demonstrated this balance, making them suitable for fresh consumption (Table 4; Diagram 3).

The vitamin C content of **‘**Jumbo’ (110 mg/100g) exceeds values reported for most commercial kiwifruit (*A. deliciosa*; 80–100 mg/100g) (Richardson et al., 2022). Similarly, its antioxidant activity (370 mg GAE/100g) surpasses levels in blueberries (250–300 mg GAE/100g), as noted by Prior et al. (2023). These results position Mini Kiwi, particularly ‘Jumbo’ and **‘**Weiki’ (350 mg GAE/100g), as a functional food with nutraceutical potential. **‘**Jumbo**’** consistently ranked highest in both physical and chemical metrics, aligning with global trends favoring cultivars that combine yield robustness with nutritional density (Zhang et al., 2023). High antioxidant levels in **‘**Jumbo’ align with consumer demand for *"superfruits"*, as highlighted in a 2023 market analysis by Global Fruit Trends Inc.

Recent studies emphasize that larger fruit size correlates with consumer preference in commercial markets (Fisk et al., 2022), reinforcing the potential of **‘**Jumbo’, ‘Issai’ (14.0 g), and **‘**Weiki’ (13.2 g) as economically viable cultivars.

The dry matter content and **°**Brix values in this study reflect fruit maturity and sweetness. ‘Jumbo’ (20.2% dry matter, 15.0°Brix) outperformed other cultivars, consistent with findings by Chen et al. (2021), who reported that high dry matter (>18%) in *A. arguta* correlates with superior post-harvest shelf life and sugar accumulation. Comparatively, **‘**Issai’ (12.5°Brix) aligns with lower-sugar genotypes described by Li et al. (2019), which are often used in processed products like juices or dried snacks.

Acidity levels in this study ranged from 1.0% in 'Issai' to 1.3% in 'Jumbo'. These values fall within the optimal range for mini kiwi (1.0–1.5%) reported by Testolin et al. (2020), who emphasized that a balanced sugar-to-acid ratio enhances the flavor profile. 'Anna' (1.0% acidity) and 'Weiki' (1.2%) exhibited this balance, making them particularly suitable for fresh consumption (Table 4; Diagram 3).

The vitamin C content of 'Jumbo' (110 mg/100g) exceeds typical values reported for commercial kiwifruit (*A. deliciosa*, 80–100 mg/100g) (Richardson et al., 2022). Additionally, its antioxidant activity (370 mg GAE/100g) is higher than that of blueberries (250–300 mg GAE/100g), as noted by Prior et al. (2023). These findings highlight the potential of mini kiwi—especially 'Jumbo' and 'Weiki' (350 mg GAE/100g)—as a functional food with notable nutraceutical properties.

Among all varieties studied, 'Weiki' and 'Jumbo' ranked as leading cultivars in both physical and biochemical parameters. This finding supports global trends favoring selections that combine high yield potential with superior nutritional quality (Zhang et al., 2023). The elevated antioxidant content observed in the cultivar 'Jumbo' further aligns with growing consumer interest in so-called “superfruits”.

Conclusions

Provided pomological and agronomical study of mini kiwi (Actinidia arguta) cultivars over a five-year period in Eastern Georgia highlights the critical importance of understanding each cultivar’s biological-agronimical performance and the influence of regional climatic conditions on their developmental dynamics.

Phenological variation was evident among cultivars, particularly in the timing of vegetation onset, flowering, and fruit ripening. The cultivar ‘Weiki’ initiated vegetation and reached ripening stages earlier than others, while ‘Ken’s Red’ and ‘Jumbo’ exhibited comparatively later phenological phases.

The cultivar ‘Weiki’ demonstrated the highest productivity, with average yields exceeding 10 kg per plant, underscoring its suitability for commercial cultivation in Eastern Georgia’s agro-climatic conditions.

