

1990: YEAR OF THE PASSIFLORA

***By popular demand, we open this series
of articles on the CRFG FRUIT OF THE YEAR
with one of our most frequently requested articles.
It appeared in the 1975 Yearbook, which was devoted
entirely to passion fruit and is out-of-print.***

Passionfruit The World Over

Muriel B Fisch

(Muriel Fisch, editor of the CRFG YEARBOOK from 1973 until her illness in 1978, died in 1980. She researched and wrote extensively on rare fruits)

The delights of passionfruit would suffice if they were purely gustatory – but add the fragrance of the fruit and the exquisite beauty of the flowers and you have the perfect plant for sentient beings.

The name "passionfruit" is not derived from any aphrodisiac quality of the fruit, a fact which may prove very disappointing to some readers. It was named, reportedly, by Spanish Catholic missionaries who saw in the flower the symbolism of the Passion of Christ:

Passus meaning "suffering", *Flos* meaning "flower" (Fig. 1)

An examination of the structure of the flower may help the reader to understand the symbolism: The corona was seen as the halo or the crown of thorns. To some, the 72 filaments of the flower corolla indicate the number of thorns in the torturous crown. The five stamens were thought to represent the five wounds or the hammers used to drive the nails. The three knobbed stigmas were compared to the three nails or to Christ and the two thieves on the crosses. The five petals together with the five sepals were thought to stand for the ten apostles (excluding Peter who denied the Lord and Judas who betrayed Him); the three bracts symbolized the trinity, the lobed, mitten-like leaves: the pointing hands of the accusers. To some the spear-shaped trifoliate leaves suggest the spears that pierced Christ's side. The reedlike stems of most passionflower vines are sometimes associated with the passage, "Christ was given vinegar on a reed." The axillary coiling tendrils are said to be the cords or whips used by the persecutors. The 30 round marks on the underside of some leaves are representative of the 30 pieces of silver which tempted Judas to betray Christ. The white in the flower represented the emblem of purity – the blue, the heaven. The

flower remains wide open for three days before it fades away, denoting the death, burial and resurrection of Christ.

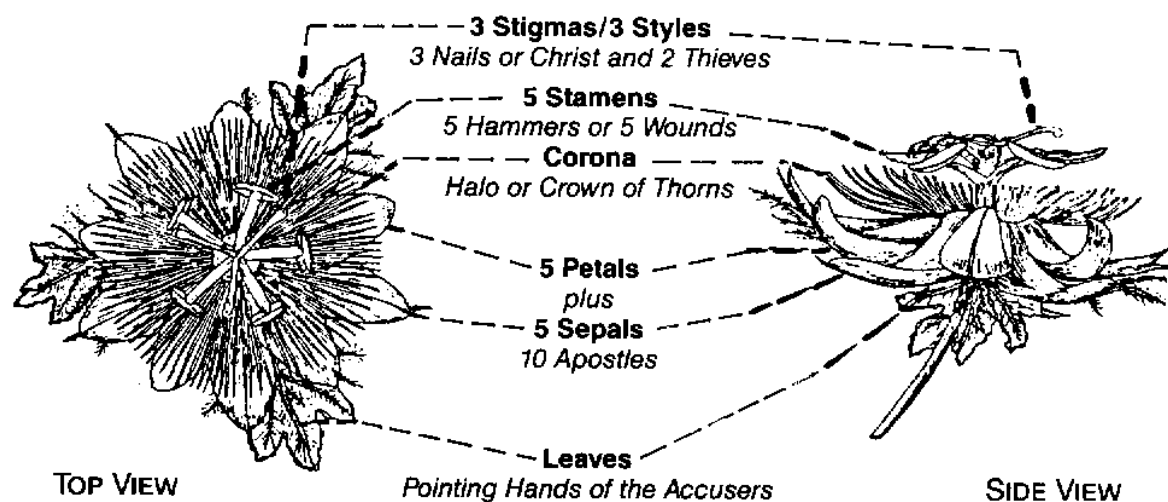


Figure 1 -- Legend of the Passionflower

In the Bahama Islands the succulent fruit of the profusely growing passionflower is touched only by scientists because the natives consider it sacred. The Spaniards reportedly regarded the blossoms as a sign that the Indians should be converted to Christianity. In South America the passionflower is often referred to as the "Holy Rood Flower" and is the ecclesiastical emblem of Holy Cross Day. St. Francis of Assisi is said to have seen the passionflower vines, during one of his fasting visions, climb the cross and twine itself around the scars in the wood made by the nails in the Crucifixion.

