Operational Group "Minikiwi Little Big Fruit"

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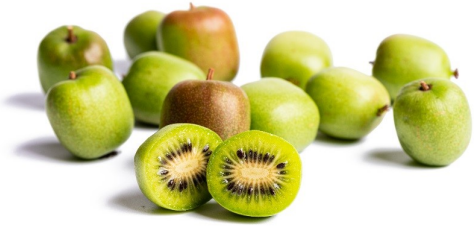
Project manager

Harvesting and post-harvest procedure for MiniKiwi (kiwiberry) fruit.

Information brochure



Project „Development of optimal post-harvest technology for minikiwi fruit (*Actinidia arguta*) and a prototype of a module that non-invasively sorts fruit according to the degree of ripeness (MODOM)"

implemented by a consortium composed of :

WULS in Warsaw (lider)
Adam Kostrzewa, Horticulture, Belsk Duży
Masovian Agricultural Advisory Center in Warsaw (MODR)

financed by the European Union under Measure No. 16 „Cooperation"

Rural Development Program for years 2014 -2020.

Warsaw 2023

Contents:

1. MiniKiwi (kiwiberry) – commercial crop. To cultivate or not to cultivate?

The possibility of organic cultivation without the use of chemical protection speaks for the introduction of MiniKiwi (kiwiberry) into cultivation. Taking into account the beneficial effects on the human body, the most important are species whose fruits can be eaten without processing, such as MiniKiwi. These fruits are not easy to grow, but they can provide potentially great benefits. Trade in new fruit in the European Union is regulated by EU law (Novel Foods Regulation) and specified in Directive No. 258/97, which states that food products that were not in significant trade in the EU before May 1997 are subject to the marketing authorization procedure. Thanks to the efforts of the European lobby dealing with the cultivation of MiniKiwi (including the Polish one), MiniKiwi fruit was included on this list, so trading in fresh fruit in the European Union became legal. I would recommend people considering growing MiniKiwi to think carefully about the project to avoid disappointment later. Plants have specific habitat requirements that should be considered before establishing a plantation. These are: fertile soil (not worse than class 4), slightly acidic (optimally 5.5-6.5) and, above all, well-drained, as the bushes are sensitive to flooding of the roots. It would be good if the site was protected from strong summer winds. On the other hand, in summer the plants should be provided with adequate soil moisture through irrigation. An efficient water source seems to be necessary when growing MiniKiwi, because the bushes also need to be protected against spring frosts. All these requirements make the cost of establishing a plantation quite high (comparable to establishing a highbush blueberry plantation). The cultivation itself also requires a significant amount of work. Actinidia, as a vine, produces strong growth every year and must be systematically cut in summer and radically cut in winter (similarly to vines). The fruit is harvested only by hand. This creates a significant amount of work that must be kept in mind.

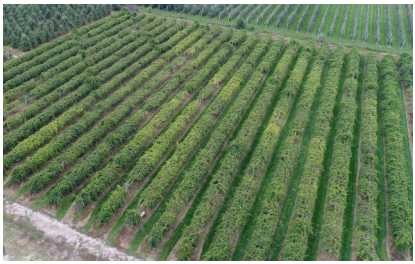


Fig.1. Mature MiniKiwi plantation from a bird's eye view.

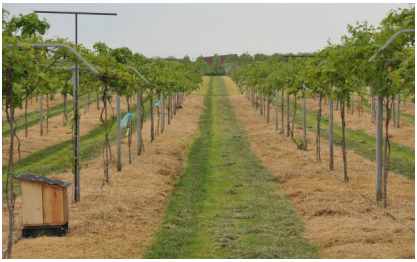


Fig. 2. A young, two-year-old MiniKiwi plantation.

Fig. 3. After winter pruning, bushes start growing in spring .

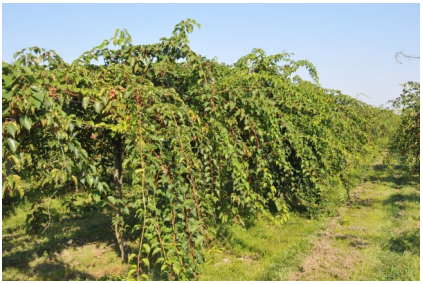


Fig. 4. Vines before harvest begins .

