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Kiwifruit Production In California

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Kiwifruit are produced by a large, deciduous vine botanically known as *Actinidia deliciosa.* Individual plants bear either male or female flowers, so both types of plants are planted in a vineyard at a ratio of 8 females to 1 male to ensure adequate cross-pollination and fruit set. Bees are necessary for pollination; wind pollination is unsatisfactory because it does not produce large fruit. Worldwide, Hayward is the preferred variety because of its large fruit. Male varieties are many with the California or Chico male the most common in California. Matua is another widely used male in California and New Zealand.

The vine is native to China where it is called Yang tao. The first commercial kiwifruit vineyard was planted in New Zealand about 1940 and more acreage was planted in the 1950s in the Bay of Plenty district near the city of Tauranga. Now kiwifruit are grown in many districts on the north island of New Zealand and in the Nelson area on the south island. Fruit was exported from New Zealand to the United States as early as 1958 and was featured first as Chinese gooseberries and later as kiwifruit. By 1981, New Zealand production had increased to 6.5 million trays (7.5 lbs) which were exported to the United States, Europe, and Asia. Four years later, New Zealand exports were 26 million flats; in 1987 and 1988, New Zealand exported 40 to 48 million trays. Bearing and nonbearing p1antings in New Zealand in 1986 totaled more than 50,000 acres (20,000 hectares).

The kiwifruit is a relatively new crop in California. The first plantings were made in 1967, and by 1971 at least 100 acres had been planted in California, most of it in Butte and Kern Counties. The original experimental vines were grown at the USDA Plant Introduction Station at Chico as early as 1934. The mother Hayward vine and father California male vine, still growing and producing at this original location, are the source of most California kiwifruit plants. The first significant commercial crop of 300,000 seven-pound trays of kiwifruit was packed in 1977. In 1982 and 1983, 3.2 million trays (11,000 tons) were packed in California. In 1985 and 1986,5.0-5.5 million trays (18,00019,000 tons), and during 1987 and 1988, approximately 8 million trays were packed in California. During the 1980s, about half of the packed California kiwifruit has been exported to Japan and Western Europe and the rest of it has been sold in the United States and Canada. Acreage in California in 1988 is over 8,000 acres, with 25% in early bearing stage and 75% near full bearing (over 6 years old). Grower returns in the 1970s were about $1.00 per pound of packed fruit. In 1986 and 1987, returns were 30 to 40 cents per pound of packed fruit. Costs to grow, harvest and pay interest on investment is close to 30 cents per pound at average yield of 8000 pounds of packed fruit per acre.

The fruit is about the size of a hen's egg and has a fuzzy brown skin which covers attractive, emerald green flesh filled with small, black, edible seeds. In the United States and worldwide, kiwifruit are sold primarily as fresh fruit. No processing method that uses significant quantities of fruit has so far been found to be profitable. Some fruit are processed into jam, others into juice or wine, and some have been frozen, but all processing outlets combined use only a few tons of fruits. Thus, production of large-sized, quality fresh fruit is essential for success in kiwifruit growing. For best flavor, fresh kiwifruit should be allowed to soften like avocados and Bartlett pears. Hard kiwifruit are very acid in taste and not palatable. Freshly picked kiwifruit will soften and be ready to eat in a few days if put in a plastic bag with apples or bananas and stored in a warm room (68°-70° F). Kiwifruit stored in a refrigerator for 4 or more weeks will soften without apples if taken out and left at temperatures over 60° F. The fruit is high in

vitamin C (100 mg per large fruit) and potassium (340 mg per large fruit) and contains 50-60 calories.

Kiwifruit in California can be stored for 4-6 months, sometimes longer in New Zealand. New Zealand picks fruit in May and June and sells stored fruit worldwide through December. California sells kiwifruit November through April. Thus, in major markets of the world, good fresh kiwifruit are available year-round. More consumer education and kiwifruit promotion are needed in the United States and these are provided by the California Kiwifruit Commission established in 1981 with headquarters at 1540 River Park Drive, Suite 120, Sacramento, CA 95815. The New Zealand Kiwifruit Authority does promotion on a worldwide basis. The market for fresh kiwifruit should expand as the avocado market has over the last 20 years. Per capita consumption in the United States is about 0.25 lb and in Japan and West Germany it is over 1.0 lb.