Very Widespread

Vines grew in Brazil and from those vines over 400 species now comprise the genus *Passiflora*.

From Brazil, their place of origin, they became naturalized in the tropics the world over, and there now are many commercial plantings. Several such plantings existed in our own region of southern California, the most recent one in Vista. Fred B. Mehner, a nonegenarian grower of passionfruit, still propagates seedlings of New Zealand specially selected purple passionfruit on his Vista ranch.

His is a fascinating tale of a Mr. B. Byrn and Mr. W. Lyttle who smuggled seeds between the pages of a book from their native New Zealand into the U.S. in 1928. They planted the seeds in Vista on a 15-acre ranch and later started a nursery for the propagation of passionfruit. By 1937, San Diego County had 143 acres planted to passionfruit. Early pioneers were Fred Mehner, Joe Clement, H. Ormsby, C.L. Merriam, Adolf Matthis, Richard Erdman, Frank Lindeman, Dale E. Hurst and Victor Kramer. The latter had a large passionfruit plantation in Cardiff-by-the-Sea and also processed the fruit and marketed the product under the name "Passionola" which was used as a cocktail mix. Member Alex Stearns also marketed a passionfruit cocktail mix under the name Tropical Mystery in the early 1930s.

In 1933 the Passion Fruit Cooperative Association plant was working day and night shifts, processing fruit syrups, with over seven tons of passionfruit delivered to its plant in a one-week period. In 1934 the Passion Fruit Association of Vista was asked to supply five tons of passionfruit seeds to a national passionfruit

organization. However, the main buyer of San Diego County fruit was Pacific Hawaiian Products Co., of Fullerton, Calif., makers of Hawaiian Punch, whose chief ingredient is passionfruit.

Fred B. Mehner, still growing seedlings at the last passionfruit outpost, 2440 El Corto, came to Vista in 1930 to work on the ranch of M. L. Nelson, an NBC-TV executive. His largest crop was in 1936 when 15 tons were harvested from 3 acres.

Through the years, Mehner's ranch at Vista has had many visitors, among them UCLA and Cal Poly professors and their students, annually, and in 1953 New Zealand Ambassador George R. Laking and the Consul General of Australia.

Fred Mehner often shipped to various U.S. cities carefully packed crates of passionfruit ordered by diplomatic employees who yearned for this delicacy from their native countries.

In 1954 he supplied passionfruit for a White House dinner for Queen Mother Elizabeth of Britain. (The British Ambassador in Washington, D.C. had learned through the Dept. of Agriculture of this single U.S. source, and officials of the department made the request.) Mehner later sent fruit and jelly to President and Mrs. Eisenhower and received a note of thanks from them.

Despite these moments of glory, Mehner and other growers were discouraged by the freeze of 1938 that killed many vines. With a demanding greenhouse routine in starting the seedlings, and the limitation of an 8-year maximum producing life of the vines, many plantations were gradually eliminated from the scene in San Diego County. But Fred Mehner carried on and still carries on.

In the U.S., passionfruit was offered for sale as early as 1877 by John Grelock of Los Angeles, who had lived in Central America and introduced several other subtropicals to California. Among early nurserymen who listed the fruit in northern California were R. J. Trumbull of San Francisco in 1882 and R.D. Fox of San Jose in 1884. In spite of these early listings, passionfruit did not become commercial in the U.S. until 1930, at which time four of the five U.S. growers were reported by the U.S. Census to be in San Diego County. Shortly after the discovery of fine specimens of *Passiflora* by the Spanish about 1610, Jacomo Bozio published the *Flos Passionis*, which contained poems, illustrations and a description of the wonderful new plant from Brazil and tropical America.

Passionfruit was introduced to Europe then, at the beginning of the 17th century, where it was grown for its unique flowers, and in 1629 it reached England.

Seeds of the purple passionfruit were brought to Hawaii from Australia in 1880 by Eugene Delemar and planted in the district of Lili'okoi on east Maui. Within a few years after the plants began to fruit, new plants appeared in the wild and soon became widespread in the district. In this way the name of the district Lili'okoi became associated with this particular species.

