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Growing Kiwifruit

Contents

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Kiwifruit Cultivars

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Kiwifruit are native to southeast Asia. There are more than 50 species in the genus *Actinidia,* and many have commercial potential.

The most common kiwifruit species grown commercially is *Actinidia deliciosa* cultivar Hayward. Consumers are very familiar with this brown, fuzzy fruit.

Fuzzy kiwi are grown commercially in New Zealand, Italy, Japan, France, Australia, Greece, Chile, and California. There is some commercial production in Oregon and Washington; however, this species is not extremely hardy and may suffer cold injury in some years in the Pacific Northwest.

More hardy kiwifruit species also are available. They include the following:

- *A. arguta,* known as the hardy kiwi or arguta (marketed as baby kiwi in Oregon and grape kiwi in British Columbia). This species shows promise for commercial production in the United States.
- *A. kolomikta,* also known as kolomikta or Arctic Beauty
- *A. polygama,* or silver vine

Although some people claim they eat the skin of fuzzy kiwi, most peel these fruit. However, the hardy, kolomikta, and silver vine kiwifruit have very edible skin. You can pop these delicious, small fruit right into your mouth.

Kiwifruit are relatively high in acid, reaching nearly 2 percent of fresh weight at maturity and declining after harvest. Kiwifruit are one of the best natural sources of vitamin C, with a level of at least twice that of the orange.

The fruit of most common kiwifruit species and cultivars have green flesh that does not brown when cut.

Fuzzy kiwifruit can be stored for months after harvest. However, the hardy and kolomikta kiwis can be stored for only 2 months at most at 32–35.5°F (0–2°C).

The kiwifruit is a dioecious plant—it has separate male and female plants (with the exception of a few self-fertile cultivars). It is essential to plant male vines for pollination and crop production.

Plant male and female vines of the same species. In general, 1 male is required for every 6 to 10 females. Self-fertile cultivars require no male pollinator, although fruit size may be larger with cross-pollination.

Yield per plant varies with species and cultivar. Hayward (*A. deliciosa*) yields from 25 to

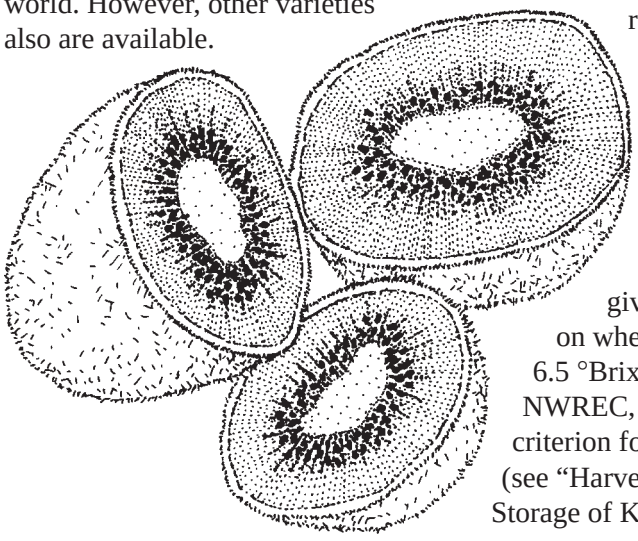
200 pounds per plant, whereas *A. arguta* yields from 50 to 100 pounds per plant.

A. kolomikta and *A. polygama* leaves contain a substance that has an effect similar to catnip. In China, kiwivine leaves reportedly are fed to large cats as a sedative. You may find that cats become a pest of your new kiwifruit planting!

The information below on ripening dates, fruit weights, and plant performance is approximate. It is based on limited test results from a cultivar planting at North Willamette Research and Extension Center (NWREC), Aurora, Oregon. Performance may vary with location.

"Fuzzy" Kiwifruit

Actinidia deliciosa, fuzzy kiwifruit, is the most widely available species. Generally, fruit are large, with a green skin covered with brown fuzz. Vitamin C content ranges from 100 to 200 mg per 100 grams fruit. The most common commercial cultivar is Hayward, which is found in supermarkets throughout the world. However, other varieties also are available.



Fuzzy kiwifruit can be grown in Oregon and Washington. Hayward needs a growing season of about 225 to 240 frost-free days. However, although this species should tolerate temperatures down to 10°F (-12°C), plants may be damaged at slightly higher temperatures.

Cold damage usually occurs when temperatures drop during the night after a warm spell. The trunk usually is damaged, which weakens older plants and sometimes kills young vines. Although methods such as wraps and plastic sleeves may help protect the trunk against freeze injury, they are not always effective. The trunk's sensitivity to cold decreases with age.

Young kiwifruit shoots and fruit are very sensitive to frost injury. Temperatures of 30°F or less (-1°C) for only 30 minutes can severely damage shoots in the spring and fruit in the fall. Still, these kiwifruit can be grown successfully with overhead irrigation for frost protection.

Although many other fuzzy kiwifruit cultivars are available in other production regions, the following cultivars are available and have been tested in the Pacific Northwest. All produce bright green-fleshed fruit. Ripening dates given below are based on when fruit reached 6.5 °Brix (percent sugar) at NWREC, a harvest date criterion for long-term storage (see "Harvest, Handling, and Storage of Kiwifruit").

Hayward

Hayward is the cultivar usually found in stores. Its large, fuzzy, brown fruit with good, sweet flavor has made it popular. Shoots are sensitive to frost injury in spring. This cultivar is recommended only for areas of Oregon and Washington with mild winters.

Ripening date: October 7–12
Fruit weight: 80–90 grams
Vine growth: vigorous

Bruno

Bruno produces a large cylindrical fruit that is darker brown than Hayward. It has a lower winter chilling requirement (50–250 hours at 32 to 45°F), and therefore may be more sensitive to late winter cold spells, particularly after a warm period.

Saanichton 12

This cultivar comes from Vancouver Island, British Columbia, where it has been grown for more than 30 years. Fruit are large, somewhat more rectangular than Hayward, sweet, and of good flavor. It seems more hardy than Hayward.

Ripening date: October 1
Fruit weight: 70–80 grams
Vine growth: vigorous

Blake

This is a relatively new cultivar. It is claimed to be "self-fertile," but it does benefit from cross-pollination. Fruit are smaller than Hayward or Saanichton 12 and are more oval in shape. Flavor is inferior to Hayward and Saanichton 12.

Ripening date: October 1
Fruit weight: 60–70 grams
Vine growth: vigorous

Male (*A. deliciosa*)

A pollinator is required for all fuzzy kiwi. There are many cultivars/selections of males available. Examples include Matua, Tomuri, Cal Chico No. 3, Chico Early, and Chico Extra Early.

Hardy Kiwi

This kiwifruit species, *A. arguta*, is hardy to -10 to -25°F (-23 to -32°C) under most conditions. Damage to the trunk from cold temperatures rarely occurs in Oregon or Washington; however, frost damage to young shoots is more common.

Maximum hardiness levels given for this species reflect only midwinter hardiness. This species has a low chilling requirement (winter rest period satisfied by temperatures at 32–45°F) and may be sensitive to cold injury at higher temperatures when warm weather precedes a cold spell, particularly in late winter.

Unfortunately, warm temperatures in February or March may promote early bud break, making this species very susceptible to frost damage of the young shoots. Only additional testing will show how much of a problem this may be for our region.

Keep in mind that young vines may be more cold sensitive. Protect them with trunk wraps (see "Establishing Your Kiwifruit Vineyard").

Hardy kiwi plants are very vigorous and produce a good quality, highly aromatic fruit that is quite different from the fruit of *A. deliciosa*. Fruit are smooth skinned (skin can be eaten), generally green in color, and much smaller than the fuzzy types. The flavor is excellent, but varies by cultivar. Vitamin C content is very good at 10 to 70 mg per 100 grams fresh fruit.

In France, hardy kiwi are cultivated commercially, but acreage is limited due to marketing limitations—small fruit size, short shelf life, and a limited ripening period. Also, the fruit on a given plant ripen unevenly, which makes harvest difficult unless fruit are picked under-ripe and forced to ripen. Vines are very vigorous, and considerable pruning is required to keep growth under control.

In general, hardy kiwifruit do not store as well as the fuzzy types. Therefore, you likely will see these kiwifruit in stores up to only a couple of months after fall harvest.

Currently, relatively little hardy kiwifruit is grown commercially. However, you no doubt will hear and see more about these types, as they do have good quality, attractive fruit.

Certainly, the hardy kiwifruit are well suited to the home garden and, with an appropriate market, to commercial production as well.

Fruit of these hardy kiwi are best when ripened on the vine to maximize development of aroma and flavor; however, shelf-life then is shortened. The following harvest dates are based on sugar levels of 8 to 9 °Brix. (If left on the vine, the fruit will reach 18 to 25 °Brix.)

