

GROWTH AND PRODUCTION OF KIWIFRUIT AND KIWIBERRY

Filip Debersaques and Omer Mekers

*University College Ghent, Faculty of Biosciences and Landscape Architecture,
University Ghent, Belgium.*

Keywords: *Actinidia*, fruit, kiwi, kiwiberry, kiwifruit, trellis, vineyard.

Contents

1. Introduction
 2. Origin and Distribution
 3. Botany
 - 3.1 Fuzzy Kiwifruit (*A. deliciosa* and *A. chinensis*)
 - 3.1.1. Structure
 - 3.1.2. Cultivars of *A. deliciosa*
 - 3.1.3. Cultivars of *A. chinensis*
 - 3.2. Kiwiberry (*A. arguta*)
 - 3.2.1. Structure
 - 3.2.2. Cultivars
 4. Ecology and Growing Conditions
 - 4.1. Climate Conditions
 - 4.2. Soil Conditions
 5. Crop Husbandry
 - 5.1. Establishing the Kiwifruit Vineyard
 - 5.1.1. Trellis
 - 5.1.2. Planting Design
 - 5.2. Pruning and Training
 - 5.3. Fertilizer Management
 - 5.4. Pests, Weeds and Diseases
 - 5.4.1. Pests
 - 5.4.2. Weeds
 - 5.4.3. Diseases
 - 5.5. Irrigation and Water Supply
 - 5.6. Mulching
 - 5.7. Windbreaks
 - 5.8. Harvest and Storage
 - 5.8.1. Fuzzy Kiwifruit (*A. deliciosa* and *A. chinensis*)
 - 5.8.2. Kiwiberry (*A. arguta*)
 6. Utilization and Use
 7. Composition and Nutritive Value
 8. Production and Trade
- Glossary
Bibliography
Biographical Sketches

Summary

Kiwifruit is a rather new temperate fruit, the commercialization of which started only in the 1950s (*Actinidia deliciosa*) and 1990s (*A. chinensis*); today, it is grown all over the world. The commercialization of kiwiberry (*A. arguta*) is more recent.

The fuzzy kiwifruit is egg-shaped with a brownish skin covered with short stiff hairs (*A. deliciosa*) or rather smooth-skinned and almost hairless (*A. chinensis*). The kiwiberry (*A. arguta*) has a similar taste, composition and nutritive value but has a smooth, edible skin; it has the size of table grapes, whereas the weight of the more common fuzzy kiwifruit can reach more than 120 grams.

Temperature is a major limiting factor for cultivation. Fuzzy kiwis cannot stand temperatures below -15 °C, but in a dormant stage kiwiberry plants are resistant to temperatures below -30 °C. Soils should be well drained. On commercial plantations, a T-bar or pergola is used to support the solid canopy of foliage and fruit. As kiwiplants are dioecious, for every eight female plants, one male vine is planted.

Kiwifruit is a fast growing plant, therefore a well-considered pruning and an adequate fertilizer management and water supply are indispensable for optimum productivity. Other management factors are weed control in young vines; pest control and protection of long shoots against wind damage on plantations in full production.

Fuzzy kiwifruit and kiwiberry are usually eaten fresh, or are mixed in desserts or salads. Storage of fuzzy kiwifruit is between 3 (*A. chinensis*) and 6 months (*A. deliciosa*); for fresh kiwiberries it is limited to 6 - 10 weeks.

Italy, New Zealand, China and Chile are important producers of *A. deliciosa* and *A. chinensis*. The production of *A. arguta* is an interesting crop for the niche market. Recently, some commercial projects have been started in Switzerland and Belgium.