The first seeds of the yellow passion-fruit were left with the Hawaii Agricultural Experiment Station in 1923 by E.N. Reasoner of Oneco, Florida, who was returning from a visit to Australia where he had collected them. These seeds were germinated and in ensuing years, numerous plants were distributed by the station to interested growers throughout the Islands. Subsequently, vines have appeared in the wild on all of the larger islands of Hawaii.

Commercially, the Reynolds Tobacco Company owns 147 acres on Maui devoted to the growing of passionfruit.

In Australia, the purple passionfruit was flourishing and naturalized in Queensland coastal areas before the beginning of this century. Its cultivation attained great importance especially since the crop was considered easily managed and relatively disease-free until 1943 when a widespread invasion of *Fusarium* wilt killed the vines. Thereafter, research was undertaken to find fungus-resistant substitutes. The neglected yellow passionfruit was found to be both wilt- and nematode-resistant and not to sucker from the roots, so was adopted as a rootstock for the purple passionfruit.

New Zealand had a thriving purple passionfruit industry in Auckland Province in the 1930s, but it declined in a few years as a result of the disease-susceptibility of that type of fruit. However, good local marketing and export prospects have resulted in increased plantings and a renewal of efforts to improve varieties and control infestations.

In 1951, when Hawaiian passionfruit plantings totaled fewer than five acres, the University of Hawaii chose this fruit as the most promising crop for development and undertook to create an industry based on quick-frozen passionfruit juice concentrate.

From the vines of the Haley Ranch, choice strains of yellow passionfruit were selected which yielded 20 tons of fruit per acre with 35% juice content, as compared with purple passionfruit yields averaging less than five tons of fruit per acre with a juice content of 25%. By 1958, in seven years, 1200 acres were devoted to yellow passionfruit production and the industry was firmly established on a sound economic basis.

In 1947, South Africa produced 2000 tons of purple passionfruit for domestic consumption. By 1950, production was doubled. In 1965, to meet market demand, passionfruit plantations were initiated over large areas of the Transvaal. The purple passionfruit is still the most important species grown commercially in South Africa, although during the past few years the yellow passion-fruit has been developed as a fresh fruit.

India has harvested purple passion-fruit for many years and the vine has proven particularly healthy and productive at altitudes between 2000' and 4000', naturalizing in many areas. The yellow form was introduced from Ceylon about a decade ago and has adapted well to low elevations in south India, where it produces heavy, regular crops within a year of planting.

There has been a general lack of enthusiasm for the passionfruit in Florida. It was growing there in 1913 "as an ornamental" and there were limited trials with the purple and yellow fruits at the University of Florida's Subtropical Experiment Station in Homestead. Yellow passion-fruit vines bore fruit in some southern and central areas of Florida year after year, and even seem to have naturalized in Everglades hammocks.

In the routine course of plant acquisition, various species of *Passiflora* have reached the U.S. Plant Introduction Station in Miami, and observations by horticulturists there resulted in reports on the need, among other things, for extensive field studies, for which they offer plant material to anyone qualified to undertake such work.

The yellow passionfruit (*Passiflora edulis* forma *flavicarpa* Deg.) until recently was largely overshadowed by the purple passionfruit (*P. edulis* Sims) which had an agreeable, less acid flavor.

The origin of the yellow form, previously unknown, was presumed, according to Colombian writings, to be a native of the Amazon region of Brazil.

The most popular species cultivated for their edible fruits are *P. edulis* Sims, *P. laurifolia* L., and *P. quadrangularis* L.; but there are still other species grown more or less locally in their native countries and highly prized for their unique ornamental qualities as well as for their fruits.

Colloquial names for *Passiflora edulis* are: Granadilla, Sweet Cup, Simitoo; Eiervrucht, Passievrucht, Kappoeweri Markoessa and Lian appel in Dutch; Grenadillas and Susze, Calabasch in German; maracujá melao, maracujá redonde, maracujá and maracujá peroba in Portuguese; Linmangkong in Thai.

It is called lilikoi in Hawaii; ceibey in Cuba; parchita and parchita maracuyá in Venezuela; parcha in Puerto Rico; purple or yellow granadilla in South Africa; grenadella, grenadelina, grenadille, barbadine, Marie tambour, pomme liane and couzou in French-speaking countries.

The name "granadilla" itself is derived from "granada" meaning "small pomegranate." Since it is applied to several types of *Passiflora* in different parts of the tropics, it is necessary to append a qualifying word in order to distinguish them. Colloquial names for other edible species are:

P. laurifolia Linn.: Water Lemon, Yellow Granadilla, Sweet Cup, Jamaica honeysuckle, Belle Apple, Makoesar, Wasser-limone, Pomme d'Or, Buah susu, Sawa-rot Pomme de liane, maracujá comun.