Ananasnaya

This is the most popular hardy kiwifruit cultivar currently available. Its Russian name means "pineapple-like." You also may hear this cultivar referred to as "Anna."

Fruit are of very good quality, with a good aroma and sweet, intense flavor. They have a green skin that develops a purple-red blush in full sun. Skin may be slightly tough.

The cultivar Ananasnaya brought to Oregon is *A. arguta*. However, the Russian cultivar Ananasnaya is *A. kolomikta*; more than one cultivar with the same name may be available in nurseries.

Harvest date: September 14–30
Fruit weight: 9–14 grams
Vine growth: very vigorous

74-49

This numbered selection/cultivar came from a USDA program in Chico, California. This cultivar produces very good quality fruit of similar size and quality to Ananasnaya.

Ripening date: September 7–14
Fruit weight: 7–12 grams
Vine growth: very vigorous

Meader

We presently are not testing this cultivar at NWREC. However, it is reported to produce good quality, medium-sized fruit. Note that a male "Meader" also is available; do not be confused.

A. arguta var. *cordifolia*

Not yet widely tested in the Pacific Northwest. Fruit are reputed to be of good flavor and very sweet. Plants are very vigorous and produce high yields. Flowers may be wind pollinated.

Ken's Red

Not widely tested in the Pacific Northwest, this kiwifruit from New Zealand is a cross of *A. arguta* var. *cordifolia* and *A. melanandra*. Fruit are nearly square to cylindrical with a "nib" at the tip. They are bright green in summer and turn red-skinned late in the season. Vines are very vigorous.

Geneva

This cultivar has not been widely tested in the Pacific Northwest, although there are preliminary results from British Columbia. Plants ripen earlier than Issai and Ananasnaya and are about the same size. Fruit have a good flavor.

Issai (self-fertile)

This cultivar from Japan is less vigorous than the other hardy kiwifruit cultivars listed above. Fruit are smaller in size, somewhat cylindrical, come to a point, and are fully green. Flavor and aroma are very good. Harvesting is somewhat more difficult than the other hardy kiwi, because fruit are smaller and ripen rather unevenly within a cluster. This cultivar, although self-fertile, produces larger fruit with seeds when cross pollinated. Vines are slightly less hardy than other *A. arguta* at 0 to -10°F (-18 to -23°C).

Harvest date: September 1–4

Fruit weight: 4–9 grams

Vine growth: moderate vigor with lower yield per vine than the other hardy kiwi.

Male

Pollinator for above *A. arguta* species. About 1 male is needed for every 8 females. There is evidence that *A. arguta* cultivars can be pollinated by *A. deliciosa* males, which produce more pollen than the arguta males. However, *A. deliciosa* males are much less hardy than *A. arguta* males; thus you risk crop loss to cold injury when using the fuzzy males.

Other cultivars/selections that may be available include Dumbarton Oaks, 74-45, 74-8, and Michigan (reported to have almost twice the fruit size of Ananasnaya). However, these have not been tested in Oregon.

Kolomikta Kiwi

These kiwi types, *A. kolomikta*, are hardy to -40°F (-40°C), but shoots are sensitive to frost damage. In the Willamette Valley, Oregon, *A. kolomikta* cultivars have been found to break bud earlier than arguta types in late winter. For example, all shoots were killed by cold in February 1995. Available cultivars differ greatly in fruit shape, size, color, and flavor. Fruit of kolomikta are smaller than those of arguta kiwivines. Plants are considered good ornamentals because of their variegated pink leaves, particularly in the male.

The fruit are small to medium sized, but are very sweet, with good aroma and flavor. Fruit are valued for their exceptionally high vitamin C content—700 to 1,000 mg/100 grams fruit (10 times higher than Hayward and 20 times higher than citrus).

Fruit are best when ripened on the vine to maximize aroma and flavor development; however, shelf life then is shortened.

It has been difficult to establish *A. kolomikta* at NWREC. Vines planted in 1990, even after 4 years, grew little and produced almost no yield. Thus, it is hard to evaluate their performance relative to the hardy kiwi.

Perhaps this species is more sensitive to wet soil or phytophthora root rot—a possible reason for its poor growth at NWREC. There also are reports that *A. kolomikta* requires some shade for optimal growth. This species also has not performed well in trials in British Columbia.

Nevertheless, the following cultivars may perform well at other sites and certainly would make good ornamental fruit plants in the home garden. This species does not have the commercial potential of *A. arguta*.

Krupnopladnaya

This cultivar, "large fruit" in Russian, is the largest of the arctic beauties tested in Oregon. Flavor is good and sweet. Plants have low to moderate vigor compared to *A. deliciosa*.

Pautske

This is the most vigorous of the arctic beauties tested in Oregon. Fruit are large and of good quality. Plants are more vigorous than those of Krupnopladnaya, but still have lower vigor than *A. deliciosa*.

Male

A. kolomikta male needed to pollenize the above cultivars.

Silver Vine Kiwi

This species of kiwifruit, *A. polygama*, is called silver vine for the silvery-white color of the young leaves. Fruit have orange skin and flesh, and are cylindrical with a point at the base. Although several sources say fruit are edible with a sweet, peppery taste when ripe, we have not had good success with this species at NWREC. Our fruit goes from green and unripe to orange and soft with an astringent peppery flavor. Plants are moderately vigorous, but more susceptible to cold injury than arguta or kolomikta. Some clones are self-fertile.

This species does not have much potential for commercial fruit production. However, it does make a nice ornamental.

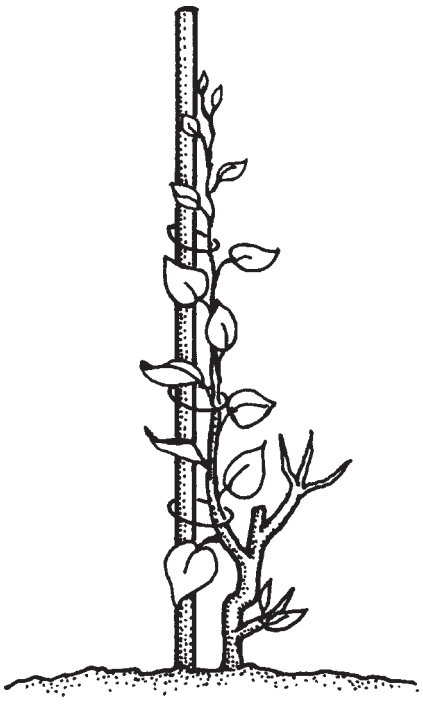
Harvest date: September 1–4

Fruit weight: 6–9 grams

Vine growth: moderate to low vigor at NWREC

Establishing Your Kiwifruit Vineyard

B. Strik



Vine growth and fruiting habit of both fuzzy and hardy kiwifruit are similar. The following information on vineyard establishment applies to all the aforementioned species unless differences are noted.

Site Selection and Preparation

Proper site selection, soil preparation, irrigation system design, planting design, and training are essential to developing a productive kiwifruit vineyard.

Site selection

The single most limiting factor for fuzzy kiwifruit production is temperature. *A. deliciosa* Hayward can withstand temperatures as low as 10°F (-12°C). Although the buds of Hayward have a high chilling requirement (700 to 800 hours), the vines are very prone to frost injury during the growing season. Cold injury to Hayward has occurred in some winters in the Pacific Northwest.

Dormant *A. arguta* vines are much more cold hardy than the fuzzy types (to -10 to -25°F or -23 to -32°C). However, young vines of this species also can suffer winter injury, particularly to the trunk, if temperatures fluctuate from warm to cold in late winter. *A. arguta* vines also are sensitive to spring frost damage to young shoots.

Male vines are less hardy than female vines (documented in Oregon).

There are several ways to help prevent freeze and frost injury:

- Do not plant in low areas or cool sites.
- Remove barriers (e.g., trees) to cold air drainage.
- Keep in mind that clean, cultivated sites are warmer during frost periods than sites with permanent cover crops.
- Do not cultivate immediately prior to a projected frost, because this reduces heat transfer from soil to air at night.
- Use overhead irrigation systems in areas susceptible to late spring frosts (see “Irrigation”).

Chemicals that reduce vine transpiration (i.e., anti-desiccants) have not been shown to reduce frost injury in kiwifruit.

Soil

Kiwi vines do best in deep, well-drained soils. They are very sensitive to standing water, especially after bud break in spring. Research in New Zealand

has shown that if roots are waterlogged for 3 days or more, the root system and vine growth are severely damaged.

In California, it is recommended that kiwifruit be planted on 3 feet of well-drained soil. However, Hayward vines have grown well on soils with an effective rooting depth of 2 feet, provided the water table is lower than this.

Another option is to plant vines on raised beds (at least 1 foot high). This is advisable in heavy soils, since it also may protect against phytophthora root rots.

Install well-designed drain tiles to improve drainage if necessary. Ripping the soil below the row before planting also can benefit growth.