2. MiniKiwi (kiwiberry) – main features of the plant and method of fruiting

Actinidia arguta (Siebold et Zucc.) Planch. ex Miq. that bears fruit called MiniKiwi, is a strongly growing vine that wraps around itself with shoots. Under favorable conditions, during the season, it is able to produce shoots up to several meters long. The species originating from Asia and growing in a continental climate is well adapted to low temperatures in winter. It is able to withstand frost down to -30°C without damage during the period of deep dormancy (although some variety differences can be seen), but it is particularly sensitive to spring frosts. Therefore, growing this plant in our conditions requires anti-frost protection. Actinidia is a dioecious plant, therefore, in addition to female bushes, the plantation also requires male bushes as pollinators (in the proportions of 1 male for 7-8 females).

The plant produces two types of vines (annual shoots) - terminating (often called short shoots, Fig. 5) and non-terminating (called long shoots) (Fig. 6). Both types of shoots can be fertile or sterile, depending on whether they produce flowers or not. The flowers of female plants appear singly or are gathered in 2-3 inflorescences. In male plants, up to 10-11 in the inflorescence (Fig. 7). On shoots ending their growth, flowers appear after 5-6 nodes to the end of the shoot or only at a certain section (if the short shoot is slightly longer). On long shoots, flowers appear only at a certain section, usually from 5-6 to 13-14 nodes (in female plants). Flower formation is favored by a sunny position, and the initiation itself takes place differently in most fruit plants, in two stages, and the final factor is the low temperature immediately before bud breaking in spring. The bushes usually bloom in mid-June (for 7-10 days). Due to the nature of its growth, Actinidia requires solid supports and systematic heavy pruning in both winter and summer (Latocha 2017).

Fig. 5. Terminating shoots with visible flower buds.

Fig. 6. Non-terminating shoots with visible flower buds.

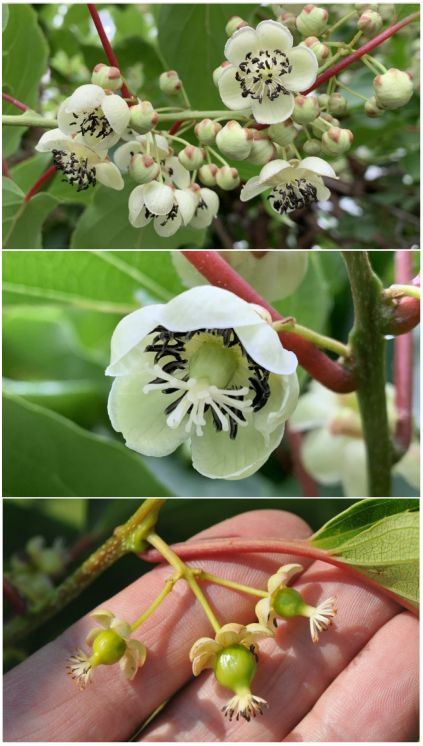


Fig. 7. From top: male flowers, female flowers and fruit buds.

3. Fruit characteristics (advantages and limitations)

The fruit of actinidia is a berry. It is small in size, most often 3.5-4 cm long and 2-2.5 cm wide. Its average weight is from 7 to 14 g (usually 10 times lighter than kiwi fruit, fig. 8). The color of the fruits of available varieties varies - from completely green, through blushing, to completely burgundy-red (skin and flesh). MiniKiwi differs from Kiwi not only in size but also in its thin, delicate, edible skin. This feature, on the one hand, is a great advantage (ease of consumption, greater nutritional value), but on the other hand, it is a limitation (it is easy to damage during harvesting and post-harvest procedures). MiniKiwi fruits, unlike other commonly grown berries, are climacteric, which significantly determines the issues of harvesting and post-harvest treatment. Fruits are extremely sensitive to the presence of ethylene and respond by accelerating ripening even to its minimal concentration in the atmosphere. The final quality of the fruit is determined by the appropriate harvest date (maturity phase), immediate post-harvest treatment and further storage conditions. Unfortunately, the ripening of MiniKiwi fruit on the vine is very uneven - the fruit softens earlier in heavily shaded places, and later in well-sunlit places (which is why proper summer pruning is very important). Due to the continuous ripening of fruit after harvest, it is important that the consumer receives the fruit in the appropriate state of ripeness and that information regarding the optimal stage of ripeness for consumption is included on the unit packaging (as is the case with some other exotic fruits - e.g. mango or avocado). In addition to varieties with green fruit, there are also varieties with red fruit (Fig. 9). The main varieties grown commercially in Poland are 'Geneva', 'Weiki' and 'Bingo' - Figs. 10, 11.

