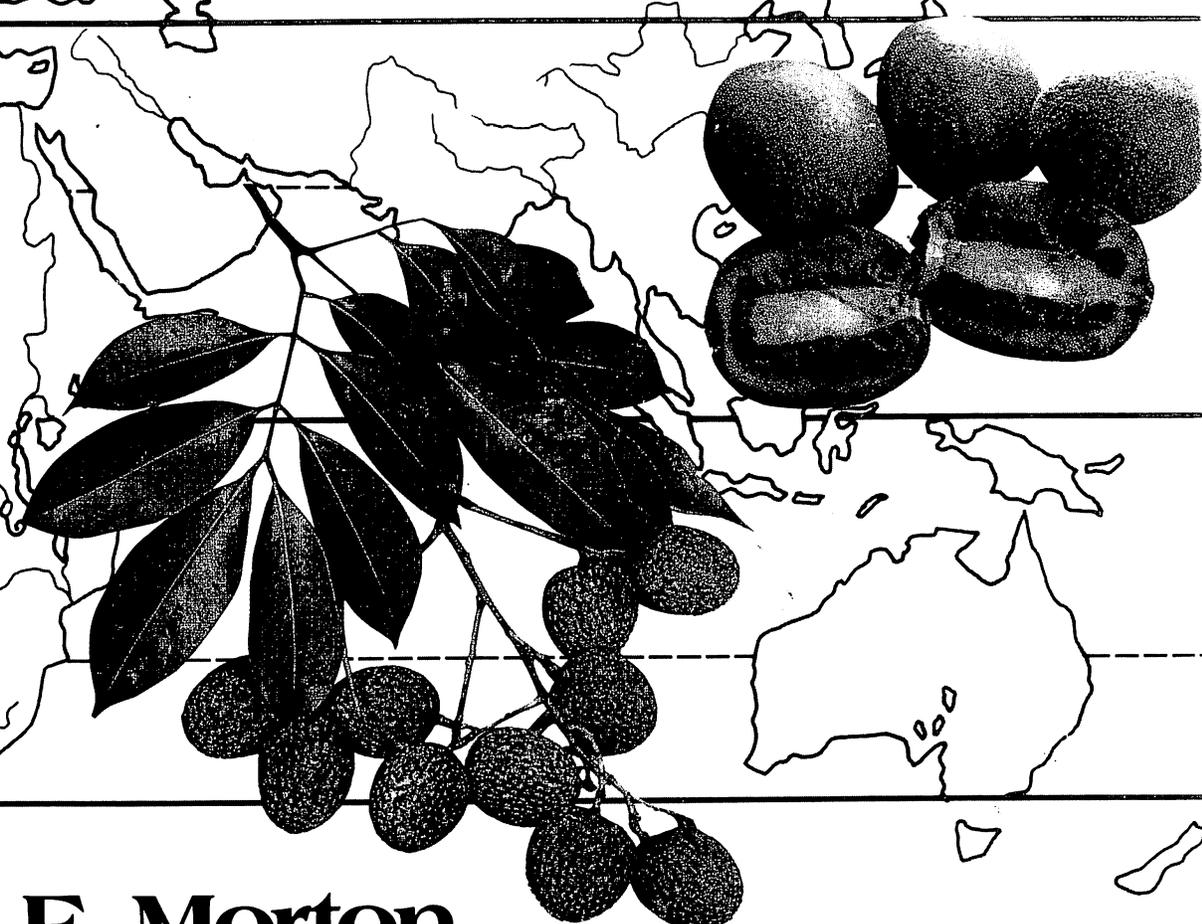


# FRUITS OF WARM CLIMATES



**Julia F. Morton**

## Kiwifruit (Plate XL)

A late-comer on the international market, the kiwifruit long identified as (*Actinidia chinensis* Planch.), was formerly placed in the family Dilleniaceae; is now set apart in Actinidiaceae which includes only two other genera. In the August 1986 issue of *HortScience* (Vol. 21 #4 : 927), there appears an announcement that China's leading authority on this fruit has renamed the stiff-haired form (which includes the kiwifruit) *A. deliciosa* (A. Chevalier) C.F. Liang et A.R. Ferguson var. *deliciosa*, and has retained *A. chinensis* for the smooth-skinned form. The Chinese name, *yang tao*, meaning "strawberry peach", was replaced by Europeans with the descriptive term, Chinese gooseberry (because of the flavor and color of the flesh). In 1962, New Zealand growers began calling it "kiwifruit" to give it more market appeal, and this name has been widely accepted and publicized despite the fact that it is strictly artificial and non-traditional. It was commercially adopted as the trade name in 1974. There are a few little-used colloquial names such as Ichang gooseberry, monkey peach and sheep peach.

### Description

The kiwifruit is borne on a vigorous, woody, twining vine or climbing shrub reaching 30 ft (9 m). Its alternate, long-petioled, deciduous leaves are oval to nearly circular, cordate at the base, 3 to 5 in (7.5–12.5 cm) long. Young leaves and shoots are coated with red hairs; mature leaves are dark-green and hairless on the upper surface, downy-white with prominent, light-colored veins beneath. The fragrant, dioecious or bisexual flowers, borne singly or in 3's in the leaf axils, are 5- to 6-petaled, white at first, changing to buff-yellow, 1 to 2 in (2.5–5 cm) broad, and both sexes have central tufts of many stamens though those of the female flowers bear no viable pollen. The oval, ovoid, or oblong fruit, up to 2½ in (6.25 cm) long, with russet-brown skin densely covered with short, stiff brown hairs, is capped at the base with a prominent, 5-pointed calyx when young but this shrivels and dehisces from the mature fruit while 5 small sepals persist at the apex. The flesh, firm until fully ripe, is glistening, juicy and luscious, bright-green, or sometimes yellow, brownish or off-white, except for the white, succulent center from which radiate many fine, pale lines. Between these lines are scattered minute dark-purple or nearly black seeds, unnoticeable in eating. Cross-sections are very at-

tractive. In some inferior types, the central core is fibrous or even woody. The flavor is subacid to quite acid, somewhat like that of the gooseberry with a suggestion of strawberry.