P. ligularis Jussieu: Sweet Granadella, Water lemon, Lemiwai, Liliwai, Poka.

P. cincinnata Mast: Crato passionfruit.

P. coccinea Aubl: Scarlet passionflower.

P. quadrangularis Linn: Giant Granadilla, Badea, Tumbo, Parcha, Timun belanda, Marquesa, Su-khontha-rot, Parcha granadina, Grandilla real, Pasionara, Djari markoesa, Groote markoesa, Markiza, Barbadine, Maracujá melao, Maracujá assu, Marocujá-mamao.

P. incarnata Linn.: Maypop, May apple.

P. maliformis L.: curuba, kuruba, granadilla de piedra.

P. mollissima HBK: Tacsonia, Banana passionfruit, Sweet Calabash.

P. platyloba Killip: Montesa Grandilla.

P. serrato-digitata L.: Tagua-Tagua.

P. vittifolia HBK: Grape-leafed passionfruit.

P. caerulea: Blue Crown passionfruit.

P. foetida Linn.: Timun padang.

Description

Passionfruit (*Passiflora edulis* Sims) is a member of the family Passifloraceae. It is a tough-stemmed, evergreen perennial vine that climbs by means of long tendrils which coil around supports.

They grow so rapidly that they may cover the side of a fairly large home in two years, although if not permitted to grow rampant, they take up little space.

The stems are green, angular when young, becoming round with age, and their centers are hollow.

There are many green tendrils on the stem, one arising from each leafstalk base, where there are also green stipules of varying shapes.

Leaves of *P. edulis* are alternate, simple, divided into three large, deep lobes, except in very young plants where they may be undivided. They may be up to 6" long and wide, although they are often smaller, and are drooping.

Edges are finely toothed and each lobe tip is pointed but short. There is a main vein to each lobe, ridged beneath, and many side veins.

Leaf color is deep green, although pale when very young, shiny above and almost dull beneath.

Leafstalks are ½"—2" long, green, deeply fissured on the upper side, with two protruding, pale green knobs (the glands) at the base of the leaf blade.

Parts of the plant, especially the leaves, contain hydrocyanic acid and are therefore poisonous. Flowers, which open at dawn and close before noon, are about 3" in diameter and have a distinctive structure. They have five sepals and five petals which are alternate, giving the flower the appearance of having 10 petals. Sepals are green and spongy, with a ridge running down the center of the outside. They are white inside. Petals are white and thin and the edges curl. Above them are many long, thin, curly whiskers or threads, called the corona, radiating in a circle from a central hollow. At the base they are violet in color and white on the upper half. The central hollow of the flower is green, with brown hairlike glands on the bottom and in the center a small, green ovary which later develops into the fruit. At its base are five spreading stamens with oblong, loosely attached yellow anthers. At the top of the ovary are three tripartite styles, each terminating in a thickened sticky, pollen-receiving, cleft stigmatic surface. On the flower stalk just above the flower are three large, green, leafy bracts called the involucre.

The fruit of *P. edulis*, a multi-seeded berry, is round or slightly oval about 2"—2½" long, about the size of a pullet's egg. Weight varies from ⅓ oz. to about 2 oz. The fruit hangs on stalks 3—4" long with green bracts about 1" from the fruit.

The shell is hard and smooth, green at first, ripening to deep purple, and finally becomes crinkled when fully mature. The rind is about ⅛" thick, pinkish and bordered by about ¼" of white pith.

Inside the rind is a hollow, filled with tart but pleasantly flavored aromatic juicy orange-yellow pulp. The small,

hard, black seeds are pitted, netted, or transversely grooved and individually embedded in the fleshy aril.

On maturing, fruit falls from the vine.

P. edulis f. *flavicarpa* is much like the purple form although under most conditions it is a more vigorous grower. It is distinguished by the suffusion of reddish, pinkish or purplish color in stems, leaves and tendrils.

The leaves resemble those of the purple form but usually are somewhat larger. In the flower, the bases of the corona filaments are a much deeper, brighter purple. The flower opens about noon and closes about 9 or 10 p.m.

The average fruit is slightly larger than the purple form and has a bright canary-yellow rind. The pulp is somewhat more acid and the seeds are dark brown rather than black. The mature fruit falls from the vine.