Climate and Production Areas

Acceptable climates for Hayward kiwifruit must have winter temperatures below 45°F (70° C) for 600-700 hours. A frost-free season of 225-240 days is needed for kiwifruit since vines leaf out in March, bloom in May, and are harvested in October or early November. Temperatures below 10° F (-12° C) in mid-winter will kill all young vines and some old bearing vines. Frost below 30° F (-1° C) in spring will kill shoots and ruin the crop. In mid-November, frosts below 27° F (-2.5° C) can damage trunks of young vines. Well-spaced overhead sprinklers can provide protection up to 6° F if they apply 50 gallons of water per minute (or 3,000 gallons per hour) per acre and are turned on before freezing temperatures occur. Hail in the spring can break shoots and reduce the crop severely. Cold hardy kiwifruit species *(A. arguta and A. kolomikta)* with very small fruit can be grown in cold climates like the eastern U.S. and they will tolerate about -10° F (-24° C).

Kiwifruit vines need frequent irrigation or rainfall to grow well so they can be grown in areas of heavy summer rainfall or hot dry summer areas when given irrigation. Kiwifruit grow well in hot summer areas with maximum temperatures up to 114° F (45° C) if adequate (8,000-10,000 gallons per acre) water is provided daily for the plants. Where 90° F maximum temperatures occur about 6,000 gallons of water per day per acre are adequate. Soils must have reasonable drainage, contain minimum salts, not be too alkaline (less than pH 7.3), and be deep enough to grow a good peach orchard.

In California, kiwifruit can be grown in most areas of the Sacramento and San Joaquin Valleys where peaches and fruit are grown. They cannot tolerate severe winds or poorly drained or alkaline soils. Major commercial kiwifruit districts in the Central Valley are Chico, Gridley, Yuba City-Marysville, Modesto-Livingston, Madera, Fresno, Reedley-Dinuba, Visalia-Exeter, Porterville, and Delano-McFarland. Other kiwifruit districts are in the central coast region (San Luis Obispo, Watsonville-Santa Cruz); intermediate valleys such as Gilroy, Fairfield-Winters, Sebastopol-Healdsburg; foothill districts below 1,500 feet elevation and with minimum frost such as Lincoln and Loomis; and some areas in Southern California with above average winter chilling without severe frosts (below 24° F). Kiwifruit are grown to a limited extent in other areas of California not specifically mentioned.

In Southern California, warm days (70° F) or lack of winter cold in December and January reduces yield many years. In foothill and north coast areas, frost limits production. Wind in many areas scars the fruit and breaks the growing and fruiting canes and so delays plant growth and reduces production. Poplar or Casurina windbreaks can reduce wind problems. In the Sacramento Valley, years of heavy spring rainfall have killed kiwifruit vineyards on poorly drained soils. Nematodes and water problems have limited plant growth in sandy soils in the San Joaquin Valley.

In addition to California and New Zealand, kiwifruit are also grown in Italy, Japan, France, Chile, China, Spain, Greece and Israel. Italy has over 12,000 acres, Japan and France each have about 6,000 acres of bearing and nonbearing vines, and other countries have 100 to 1,000 acres each. In the United States some small acreages exist in Oregon, South Carolina, Florida, Texas, and Louisiana but winter cold caused severe damage to these plantings in 1981, 1983 and 1985.

Economics

Production of kiwifruit is expensive since a high capital investment is required for vines, trellises, and a permanent sprinkler or drip irrigation system. It takes 4 years after planting to produce a commercial crop. Vines are commonly planted 15-18 feet apart in rows 15 feet apart, resulting in 160-190 plants per acre. The current price for most grafted plants is $7.00-$9.00 each. For support, vines must be trained on a sturdy trellis system consisting of 4-5 inch diameter poles 9 feet long with 2" x 6" x 6' cross arms. The trellis posts are set about 3 feet deep in the soil to hold up the vines. This T-shaped trellis (called a T-bar) with wires, end posts, and anchors costs about $2,000 per acre installed. Many California growers now train kiwi vines on a solid overhead trellis called a pergola or arbor. Costs of materials and installation for a pergola is $2,500 to $3,000 per acre. Other popular trellis systems are 2 or 4 row arbors with driveways every 2 or 4 rows and the II system when an 8-foot cross arm is supported by two posts per vine. They cost $2,000-$2,500 per acre installed.