### Origin and Distribution

This interesting species is native to the provinces of Hupeh, Szechuan, Kiangsi and Fukien in the Yangtze Valley of northern China—latitude 31°N—and Zhejiang Province on the coast of eastern China. It was cultivated on a small scale at least 300 years ago, but still today most of the 1,000-ton crop is derived from wild vines scattered over 33 of the 48 counties of Zhejiang. The plants may be seen climbing tall trees or, near Lung to ping, Hupeh, sprawling over low scrub or rocks exposed to strong north-east winds and bearing heavily. The Chinese have never shown much interest in exploiting the fruit. Because of the dense population, there is little room for expansion of the industry. Nevertheless, trial shipments of canned fruits were made to West Germany in 1980.

Specimens of the plant were collected by the agent for the Royal Horticultural Society, London, in 1847 and described from his dried material. In 1900, seeds gathered in Hupeh were sent to England by E.H. Wilson. The resulting plants flourished and bloomed in 1909. When both male and female vines were planted together, fruits were produced but usually only solitary vines were grown as ornamentals. Seeds from China were introduced into New Zealand in 1906 and some vines bore fruits in 1910. Several growers raised numerous seedlings (many of which were males) and selected the best fruiting types, which were propagated around 1930. By 1940 there were many plantings, one with 200 vines, especially on the eastern coast of the North Island. The fruits were being marketed and were very popular with American servicemen stationed in New Zealand during World War II. Commercial exporting was launched in 1953, the fruits going mainly to Japan, North America and Europe, with small quantities to Australia, the United Kingdom and Scandinavia. In 1981, a survey of smallholders in the Auckland suburbs revealed that the great majority of them intended to plant kiwifruit for the local market. Today, West Germany is New Zealand's biggest customer for kiwifruit. Production in 1983 was reportedly 40,000 tons as compared with 300 tons in 1937. New Zealand supplies 99% of the world production of kiwifruit and

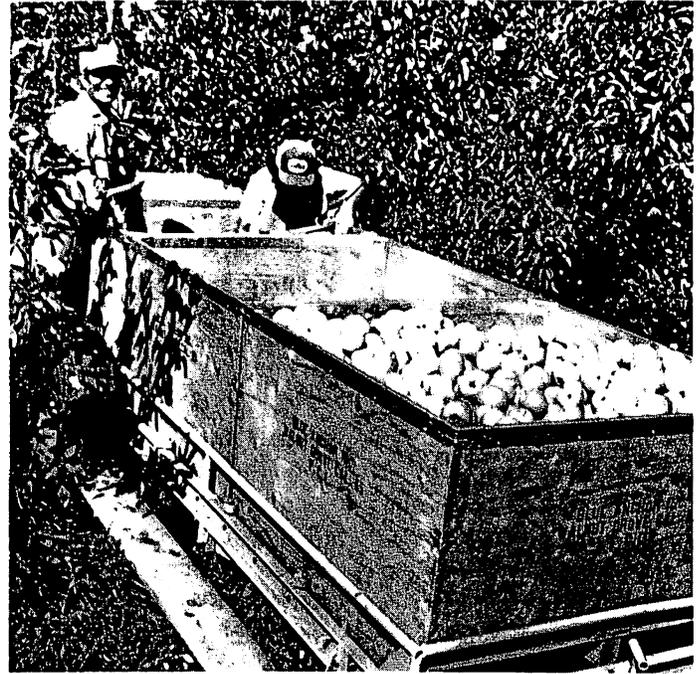


Fig. 83: Kiwifruits on the vine and harvested fruits *en route* to packing house. Courtesy Blue Anchor, Inc., Sacramento, California.

95% of the crop is harvested within 35 miles (56 km) of the little town of Te Puke, Bay of Plenty—38° S latitude. The small industry was greatly assisted in 1971 by an arrangement with the Bay of Plenty Co-operative Dairy Company for the use of cool storage facilities and the construction of a cooperative central packing house. In 1984, there were 2,500 growers, more than 400 packing sheds and 200 “coolstores” with a capacity of 1.9 million tons. A \$10,000 prize was offered for the design of a new package for export that would accommodate fruits of varying shapes and sizes.

Plants and seeds have been distributed from New Zealand to the United States of America (including Hawaii), and to Australia, South Africa, Germany, the Netherlands and Denmark. In 1981, plant exports amounted to \$430,000 NZ. But in 1982 the New Zealand Kiwifruit Authority issued an appeal to cease exporting plants to reduce the likelihood of competition for foreign markets.