Probably because there is little or no overlapping of the functional period of the flowers, not much crossing has taken place in the past between the two forms of *P. edulis*. However, much is being done artificially in this area to develop hybrids which will be disease- and pest-resistant and also will withstand some frost.

Other Species of *Passiflora*

***P. quadrangularis* Linn.**

The Giant Granadilla is cultivated throughout the tropical world. It is closely related to *P. alata* Dryander, which also is native to Peru and Brazil. Both are variable and distinguishable with difficulty.

They have large, entire, pinnately veined leaves, *quadrangularis* with 10—12 lateral nerves per side and three pairs of petiolar glands, *alata* with 7—8 nerves and one or two pairs of glands. Both have squared stems, but those of *alata* are winged with narrower stipules.

The striking flower of *P. quadrangularis* can be up to 4½" in diameter, with pale pink petals, sepals green outside and white inside, and corona banded blue and purple.

The perianth of *quadrangularis* is generally lighter white, tinged with pink or crimson; that of *alata* is usually crimson or carmine. The radii of *quadrangularis* are as long or longer than the perianth and are crinkled at the tips; those of *alata* are not so long, and straight. Both have radii banded with reddish-purple, bluish-purple, and white. The flowers of the *quadrangularis* are among the most beautiful and exotic of the passionflowers.

The greenish-yellow fruits of *P. quadrangularis* resemble melons and are the largest in the genus, about 20—30 cm (8"—10") long. The fruit is oblong, with a delicate aroma and a thin, smooth skin which may have a few faint lengthwise ridges. Inside there is an inch or more of firm, whitish or pinkish flesh and a large central cavity filled with a mass of purplish-pink pulp surrounding ½"-long, dark seeds.

The Giant Granadilla thrives in a warm, humid climate and, being less hardy than the purple granadilla, is endangered if temperatures fall below 55°F (13°C). Fertile, well-drained sandy barns are best.

Propagation is by seeds, layers or cuttings of mature wood, and spacing should be 7'—10'. Vines require trellises lower and stronger than those of *P. edulis*.

A trellis, lattice, pergola or arbor utilizes the ornamental quality of this vine and provides the necessary support as well. The Giant Granadilla is short-lived, plants usually needing replacement after having fruited for about six years.

Hand-pollination may be required for proper fruiting when the plant is grown outside of its native habitat.

Since this plant has attractive, delicious and nutritious fruit and grows easily and rapidly, having the same cultural requirements as *P. edulis* it deserves wider cultivation in California.

Immature fruits are sometimes boiled and used as a vegetable, but more commonly the pulp and aril are mixed together and eaten with a spoon directly out of the fruit, or made into a refreshing drink.

P. quadrangularis produces a large tuberous root which is used as a substitute for yams in Jamaica but is considered poisonous in other areas.

Cooked, when not yet ripe, this fruit is considered delicious as a vegetable.

***P. ligularis* Jussieu**

The Sweet Granadilla is easily recognizable by the 4—6 strap-shaped petiole glands which are 1 cm (3/8") long. The entire, pinnately veined leaves are almost heart-shaped. The bracts are large and partly joined. The flowers are 2¼"—4" (7—10 cm) in diameter; sepals and petals (the perianth) are greenish to pinkish white; the radii (corona) which are as long as the petals, are white, banded with red-purple.

The hard-shelled fruit is about 7—8 cm (3") in diameter, orange-brown changing to buff-yellow to tan when ripe, with edible white aromatic pulp.

This species is native from Central America to Venezuela and Bolivia and is cultivated in many other areas including northern California. The fruit is used extensively in the mountainous regions of Mexico and Central America. The vine has been growing naturalized in the Hamakua and Hilo regions of Hawaii probably since the latter part of the 19th century.

***P. laurifolia* L.**

Variously known as Water Lemon, Jamaica Honeysuckle, Belle Apple, and Pomme de Liane, it grows wild in thickets and forest borders in the West Indies and northeastern South America. It is a glabrous woody climber.

The leaves are oblong, entire, coriaceous up to 14 x 6 cm (5½" x 2¼") with two glands near the apex of the petiole.

The bracts are large and free; the perianth is red-spotted inside and outside or reddish-purple inside; the radii are very thick, beaded with white and reddish-

purple to blue. The fruit has a white-spotted leathery shell. This form is common in the West Indies, coastal Venezuela, Peruvian Amazonia and eastern Brazil.