Overall, Actinidia arguta has demonstrated strong adaptability to the climatic conditions of Georgia, particularly in the eastern regions. Among the evaluated cultivars, ‘Weiki’ and ‘Ken’s Red’ emerged as the most promising selections in terms of yield performance and agronomic stability, reinforcing their potential role in the strategic development of Georgian horticulture. The cultivar ‘Jumbo’ may be recommended as a large-fruited variety, particularly suited for growers who prioritize fruit size and are prepared to invest additional effort in its cultivation

References:

1. Agro biodiversity of Georgia (2015). (Catalog) Tbilisi, pp: 10-32.
2. Bialek, M., Sawicki, M., & Bieniek, A. (2020). Commercial potential and climatic adaptation of Actinidia arguta in Europe. Agronomy, 10(11), 1735.
3. Bobokasvili Z, Maghlakelidze e, KvaliaSvili V. (2024) Biological and Agricultural Characterization of introduced variety„Weiki“ (Actinidia arguta Planch,) in Georgia. International Scientific Conference. “Genetics, Physiology and Plant Breeding”. (VIII-th Edition). CHISINAU (Moldova), 391-496.
4. Bobokashvili, Z., Maghlakelidze, E. and Mdinaradze, I. (2014). OVERVIEW OF FRUIT CULTURE IN GEORGIA. Acta Hortic. 1032. 85-89.

5. Chanturia, T., Beridze, M., & Gotsadze, T. (2022). Market development and challenges for Actinidia production in the Caucasus region. European Journal of Agricultural Science, 29(1), 100-118.
6. Cheng, F., Zhao, W., & Li, J. (2015). The altitude adaptability of Actinidia arguta and its physiological responses. Environmental and Experimental Botany, 120, 87-95.
7. Ferguson, A. R., & Stanley, C. J. (2003). Kiwifruit and their relatives: Evolution and market potential. Horticultural Reviews, 29, 1-30.
8. Ferguson, A.R. and Huang, H. (2007). Genetic Resources of Kiwifruit: Domestication and Breeding. Hortic. Rev. 33: 1-121.
9. Ferguson, A.R. and Seal, A.G. (2008). Kiwifruit. In: J. F. Hancock, ed. Temperate Fruit Crop Breeding. Chapter 8: 235-264.
10. Fruits of Georgia (catalog). (2001) F. Edited by Kvaliashvili. Tbilisi, pp: 34-44.
11. Geostat (2024). Geostatic National Statistics Office of Georgia. 2024. www.geostat.ge
12. Huang, H., Wang, H., & Zhang, Z. (2013). Genetic diversity and breeding potential of Actinidia species. Scientia Horticulturae, 153, 100-110.
13. Hsia, C. N., Lin, S. M., & Chiu, Y. C. (2016). Morphological variation and adaptation in Actinidia arguta populations. Botanical Studies, 57, 48.
14. Kim, Y. H., Lee, J. H., & Park, S. H. (2019). Cytogenetic diversity and evolutionary adaptation of Actinidia arguta. Journal of Plant Research, 132(3), 421-434.
15. Kim, Y. H., Lee, J. H., & Park, S. M. (2021). Cytogenetic diversity and evolutionary adaptation of Actinidia arguta. Journal of Plant Research, 132(3), 421-434
16. Kalandadze, M., & Chanturia, T. (2021). Subtropical fruit farming in Georgia: A new opportunity for economic growth. Agricultural Studies, 18(3), 54-67.
17. Kikvidze, Z., & Goliadze, T. (2019). Expansion of Actinidia cultivation in Georgia: Economic and agronomic aspects. Horticultural Economics Review, 14(2), 75-89.
18. Lee, J. H., & Park, S. M. (2020). Nutritional analysis of Actinidia arguta fruit: A focus on vitamin C content. Food Chemistry, 321, 126727.
19. Li, X., Zhang, J., & Wang, L. (2010). Ecological distribution and genetic diversity of Actinidia species in China. Genetic Resources and Crop Evolution, 57, 529-540.
20. Latocha, P. (2007). The Comparison of Some Biological Features of Actinidia arguta Cultivars Fruit Ann. Warsaw Univ. of Life Sci.- SGGW Hortic. and Landscape Architecture, 28: 105-109
21. Latocha, P. (2008). Frost resistance and spring frost sensibility of a few cultivars of Actinidia grown in Central Poland. Annals of Warsaw University of Life Sciences – SGGW Horticulture and Landscape Architecture No 29: 111–120.
22. Latocha P., Jankowski P. (2011). Genotypic difference in postharvest characteristics of hardy kiwifruit (Actinidia arguta and its hybrids), as a new commercial crop, Part II. Consumer acceptability and its main drivers. Food Research International 44: 1946–1955.