The United States Department of Agriculture received seeds from Consul-General Wilcox in Hankow in 1904 (P.I. 11629, 11630) and the resulting vines were fruiting at the Plant Introduction Field Station at Chico, California in 1910. In 1905, a Rev. Hugh White sent in seeds from Kiangsi (P.I. 18535). E.H. Wilson supplied seeds from western Hupeh and Szechuan (P.I. 21781). In 1917, the agricultural explorer, Frank Meyer, sent back to Washington seeds from fruits he found growing near Lung ping, Hupeh, ranging in size from “that of a gooseberry to a good-sized plum” (P.I. 45946). A plant from this introduction was given to Mr. William Hertrich of San Gabriel, California. It had perfect flowers and bore fruit “of good size and quality.” Mr. Hertrich reproduced it by cuttings and in 1919 supplied some of the plants to the

Station at Chico (P.I. 46864). In 1935, a New Zealand grower sent plants of a large-fruited kiwifruit (later named ‘Hayward’ in New Zealand). One of the plants was reported as still flourishing and fruiting—400 lbs (160 kg) annually—in 1982. After cultural techniques were developed in the 1960’s, two California growers imported several thousands of plants from New Zealand. Special kiwifruit nurseries were established in 1966 and, by 1970, there were 40 acres (20.25 ha) devoted to this crop. By 1977 there were over 2,000 acres (800 ha) planted with kiwifruit vines but only 10% of the plants had reached bearing age. In 1982, there were about 1,000 small commercial farms in the state. In 1984, kiwifruit groves in California totalled 6,000 acres (2,040 ha). Most of the crop, worth \$18,000,000 to the growers, is sold locally, but some has been shipped to Japan and to the Netherlands. The trade association, Kiwi Growers of California, was organized in 1972 and incorporated in 1975 to sponsor research and exchange and publish information. Nationwide publicity and marketing is handled by Blue Anchor, Inc., the California Fruit Exchange, greatly stimulating demand despite the high retail price of the fruits. The California Kiwifruit Administration Committee has set rigid quality standards, preventing the shipping of “unclassified” grade.

The Fruit and Fruit Technology Research Institute of Stellenbosch, South Africa, obtained budwood of New Zealand cultivars in 1960 and experimental plantings were made in a number of areas around the country. The success of the vines in the northeastern Transvaal inspired the installment of a large plantation of mostly seedlings, some plants from cuttings, at Chiremba in the lower Vumba based on New Zealand and California selec-

tions. At this location, the altitude is 3,280 ft (1,000 m) and the annual rainfall is 60 in (152 cm). The mean temperatures in southern Cape areas are close to those at Sacramento, California. However, there are great extremes in South African weather and occasionally very high day temperatures which may cause sunburn on exposed fruits. Nevertheless, the South African Kiwifruit Association was formed in 1981 at the University of Natal with expectations of developing successful cultivation.

The kiwifruit was already being grown in Cambodia, Vietnam and southern Laos, France, Spain, Belgium, and Italy where plantings were first made in the late 1960's and commercial growing started in the late 1970's. Italy advanced to third place in world production by 1983, with a crop of 6,000 tons from 4,800 acres (2,000 ha). Over one-half of Italy's crop is exported to France and other European countries.

French interest in the kiwifruit has been stimulated by the low returns from apple-growing. By 1971, there were small plantings scattered around southwestern and southeastern areas of the country—valleys of the Garonne, Dordogne, Rhone and Loire rivers—totalling about 123 acres (50 ha). Greece is now producing kiwifruits for export to other European countries, filling the seasonal gap when fruits from New Zealand are not available. A recent development is the raising of kiwifruits in greenhouses in the Channel Islands, especially as an alternative to tomatoes suffering from European competition.

The vine was introduced into the Philippines at Baguio, in 1923. It succeeds there only above 3,280 ft (1,000 m) and has not been exploited. Large plantings are being made in Chile, not far from Santiago.

## Varieties

There are 4 main Chinese classes of kiwifruit:

1) 'Zhong Hua' ("Chinese gooseberry")—round to oval, or oblate; weight varies from 6.5 to 80 g, averaging 30 to 40 g. Sugar content is 4.6 to 13.1%; ascorbic acid, 25.5 to 139.7 mg per 100 g. This is the most commonly grown.

Three subvarieties are: "Yellow flesh"—average weight, 30.2 g; sugar content, 9.0%; ascorbic acid 101.9 mg per 100 g. "Green flesh"—average weight 18.4 g; sugar content, 5.4%; ascorbic acid, 55.7 mg per 100 g. "Yellow-green" and "Green-yellow"—average weight 31 to 48 g; sugar content 5.4%; ascorbic acid 85.5 mg per 100 g. Not suitable for canning sliced or for jam.

2) 'Jing Li' ("northern pear gooseberry")—elongated oval with green flesh. Leaves usually hairless.

3) 'Ruan Zao' ("Soft date gooseberry")—small, with green flesh; quite sweet. Good for jam. Usually grows in the hills.

4) 'Mao Hua'—may be tight- or loose-haired; has green, sweet flesh. The leaves are elongated oval, relatively broad and thick.

Selections made by growers for fresh fruit market:

1) 'Qing Yuan #17'—fruit weighs a maximum of 70.3 g; skin is yellow-brown, smooth, thin; flesh is juicy and of excellent flavor; sugar content 8.2%; ascorbic acid, 169.7 mg per 100 g. Rated as of superior quality.

2) 'Qing Yuan #22'—fruit has maximum weight of 67 g, average is 47.3 g; skin is yellow-brown, smooth, thin; sugar content 7.9%; ascorbic acid, 11.42 mg per 100 g. Of high quality.