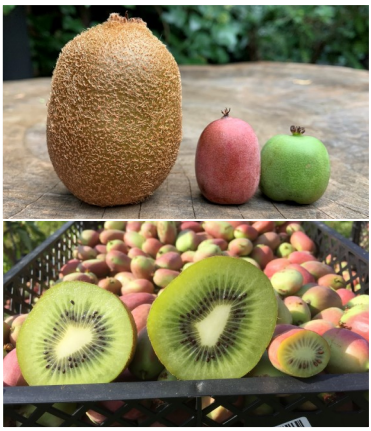


Fig. 8. MiniKiwi fruit compared to kiwi fruit.

Fig. 9. MiniKiwi fruit in cross-section.

Fig. 10. Fruits of the 'Bingo' cv.

4. Commercial requirements for MiniKiwi fruit

MiniKiwi fruit is a new product on the market, not only in Poland but also in other countries. Their production is developing dynamically both in Poland and in other countries (Latocha et al. 2018). Its advantages (good taste, health-promoting values, ease of consumption) have a positive impact on both the increase in the cultivated area and the popularity of the fruit among consumers.

Fig. 11. Fruits of the basic cultivars 'Weiki' (left) and 'Geneva'.

However, like any new product, it requires time and extensive marketing to establish itself on the market for good. Therefore, the condition for further increase in the consumption of MiniKiwi fruit is the good quality of the fruit purchased by the consumer. Only then will he become interested in the fruit again in the next season, gradually increasing the demand for it. Otherwise he will never use it again. Therefore, the care of producers and traders for good (correct) quality of fruit from the moment of harvesting to purchase by consumers in the store is a basic condition for the further development of the MiniKiwi market. MiniKIwi fruits have been present on the Polish market for several years and their sales are increasing significantly every year (Kantar 2022), although not as quickly as everyone would expect. This is largely due to the still low knowledge of fruit among traders and consumers and their not always appropriate quality. Everyone involved in the production of MiniKiwi fruit should follow the principle - "quality before quantity". This is what growers in other European Union countries are guided by, where the popularity of MiniKiwi fruit is growing much faster than in Poland. This creates the possibility of exporting our fruit, provided that its good quality is maintained.

5. The right moment for harvesting fruit (harvesting ripeness stage)

Since the fruit ripening process is continuous, even after harvesting, it is crucial to properly determine the moment of harvest. Fruit harvested too early will not achieve its full flavor and will be tasteless. In turn, fruit harvested too late will ripen too quickly, which in turn limits the possibility of selling them. There are various methods for determining the optimal phase of harvesting MiniKiwi fruit (so-called harvest ripeness), but so far the best method is based on the color of the seeds and the content of the extract. Until they are picked, the fruit accumulates an extract which will no longer be available after picking. It will only undergo qualitative changes and will determine the final taste of the fruit. In the light of previous experience on commercial plantations and wholesale, the fruits should have brown seeds when harvested (Fig. 12) (basic condition) and have an average of at

Fig. 12. The change in seed color from white to brown is a sign of reaching physiological maturity.

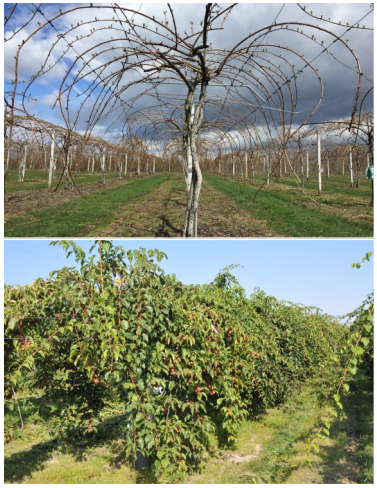


Fig. 13. MiniKiwi plantation in spring and summer.