1. Introduction

The genus *Actinidia* is known for the famous 'kiwifruit' (*A. deliciosa* (A. Chev) C.F. Liang [stet] A.R. Ferguson var. *deliciosa*). Kiwifruit is native to the Yangtze Valley of China, and was originally called “Yang Tao” in China and “Chinese gooseberry” in the rest of the world. When kiwifruit farmers in New Zealand decided to market the fruit overseas, they gave it the name “kiwi” to identify it better with New Zealand. The name “kiwi” or “kiwifruit” comes from the kiwi, a flightless bird and New Zealand's national symbol, and also a colloquial name for the New Zealand people.

All *Actinidia* species are climbers. They have no specific organs enabling them to attach, but the young shoot tops curl around older woody shoots. Some of the *Actinidia* species are grown for their berries, while others are used as an ornamental plant in gardens and parks.

About 15 *Actinidia* species produce edible fruit, but there are currently only three species of commercial importance: the fuzzy kiwifruit or *A. deliciosa* (the green kiwi) and *A. chinensis* (the yellow kiwi); both are widely grown commercially. In recent years a growing attention is paid to a third species, *A. arguta* or kiwiberry.

2. Origin and Distribution

The genus *Actinidia* is widely distributed in eastern Asia. Most of the at least 76 species of the genus are represented in south-central and southwest China. Some of the species, such as *A. polygama*, *A. arguta*, and *A. kolomikta*, have broad distributions, from Japan through northeastern Asia to western China.

The genus *Actinidia* belongs to the Actinidiaceae. The four infra-generic sections in this genus are: *Leiocarpae*, *Maculatae*, *Stellatae*, and *Strigosa*. This classification is based on the characteristics of the fruit (presence or absence of lenticels), pith (lamellate or non-lamellate), and hair (simple or stellate). Although kiwifruit is now an important crop in many parts of the world, much fruit is collected each year from the wild in China.

3. Botany

All *Actinidia* species are perennial, climbing or scrambling plants, mostly deciduous, although a few are evergreen. The woody vines with young shoots can grow to a height of more than 9 m. Young shoots are covered with hairs. *Actinidia* species produce long-petioled leaves not equally shaped and colored.

Flowers appear approximately 60 days after bud burst in spring. The flowers of both the fuzzy kiwifruit and kiwiberry have white petals that become yellow as they age. There are some exceptions, but usually the plants bear only flowers of one sex, either male or female. Flowers on male vines produce viable pollen but lack a properly developed style. Flowers of female vines have a well developed style and produce non-viable pollen. In commercial plantations one male vine is planted for every six to ten female vines.

Botanically, the fruits of the various *Actinidia* species are berries. Since they are fleshy, they have many seeds embedded in the flesh, and they do not split open at maturity. The commercial interesting kiwifruits vary in size, shape, hairiness, and internal and external color (Ferguson, 1999). Some varieties have early-maturing fruits compared to others.

3.1 Fuzzy Kiwifruit (*A. deliciosa* and *A. chinensis*)

3.1.1. Structure

The species *A. deliciosa* (green kiwi) and *A. chinensis* (yellow kiwi) are very similar, and it was only in 1984 that Liang and Ferguson discovered that they represent two different varieties. The leaves of the fuzzy kiwifruit are heart-shaped. The creamy colored flowers can have a diameter up to 5 cm; they have five petals and sepals and numerous stamens (Figure 1). The stigmas are positioned radially.

The fuzzy kiwifruit *A. deliciosa* is egg-shaped with a brownish skin covered with short stiff hairs. Inside, the flesh is bright green around a white core with fine pale lines radiating from it. Numerous very small black seeds surround the whitish core.



Figure 1. Female flowers of the *A. chinensis* (photograph C. De Kezel, with permission)

Most of the yellow-fleshed fuzzy kiwifruit belong to the species *A. chinensis* and have a smooth-skinned and almost hairless fruit when ripe. The taste of this fruit is also sweeter than *A. deliciosa* and has a more aromatic flavor. Both *Actinidia* species are normally peeled before consumption because of the presence of surface hairs and a less tasteful skin.

3.1.2. Cultivars of *A. deliciosa*



Figure 2. Fruits of *A. deliciosa* 'Monty' (photograph C. De Kezel, with permission).