3) 'Qing Yuan #28'—fruit cylindrical; weighs a maximum of 46 g; averages 40.6 g. Skin is smooth; flesh fine-textured and juicy. Sugar content 9.1%; ascorbic acid 103.2 mg per 100 g. Of medium quality.

4) 'Qing Yuan #18'—fruit cylindrical; maximum weight 56 g, average 36 g; flesh very tender, medium juicy, of good flavor. Ascorbic acid content 178.9 mg per 100 g. Good fresh and for processing.

5) 'Qing Yuan #20'—small, elongated cylindrical; maximum weight 26 g; average 21.5 g. Sugar content 12.4%; ascorbic acid, 189.2 mg per 100 g. Excellent quality.

6) 'Long Quan #3'—oblate; average weight 31 g. Flesh yellow, fine-textured, juicy, and of good flavor. Sugar content, 9.5%; ascorbic acid, 99.7 mg per 100 g. Above average quality.

Selections made by growers for processing because of uniform shape and size, yellow or reddish-brown flesh, minimum woodiness at base, high ascorbic acid content:

1) 'Qing Yuan #27'—cylindrical; average weight, 27.9 g; flesh yellow, fine-textured; seeds few; core small. Good for processing.

2) 'Qing Yuan #29'—average weight, 27 g; flesh yellow, fine-textured, with small core.

3) 'Qing Yuan #6'—average weight 27.3 g. Flesh pale-yellow and fine-textured. Sugar content 7.6%; ascorbic acid 140 mg per 100 g. Of superior quality for processing.

4) 'Huang Yan'—yellow-skinned, cylindrical; average weight 21.9 g; flesh yellow-white, fine-textured, and of good flavor, with medium-large core. Sugar content 7.4%; ascorbic acid 170.8 mg per 100 g. Above average quality for processing.

The leading cultivars in New Zealand are:

'Abbott' ('Green's'; 'Rounds')—a chance seedling, discovered in the 1920's; introduced into cultivation in the 1930's. Fruit oblong, of medium size, with brownish skin and especially dense, long, soft, hairs; flesh is light-green and of good flavor. Of good keeping quality. Resembles 'Allison'. Ripens in early May. Vine is vigorous, precocious, productive. Petals do not overlap; styles are horizontal. Most exports to the United Kingdom have been of this cultivar.

'Allison' ('Large-fruited')—a chance seedling discovered in 1920's; introduced in early 1930's. Fruit oblong, slightly broader than 'Abbott'; of medium size, with densely hairy, brownish-skin; flesh is light-green, of good flavor. Fruit is of good keeping quality. Vine very vigorous, prolific; blooms later than 'Abbott'; fruits ripen early May. Flowers have broader, more overlapping petals than 'Abbott' and they are crinkled on the margins. Styles elevate to 30 or 60° angle as flower ages. Formerly very popular but has lost ground to 'Hayward'.

'Bruno' ('McLoughlin'; 'Longs'; 'Long-fruited'; 'Te puke')—a chance seedling; discovered in the 1920's; introduced in the 1930's. Fruit large, elongated cylindrical, broadest at apex; has darker-brown skin than other cultivars and dense, short, bristly hairs. Flesh is light-green, of good flavor. Ripens in early May. Vine is vigorous and productive, blooms with or slightly after 'Allison'. Sometimes exported. Flowers borne singly or sometimes in pairs. Petals narrower and overlap less; styles longer and stouter than those of 'Abbott', more regularly arranged than those of 'Allison'.

'Hayward' ('Giant'; 'Hooper's Giant'; 'McWhannel's')—chance seedling in Auckland; discovered in 1920's; introduced into cultivation in early 1930's; introduced into the United States as P.I. 112053 before being named in New Zealand and was called 'Chico' in California. Fruit exceptionally large, broad-oval, with slightly flattened sides; skin light greenish-brown with dense, fine, silky hairs. Flesh light green; of superior flavor and fruit is of good keeping quality. Ripens in early May. Vine is moderately vigorous, blooms very late; is moderately prolific, partly because of scanty pollination and late-blooming males must be planted with it. Flowers borne singly or, rarely, in pairs. The petals are broad, overlapping, cupped, and the styles more erect than those of other cultivars though they vary from horizontal to vertical. This is the leading cultivar in New Zealand; the only commercial cultivar in California; produces 72% of Italy's crop.

'Monty' ('Montgomery')—a chance seedling in New Zealand, discovered in the early 1950's; introduced into cultivation about 1957. Fruit oblong, somewhat angular, widest at apex; of medium size; skin brownish with dense hairs. Flesh is light-green. Fruit ripens in early May. Vine is highly vigorous and productive, sometimes excessively so. Petals overlap only slightly at the base.

'Greensill'—a more recent selection; it is the most cylindrical of all, flattened on both ends, slightly wider at base than at apex; a little shorter than 'Allison' but thicker. Petals narrow, constricted, do not overlap at the base; styles are mostly erect.

Plant breeders are endeavoring to develop an acceptable hairless kiwifruit and several thousand seedlings of a promising clone were set out in an experimental plot in Pukekohe, New Zealand, in 1980.

Male plants commonly used for pollination are:

'Matua', with short hairs on peduncles and flowers in groups of 1 to 5, usually 3.

'Tomuri', with long hairs on peduncles, flowers in groups of 1 to 7, usually 5.

### Climate

The kiwifruit vine grows naturally at altitudes between 2,000 and 6,500 ft (600–2,000 m). The Kwangsi latitude is approximately that of Galveston, Texas; the climate has been likened to that of Virginia or North Carolina, with heavy rainfall and an abundance of snow and ice in the winter.