The climate, soil and cultural requirements are similar to those of the Giant Granadilla. The fruits are eaten fresh, and for juice in the same way as the purple granadilla.

***P. maliformis* L.**

The curuba is a vigorous vine that has been cultivated in tropical America where it is native. It has ovate-cordate leaves, light green in color, which are about 7.5 cm (3") long.

The flowers have a conspicuous whitish-green calyx and the corona is white, marked with purplish-blue.

The fruit is round, rarely more than 5 cm (2") in diameter, with a thin, extremely hard shell which is yellowish-green on the outside and whitish inside. Within the fruit are small black seeds surrounded by pale orange-yellow juicy pulp which is acid and highly aromatic.

This vine is now being grown in Santa Maria by member John Moore.

***P. incarnata* Linn.**

This is the Maypop of southeastern U.S., native from Virginia to Missouri to Florida and Texas, and known in Bermuda as well. It is very closely related to *P. edulis* Sims, but has thinner, duller leaves which are three-lobed, from 7.5—12.5 cm (3"—5") long with finely serrated edges. The flowers are lavender and purplish-blue, 7.5 cm (3") across. The yellow fruit is 5 cm (2") or more in length, about the size and shape of a pullet's egg. The fruit can be eaten fresh; it makes an excellent jelly and the juice is used for drinks. *P. incarnata* is hardy in all zones in California. It spreads by root runners and can be propagated from seed.

***P. alato-caerulea* ('*P. pfordtii*,)**

This is a hybrid between *P. alata* and *P. caerulea* and is an evergreen or semi-evergreen perennial in California, depending upon hardiness areas. It is the best-known, most widely planted and probably least subject to caterpillars of all the *Passiflorae*.

Leaves are 3-lobed, 7.5 cm (3") long. The 9—10 cm (3 ½"x 4") fragrant flowers are white, shaded pink and lavender. The corona is deep blue or purple. This species blooms all summer. In windy areas it should be planted against a warm wall or under an overhang. In cooler areas, roots should be mulched in winter.

P. caerulea

This is much hardier than other *Passiflora* species, often being grown outdoors as an ornamental in England where it produces fruit in a warm summer. Therefore it may be possible to use it as a hardy rootstock or to cross it with other more desirable fruit-bearing passionfruit vines. Some experimentation with building onto a selected rootstock has been conducted in South Africa and it has been hybridized with other species.

***P. foetida* L.**

This is a variable weedy species that grows wild in the West Indies and South America. It has been introduced into many tropical countries of Africa and Asia where it has become naturalized. It is a herbaceous perennial climber with very hairy stems, ovate hairy leaves, usually 3-lobed, about 4—5 cm (1½"—2") long, foul-smelling when crushed.

Flowers are 4—5 cm (1½"—2") in diameter, white with purple and white corona.

Fruit is ovoid, yellow, about 3 cm (1¼") long. The pulp of the ripe fruit is edible but little used. The leaves and unripe fruit contain a cyanogenetic glucoside and are therefore poisonous.

P. foetida L. has been grown as a cover crop in Malaya and East Africa and is useful in smothering weeds and preventing erosion.

P. ***mollissima*** (HIBK) Bailey

Known as the Banana Passionfruit, this grows wild in the Andes. Rampant growth makes it a good bank cover, but a problem planted among trees and shrubs.

All vegetative parts of the plant are softly pubescent. The leaves are deeply serrated, 3-lobed, 10—12 cm (4"—4¾") long; the petiole has 8—10 glands.

Flowers are long-tubed, pink to rose, about 7.5 cm (3") in diameter, with the corona reduced to a warty rim.

Fruit is ellipsoidal, downy, yellow, about 7 cm (2¾") long, with edible pulp.

This species is suited to colder conditions and has become naturalized at elevations of 4000'—5500' in Hawaii. It has been introduced into New Zealand. (Seeds of this species remained viable for 10 years, after having been brought to the U.S. by a serviceman stationed there during World War II.)

P. antioquiensis Karst.

This also is known as the Banana Passionfruit and is very similar in appearance to *P. mollissima* except that the flowers are bright red. It is native to Colombia and is grown for its edible fruit at the higher altitudes. It is hardy in northern California.

Climate

Since there has been an expanding interest in California in growing and eating the fruit of this vine, it may be in order to discuss the care and requirements of the most common of passion-fruits and probably the parent of them all, *Passiflora edulis*.