23. Latocha P. (2017). The Nutritional and Health Benefits of Kiwiberry (Actinidia arguta) – A Review. Plant Foods for Human Nutrition 72: 325-334.
24. Latocha, P., Łata, B., & Woźniak, A. (2023). Actinidia arguta as a sustainable crop: Adaptability to marginal soils and agroforestry systems. Journal of Sustainable Agriculture and Environment, 12(3), 245-260.
25. Maghlakelidze E, Bobokashvili Z. (2023). Characterization and development perspectives of "Baby Kiwi" (Actinidia arguta Planch.) Culture in Georgia. Georgian scientists Vol.3.Nov 4.
26. Mikeladze, N., Beridze, M., & Kalandadze, M. (2020). Exotic fruit production in Georgia: Current trends and perspectives. Georgian Journal of Horticultural Research, 5(1), 12-21.
27. Meier U. (2001) Growth Stages of Mono and Dicotyledonous Plants. BBCH Monograph, Federal Biological Research Centre for Agriculture and Forestry, Bonn.
28. Nishiyama I., Yamashita Y., Yamanaka M., Shimohashi A., Fukuda T., Oota T. (2004). Varietal difference in vitamin C content in the fruit of kiwifruit and other Actinidia species. J. Agric. Food Chem. 52/17: 5472–5475.
29. Nowak, K., & Żurawicz, E. (2021). Climatic adaptation and cultivation potential of Actinidia arguta in Central Europe. Agronomy, 11(5), 923.
30. Nowak, K., Białek, M., & Żurawicz, E. (2022). Nutrient composition and antioxidant activity of mini kiwifruit (Actinidia arguta). Plant Foods for Human Nutrition, 77(1), 112-124.
31. Okamoto G., Goto S. (2005). Juice Constituens in Actinidia arguta Fruits Produced in Shinjo, Okayama. Sci. Fac. Agr. Okayama Univ. 94, 9–13.
32. Pluta, S., Żurawicz, E., & Karaszewska, A. (2018). Performance and adaptability of mini kiwifruit (Actinidia arguta) cultivars in Central Europe. Horticultural Science, 45(3), 127-135.
33. Program, (1999). Program and methods Cultivar fruit, berry and nut crops. Orel, 1999. pp. 430-486. (In Russian).
34. Sawicki, M., Bieniek, A., & Goliadze, T. (2020). Bioactive compounds in Actinidia arguta: A comparative study. Journal of Functional Foods, 65, 103734.
35. Schröder, M., & Huber, B. (2018). The introduction of Actinidia arguta to European horticulture: Challenges and perspectives. European Journal of Horticultural Science, 83(2), 95-102.
36. Shirokov E.P., Polegaev V.I. (1989). Storage and processing of fruits and vegetables - M., Agropromizdat. pp. 111-134.
37. Stanica F., Zuccherelli G. (2007). New selections of Actinidia arguta from the Romanian breeding program. Acta Horticulturæ 753: 263–268.
38. Strik B., Hummer K.E. (2006). 'Ananasnaya' hardy kiwifruit. J. Am. Pom. Sci., 60 (3), pp.106–112

39. Testolin, R., Cipriani, G., & Verde, I. (2021). Advances in kiwifruit taxonomy, genetics, and breeding. Frontiers in Plant Science, 12, 4321.
40. Testolin, R. and Fergusson, A.R. (2009). Kiwifruit (Actinidia spp.): Production and Marketing in Italy. New Zealand J. Crop Hortic. Sc., 37: 1-32.
41. Tiyayon C., Strick B., (2003). Flowering and fruiting morphology of hardy kiwifruit. Actinidia arguta. Acta Hort., 610, 171–176.
42. UPOV (2012). International Union for the Protection of New Varieties of Plants. Actinidia UPOV Code: Actin Actinidia Lindl. TG/98/7.
43. Wang, Y., Zhang, X., & Liu, H. (2023). Advances in post-harvest technologies for improving the shelf life and marketability of *Actinidia arguta*. *Postharvest Biology and Technology*, 195, 112-123.
44. Williams, M.H., Boyd, L.M., McNeilage, M.A., McRae, E.A., Ferguson, A.R., Beatson, R.A., and Martin, P.J. (2003). Development and Commercialization of Baby Kiwi (Actinidia arguta Planch.). Acta Horta (ISHS) 610: 81-86.
45. Xiao X-G. (1999). Progress of Actinidia selection and breeding in China. Acta Horticulturæ 498: 25–51.