The optimum pH for Hayward is between 5.5 and 6.0. Vines show poor growth at a pH above 7.2. It is not known if other species differ in pH requirements.

Previous cropping history

Kiwifruit are susceptible to verticillium wilt. Avoid planting in soils with a history of strawberry, black raspberry, potatoes, or other solanaceous crops.

Plants also are sensitive to phytophthora and root knot nematodes (*Meloidogyne* spp.). Although the literature relates to Hayward, it's best to assume that arguta is similarly sensitive. Kiwifruit also are susceptible to *Armillaria* oak root fungus, which may be present on sites previously planted to oak trees.

A preplant soil test for nematodes is recommended. If nematodes or oak root fungus are present, use a preplant fumigation.

Table 1.—Irrigation water guidelines.

chloride	< 70 ppm
bicarbonate	< 200 ppm
boron	< 0.25 ppm
sodium	< 50 ppm
electrical conductivity, EC x 10	< 0.75

Young kiwifruit vines compete poorly with weeds, so eliminate as many perennial weeds as possible before planting. A permanent cover crop or a natural weed strip may be maintained between rows.

Water

A plentiful supply of good quality water is required for kiwifruit production. Plants need 40–48 acre-inches of water a year. Table 1 shows irrigation guidelines that are considered safe in California.

Wind damage

Long shoots in spring and summer are very susceptible to wind damage or breakage. Not only can wind cause fruit loss, but it also may reduce economic yields by rubbing the fruit. When rubbed, fuzzy kiwi first lose their "fuzz" and then develop callus, whereas the hardy types develop a callused or scabbed area.

In windy areas, wind breaks such as poplars help reduce economic losses. Plant wind breaks to provide 200 to 250 feet of protection downwind. Make sure wind breaks are not planted close enough to the vineyard rows to reduce yield of the kiwifruit.

Vineyard Planning, Planting, and Spacing

It costs from $8,000 to $12,000 per acre, not including land cost, to establish a kiwifruit vineyard and bring it to production. It takes 3 or more years after planting to produce a commercial crop.

Planting design

For a T-bar trellis, vines commonly are planted 15 to 18 feet apart in rows 15 feet apart, resulting in 160 to 190 plants per acre. For the pergola, you may want to space rows 20 feet apart (see "Trellis").

Kiwifruit vines are extremely vigorous. Canes grow 6 to 12 feet per year, and occasionally 20 feet. Higher density plantings may increase production in the early years, but in later years, overgrowth and shading will require excessive summer pruning.

The kiwifruit is a dioecious plant—it has separate male and female plants (with the exception of a few self-fertile cultivars). Male vines are essential for pollination and crop production.

In general, plant the same species of male as the female vines. Although *A. deliciosa* males are reported to be good pollinators of *A. arguta* females, they are

much less cold hardy than arguta males, and thus increase the risk of crop loss to cold damage.

Male and female vines must be present in a block and must flower at the same time. In general, plant about 1 male plant for every 6 to 10 female plants.

You can achieve a 1:8 male-female ratio with the following design:

- Plant only female plants in all outside rows.
- Plant the following row with a male plant between every two female plants.
- Plant the next 2 rows of all female plants.
- Plant another row with a male plant between every two females.
- Plant 2 more rows of all female plants.
- Continue as above.

If you plant a male every third vine in every second row, the ratio is 1:6.

Male plants in these planting systems run at right angles to the rows. For T-bar systems, you may want to place males in every row, as there is some evidence that bees prefer to work down rows rather than across.

Planting

Self-rooted vines perform better in the Northwest's cold winters. Although grafted kiwifruit are available from many nurseries, planting kiwifruit on their own roots in areas where cold injury may occur is recommended. Severe cold spells can kill a grafted vine past the graft union, thus killing the vine. On cold-injured, self-rooted vines, suckers can be trained up from below the winter-killed portion.

Using rootstocks in kiwifruit production could offer many advantages:

- Reduced plant-to-plant variability
- Vigor reduction
- Greater tolerance for adverse soil conditions such as water-logging
- Greater physiological cold tolerance
- Resistance to pests or diseases
- More precocious and higher-yielding vines

However, research needs to be done on rootstock possibilities in kiwifruit.

Plant 2-year-old bare-root or container stock. If grafted, the scion (fruiting portion) should have been grown for one season before purchase.

Purchase bare-root nursery stock as close to planting time as possible. Don't allow the roots to dry out. Plant as early in the spring as possible. Container-grown plants can be planted at any time except midsummer.

It's a good idea to plant on raised beds to reduce risk of phytophthora. Carefully mark your field prior to planting. Planting all males first and then filling in with females is recommended.

Install your irrigation system before planting (see "Irrigation"). Establish your trellis prior to, or just after, planting (see "Trellis"). Place the row posts between plants so that if post repair is needed, the vine trunk is not in the way.

Make the planting hole large enough to accommodate the roots without bending them. You may trim the roots a little to make them fit the hole. Do not dig the hole deeper than needed. Do not add any fertilizers, including manures, to the planting hole, as the roots are very sensitive to fertilizer burn.

Plant vines deeply enough just to cover the top roots. Never mound soil around the plant. Keep the soil moist enough to promote root growth, but don't over-water, which can cause anaerobic conditions that promote root rots.

You can paint the trunks with a mixture of 1:1 water and interior white latex to help prevent sunburn. Milk cartons also can protect against sunburn and rodent feeding. Place a trunk wrap around all species of kiwifruit vines. This helps reduce the risk of cold injury to the susceptible young vines.

Irrigation

Good irrigation is critical for good growth and production. Irrigate young plants enough to wet the root zone without keeping the crown too wet; otherwise, crown or root rot may occur. In young plants, the range between too wet and too dry is narrow.

Unfortunately, there is relatively little direct experience on water requirements of hardy kiwifruit in the Pacific Northwest. The following information relates

to Hayward production, but should be a good starting point for other cultivars as well.

Growers often irrigate by experience rather than irrigation scheduling tools. In kiwifruit, however, observing vines for trouble signs doesn't work well, because by the time water stress symptoms are visible, damage has occurred.

Vines under mild or moderate water stress have a subtle off-color look, with the foliage turning blue-green. Other symptoms include poor shoot growth, wilting, small fruit, sunburn, and reduced yield in the current and following season.

There are various types of irrigation systems. Unfortunately, there is no single best system. Design a system that can supply an average of 25 to 35 gallons of water per mature vine per day during the growing season. Irrigate vines once or twice per week. Surface mulch may help conserve soil moisture.

Drip systems

Drip systems economize on water use, but on lighter soils often supply water to only a narrow cone of soil. Frequent irrigations are necessary, particularly to young plants with small root systems. However, as the crown tends to stay drier, risk of crown rot (phytophthora) may be reduced. You can't use drip systems for frost protection.

Drip irrigation systems commonly are used in California in young plantings. At planting, one emitter is placed near each plant. The second year, two emitters are placed 12–18 inches from the trunk, and the one near the trunk is removed (to keep the trunk relatively dry). When the plant is 4 years old, two more emitters are added 3 feet away from the trunk.

When plants are mature, California growers find it difficult to supply enough water with four emitters per vine, so they add more emitters or switch to minisprinklers. For larger vines, up to 10 emitters per vine may be necessary.

Minisprinkler systems

Under-vine minisprinkler systems, which produce a wetted area of greater size, often are preferred. In general, they wet more soil than drip emitters do, are easy to install, and tend to plug less frequently than drip emitters. They can be used to replace drip systems as vineyards age. In young vineyards, however, minisprinklers tend to over-irrigate.

These sprinklers spray water in a 6- to 18-foot diameter circle. One full-turn minisprinkler per vine, located equidistant between vines, should be adequate in mature plantings. Generally, they are allowed to run 6, 8, or 12 hours, two to four times per week.

Impact sprinklers

Impact sprinklers also are used in kiwifruit vineyards, especially in more mature plantings. They can be placed over or under the canopy.

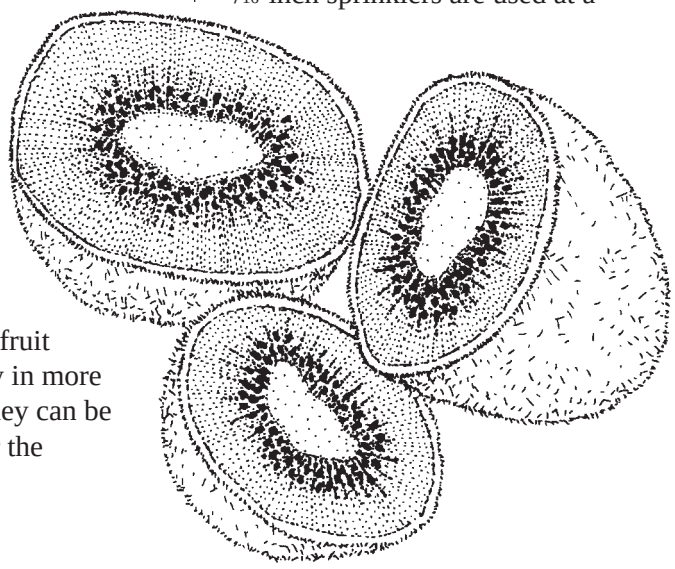
Overhead sprinklers are best for frost protection, but may spot or discolor the fruit when used in summer. They also may leach nutrients from the leaves and increase incidence of fungus diseases.