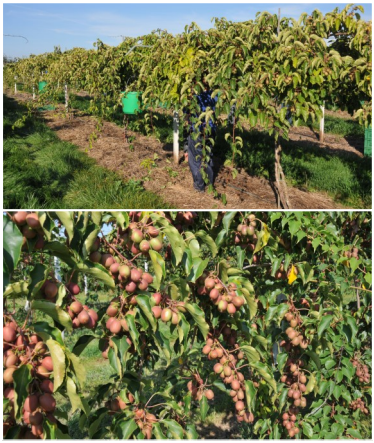


Fig. 14. 'Geneva' (above) and 'Weiki' cultivars just before harvest. .

least 6.5°Brix. The extract level for a given variety should be determined using a refractometer (preferably digital) on a sample of approximately 30 fruits in various locations on the vine and on the plantation (Fig. 15). Optimally, it will be between 6.5-7.5 °Brix. The collected fruit should be firm (hard). In the case of a shortened supply chain (direct sales), the fruit can be harvested a little later, as long as the consumer receives firm fruit that is starting to soften. Due to the uneven ripening of the fruit on the vine, a good solution may be to harvest it in two approaches - first, the fruit is collected from more shaded places "inside" the bushes, and then the fruit is collected from the sunnier places. This allows you to collect fruit that is more uniform in terms of ripeness. Proper winter and summer pruning improves the uniformity of fruit ripeness on vines so that all fruit is exposed to more even light.

Fig. 15. A digital refractometer is a helpful device in assessing the degree of ripeness.

6. The optimal way to harvest fruit in our conditions

There is no one universal method of harvesting MiniKiwi fruit. Different methods/variants have been developed in different countries, depending on local opportunities, conditions and needs. Nevertheless, the fruit is always picked by hand at the ripeness stage described above. Regardless of the method of harvesting, it is always most important to pay attention to the gentle handling of the fruit. Otherwise, it will be difficult to store the fruit in a cold store even for a short time, and the fruit will have an unattractive appearance when it reaches the consumer. Taking into account the final quality of the fruit in our conditions, the best method seems to be a two-stage fruit harvest. In the first stage, whole shoots with fruits and leaves as well as fragments of long shoots containing fruits are cut off from the plant. These shoots are gently placed into large boxes (Fig. 16). The presence of leaves prevents micro-damage to the fruit. In the second stage, the fruits are cut off from these shoots directly into smaller (flatter) boxes (Fig. 17). It is important to cut off the fruit without the stalks, which, in the case of some varieties, if left, may damage other fruits in the box. Both stages can be carried out directly on the plantation or separated, the second stage can be performed in the hall. It all depends on the grower's capabilities and weather conditions. The hall should be as close to the plantation as possible to shorten transport time as much as possible. At this stage it is important to avoid damaging the fruit, e.g. by the pickers' long fingernails (using cotton gloves).

Fig. 16. The first phase of harvesting - cutting the shoots with fruit.

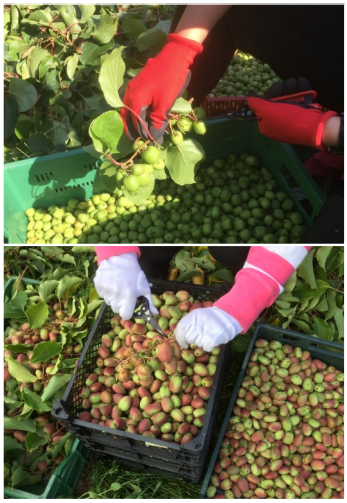


Fig. 17. The second phase of harvesting - cutting off the fruit from the shoots .

When cutting fruit from shoots, make sure that the pickers cut the fruit as low as possible above the box so that the fruit does not fall from a great height (which unfortunately often happens, although it is not difficult to do). This is more difficult when cutting off the fruit takes place on a plantation, it is easier to supervise it when the work is carried out in the hall at the tables. When harvesting, soft fruit should be discarded immediately, if possible, as it will significantly reduce the storage capacity of the remaining fruit. Soft fruits can be recognized not only by touching them, but also by changing the shade of color - soft fruits become clearly dark green in comparison to firm, hard fruits (Fig. 20). We also reject distorted or excessively russet fruit as unsuitable for sale as dessert fruit. Any rejected fruit can be used for processing. To sum up, it is important that the fruit is placed in a cool place as quickly as possible after harvesting to limit heat accumulation as much as possible. Especially when harvesting takes place in warm weather.

Fig. 18. Fruit ready to be taken from the field.

Fig. 19. Quick removal of fruit from the field.