Young and old kiwifruit vines require frequent irrigation every 2-3 days for the best growth. This means a solid set, permanent irrigation system is required. It may be a drip, minisprinkler or undervine sprinkler system. Costs for drip or minisprinkler systems installed are about $1,000 per acre including filters but not the cost of the well and pump. Costs for solid set of under or overvine impact sprinkler systems are about $2,000 per acre plus cost of well and pump. Growers in the Sacramento Valley or foothills use an overhead sprinkler system for frost protection and to maintain a cover crop and use a drip or

minisprinkler system to provide frequent vine irrigation. These dual systems double the cost for irrigation systems. Generally it is undesirable to irrigate over the vines during the summer since water causes stains on the fruit. Many California water sources are high in calcium and bicarbonate and when irrigation water is applied during the day over the vines, white "hard water" deposits develop on the fruit which ruin their appearance. Thus undervine drip or minisprinklers are used for summer irrigation.

Total costs to train and give cultural care to a new kiwifruit vineyard for the first 4 years are $2,500-$3,000 per acre. Weed control, training and pruning, irrigation, fertilizing, and windbreak planting make up the major costs. Costs in 1986 for good orchard land that can be used for kiwifruit range from $3,000-$5,000 per acre, but have been as high as $6,000-$10,000 in 1979-80. If the soil is fumigated for nematodes prior to planting, this adds $400-$600 per acre. Prior to fumigation, land leveling and ripping is desirable and may cost $500 or more per acre. (See Table 1.)

To the total of $8,300- 11,800 per acre (Table 1), add the price of a tractor, mower, sprayer, forklift, pickup, well and pumps, tools, interest costs, and maybe a packinghouse. The actual costs of these vary with each grower.

Production and income will vary with choice of vineyard site, packout and grade of fruit, future prices for fruit, management ability, and success of venture. Approximate yields are listed below that may be expected with good management and a good growing site. This is about twice that of the average California planting. Higher and lower yields by individual growers can easily be found. The average output of all bearing California vineyards is about 1,000 packed trays per acre. Most vines are expected to be productive until the age of 20 years with yields under favorable conditions of 9.5 tons or 2,000 packed flats per acre. The following table shows approximate returns to the grower after packing, cold storage, assessment and selling charges have been withheld. As an example, if fruit sells for $7.00 per tray of 7.5 lbs at the packinghouse, the grower would receive $3.00 if packing, storage, selling charges etc. were $4.00 per flat. If selling price is $6.00 and costs are $3.80, then the grower would receive $2.20. (See Table 2.)

Annually it costs (for labor and materials only) $1,500-$2,000 per acre to grow and harvest kiwifruit. If these costs are subtracted from the above listed returns, it will take 9-10 years at $3.00/tray just to recover establishment costs exclusive of land and interest costs. Should the lower returns of only $2.20/tray exist, it will take 12 or more years to recover development costs. However, at the state average yield of 1,000 packed trays per acre, the grower can never payoff the investment since his returns will only cover his production costs. High yields over 2,000 trays per acre are the only answer for profits. Long-term prices for kiwifruit are hard to project but growers should be able to receive after picking and selling costs somewhere between $2.00 and $3.00 per tray most years in the 1990s.

One also must consider possible delays in plant growth, crop losses from frost or wind, variable yields due to nature and management, and packinghouse and storage problems, which can reduce yields and sales of packed fruit and add unexpected costs or losses. Despite these problems, it still appears that kiwifruit in good production areas can be profitable assuming normal economic conditions and providing the grower or investor has adequate capital and can provide good management and wait for full production.

Cultural and harvest costs for full-bearing kiwifruit vineyards have been $1,500-$2,000 per acre annually. Pruning and harvest costs together are 50%-60% of the annual costs. Interest on investment is another high cost that varies with each grower and has not been added to the costs shown.

Soil and Water Needs

Kiwifruit vines grow best on class 1 soils, especially deep, alluvial soils. Good and sometimes excellent production is obtained on class 2 soils if properly managed. Kiwifruit vines grow and produce better on loam and silt-loam soils than on loamy sands.

Kiwifruit vines require low-salt water as other fruit crops do. Chloride, bicarbonate, boron, and sodium are the most damaging. Approximate safe levels for irrigation water are: chloride less than 70 ppm, bicarbonate less than 200 ppm, boron less than .25 ppm, sodium less than 50 ppm, and electrical conductivity EC x 103 less than .75. Soil for kiwifruit vineyards should have less than .25 ppm boron, low sodium, electrical conductivity of .75 or less and pH less than 7.3.