Some California growers use a T assembly on the sprinkler riser to switch from over-vine sprinklers to under-vine sprinklers. They use the over-vine positions for frost protection (shoots in the spring, fruit in the fall) and switch to the under-vine position in summer. (Note that only fuzzy kiwifruit are sensitive to fall frosts, because hardy kiwifruit mature earlier.)

Impact systems work well if the canopies aren't in the way, but they tend to use more water. Under-vine sprinklers should be between vines in order to reduce impact on the trunk.

Frost protection

Over-canopy sprinklers can provide 6 to 8°F frost protection, whereas under-vine impact sprinklers can provide about 2 to 3°F protection. In California, $^{5}/_{16}$-inch sprinklers are used at a



spacing of 30 x 40 feet (at 50 lb/inch pressure) to supply 0.1 inch/hour (50 gallons/acre/minute). Start sprinkler irrigation before temperatures fall below the critical level and continue until temperatures are above critical levels.

Fertilization

It is relatively easy to burn the roots of kiwivines, so apply fertilizer cautiously. The following recommendations are based on Hayward in California and New Zealand.

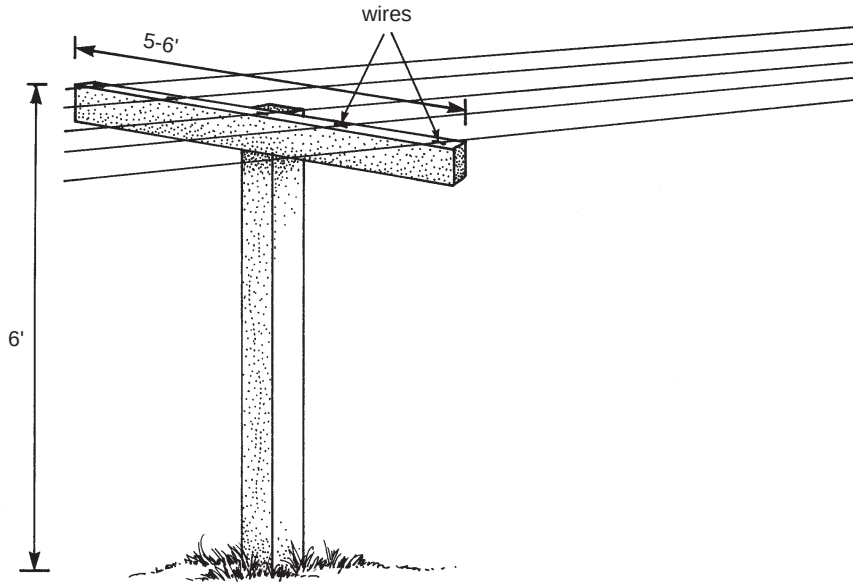


Figure 1-A.—Standard T-bar trellis system for kiwifruit.

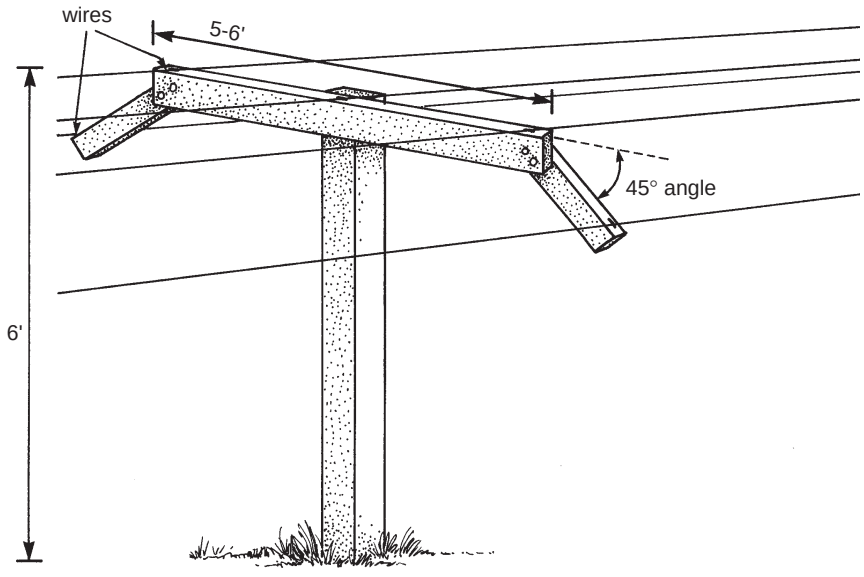


Figure 1-B.—Winged T-bar trellis system for kiwifruit.

Fertilize young kiwifruit vines monthly with small amounts of nitrogen. Ammonium nitrate and urea are good sources of nitrogen for kiwifruit.

In the first year, apply no more than 0.4 oz of actual N per plant per month in May, June, and July (total of 12 lb actual N/acre based on 160 plants per acre). Spread the nitrogen in a circle 6 to 12 inches from the base of the trunk.

In the year after planting, apply 0.8 oz of N per plant per month in April, May, June, and July (32 lb N/acre total). Spread the fertilizer in a ring about 12 to 36 inches from the trunk.

Fertilize third- and fourth-year plants with 2 to 3 oz of actual N every other month from March through July (60 to 90 lb N/acre).

You may liquid feed nitrogen to young plants on a 2-week to monthly interval instead of using granular fertilizer.

Do not fertilize young plants with liquid or granular forms of nitrogen later than July. Late fertilization forces late vegetative growth that is very sensitive to cold injury. Once plants bear fruit, the crop load tends to suppress late vegetative growth and reduce risk of fall frost damage.

Other nutrients may be added in spring either foliarly or to the soil surface. Base applications on nutrient needs/analysis. Kiwifruit vines tend to take up a considerable amount of phosphorus (P) and potassium (K). Test soil for P and K prior to planting, and incorporate nutrients preplant if necessary. Do not use fertilizer containing potassium chloride, as kiwivines are very sensitive to chloride.

Trellis

Kiwifruit vines are not self-supporting; their size, vigor, longevity, and heavy crop load mean they need a strong, permanent support structure.

Two main types of support structures or trellises are used in commercial kiwifruit production: the T-bar and the pergola.
A pergola provides a single plane of canopy about 6 feet above the ground. The T-bar trellis system consists of posts in rows with a cross arm at 6 feet high.

T-bars are less expensive to construct, less labor intensive, better suited to bee pollination, and they reduce the risk of botrytis infection. However, pergola systems tend to produce more yield per acre, and the fruit are less susceptible to wind damage. Also, once the full canopy is established in a pergola, the shade reduces weed growth.

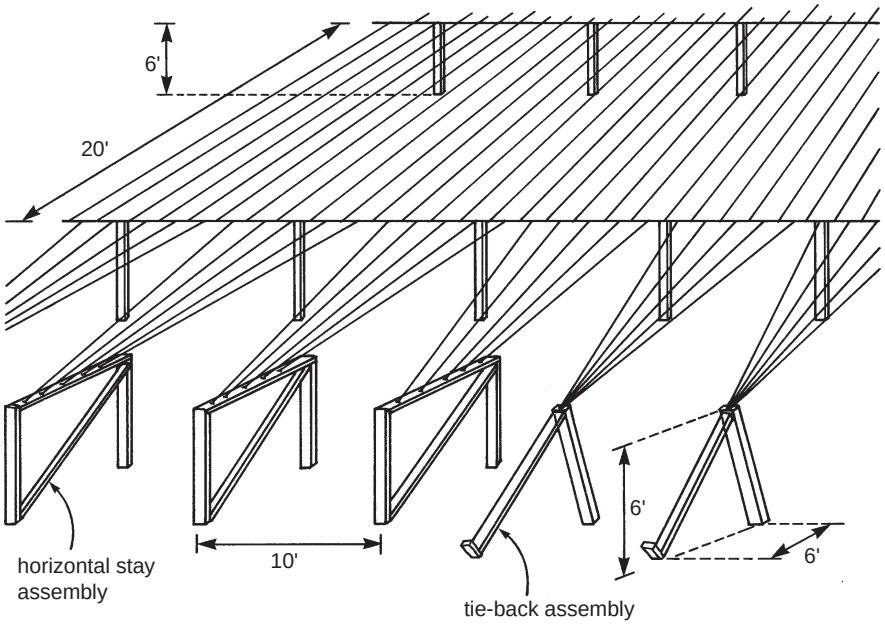


Figure 2.—Pergola trellis system for kiwifruit.