7. Optimal post-harvest procedure

Post-harvest proceedings depend largely on the form of fruit sales adopted. Compliance with the following rules is even more important the longer we want to store the fruit and put it on the market for a longer period of time. In the case of repeated harvesting, short-term storage (1-2 weeks) and direct sale of small quantities of fruit, strict compliance with the following rules is not so necessary. However, in the case of large production and single harvesting of fruit, as well as their long-term storage and wholesale, it becomes crucial. As mentioned above, it is advisable to pre-sort soft fruit already during harvesting. However, this requires training of fruit pickers in this area. However, even in this case, it is unfortunately very difficult to sort out all the soft fruits. Therefore, as part of the operation financed by ARiMR under the "Cooperation" measure, a prototype of a module for sorting minikiwi fruit non-invasively in terms of the degree of ripeness was developed, using near-infrared technology. This solution will allow you to sort out overly ripe fruit, which will extend the storage capacity of the remaining fruit (Fig. 21).

Fig. 20. Soft fruit (left) is darker than firm fruit (right) ('Weiki').

Fig. 21. Fruit sorting aims to reject unmarketable and overly ripe fruit.

The prototype has been submitted to the Patent Office of the Republic of Poland and we hope that it will be put into production soon. We hope that this technology will soon be available to every grower. In each case, the fruit should be transported from the field to the hall as quickly as possible (preferably within 1 hour from harvest) in order to avoid excessive heat accumulation. On the same day, the fruit should be sorted (if additional sorting is necessary), packed into small and possibly flat boxes (the fruit in the box should occupy a maximum of 3 layers so that ethylene quickly enters the atmosphere and does not affect the fruit, photo 23 -25) or in unit packages and placed as standard in the target cold store (temp. 0.5-1°C; relative humidity approx. 90%; ethylene absorbing filter). Independently, an ethylene filter sachet should be placed in each box, and to maintain the firmness of the fruit, it is beneficial to additionally wrap the boxes on the pallet with stretch foil. Apart from sachets, the removal of ethylene from cold stores is extremely important because its presence, even in low concentrations, significantly accelerates the ripening process. The main problem of fruit stored in cold storage is, apart from softening, rapid loss of water and wrinkling of the skin. Therefore, it is important to maintain higher air humidity in the cold room. In this way, you can store fruit for 2-3 weeks so that they are still suitable for wholesale trade, or even 4 weeks for direct sales.

Fig. 22. When harvesting, the peduncle should be removed - it may damage the fruit.

Fig. 23. 'Weiki' variety before being taken from the field.

Fig. 24. 'Bingo' cultivar before being taken from the field.

Fig. 25. 'Geneva' fruit in small boxes, ready to be put into cold storage.

8. Methods of long-term cold storage.

In the event of an increased supply of MiniKiwi fruit on the market, there may be a problem with selling them in a short period of time. Therefore, maximizing the fruit supply becomes extremely important. Although MiniKiwi fruits belong to a group of fruits with a relatively low storage capacity, if the above-described regime is observed during and immediately after harvesting, it gives the opportunity to extend the supply period by up to 100%. As part of the implementation of the operation financed by ARiMR under the "Cooperation" measure, several post-harvest technologies for MiniKiwi fruit were assessed, including one-time ozone treatment immediately after harvest and storage technologies with a fairly wide availability for growers.

In addition to the regular cold store, these included: an ordinary atmosphere containing ozone, a modified atmosphere (Xtend® bags) and a controlled atmosphere (KA). The concentration of ozone (0.2-0.3 ppm) and the composition of the controlled atmosphere (O2:CO2=2-3%:5-6%) were adopted on the basis of our own previous experience with this species and foreign experience. Experiments conducted over two seasons using Xtend® bags in cooperation with their manufacturer also allowed for the optimization of their structure so that they were better suited to MiniKiwi fruit. As a result of two years of research, it was found that only storing the fruit in controlled atmosphere conditions (temperature 0, 5-1°C; O2:CO2=2-3%:5-6%; relative humidity approx. 90% + ethylene removal filter) allows the fruit to be stored for 6-8 weeks, while maintaining the regime described above. during harvesting and post-harvest proceedings. The use of a modified atmosphere (Xtend® bags + ethylene filter) allows the fruit to be stored for up to 4 weeks. Their advantage is also maintaining a constant fruit weight, which cannot be achieved with other technologies. A regular cold store with ozone (0.2-0.3 ppm) did not have a positive effect on the storage capacity of the fruit, nor did one-time ozonation before placing it in the cold store. The key to the storage capacity of MiniKiwi fruit is to sort out overly ripe fruit because their presence (and their production of ethylene) is the main factor limiting longer storage, regardless of the storage method.