The most widely planted kiwifruit cultivar is *A. deliciosa* 'Hayward' selected in New Zealand in 1925. The name is derived from Hayward Wright, the Auckland nurseryman who raised this cultivar from a chance seedling discovered in the 1920s. 'Hayward' fruit represents about 90-95% of the international kiwifruit trade.

The fruits of 'Hayward' are very distinctive, being larger than any other and much wider in relation to their length. Usually, they are slightly flattened laterally. The flowers and fruits are mostly arranged in a single stand at the nodes.

Some important 'Hayward' clones for production are 'Clone 8', 'Clone K', Clone Maeba®. In addition, 'Top Star®', 'Green Light®', 'Earligreen®' and BO-Erica® are bud mutations selected in Italy. Worth mentioning is also the Italian 'Summerkiwi®', a trade name for the early maturing selections "Summer 3373" and "Summer 4605" which are normally harvested 30-50 days before the Hayward variety.

The second most widely planted *A. deliciosa* cultivar is 'Qinmei' which is selected in the Qinling Mountains in China; it is only commercially grown in this country. This cultivar and its males represent about 30% of Chinese kiwifruit plantings or about 15% of the world total. The plant is quite resistant to cold winters and dry and warm summers.

The third most widely planted *A. deliciosa* cultivar is 'Jinkui', also grown in China as well. It is a seedling from open-pollination of a cultivar itself selected from the wild. Other significant cultivars are Abbott, Allison, Bruno, Monty (Montgomery) (Figure 2), Koryoku and Greensill.

3.1.3. Cultivars of *A. chinensis*

The most widely planted cultivar of *A. chinensis* is 'Hort16A', marketed as ZESPRI™ Gold. In 2006 'Hort16A' represented about 20% of the kiwifruit plantings in New Zealand. This yellow fleshed cultivar is more productive than 'Hayward', but is more susceptible to skin damage at the time of harvest.

The second most widely planted *A. chinensis* is the Chinese cultivar 'Jintao', marketed in Italy as Jingold or Kiwigold. 'Jintao' (golden peach in Chinese) is a yellow-fleshed kiwifruit developed from the breeding program at the Wuhan Institute of Botany, in Wuhan, Hubei, China. It is a midseason cultivar selected for warmer climates.

Some other Chinese *A. chinensis* cultivars grown outside China are 'Jiangxi 79-1' (syn. 'Koushin', 'Kosuei 79-1', 'Lushan 79-1', 'Red Princess'), and more recently (registered in 2005) Sanuki Gold, a vigorous, early flowering cultivar, with fruits ranging from 160 to more than 180 grams each.

3.2. Kiwiberry (*A. arguta*)

3.2.1. Structure

Because of their frost hardiness, kiwiberry (*A. arguta*) as well as the less known *A. kolomikta* and *A. polygama* are commonly called hardy kiwifruit. They resist

temperatures as low as - 35 °C.

The vines of *A. arguta* are vigorous, have shiny green leaves, with green or red petioles depending on the cultivar. At the base of the young green shoots, and on second-year wood, a lot of lenticels can be seen. Flowers are smaller than those of the fuzzy kiwifruit. Both, male and female flowers have a diameter of about 1 to 3 cm (Figure 3). Female flowers can be pollinated by male selections of *A. arguta* and *A. deliciosa*. As in all *Actinidia* species, only one year canes produce fruit bearing shoots.

The fruit weight of the *A. arguta* ranges from 2 to 25 grams. The berry can vary in color from green to red bluish, or Bordeaux red. The smooth edible skin of the fruit is one of the strong commercial aspects of this fruit.



Figure 3. Leaves and female flowers of *A. arguta*.