T-bar

A typical T-bar trellis consists of posts with a 5- to 6-foot (depending on row width) long cross arm extending across each post (Figure 1-A). The kiwivine fruiting canes are tied to wires on top of the cross arm.

Use pressure-treated 4–6 inch diameter posts that are 8–9 feet long spaced at 15–20 feet down the row. Square posts are easier to work with. Drive posts 2 to 3 feet into the ground. Use end posts that are at least 6 inches in diameter, and drive them at an angle with the top of the post leaning 1 foot from perpendicular away from the row. Anchor the end posts well.

The top of the cross arm is 6 feet above the ground. Cross arms usually are a 2 x 6 inch board bolted into a cut notch on the post. You can brace cross arms back to the post for added strength.

Run a wire down the row from the top middle and each side of the crossarms (Figure 1-A). Two additional wires can be added, one between the center and each end wire. Use galvanized, high-tensile, 12-gauge wire for the vine supports. Good wire tighteners are needed to keep a strong tension on the wires to support the vines and crop.

A common modification of the T-bar is the winged T-bar, in which an additional wing and wire are added to each side of the T-bar cross arm (Figure 1-B). Tying down a cane from the center wire onto the two wires pulls it into a more natural curve.

Pergola

A pergola trellis is designed to support a solid canopy of foliage and fruit (Figure 2). Wires not only extend down the row, but also are used as “cross arms” (more commonly than using wood) running perpendicular to the vine rows. The wires are placed 1 to 3 feet apart.

Training Young Vines

Proper pruning during the establishment years is necessary to establish a well-formed permanent framework for the vine. Developing or training young kiwifruit vines into a bilateral cordon allows for easier management when the plants are mature. Kiwifruit produce a crop on shoots (fruiting laterals) that grow from 1-year-old canes (last year's growth). In the first few years, you train vines the same way for both the pergola and the T-bar system.

Prune dormant kiwivines in late December to mid-February in the Pacific Northwest. Later pruning may cause excessive sap flow.

First growing season

The main objective during the planting year is to develop a single, straight trunk. At planting, prune plants back to one or two buds (above the graft union in grafted plants) (Figure 3-A).

Once shoots start to grow, select one vigorous shoot to train upward as the trunk. Place a stake beside the shoot to facilitate training. String from the wire to the stake can add support as well. Tie the shoot to the stake (not too tightly or you'll girdle the shoot) at frequent intervals to help prevent breakage.

Do not allow the shoot to wrap around the stake. Concentrate growth into this shoot by removing suckers at the base of the vine (Figure 3-B).

Remove all basal lateral shoots that break along the trunk. If the main shoot loses vigor and begins to twist slightly, top the shoot and train up the strong new "leader" (Figure 3-C). Continue to train the trunk until it's 2 to 3 inches above the wire (Figure 3-D).

If the shoot reaches the wire early in the season, you may try to form the cordons in the first year. To do so, top the shoot to about 4 inches below the training wire to encourage lateral branch formation. This forms a nice "Y" for the cordons. Select two shoots, growing in opposite directions, and train them along the center wire to form the two main arms, called cordons (Figure 3-E).

Another option is to train the trunk up one way along the wire and wait until the next season to train a shoot the other way. This results in cordons of unequal age, which may make management more difficult.

During the first dormant season, head back the cordon(s) to wood of 1/4 inch in diameter or larger (Figure 3-E). If vines did not have adequate growth to form cordons the first season, head the trunk back about 2 inches below the trellis wire to force new buds early the next season.

Second season

The objective in this season is to develop two permanent cordons from two strong shoots growing in opposite directions from the trunk along the center wire. As each cordon grows, hang it over the wire and wrap it every 18 to 24 inches to ensure that it's securely attached to the wire.

Retain lateral branches that are produced along the cordons at about 8- to 12-inch intervals (Figure 3-F). Carefully tie these canes to the outer trellis wires. Remove all others by summer pruning before they twist around the shoots you want to keep.

In the dormant season, prune the main cordons and the retained lateral canes back to wood 1/4 inch in diameter or larger (Figure 3-F). The first crop will form on shoots from these canes in the third year. Pruning the canes during the dormant season encourages fruiting the following year. Remove any suckers and new growth on the trunk (Figure 4).

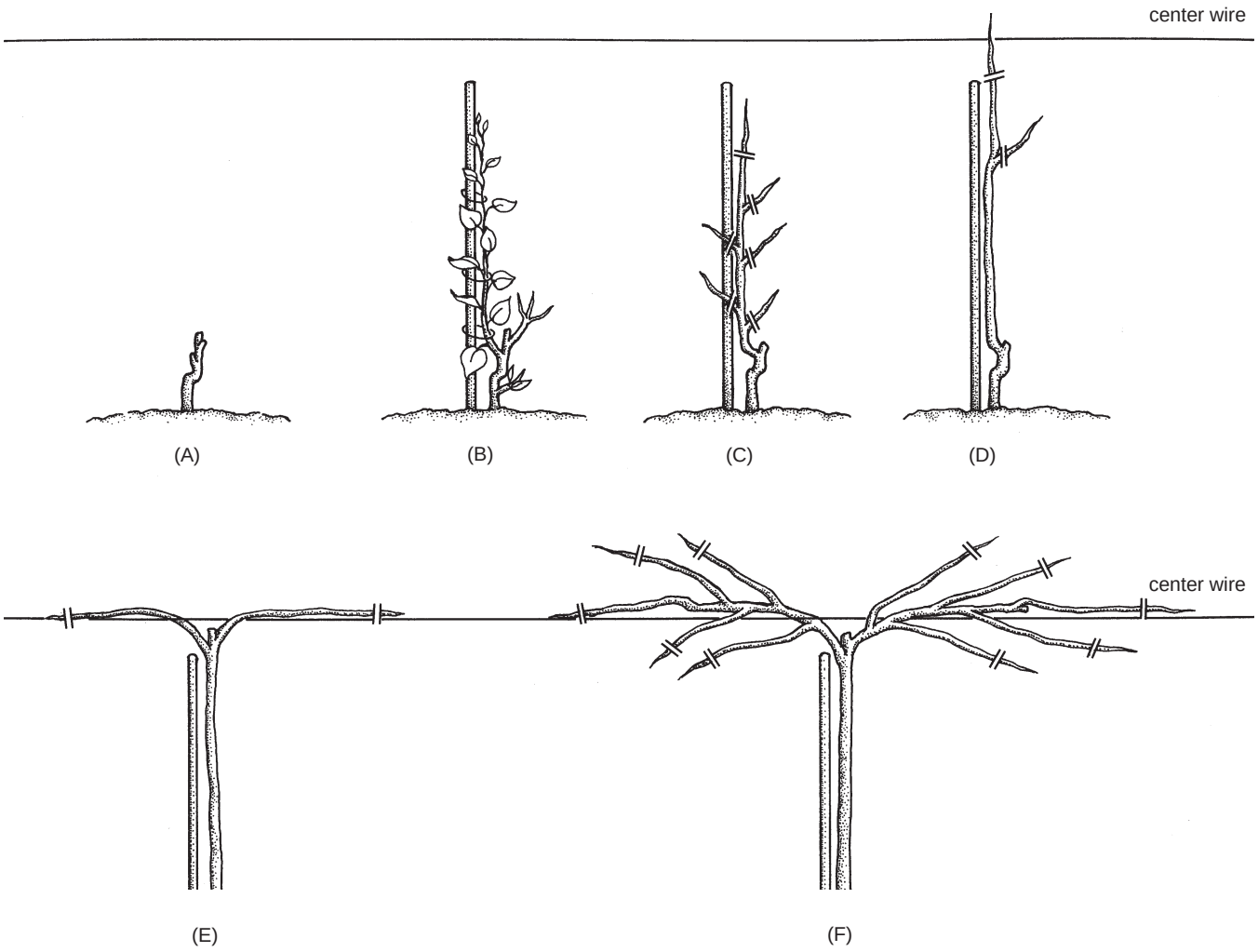


Figure 3.—Training a young kiwifruit vine.
(A) Prune to two buds at planting.
(B) Train one shoot as trunk, remove all others (Year 1).
(C) Head back "trunk" as shoot growth at terminal loses vigor.
(D) Continue to remove lateral shoots; let "trunk" grow beyond wire. Then head to just below wire.
(E) Choose two shoots to form cordon, one each way on wire. Head back to ¼-inch diameter in dormant season (Year 1).
(F) Shows shoot growth Year 2. Pruning cuts in dormant season Year 2 are shown.

Third season

Continue to extend the cordons, if necessary, by training the strongest shoots down the center wire until they're within about 1 foot of the cordon of adjacent vines. Do not allow them to twist tightly around the wire, because this may restrict sap flow later.