Table 1. Briefly summarized, the costs per acre of establishing a kiwifruit vineyard (over a 4 year period) are:

Land preparation (level, rip, fumigate)	$1,000
Plants, stakes and planting (160 vines/acre)	$1,800
Trellis materials, anchors, posts, wire+ installation	$2,000-4,000
Sprinkler systems installed	$1,000-2,000
Care and training vines for 4 years	$2,500-3,000
Total	$8,300-11,800

Table 2. Grower Returns From Packinghouse With Good Yields and 75% Packout

Age	$3.00/tray or 40¢/lb.	$2.20/tray or 30¢/lb.	Yield/Acre	Packed Trays/Acre
4	$1,500	$1,100	2-3 tons (2.4)	500
5	$2,550	$1,870	3-5 tons (4.0)	850
6	$3,750	$2,750	5-8 tons (6.0)	1,250
7	$4,500	$3,300	5-9 tons (7.0)	1,500
9	$6,000	$4,400	8-12 tons (9.5)	2,000

Primary Cultural Factors

Getting good bare root or container plants is essential for a good start, and ordering should be done a year or two ahead of planting. The larger plants are preferred. Plants should be 3-6 feet high with a diameter near the bud union of about ½ inch. More plants are lost in the first year when smaller plants are used, and smaller plants take longer after planting before they produce fruit. Most plants are grafted on Hayward or Bruno seedling rootstock; rooted cuttings of ½ inch diameter make good plants.

The only acceptable commercial variety is Hayward. Any good male pollinator that blooms at the same time as the Hayward is satisfactory. The California male is most widely used in the state of California. Plant an outside row of all female (Hayward) plants. Follow that with a row consisting of one male plant between every two female plants, then 2 rows of all female plants, another row with one male between every two females, 2 more rows of all females, etc. This means that every third plant every third row should be a male.

Irrigation is extremely important for optimum plant growth and good production. Irrigating daily or every two days in the summer is usually advisable for the first 3 years after planting, and three to four times per week for bearing plants. Excessive irrigation or poor drainage can cause crown rot, yellow vines, and plant death. Under-irrigation reduced growth, causes some sunburned leaves, produces small fruit, and stunts plant growth. Severely deficient irrigation causes leaf burn and will ultimately result in plant death. Kiwifruit vines need more irrigation than grapes or fruit trees under similar soil and weather conditions.

Irrigation Systems

Three different irrigation systems are used for kiwifruit vineyards. Drip irrigation saves water and is commonly used on most young plantings. At the time of planting and for the first year, one emitter is placed near each plant. The second year one emitter is put on each side of the plant about 12-18 inches away from the plant. When the plant is 4 years old, two more emitters are added 3 feet away from the first emitters. Drip systems can supply water to vines every day or every 2 days which usually results in rapid growth. When plants reach full bearing, it is difficult to wet enough soil with 4 emitters per vine to get maximum yield and plant growth. At that time many growers shift to minisprinklers for irrigation or add more emitters per vine.

Minisprinklers are small plastic sprinklers that throw a fine spray of water through a fixed or rotating head depending on the make. Minisprinklers will spray water in a circular pattern 6-18 feet in diameter. Full circle and partial circular patterns are available. Each minisprinkler is set on a plastic stake, placed in the soil under the vine, and attached to the lateral plastic water line with small spaghetti-shaped tubing. Minisprinklers may be hung on a small plastic tube connected to a lateral line attached to the trellis system instead of being placed on a stake set in the soil. Generally minisprinklers wet a circular area between plants and are allowed to run 6, 8, or 12 hours two to four times per week. They wet more soil than the drip system does, are easy to install, can be used to replace drip, and plug less frequently than do drip emitters.

The third system widely used in older kiwifruit vineyards is an impact sprinkler. These traditional sprinklers can be placed over or under vines. Overhead irrigation systems are good for frost protection but do cause some spotting or discoloration of the fruit when used for irrigation during the summer. To avoid this, many growers are changing overhead sprinklers to undervine sprinklers by putting a T assembly on the plastic sprinkler riser and transferring the sprinkler to this during the irrigation season. The upper sprinkler adapter is plugged in the summer. When frost season arrives in the fall, the sprinkler is transferred back to an overhead position and the T assembly is plugged. These sprinkler systems can work fine if no vine interference occurs. They tend to use more water than the other systems but also have fewer plugging problems.