In the Bay of Plenty region the winter mean minimum daily temperatures are from 40° to 42°F (4.44°–5.56°C); mean maximum, 57° to 60°F (13.89°–15.56°C); in summer, mean minimum is 56° to 57°F (13.33°–13.89°C); mean maximum, 75° to 77°F (23.89°–25°C). Annual rainfall is 51 to 64 in (130–163 cm) and relative humidity 76 to 78%.

In California, the kiwifruit is an appropriate crop wherever citrus fruits, peaches and almonds are successful, though the leaves and flowers are more sensitive to cold than those of orange and peach trees. Autumn frosts retard new growth and kill developing flower buds, or, if they occur after the flowers have opened, will prevent the setting of fruits. Late winter frosts are said to improve the flavor of full-grown fruits.

Kiwifruit vines in leaf are killed by drops in temperature below 29°F (-1.67°C), while dormant mature vines can survive temperatures down to 10°F (-12.22°C). In France, 1-year-old plants have been killed to the ground by frosts. California growers report that the kiwifruit requires a temperature drop to 32°F (0°C) to cause it to drop its leaves and then 400 hours of dormancy, or 40 days of 40°F (4.44°C), in order to set fruit properly. At Pietermaritzburg, South Africa, where there are only 150 to 200 hours of chilling weather, the vines are slow to put out new spring leaves.

Alternating warm and cold spells during the winter will reduce flowering. A seedling selection at the Citrus and Subtropical Fruit Research Institute, Nelspruit, has borne well and appears to be more tolerant of mild winters than other cultivars which are not successful in this warm region of the eastern Transvaal. There have been several attempts to grow kiwifruits in northern and central Florida, and a few vines are growing experimentally in the southern part of the state and even on the Florida Keys but, so far, only the plants at Tallahassee have fruited to any extent.

### Soil

For good growth, the vine needs deep, fertile, moist but well-drained soil, preferably a friable, sandy loam. Heavy soils subject to waterlogging are completely unsuitable. In Kiangsi Province, China, the wild plants flourish in a shallow layer of "black wood earth" on top of stony, red subsoil.

### Pollination

The flowers are mostly insect-pollinated. For small, single-row plantings, one male vine to every 5 females is necessary. In commercial plantings, 10 to 12% of the vines must be males, that is, about 1 male for every 8 or 9 female vines, and the males should be staggered evenly throughout the block plantations. The time of flowering must be ascertained so that the male and female plants will coincide. The female plants yield no nectar. It is recommended that there be 3½ beehives per acre (8 per ha) when 10 to 15% of the flowers are open in order to assure adequate pollination. In anticipation of a shortage of hives for expanding culture, work was begun in New Zealand about 1980 to perfect means of collecting and drying pollen and preparing a suspension for spraying onto the blooming vines by tractor-drawn equipment. Pollen is commercially available in California also for artificial pollination.

### Propagation

Inasmuch as seedlings show great variation, it is not recommended that the vine be grown from seed except in experimental plots for clone selection or to produce rootstocks for budding or grafting. To obtain the small seeds, ripe fruits are pulped in an electric blender and then the pulp is strained through a fine screen. The seeds, mixed with moist sand, are placed in a plastic bag, plastic box

or other covered container, and kept in a refrigerator (below freezing temperature) for 2 weeks. Then the seed/sand mixture can be planted in nursery flats of sterilized soil, or directly in the garden or field, no deeper than  $\frac{1}{8}$  in (3 mm) and kept moist. Germination will take 2 to 3 weeks. The seedlings should be thinned out to prevent overcrowding and can be successfully transplanted when 3 in (7.5 cm) high if the soil is taken up with the root system intact. If intended for rootstocks, they should be set 12 to 15 in (30–45 cm) apart in nursery rows. When 1-year-old, the plants are ready for budding.

Budwood is taken from the current season's growth and defoliated, leaving only  $\frac{1}{2}$  in (1.25 cm) of the petiole of each leaf, and is inserted in the rootstock about 4 in (10 cm) above the ground, using the "T" or shield method. When the buds have "taken", the stock is cut back to just above the union.

For grafting, scions are taken from a parent vine while it is dormant and should be trimmed at both ends, leaving 2 or 3 buds. The scion is joined to the stock by either the whip or tongue process about 4 in (10 cm) from the ground.

Soft-wood cuttings, trimmed to leave only 2 leaves, are treated with hormones and rooted under intermittent mist. Dormant cuttings have a low percentage of success. In New Zealand, cuttings are not popular because they do not develop a strong root system and are prone to attack by crown-gall. Root-grafting was formerly practiced but abandoned because of susceptibility to crown-gall at the graft union.

Old vines bearing inferior fruits can be reworked by budding or, preferably cleft-grafting, which must be done before new growth begins or the vine will bleed sap. Some growers graft a branch of a compatible male onto a female vine to promote pollination. The increasing demand for plants of cv. 'Hayward' in South Africa has led to *in vitro* propagation using vegetative buds of female plants.