-
-
-

TO ACCESS ALL THE 26 PAGES OF THIS CHAPTER,
Visit: <http://www.eolss.net/Eolss-sampleAllChapter.aspx>

Bibliography

Belrose Inc. (2009). *World Kiwifruit Review for 2009*. Belrose Inc., Pulman, WA. [An annual review of the world kiwi production. An interesting tool to understand the changes taking place in the kiwi market].

Chat, J., Jaurequi, B., Petit, R.J., and Nadot, S. (2004). *Reticulate Evolution in Kiwifruit (Actinidia, Actinidiaceae) identified by Comparing their Material and Paternal Phylogenies*. *Am. J. Bot.*, 91(5): 736-747. [A study of the evolutionary relationships within the genus *Actinidia*. The phylogenetic analysis is based on chloroplast and mitochondrial restriction site and sequence data].

Ferguson, A.R. (1999). *New Temperate Fruits: Actinidia chinensis and Actinidia deliciosa*. In: J. Janick (ed.), *Perspectives on New Crops and New Uses*. ASHS Press, Alexandria, VA. 342–347. [Comprehensive summary about *Actinidia* in the perspective of the New Zealand tradition of introducing new fruits].

Ferguson, A.R. and Huang, H. (2007). *Genetic Resources of Kiwifruit: Domestication and Breeding*. *Hortic. Rev.* 33: 1-121. [A very complete reference work wherein the genetic diversity and the natural distribution of the *Actinidia* is discussed. Domestication and commercialization and the genetic resources of kiwifruit are considered also].

Ferguson, A.R. and Seal, A.G. (2008). *Kiwifruit*. In: J. F. Hancock, ed. *Temperate Fruit Crop Breeding*. Chapter 8: 235-264. [In this paper the past realizations, the present situation and the future challenges for breeding, commercial growing and trade of *A. chinensis* and *A. deliciosa* are discussed].

Kabaluk, J.T., Kempler, C. and Toivonen P.M.A. (1997). *Actinidia arguta: Characteristics relevant for Commercial Cultivation*. *Fruit Varieties Journal*, 51: 117-122. [Summary of some characteristics for evaluating the commercial production of kiwiberry (*A. arguta*)].

Latocha, P. and Olszewska-Kaczynska, I. (2003). *Preliminary, Morphological, Chemical and Sensory Analysis of Fruit of different Actinidia Genotypes (Actinidia Lindl.)*. *Ann. Warsaw Agric. Univ. – SGGW Hortic. and Landscape Architecture*, 24: 51-56. [Study of the initial chemical (polyphenolic compound), morphological (fruit weight and size) and sensory analyses (method of profiling) for 6 genotypes of *Actinidia*].

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. [This paper summarizes preliminary data about some morphological characteristics and of vitamin C content of popular cultivars of kiwiberry (*A. arguta*), grown in Poland].

Liang, C.-F. and Ferguson, A.R. (1984). *Emendation of the Latin name of Actinidia chinensis Pl. Var. Hispidula* C.F.Liang. *Guihaia* 4, 181-184. [Reference work where the authors determined *A. Deliciosa* and *A. Chinensis* as two distinct species].

Mills, H.A. and Jones, J.B. jr. (1996). *Plant Analysis Handbook II*. MicroMacro Pub. Inc. (Georgia, USA), 421pp. [Practical handbook and interesting guide for sampling, preparation and analysis of plants. This book includes also tables of interpretative plant analysis data for over 1 000 individual crops].

Nishiyama, I. (2007). *Fruits of the Actinidia Genus*. *Advances in Food and Nutrition Research*, 52: 293-324. [A well documented overview of the fruits of the *Actinidia* genus with a lot of information about the different chemical fruit components. Also the allergenic properties of the fruits received the author's attention].

Okamoto, G. and Goto, S. (2005). *Juice Constituents in Actinidia arguta Fruits produced in Shinjo, Okayama*. *Scientific Reports of the faculty of Agriculture, Okayama University*, 94: 9-13. [Kiwiberry (*A. arguta*) fruits were collected in the wild and analyzed for their chemical composition. The studied parameters were vitamin C, polyphenol content, minerals, sugars, amino acids and total nitrogen].