Continue to train lateral branches perpendicular to the cordons (Figure 4). Do not train shoots along the outer wires parallel to the cordon; they will cause too much competition for light.

In the third year, concentrate on developing the vine's framework. Fruit will form on shoots produced on last year's growth (Figure 4). Fruit in the third year may sunburn due to inadequate canopy cover. Do not overcrop the vine. It may be a good idea to remove some of the fruit to divert more energy into vegetative growth.

In the third dormant period, prune so that 15 to 20 well-spaced lateral canes remain on the vine, depending on vigor. Remove any suckers or side growth on the trunk.

The permanent vine structure should be established by the fourth year. Future pruning will renew fruiting canes and maintain the vine framework and crop load. See "Maintaining Your Kiwifruit Vineyard" for diagrams/descriptions of pruning producing vines.

Training of vines to a T-bar and pergola system is similar. In a pergola, the vines are grown as straight, single trunks until they reach the top of the structure. A single strong permanent leader (cordon) then is allowed to grow in each direction along the main wire.

To form the canopy of a pergola, develop a system of fruiting canes from the cordons at right angles to the wires. Fruiting canes can be retained longer on pergolas and may be more permanent than on T-bars. Fruiting laterals or shoots develop on the fruiting canes. It takes up to 7 years to develop a full canopy in a pergola.

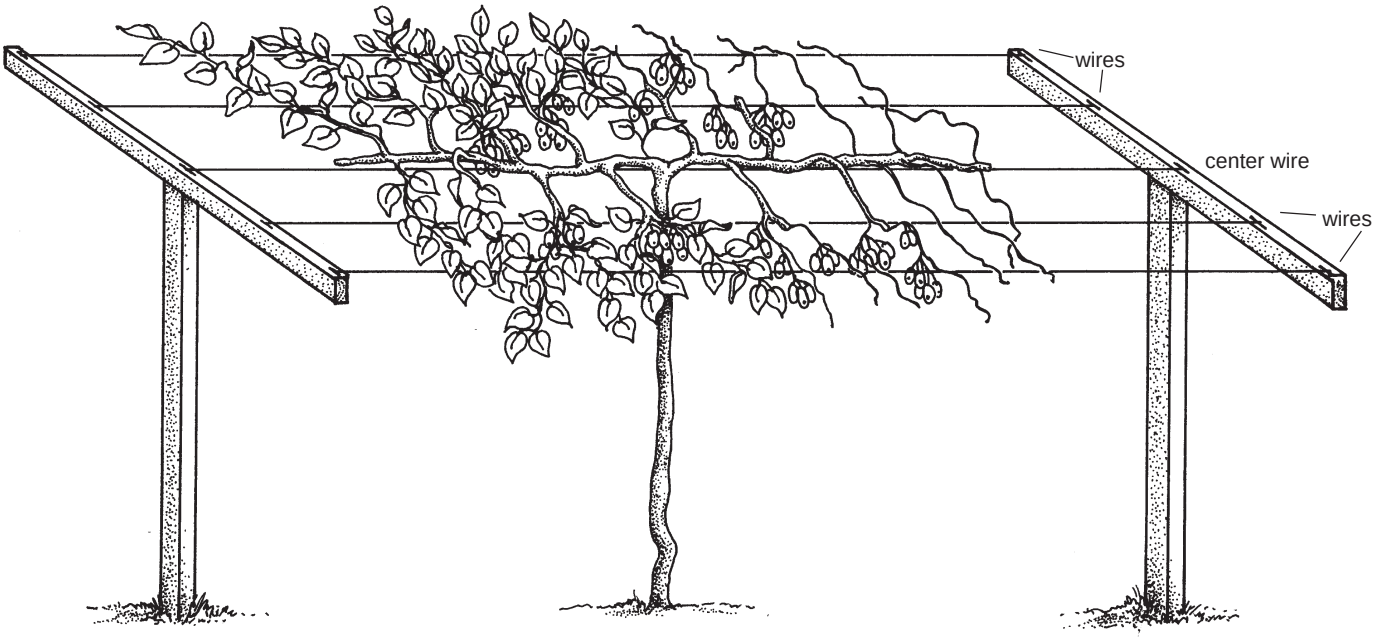
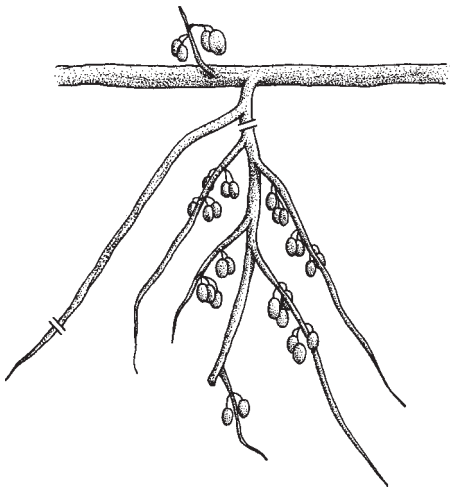


Figure 4.—Kiwifruit vine in third growing season during fruiting. Leaves not shown on right to simplify drawing.

Maintaining Your Kiwifruit Vineyard

B. Strik



It is essential to maintain your kiwifruit vineyard well for optimum growth and productivity. Pruning probably is the most challenging aspect of vineyard maintenance.

Most of the research and experience on kiwifruit production is with *Actinidia deliciosa*, particularly Hayward. Unfortunately, there is relatively little direct experience with hardy kiwifruit production. The following information should, however, provide a good starting point for production of hardy kiwifruit as well as the fuzzy types.

Fertilization

It is relatively easy to burn the roots of kiwivines, so apply fertilizer cautiously. When applying granular N, be sure to broadcast it over the entire root zone area; concentrating it near the trunk can burn roots. Leaf necrosis is a symptom of fertilizer root burn.

Mature vines, of 5 to 7 years and older, use about 1 lb of actual nitrogen (N) per vine per year, or about 190 lb N/acre/year (with 15 x 15 foot rows).

Apply about two-thirds of the nitrogen in March at bud break as a broadcast application under the canopy. This provides the nitrogen needed for early season growth and fruit set in May–June. A second application of granular N, the remaining one-third, is recommended in May–June.

Plants should have good soil moisture when they are fertilized. Irrigate first, wait 1 to 2 days, then fertilize; or fertilize after a good rainfall.

You can substitute liquid fertilizer applied through the irrigation system for dry fertilizer. When applying liquid fertilizers containing N, use about 10 lb of actual N in each application from April through July. Higher rates of liquid N, 20 lb per application, have injured roots on lighter soils.

Base fertilization with other nutrients on tissue and soil analysis. Critical levels for leaf samples taken in late August in California and for New Zealand are given in Table 2 (recommendations from both areas are combined). It is not known if species differ in nutrient needs or if critical levels vary by region. However, these values can be used as a guide.

Based on experience in New Zealand and California, growers typically apply the following as a maintenance application:
55 lb/acre phosphorus in February–March; and 80–130 lb/acre potassium split between February–March, April, and May.

Maintain soil pH at about 6.0 with lime application in the fall.

Kiwifruit seem to be sensitive to chlorine, so avoid any fertilizers with chloride.

Irrigation

The water a vine loses through transpiration must be replaced by irrigation or rainfall. On a warm summer day in California, mature, full-canopy kiwifruit vines can transpire 7,000 to 8,000 gallons of water per acre per day. Transpiration occurs when leaves use carbon dioxide to produce carbohydrates through photosynthesis.

Irrigation is necessary to keep vines growing and productive and to maximize fruit size. Water stress can reduce fruit size, limit flower numbers (through reducing flower bud initiation), and cause premature fruit drop. Summer drought can cause leaf drop and premature fruit ripening in arguta; however, fruit ripen more unevenly and are of poorer flavor. Severe drought also may cause fall flowering, which reduces the following year's production. Maturity of wood also seems to be delayed by drought, thus increasing risk of cold injury. However, too much water also may cause production problems.

Judging vine water needs is difficult. At this time, it's not known whether irrigation requirements in the Pacific Northwest differ from those in other regions. Based on information from British Columbia, Canada, vine water use ranges from 25 to 35 gallons/vine/day (at 70 to 80°F).

Irrigation for frost protection also is necessary to protect young shoots in spring and potentially fruit in fall. See "Establishing Your Kiwifruit Vineyard" for more information.

Pollination

For fruit to be produced, male and female vines must be present in a block and must flower at the same time. Male flowers produce viable pollen for only the first 2 to 3 days after opening. However, female flowers are receptive to pollen for 7 to 9 days after opening, even when the petals have started falling.

Pollination is extremely important in kiwifruit production. Large fruit contain 1,000 to 1,400 seeds (research on Hayward). If pollination is poor, fruit will have indentations (narrow valleys) on one side or be non-uniform in shape. If you cut through these fruit, you'll find no seeds in these areas.

Kiwifruit flowers are pollinated mainly by insects, although wind may play a minor role. Honey bees are the main pollinator used in kiwifruit vineyards.