## Culture

The kiwifruit is alleged to be a difficult crop to establish, and many new plantations in California have been costly failures. The soil should be well worked to a fine tilth for easy penetration by the shallow, fibrous root system. It is important to fumigate in advance of planting. The land should be level to give all plants equal moisture. There should be good drainage and protection from strong winds which severely damage tender spring shoots. The vines are set not opposite each other but alternated and a generally used spacing has been 18 to 20 ft (5.56–6 m) apart in rows 15 ft (4.5 m) apart. In 1983 it was announced that between-plant spacing was being reduced to 8.2 ft (2.5 m). It has been customary to train the vines to grow on strong horizontal trellises with wood "T" supports 6 to 7 ft (1.8–2.1 m) high, holding 3 wires 2 ft (60 cm) apart. One New Zealand grower has developed a metal arch system which provides headroom under the canopy for pruning and harvesting, and also provides frost protection by allowing cold air to flow downward

and settle on the ground, and this air movement helps reduce the frequency of disease. Also, it has been found that A-frame pergolas are producing 3 times as much fruit as the traditional flat trellises.

By the common method, the plants are staked until they reach the wire and, as they develop, they must be kept under control, otherwise a tangled mass of unwieldy vegetation will result. Training of the vines is very important. There should be a single leader and fruiting arms every 18 to 28 in (45–71 cm). Summer pruning is for the purpose of heading the fruiting arms and suppressing shoots. Shoots from summer pruning will not bear fruit until the following year after dormancy. Male plants will yield more pollen in the spring if new shoots are topped to leave 5 to 7 buds during the summer. Renewing of fruiting arms is done every 4 years, in the winter. The vines should be trained to fruit above the foliage instead of beneath it because excessive shading from the canopy results in poor shoot development, delayed blooming, dehydration and dying of flowerbuds, reduced size of fruits. This is more critical in New Zealand than in California where the light is more intense and penetrating.

The mature plants require a minimum of 150 lbs nitrogen per acre (about 150 kg/ha). In New Zealand, they are usually fertilized twice a year, once in spring and once in early summer, using a total of 500 lbs (225 kg) nitrogen, 220 lbs (100 kg)  $P_2O_5$ , 121 lbs (55 kg)  $K_2O$ , per hectare—equivalent to 202 lbs (92 kg) nitrogen, 89 lbs (4.5 kg)  $P_2O_5$ , 49 lbs (22.2 kg)  $K_2O$  per acre.

Apart from land cost, it takes a minimum of \$3,500 to bring each acre into production. The first 2 years are the most critical, coping with the variable growth habits of individual plants, but the vines become more manageable with age. One producer in California, who also raises and sells grafted plants, believes that many people have set out plants that are too young. He sells only 2-year-old vines, bare-root for planting in the dormant season, which gives the roots maximum freedom unlike those which develop in containers. In France, where cuttings from New Zealand are kept in cool storage during the winter and planted out in the spring, vines have made 5 to 6 ft (1.5–1.8 m) of growth in the first 2 months.

Kiwifruit vines can stand wet seasons that destroy peach orchards. Drip irrigation is now being used in California plus overhead sprinklers which have the additional value of plant protection during cold spells and protection from heat in dry seasons. A mature orchard is said to require 40 in (1,000 mm) of water during the 8-month growing season, more than  $\frac{1}{2}$  of it in the 3 summer months. Some growers plant a permanent cover crop of inoculated clover to control dust, aid water penetration and provide additional nitrogen for the kiwifruit crop. However, clover must be mowed at pollinating time to prevent the flowers from attracting the bees away from the kiwi vines.

## Season

New Zealand production begins in May and the fresh or stored fruits are exported through November. In Cali-

fornia, the vines put out new leaves in mid-March, bloom in early May and the fruit ripens in November after the leaves have fallen. The marketing season extends from November through April because the fruits hold so well in storage. The French season corresponds to that of California.

### Harvesting and Packing

In New Zealand, a minimum picking-maturity standard is 6.25% soluble solids. California kiwifruits are harvested when they attain 6.5 to 8% soluble solids. They are picked by hand, either by breaking the stalk at its natural abscission point or are clipped very close to the base of the fruit to avoid stem punctures. They are carried in field boxes to packing stations. In well-equipped packing plants, the fruits are mechanically conveyed across a brushing machine that removes the hairs and, in some plants, the styles and sepals as well. The fruits are graded for size (25 to 54 per flat). For shipment, about 7 lbs (3¼ kg) of fruits are arranged in a plastic tray covered with perforated polyethylene and packed in a fiberboard or wooden box.

### Yield

In California, 4-year-old vines have yielded 14,000 lbs per acre (15.7 MT/ha). Vines 8 years old have yielded 18,000 lbs per acre (20 MT/ha), which is nearly the maximum for mature plants (8 to 10 years old).

The bearing habits of the vine are variable—a light crop one season is likely to be followed by a heavy crop the next season, and *vice versa*.

### Keeping Quality

Firm fruits can be kept 8 weeks at room temperature, 65° to 70°F (18.33°-21.11°C). Fully ripe fruits can be kept for a week or more in the home refrigerator. Fruits harvested at the firm stage will keep for long periods at 31° to 32°F (-0.56°-0°C) and at least 90% relative humidity, wrapped in unsealed polyethylene in containers. Lower relative humidity, even 85%, will cause a weight loss of as much as 4.5% in 6 weeks. Fruits that are cooled to a temperature of 32°F (0°C) within 12 hours after harvesting, will keep in good condition for as long as 6 months under commercial refrigeration. Experiments have shown that an atmosphere modified with 10 to 14% CO<sub>2</sub> will increase cold storage life by 2 months, providing the fruits enter storage within a week after harvest and are removed from the controlled atmosphere shortly in advance of marketing. Some studies by Arpaia *et al.*, indicate that optimum storage atmosphere may be obtained with 5% CO<sub>2</sub> and 2% O<sub>2</sub>, with C<sub>2</sub>H<sub>4</sub> excluded and/or removed to keep it below 0.05 mcg per liter. Kiwifruits freeze at storage temperatures between 28° and 30°F (-1.8° and -2.1°C).