Smith, G.S., Clark, C.J. and Buwalda, J.G. (1992). *Kiwifruit*. In: IFA World Fertilizer Use Manual, International Fertilizer Industry Association, Paris, 419-422. [The manual is a 600-page handbook, containing detailed information on current fertilizer use recommendations and practices, for a wide range of world crops. A chapter deals with kiwifruit. The information is also available on Internet: www.Fertilizer.org]

Strik, B. (2005). *Growing Kiwifruit*. Oregon State University Extension Service Publications (PNW), 507,

23pp. [A practical guide describing the characteristics of fruits and the growing of the fuzzy kiwifruit (*A. deliciosa* and *A. chinensis*), kiwiberry (*A. arguta*) and *A. kolomikta*].

Testolin, R. and Fergusson, A.R. (2009). *Kiwifruit (Actinidia spp.): Production and Marketing in Italy*. *New Zealand J. Crop Hortic. Sc.*, 37: 1-32. [This paper reviews the development and current status of the Italian kiwifruit (*Actinidia spp.*) industry, both in a national and international context].

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 Hort.* (ISHS) 610: 81-86; http://www.artahort.org/books/610/610_8.htm [The many opportunities in contrast with the difficulties of a commercial production of kiwiberry are discussed. A number of commercial New Zealand selections of *A. arguta* were described in this report].

Internet Sources

http://www.hort.purdue.edu/newcrop/nexus/Actinidia_deliciosa_nex.html [Webpage containing interesting internal and other links of the Department of Horticulture and Landscape Architecture of Purdue University].

<http://www.aces.edu/pubs/docs/A/ANR-1084/> [Kiwifruit production guide from the Alabama Cooperative Extension System].

<http://extension.oregonstate.edu/catalog/pdf/pnw/pnw507.pdf> [Growing Kiwifruit: A Pacific North-west Extension Publication, Oregon State university-University of Idaho-Washington State University].

<http://www.crfg.org/pubs/ff/kiwifruit.html> [Fruit facts for *A. deliciosa* on the website of the California Rare Fruit Growers, Inc.].

http://www.hort.purdue.edu/newcrop/morton/kiwifruit_ars.html [Comprehensive information about *A. deliciosa* of the Department of Horticulture and Landscape Architecture of Purdue University].

www.kiwiberry.com [Website of Kiwi Korner, located in Northeastern Pennsylvania where they have researched, developed and grown (multi-cultivar) hardy kiwi vines for the past twenty-one years].

www.nzkiwiberry.com [Website of the New Zealand KiwiBerry Growers Inc.].

Biographical Sketches

Filip Debersaques is lecturer and researcher at the University College Ghent, Faculty of Biosciences and Landscape Architecture, associated with the University Ghent (Belgium). He graduated in 1985 at the above mentioned University College as industrial engineer in agriculture. His main topics of interest are fruit growing, and nutrient management of plants. Since 1985 he coaches students in horticultural sciences for their Master thesis. As committee member of the Belgian Pomological Society he has intensive contacts with the fruit growers.

In 2006 he introduced, together with the co-author Omer Mekers, the production of kiwiberry in Belgium. In November 2008 he started together with growers from France, Austria and Switzerland an international working group to optimize the growing of kiwiberry in these countries.

Omer Mekers is professor in horticulture at the University College Ghent, Faculty of Biosciences and Landscape Architecture, associated with the University Ghent (Belgium). He graduated as Master in Agriculture in 1973 and as Doctor in Agricultural Sciences in 1986 at the University of Leuven (Belgium). His main activities have been initially on breeding and growth regulation of ornamental plants, and since 1988 on applied research and teaching horticultural sciences. He has been promoter of different MSc theses on horticultural topics related to fruit, vegetables and ornamental plants growth, tissue culture and hydroponics.