Kiwifruit flowers do not produce nectar and are relatively unattractive to bees. About three to four hives per acre are needed to adequately pollinate kiwifruit. Place these in the vineyard no sooner than 10 percent bloom of the *female* vines.

In some years, you may have no male vines in flower as a result of winter injury to male plants (they are less hardy than the females). In this case, no naturally produced pollen will be available. To get a crop, the females will have to be pollinated artificially. Call your county Extension agent for more information on sources of pollen and methods of artificial pollination.

Fruit Thinning

Fruit thinning, or removing fruit after set, can be done to remove misshapen fruit that are unmarketable and to increase the size of the remaining fruit. However, it is doubtful whether thinning is economical in kiwifruit. Usually, proper dormant season pruning balances the crop load. Also, there's evidence that in Hayward the yield loss due to fruit thinning is not compensated for by increased size of remaining fruit.

Table 2.—Kiwifruit leaf sufficiency levels for nutrients.

Nutrient	% dry weight	Nutrient	ppm
Calcium	2.0–4.0	Boron	25–200
Magnesium	0.20–0.80	Copper	5–15
Nitrogen	2.0–2.8	Iron	60–200
Phosphorus	0.13–0.30	Manganese	50–200
Potassium	1.5–2.5	Zinc	15–30
Sulfur	0.15–0.45		

Pruning and Training

Proper pruning is necessary for several reasons:

- To establish and maintain a well-formed permanent framework for the vine
- To obtain a balance between vegetative growth and fruit production
- To develop a canopy that uses available light efficiently (for photosynthesis), yet is open enough to obtain maximum fruit quality and flower bud formation for next year's crop. An open canopy also facilitates harvest and reduces risk of fungal diseases such as botrytis.

All species of kiwifruit can be pruned in a similar manner. However, there are many different ways to prune a kiwivine. The following description covers the basic techniques. Grower experience may lead to modifications.

Dormant pruning

Dormant pruning of kiwivines is best done in late December to mid-February in the Pacific Northwest. Late-pruned vines may have excessive sap flow.

In kiwifruit, flowers are produced on current season shoots that grow from buds developed on 1-year-old canes (last year's growth). Shoots that grow from older wood seldom produce fruit in their first season. Shoots from buds that were heavily shaded during the preceding season will be less productive than those from buds that were exposed to the sun.

Ideal 1-year-old canes have short internodes with well-formed buds, and stop growing early in the season. These canes develop early in the growing season. Fruiting laterals are current season's shoots that have fruit on the basal nodes (4 to 6 buds); all the buds beyond the fruit are capable of producing flower buds for next year's crop.

Male and female plants should be pruned differently when mature.

Female vines. When pruning a mature vine, remove about 70 percent of the wood that grew last season. Most of the wood removed is older wood that already has fruited. New fruiting canes usually will have developed at the base of last year's canes. Figure 5 shows a typical fruiting cane that developed from the permanent cordon.

Replacement fruiting canes that originate from the cordon may be left to replace older wood in the future. Fruiting canes should be separated by about 8 to 12 inches on the cordon. Head back replacement fruiting canes to force growth next season, and tie them to the wires for support. Do not tie canes too tightly or they'll girdle during the growing season.

Spurs (shorter fruiting branches with short internodes) often originate from the older wood. Do not remove them unless absolutely necessary, as they are very fruitful (Figure 5).

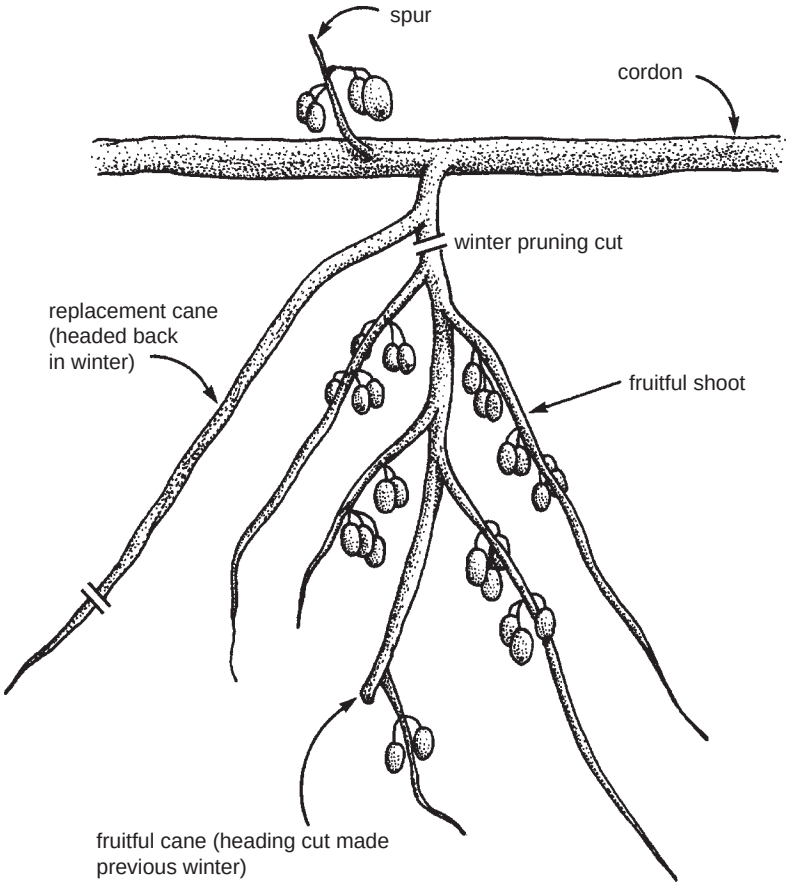


Figure 5.—Mature portion of a kiwifruit cordon in production. Leaves are not drawn to simplify the figure. Fruit are produced on shoots growing from last year's growth. Winter pruning cuts are shown by =.

Remove most of the older wood back nearly to the cordon. When necessary, you can leave some second-year canes for fruiting wood if 18–48 inches of new growth is present beyond where fruit was formed last season (Figure 6). Head back these fruiting laterals to 2 to 4 buds in fuzzy kiwifruit and to 8 to 12 buds in hardy kiwifruit beyond where fruit was formed last year.

Take care that 1-, 2-, and sometimes 3-year-old fruiting canes are evenly distributed on the trellis to avoid overcrowding in any area of the canopy.

Remove twisted and tangled growth, shoots that cross from one side of the vine to the other, and wind- or winter-damaged shoots. Mature vines, spaced at 15 feet in the row, should have 30 to 45 fruiting canes per vine (spaced at 8 to 12 inches on both sides).

Male vines. The goal when pruning male vines is to produce as many flowers for pollination as possible, while keeping the vine manageable. One popular way to prune male vines is to cut most of the canes back to 6 to 12 inches as soon as flowering is finished. New growth during the summer will be sufficient to produce flowers for next year. If needed, you can trim the vine during the dormant season.

Summer pruning

In New Zealand, summer pruning begins in mid-spring before flowers open. Remove shoots without flowers that originate outside of the wires (T-bar system). Cut back flowering laterals to four to six leaves beyond the last flower. Cut back watersprouts (vigorous shoots from older wood), and remove any tangles. During the summer, vegetative growth can be very vigorous. Remove shoots not wanted the following year for replacement canes and tip replacement canes to prevent tangling.

In California, more summer pruning is done on the pergola than the T-bar training system. However, take care not to excessively summer prune as fruit and sometimes canes may become sunburned.

Remove all suckers or shoots that grow from the trunk during the growing season.