For consumption fresh or for processing, kiwifruits are customarily kept refrigerated for at least 2 weeks to induce softening and then allowed to further soften at room temperature to improve flavor. The fruits will ripen too rapidly and lose quality if stored with other fruits, such as apples,

pears, peaches, plums, etc., because of the ethylene these fruits emit.

### Pests and Diseases

Kiwifruit vines are subject to attack by rootknot nematodes—*Meloidogyne hapla* and, to a lesser extent, *Heterodera marioni*—in New Zealand. Because of the surface hairs, the fruit is not damaged by fruit flies. The leaf roller, *Ctenopseustis obliquana*, which scars the surface of the fruit, sometimes eats holes where 2 or more fruits touch each other. In New Zealand, crawlers of the greedy scale insect, *Hemiberlesia repac*, have been conveyed to the plants by wind. This pest infests the leaves and fruit and kills the growing tips of the vines. The passionvine hopper sucks the sap of the vine and deposits honeydew on the fruit, and sooty mold growing on this sticky substance renders the fruit unmarketable. A small moth native to New Zealand—*Stathmopoda skellone*—may occur in abundance some seasons and do damage to the fruit under the sepals or where fruits touch each other. Silvering and browning of the leaves may occur in late summer or early fall because of infestation by thrips (*Heliothrips haemorrhoidalis*). Other pests in New Zealand include the salt marsh caterpillar and mites. In Chiremba, South Africa, red scale has been observed but it is easily controlled by spraying. In 1984, the New Zealand Pesticides Board approved Ivon Watkins-Dow's Lorsban insecticides for spraying on kiwifruit crops for export, and also cleared 4 herbicides for kiwifruit orchards.

A major disease of the vine is crown gall caused by *Agrobacterium tumefaciens*, but many suspected cases have turned out to be merely natural callousing. Crown gall can be avoided in budded or grafted plants by leaving the upper roots exposed. The roots may be attacked by *Phytophthora cactorum* and *P. cinnamomi*, and also by oak root fungus (*Armillaria mellea*) which is fatal. In humid climates, *Botrytis cinerea* infects the flowers and contaminates the young fruits. New Zealand growers may apply 8 or 9 sprays during the dormant period to achieve control of pests and diseases.

Post-harvest fruit decay is caused by *Alternaria* spp. and *Botrytis* spp. The greatest enemy is gray mold rot arising from *Botrytis cinerea* which enters through even minute scratches on the skin during storage at high humidity. *Alternaria alternata* mold is superficial and can be avoided if styles and sepals are completely removed during the brushing operation. *Alternaria*-caused hard, dry rot often is found on stored fruits that have been sunburned in the orchard. Such fruits should be culled during grading. Blue mold, resulting from infection by *Penicillium expansum*, may occur on injured fruits.

Leaf scorch results from hot dry winds in summer and early fall.

### Food Uses

The Chinese have never been overly fond of the kiwifruit, regarding it mainly as a tonic for growing children and for women after childbirth. It is ripe for eating when it yields to slight pressure. For home use, the fruits are hand-

picked. In addition to eating out-of-hand, they are served as appetizers, in salads, in fish, fowl and meat dishes, in pies, puddings, and prepared as cake-filling. Ice cream may be topped with kiwifruit sauce or slices, and the fruit is used in breads and various beverages. Kiwifruit cannot be blended with yogurt because an enzyme conflicts with the yogurt process. A cookbook, *Kiwifruit Recipes*, is published by the Kiwi Growers of California.

For commercial canning, the partly softened fruits are peeled by a mechanical steam peeler or by immersing in a boiling 15% lye solution for 90 seconds. Then they are washed in cold water, trimmed by hand, rinsed, and cooked in sirup in standard #2½ vacuum-sealed cans.

For preservation by freezing, the fruits are similarly peeled, sliced and immersed for 3 minutes in a solution of 12% sucrose, 1% ascorbic acid, and 0.25% malic acid, quick-frozen, then put into polyethylene bags and stored at 0°F (-17.78°C). Experiments have shown drying to be practical if the lye-peeled whole fruits are first dipped in a sugar solution to improve flavor, then dehydrated at temperatures below 150°F (65.56°C).

Only overripe or poorly shaped fruits are utilized for flavoring ice cream and for commercial juice production blended with apple to reduce acidity. The fruits so used are not peeled but put through a processing machine that removes the hairs, skin and seeds. In 1983, 2,378 gals (9,000 liters) of kiwifruit concentrate from 1,000,000 fruits were sold in Germany, and 13,210 gals (50,000 liters) were to be provided in 1984.

Slightly underripe fruits, which are high in pectin, must be chosen for making jelly, jam and chutney. Freeze-dried kiwifruit slices are shipped to health food outlets in Sweden and Japan. In the latter country, they are sometimes coated with chocolate. The peeled whole fruits may be pickled with vinegar, brown sugar and spices. Cull fruits can be made into wine. The Kiwifruit Wine Company of New Zealand, Ltd., has a contract to sell "Durham Light", a medium-sweet wine, throughout Japan. The Gibson Wine Company in Elk Grove, California, is making kiwifruit wine with an 11.5% alcohol content.