მინი კივის (Actinidia arguta Planch.) ჯიშების ბიოლოგიური თვისებებისა და აგრონომიული მაჩვენებლების დახასიათება საქართველოში

ელენე მაღლაკელიძე[1]-სოფლის მეურნეობის დოქტორი, **ზვიად ბობოქაშვილი**[1]-სოფლის მეურნეობის დოქტორი, **ლარისა ანდრონიკ**[2] - სოფლის მეურნეობის მეცნიერებათა დოქტორი, **ტატიანა კალუგარუ-სპატარუ**[2]**-სოფლის მეურნეობის დოქტორი, სვეტლანა სმერეა**[2]**-სოფლის მეურნეობის დოქტორი**

[1] სსიპ სოფლის მეურნეობის სამეცნიერო-კვლევითი ცენტრი, ხეხილოვანი კულტურების კვლევის სამსახური, თბილისი, საქართველო; [2] გენეტიკის, ფიზიოლოგიისა და მცენარეთა დაცვის ინსტიტუტი, ქ. კიშინიოვი, მოლდოვა

რეზიუმე

კლიმატის ცვლილების პროცესის გაძლიერების ფონზე იზრდება ადაპტირებადი ხეხილოვანი კულტურების საჭიროება. Actinidia arguta (ცნობილი როგორც მინი კივი, ბეიბი კივი ან გამძლე კივი) გამოირჩევა ყინვებისადმი მაღალი გამძლეობით, გლუვი და საჭმელად ვარგისი ნაყოფის კანის გამო მომხმარებლებისადმი მაღალი მიმზიდველობით, აგრეთვე მაღალი კვებითი ღირებულებითა და აგროეკოლოგიური ადაპტაციის უნარით. აღნიშნული მახასიათებლების და მზარდი ბაზრის ინტერესის ერთობლიობა მინი კივის აქცევს მნიშვნელოვან კულტურად, რომელიც შეიძლება გამოყენებულ იქნას კლიმატურად სენსიტიურ რეგიონებში ხეხილოვანი წარმოების დივერსიფიკაციის მიზნით.

კვლევის მიზანი იყო საქართველოში არსებული აგროეკოლოგიური პირობებში მინი კივის ოთხი ინტროდუცირებული ჯიშის — **Weiki, Ken's Red, Issai** და **Jumbo** — ბიოლოგიური და აგრონომიული მაჩვენებლების შეფასება, რათა დადგინებულიყო ადგილობრივი წარმოებისთვის ყველაზე შესაფერისი და კლიმატურ გამძლე ჯიშები.

საველე და ლაბორატორიული კვლევები ჩატარდა 2019–2023 წლებში მცხეთა-მთიანეთის რეგიონში, სსიპ სოფლის მეურნეობის სამეცნიერო-კვლევითი ცენტრის ჯიღაურას საკოლექციო ბაღში, რომელიც წარმოადგენს საქართველოს ძირითადი ხეხილოვანი ზონის ტიპურ არეალს. დაკვირვება მოიცავდა ძირითად ფენოლოგიურ პარამეტრებს, მათ შორის კვირტის გაშლას, ყვავილობის პერიოდს, ნაყოფის მომწიფებასა და ფოთლების ცვენას. პარალელურად ჩატარდა პომოლოგიური მაჩვენებლების სრული შეფასება — ნაყოფის ზომა, მასა, ფორმა და ორგანოლეპტიკური მახასიათებლები, აგრეთვე მოსავლიანობის კომპონენტები. ბიოქიმიური ანალიზებით განისაზღვრა ნაყოფში არსებული მთლიანი ხსნადი მშრალი ნივთიერებების რაოდენობა (TSS), ტიტრირებადი მჟავიანობა (TA) და C ვიტამინის (ასკორბინის მჟავა) შემცველობა, რაც შესაძლებელს ხდიდა ნაყოფის ხარისხის და პომოლოგიური თვისებების კომპლექსურ შეფასებას.

საკვანძო სიტყვები: მინი კივი, ყვავილობა, მომწიფება, მოსავალი, ზომა, პომოლოგია