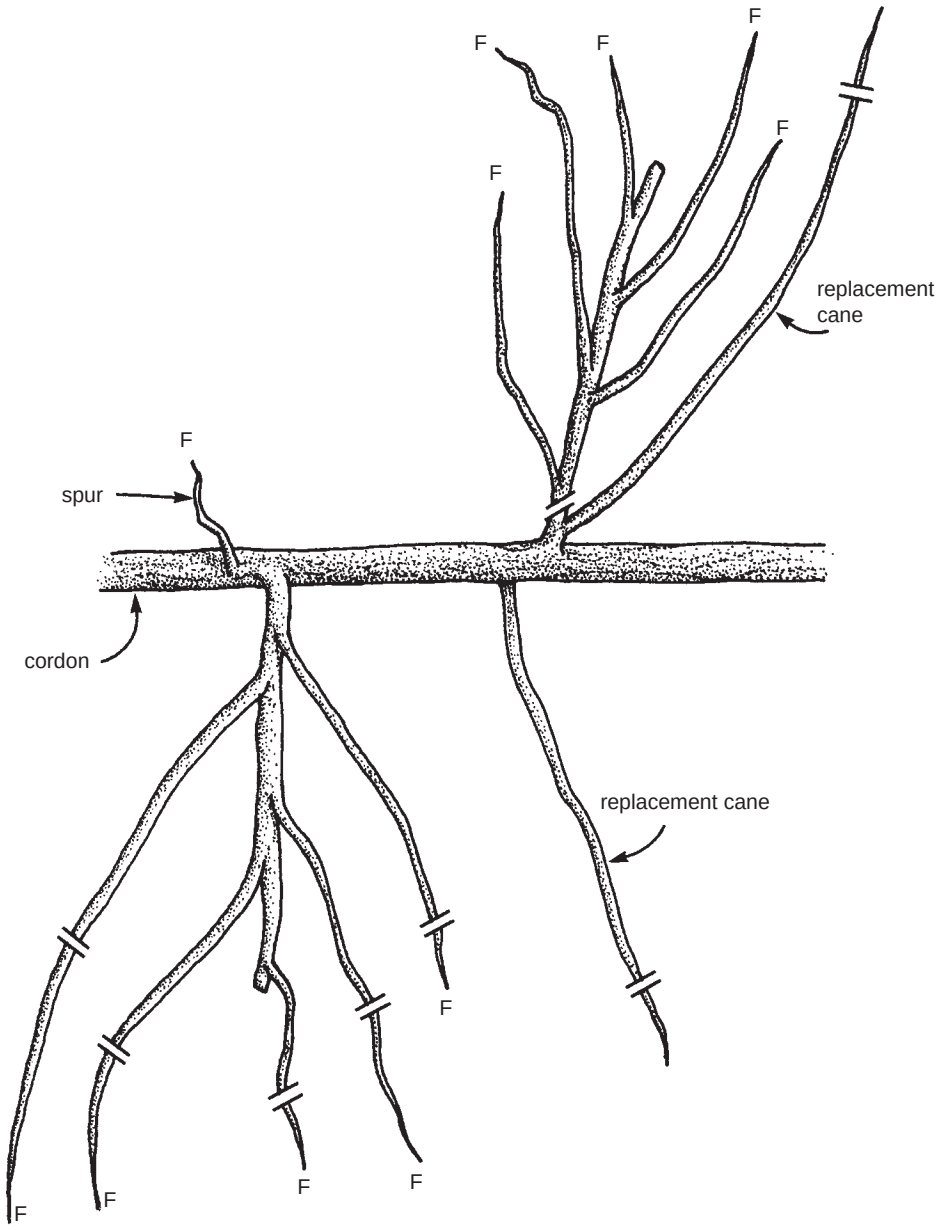


Figure 6.—Dormant portion of a mature kiwifruit vine cordon. Winter pruning cuts are shown by =. Shoots labeled with an "F" fruited last season.

Harvest, Handling, and Storage of Kiwifruit

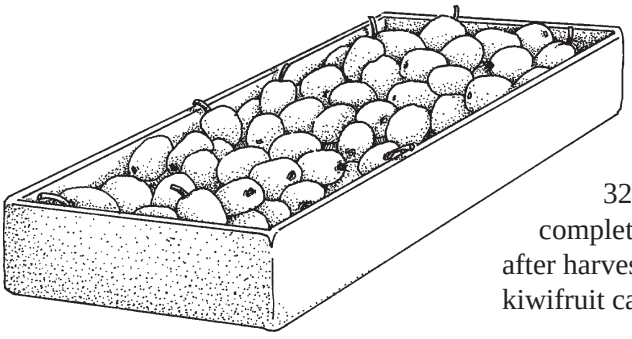
B. Strik

Most of the research on harvest, handling, and storage of kiwifruit has been done with the most common kiwifruit grown commercially, Hayward (*Actinidia deliciosa*).

Although there is a great deal of interest in growing hardy kiwifruit (*A. arguta*) commercially in the Pacific Northwest, very little information is available specific to this species. Most of the following information relates to the fuzzy kiwi, Hayward. However, where information on hardy kiwifruit is available, differences are noted.

Fruit Maturation

Kiwifruit continue to increase in fresh weight and size until harvested, but the most rapid size increase occurs the first 100 days after bloom. Kiwifruit are one of the few fruits that retain a high starch content at maturity.



Starch hydrolysis, or breakdown, continues after harvest, even at 32°F, and is essentially completed within a few weeks after harvest. Freshly harvested kiwifruit can be cleared of starch in 4 to 6 days if held at 68–77°F (20–25°C) in an ethylene environment.

A decline in starch content as fruit mature is coupled with an increase in percent soluble solids (sugars). The increase in soluble sugars that begins as kiwifruit approach maturity continues after harvest and peaks about when starch hydrolysis is complete. As fruit mature on the plant, part of the increase in sugars occurs as the plant produces more carbohydrate through photosynthesis.

With advancing maturity, the accumulation of carbohydrate slows, yet the sugar content continues to increase. At this point, the increase in sugars primarily is due to the conversion of stored carbohydrates (mainly starch) to sugars. Kiwifruit contain lots of glucose and fructose and a small amount of sucrose.

At the peak of carbohydrate accumulation, fruit have essentially achieved their best potential eating quality, and further delays in harvest will not improve flavor.

Fruit size within a vine is not related to fruit maturity. Also, most cultivars show little visual change in fruit appearance as they mature. For these reasons, it is unreasonable to attempt multiple

harvests from a vine. Hayward tends to have more uniform ripening of fruit within a vine than do the arguta cultivars (Ananasnaya, for example).

Soluble solids (sugar) content (°Brix) is the most commonly used maturity index for kiwifruit. In California, Hayward are harvested at a 6.5 percent soluble solids standard (6.5 °Brix). Fruit then will attain good quality in storage. Soluble solids content is about 12 to 18 percent when ripe.

In the arguta cultivars, fruit are at about 18 to 25 percent soluble solids when ripe. However, to increase shelf life and facilitate harvest, this species of kiwifruit is harvested between 8 and 9 °Brix when fruit are very firm.

The soluble solids content of kiwifruit can be measured with a hand-held refractometer. Cut a wedge extending from the stem to blossom end of the fruit and squeeze the juice from the fruit.

Starch in unripe kiwifruit will cloud the solution and make refractometer readings difficult. Pour the sample through a few layers of facial tissue to clear the solution. For a non-temperature-corrected refractometer, follow the directions for accurate °Brix readings carefully.

A sample of kiwifruit can be ripened fairly easily to monitor ripe fruit soluble solids content, but this takes several days. To ripen small samples, place fruit with fresh apples to provide a source of ethylene. At 77°F (25°C), ripening will take 4 to 5 days.

Harvesting

Once the minimum maturity standards have been achieved, all of the fruit can be harvested in one picking. Harvest fruit by hand. To harvest fuzzy kiwifruit, pickers should wear soft cotton gloves to prevent damage to the skin (fuzz) of the fruit. Fruit are easily damaged by rough handling even though they seem quite hard at this stage of maturity.

If arguta fruit are too vine ripe or soft, fruit will tear at the stem end. This is not a problem when harvesting at 8 to 9 °Brix and fruit are hard. Do not harvest prematurely softened fruit, as their shelf life is very poor.

Keep fruit in the shade while awaiting transport, and cool them as quickly as possible to maximize storage. Field heat must be removed quickly from fruit after harvest, because the fruit can lose water quickly. After 3 to 4 percent water loss, fruit may appear shriveled, especially at the stem end. This is less of a problem with *A. deliciosa* in the Pacific Northwest (compared to California), because fruit are harvested in October.

Softening of kiwifruit also is temperature-dependent—fruit at 41°F (5°C) soften three times faster than fruit at 32°F (0°C). Avoid exposing fruit to ethylene, a gas that promotes ripening and fruit softening.

Fruit usually are sorted for size and quality before packing. If fruit are not packed immediately, store them in large bins.

Storage

Store kiwifruit as near to 32°F (0°C) as possible at 90 to 95 percent relative humidity. Even when fruit are held at this temperature, about one-third to one-half of the remaining flesh firmness may be lost per month of storage in Hayward. Fruit are sensitive to freezing injury; be careful that the temperature of the fruit does not drop below 32°F.

For long-term storage, use of controlled atmosphere (5 percent CO_2; 2 percent O_2) has been effective in Hayward, provided temperature is kept at 32°F and ethylene-free atmospheres are maintained. Note that only battery-operated forklifts should be used in storage rooms to avoid generating ethylene. Monitor levels of ethylene in storage on a regular basis, because a week or more of 10 ppb ethylene will hasten fruit softening.

Hayward fruit can be stored 3 to 6 months under ideal storage conditions. Arguta or hardy kiwifruit, however, cannot be stored as long, because fruit are more perishable.

To optimize shelf life of arguta fruit (e.g., Ananasnaya), harvest at 8 to 9 °Brix, handle fruit carefully to avoid bruising, immediately cool fruit to 32°F, and store them at 95 percent relative humidity. Fruit should keep for up to 2 months under these conditions and can be ripened with ethylene.

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