In the home kitchen, meat can be tenderized by placing slices of kiwifruit over it or by rubbing the meat with the flesh. After 10 minutes the fruit must be lifted or scraped off, otherwise the enzymatic action will be excessive. The meat should then be cooked immediately.

### Toxicity

The hairs on the skin can cause throat irritation if ingested. It might be wise to avoid excessive consumption of

### Food Value Per 100 g of Edible Portion\*

	Fresh	Canned	Frozen
Calories	66		66
Moisture	81.2 g	73.0 g	80.7 g
Protein	0.79 g	0.89 g	0.95 g
Fat	0.07 g	0.06 g	0.08 g
Carbohydrates	17.5 g	25.5 g	17.6 g
Ash	0.45 g	0.45 g	0.53 g
Calcium	16 mg	23 mg	18 mg
Iron	0.51 mg	0.40 mg	0.51 mg
Magnesium	30 mg	30 mg	27 mg
Phosphorus	64 mg	48 mg	67 mg
Thiamine	0.02 mg	0.02 mg	0.01 mg
Niacin	0.50 mg	0.40 mg	0.22 mg
Riboflavin	0.05 mg	0.02 mg	0.03 mg
Vitamin A	175 I.U.	155 I.U.	117 I.U.
Ascorbic Acid	105 mg	103 mg	218 mg

(natural and added by pre-dip)

\*Analyses made at the University of California.

Quinic acid predominates in young fruits, disappears with the formation of ascorbic acid. Boiling for 2 hours reduces ascorbic acid content by 20%. The same amount is lost when frozen fruits are thawed at room temperature.

Kiwifruits, even when ripe, contain the proteolytic enzyme actinidin, which is said to aid digestion. It can be extracted and purified as a powder for tenderizing meat. The tannin content is low, 0.95%, in mature fruits. According to a recent report from New Zealand, the kiwifruit is rich in folic acid, potassium, chromium and Vitamin E.

raw kiwifruits until more is known of the body's reaction to actinidin.

### Medicinal Uses

The branches and leaves are boiled in water and the liquid used for treating mange in dogs. In China, the fruit and the juice of the stalk are esteemed for expelling "gravel". The scraped stems of the vine are used as rope in China, and paper has been made from the leaves and bark. If the bark at the base of the vine, close to the roots, is removed in one piece and placed in hot ashes, it will roll into a firm tube which can be used as a pencil.

## Related Species

The United States Department of Agriculture has, in the past, made various introductions of other species, especially *A. arguta* Planch. ex Miq., *A. kolomikta* Maxim., and *A. polygama* Maxim., which are often grown as ornamental vines in the northern states.

*A. arguta*, KOKUWA, or TARA VINE, from Japan, Korea and Manchuria, has greenish-yellow fruit, or sometimes dark-green blushed with red; oblong or oval, about 1 in (2.5 cm) long, tipped with the persistent style. The skin is smooth and very thin; the flesh is green and

sweet when fully ripe, and the seeds are minute. The fruits are edible but somewhat purgative.

The vine was growing in a private garden in Marblehead, Massachusetts, in 1888. The United States Department of Agriculture received seeds from that vine in 1908; but had been sent seeds from Germany in 1901; and more seeds came from Korea in 1909. This species has been cultivated as an ornamental and screening vine in subtemperate zones of this country since these early dates. Currently, Henry Field's Seed and Nursery Company, Shenandoah, Iowa, is glamorizing the "Hardy Kiwi" as a new "tropical fruit . . . surviving down to 25° below zero". The Richard Owen Nursery in Bloomington, Illinois, is advertising "*A. arguta annasnaja*" as a "Hardy Kiwi"  $\frac{3}{4}$  to 1  $\frac{1}{2}$  in (2-4 cm) in diameter, ripening in late September or early October.

It is true that the wild fruits of *A. arguta* are gathered and sold in northern China, and the success of the kiwifruit has aroused some interest in the fruits of *A. arguta* in cool areas of the United States. However, most seedlings are non-fruiting males, and female or bisexual specimens are rare and may be unreliable bearers. Much experi-

mental work may be necessary to determine whether or not the kokuwa can be developed into a practical fruit source.

In June, 1923, Dr. David Fairchild applied pollen of the kiwifruit on the flowers of a vine of *A. arguta* in a garden in Maryland and he harvested some fruits in October of that year. He had hopes for the future of his hybrid and distributed cuttings and seeds. Later, he sadly reported that all his "hybrid plants made poor growths and never bore."

*A. kolomikta*, ranging from Japan to Manchuria and western China, has blue, oblong-ovoid fruits, of sweet flavor. Cats are very partial to the plant.

*A. polygama*, SILVER VINE, is native from Japan to western China. It has beaked, yellow, bitter fruits to 1  $\frac{1}{2}$  in (4 cm) long. The Japanese eat the salted fruits and the leaves. This species is prized in horticulture for the silvery tone of the young growth of male plants. The bark, twigs and leaves contain actinidine and also metatabilacetone, similar to catnip oil, and they lure and intoxicate cats. They are said to be used for taming lions and tigers in captivity.

Fig. 83-a: A by-product of kiwifruit culture: California growers have found the vine trimmings unsuitable for mulch or disposal by burning. They are shipping them to florists. Being naturally coiled and curiously twisted, they are attractive and useful in enhancing flower arrangements. Some that are fairly fresh may put out a temporary flurry of downy green leaves and tendrils. (Stems courtesy Flower Wagon, Miami, FL).