Wind and Windbreaks

Only areas with minimum wind should be used for growing kiwifruit because wind easily breaks canes, damages fruit, and reduces plant growth. Both daily coastal breezes of 5-15 miles per hour and hard spring and fall winds of 15-50 miles per hour break canes and reduce growth and production. Every cane broken by the wind means 4 to 6 less fruit per vine.

Use of windbreaks will provide partial to adequate protection depending on the type of tree used and the severity of the winds. Poplars and certain willows are generally considered the fastest growing windbreaks, although some growers find certain kinds of Casurina, pine and eucalyptus acceptable. A windbreak protects 200-250 feet downwind so windbreaks are best placed every 200 feet through a kiwifruit vineyard. Roots of windbreak trees

do compete with vines so windbreaks should be irrigated frequently and kiwifruit vines spaced at least 20 feet from windbreak trees. Many areas in California have infrequent wind conditions so growers do not use windbreaks. New Zealand needs more wind shelters than California because it is a windy island.

Frost Problems

Frost damage to young vines in the fall and spring can result in plant death or killing of the budded portion of the vine. Temperatures below 30° F (-1° C) in the spring will damage new leaves, fruit, and tender shoots. In November, temperatures below 27° F (-2.5° C) may cause trunk damage to young vines and will freeze leaves. After 2-4 nights of freezing temperatures (with or without frost protection), vines usually tolerate temperatures in the mid- to low 20s F (-4° to -5°C). Cold sites, generally, are not satisfactory for kiwifruit vines, although some growers are able to grow vines in these areas but often take plant losses due to the cold. Minimum temperatures that mature, winter-hardy Hayward kiwifruit vines will safely tolerate appear to be about 10°-15° F (-9° to -12° C).

In Europe in January of 1985, some kiwifruit vines survived -18° C, but many were killed to the ground. Sprinklers can help protect vines against cold damage, but protection is limited to 6°-8° F (3°-4° C) of frost when overhead sprinklers apply 50 or more gallons of water per minute (or 3,000 gallons per hour) per acre. Undervine sprinklers and misters give only 2°-3° F frost protection. Sprinklers must be started when temperatures are several degrees above the critical temperature to perform as described.

Pests, Diseases and Chemicals

So far in California pests and diseases are not serious. However, spraying is necessary in most older vineyards and in established kiwifruit districts. Looper worms, especially Omnivorous Leaf Roller (O.L.R.), and small white scale (Greedy, Latania, Ivy, and Oleander scales) are increasing problems to California growers. These pests require 1-3 sprays per year in grape growing areas of the San Joaquin Valley and one spray in other areas. Worms and scale are perennial problems for New Zealand growers necessitating 4-6 sprays per year. Soil diseases such as *Armillaria mellea* (oak root fungus) and *Phytophthora sp.* (crown rot) are fatal to kiwifruit vines. Vines growing in low spots, in saturated soils, or in standing water are likely to be killed by crown rot. Too much wetting of the trunk and crown by frequent irrigations increases *Phytophthora.* Saturated soils will kill vines during any time of the year.

Rootknot and lesion nematodes are damaging to kiwifruit roots if the numbers of nematodes are large. When kiwifruit follow crops infested with these nematodes, the soil should be fumigated with a good nematicides before planting vines.

Fruit in storage may show gray Botrytis mold and other forms of decay when it is injured or becomes soft. Several chemicals to control Botrytis are being tried as sprays but none are proven or widely used in California.

Absence of chemicals registered in the United States, Japan, and Europe for pest, disease, and weed control is a problem of the kiwifruit industry. In 1988, there were at least two chemicals registered in California for worm control, two for scale control, two contact herbicides (with permit), and two for preemergent weed control.