Fig. 26. Cooling fruit faster extends their storage capacity.

Fig. 27. Modified atmosphere packaging is a good solution for cold storage for up to 4 weeks. There are also versions for entire pallets.

9. Rules necessary to follow at every stage - summary.

Summarizing the above information, it can be stated:

I. MiniKiwi is a climacteric fruit, it is extremely sensitive to ethylene and is very delicate. Therefore, regardless of the technology of their storage, it is crucial:

1) to determine the appropriate phase of fruit harvest;

2) harvesting technology that limits (eliminates) microdamage to the fruit and

3) quick removal of the fruit from the field and its cooling, as well as removal of ethylene during storage.

Fig. 28. Gray mold after cold storage. The fruit that spoils first is when it is too ripe or damaged.

II. MiniKiwi fruit differs from other berries with which they often share the shelf because they ripen after harvesting. Therefore, they are harvested at the stage of harvest maturity and reach consumption maturity over time. Therefore, it may happen that in a unit package in a store, next to ripe fruit for consumption, there will be unripe fruit. This requires appropriate information on the packaging and consumer education.

III. MiniKiwi fruit intended for cold storage should be free from ripe (soft) fruit. The storage capacity of the remaining fruits depends on the effectiveness of sorting such fruits.

IV. In the case of small production, multiple harvests and direct sales or a short supply chain, MiniKiwi fruit can be effectively stored in a conventional cold store with ethylene removal (temp. 0.5-1°C; relative humidity approx. 90%).

V. An absolute condition for long-term fruit storage is, in addition to the effective sorting of over-ripe fruit, also the maximum shortening of the time from harvesting the fruit to placing it in the cold store. Fruits can be stored for up to 4 weeks in modified atmosphere conditions (Xtend® bags + ethylene filter) and up to 6-8 weeks in controlled atmosphere conditions (temp. 0.5-1°C; O2:CO2=2-3%:5- 6%; relative humidity approx. 90% + ethylene removal filter).

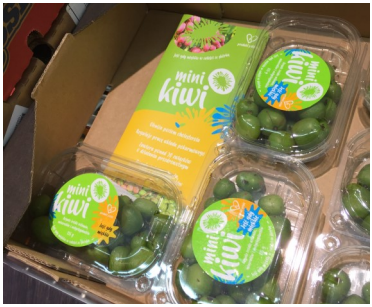


Fig. 29. MiniKiwi fruit in the Polish retail chain.

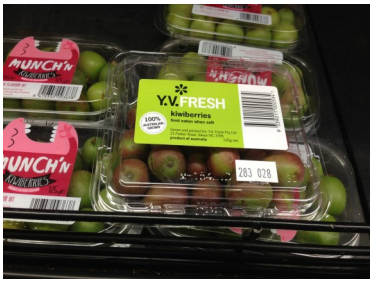


Fig. 30. MiniKiwi fruit abroad (New Zealand).

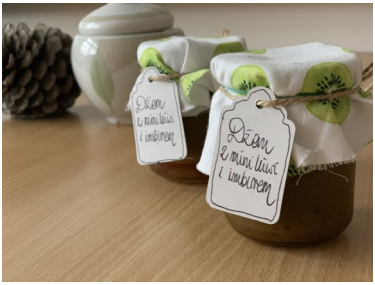


Fig. 31. MiniKiwi is not only fresh fruit but also processing.

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www.minikiwi.sggw.pl

www.aktinidia.pl

e-mail: piotr_latocha[@]sggw.edu.pl

https://www.modr.mazowsze.pl/

www.Programy i projekty UE (modr.mazowsze.pl)

https://sir.cdr.gov.pl/2022/10/27/minikiwi-maly-wielki-owoc/

More about growing MiniKiwi (in Polish):

https://www.plantpress.pl/produkt/minikiwi-uprawa-w-warunkach-polski/

***Actinidia arguta*, kiwiberry, Growers Manual** - book in English available under email: piotrlatocha[@]gmaill.com

Links to video materials :

https://youtu.be/BLtDY5TI8pw

https://youtu.be/C0v2pGmrADU

https://youtu.be/fDHg6V_sLn8