Fertilizer

Fertilization is important in kiwifruit culture and consists mostly of nitrogen fertilizer applied two or more times per year. Growers should avoid using too much, too close to plants, and should use minimum fertilizer the first year after planting. Young plants that grow vigorously late in the fall from heavy use of nitrogen and water in September and October are very prone to winter frost damage. For full-bearing vines, use 1 pound of nitrogen per plant or 150 pounds per acre. One pound of nitrogen is equal to 2.2 pounds of urea or 5 pounds of ammonium sulfate. For bearing vines, at least 50-60% of nitrogen should be applied in March-April and the balance in May, June and July. Liquid feeding in irrigation is often used applying about 100 ppm nitrogen or 10 pounds nitrogen per acre per week. Younger plants should receive proportional amounts during the year depending on age. Thus, second leaf plants can have 0.2 lb. of nitrogen per plant per year, 3rd leaf = 0.4 lb., 4^{th} leaf = 0.8 lb., and 5^{th} leaf = a full pound of nitrogen per year.

Use of potassium fertilizer may be necessary in older vineyards in the Sacramento Valley. Zinc and iron are sometimes needed by plants where deficiency symptoms appear or pH needs to be lowered by sulfur applied to the soil or acid in the irrigation water.

Pruning

Pruning and vine training are major annual costs and should follow some general guidelines, although pruning and training techniques vary among growers. Most pruning in California is done during the winter while New Zealand growers do as much summer pruning as winter pruning. In the hot California climate summer shade must be maintained over the fruit, while in New Zealand growers remove part of the summer shoot growth to let light into their plants to encourage fruit bud formation for the next year's crop. Despite these differences, California and New Zealand yields are similar. California should do some summer pruning to reduce shade and vine growth and encourage better fruit bud development.

Normally kiwifruit vines are trained to a single trunk. All rootstock shoots must be cut off to prevent their growth and competition with the grafted top. After the strongest trunk cane of the grafted top grows above the trellis, it is cut off just below the trellis wire and two canes are encouraged to grow in opposite directions down the center wire of the trellis forming two main arms or cordons from which all future fruiting canes originate. Each year the cordons are headed 20-30 inches beyond the last cut to encourage cane growth from each bud on the cordon cane. Most new canes produce 4-6 fruit at their base and then form flower buds during the summer along the rest of the cane. Winter pruning of young female vines usually leaves

about 5 or 6 flower buds on most canes. On older vines usually 6-12 flower buds are left on canes depending on their diameter. The larger the diameter, the more buds can be left. Pruning in the winter removes most older canes that have fruited for 2 or 3 years. Summer pruning usually consists of cutting back vigorous canes that grow beyond the T-bar into the driveways between the trellis and removing a few vigorous upright growing "sucker-like" canes.

Male vines are pruned differently from female vines. Winter pruning in male vines consists of cutting out twisted, dead, or weak canes but leaving most canes 3-5 feet long. After flowering and pollination in May, male vines are cut back leaving short, new canes spread on the trellis. New growth appears soon and will grow and produce flower buds for the next year. Since male plants only produce flowers it is best to leave them long before bloom to get maximum flowering. Pruning after bloom restricts male plant size and maintains good annual flowering canes. Growers should avoid overly severe summer pruning since this can cause serious sunburn of the main cordons or arms of the vine. Post-bloom pruning must be done in May or summer heat will cause sunburn damage to the plant. In some cases during very hot weather, white latex paint may be advisable after pruning is finished in May to protect big arms from sunburn damage.

Harvest and storage

Fruit is hand-picked when about 7% sugar and at a hard stage (14-20 lbs pressure) in October or early November. It should be cooled to 32°-40° F (0-4° C) within 12-24 hours after picking and stored at 32° F (0° C). Proper cold storage can keep fruit firm for 3-6 months. Kiwifruit should not be stored with other fruit, especially those that produce ethylene since this will cause fruit softening and drastically limit storage time and sale of fruit. Fruit should be packed as soon as picked or if this is not possible then within 1-3 weeks after harvest. During packing, the fruit is sized and placed in plastic trays, then covered or wrapped with clear polyethylene plastic and put in one-layer flats. These packed flats should be cooled quickly so fruit core temperature is 32° F within 24 hours of packing or storage life will be shortened. Commercial packing is available in most areas. Only battery operated forklifts should be used in storage rooms to avoid generating ethylene which would quickly cause softening of kiwifruit. Storage rooms should be thoroughly aired to remove any residual gases before newly packed fruit are stored. Levels of ethylene in storage should be monitored on a regular basis because a week or more of 10 ppb or more ethylene will hasten fruit softening. Season-long ethylene levels over 5 ppb will shorten storage of kiwifruit.

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