The granadilla was the term applied to the edible fruit of the species of passion vine which according to Edward Wickson in 1910 "is quite hardy and is growing in different parts of the state" Although in the tropics it does best at elevations of 1000'—3000', it also grows at sea level. Since altitude may be substituted for latitude, allowing 1000' elevation for every 5½° latitude, it may be worthwhile to try to hybridize passionfruit in California from the many forms available.

P. edulis is injured by temperatures more than 1° - 2° below the freezing point when young but withstands light frosts after its first year and is hardy down to 28°. It may be grown in any climate suitable for lemons and limes. Extremes of

heat and cold may prove damaging to the vine, high temperatures causing them to grow luxuriantly but with very little fruit setting. Heavy yields are obtained in areas having warm, rather dry air.

Passiflora has had its problems in California, although it is widely grown in non-commercial quantities. Passionfruit growers have lost vines through frost and disease.

However, member John Moore reports the coldest temperature ever recorded this past January 1, 1976, 20°F, with all of his passionfruit vines surviving.

Passiflora will mature fruit in cool summers such as those in the San Francisco Bay area, but to a less pleasant flavor and in much smaller quantities than in warmer areas. For best results a warm climate with well-distributed rainfall or irrigation is required.

If not planted in protected locations where there is frost, *Passiflora* should be brought indoors in winter.

Heavy rainfall areas are not considered suitable for its cultivation and though passionfruit has poor drought resistance, it has no resistance to flooding. Winds, too, may cause damage to the plants.

Soil

Although *Passiflora* thrives well in many types of soil, some very poor and dry, very heavy, poorly drained soils should be avoided. Plants in heavy soils are more susceptible to root and fruit diseases and will do much better in a deep, light soil which contains organic matter. On light decomposed granite and poor coastal soil, no other fruit will give the same return as this, and with proper treatment and heavy composting, the amount of fruit which can be derived from an acre of these vines is amazing.

Passionfruit grows best in an almost neutral soil (pH of 6— 8), such as that prevalent in much of southern California.

Irrigation

Water requirement is high when fruits are approaching maturity. Regular watering will keep a vine flowering and fruiting almost continuously. However, drainage must be provided so as to eliminate puddling, since passionfruit vines have no resistance to waterlogging or flooding.

Member John Moore maintains his plants with drip irrigation.

Fertilization

When growth is active, in the spring before flowering, the vine is improved by a feeding with liquid manure. On lighter soils, some growers use considerable quantities of blood and bone with a little potash. Some use bone, superphosphate and potash. Others use a mixture of nitrate of soda, dried blood, super-phosphate and sulphate of potash.

An application of a complete fertilizer such as Terrovite is recommended at planting time and at the beginning of spring and summer growth periods. Heavy applications of 10-5-20, or fertilizers having similar ratios, are recommended for

vines four times a year at three pounds per vine. In newly transplanted orchards, the application should be 2—4 oz. per plant, with this application repeated six weeks after planting. Many California growers rely upon organic fertilizers such as tankage and blood meal. It is obvious that scarcely any two growers use the same fertilizer mix and program but all seem to produce gratifying results.

Fruit Production

Under favorable conditions passion-fruit vines grow rapidly and will flower and produce fruit within one year to 18 months of having been started from seed.

Flowering occurs in two distinct periods, the first during early spring and the other during early fall. Because of this flowering behavior there is a period of fruit maturity in midsummer and in midwinter. The least number of flowers develop during the short day length of the winter.

Several flowers may be produced along a vine but, even if hand-pollinated, the last may not set fruit. After a certain number of fruits have set along the branch, further fruit setting ceases. Flower setting may resume, for the remainder of the flowering period, when the first-set fruits have begun to mature. This alternating between fruit setting and cessation of setting results in fruit being borne along several sections of the vine, with fruitless spaces between them. Scientists do not yet understand the reason for this fruiting behavior, but believe it related to the plant's physiology.

Although 50% of the development of the fruit takes place 10—11 days after flowers have been pollinated, complete development and maturity of the fruit requires 10—12 weeks so that one often sees buds, flowers and fruit on one plant simultaneously.

While passionfruit vines bear abundantly in California, plants grown in Florida have in some instances failed to produce fruit. The reason for this is not definitely known but is thought to be due to defective pollination.

Pollination

Paul Knuth, in his *Handbook of Flower Pollination* states that the *Passifloraceae* are protrandrous (the anthers shedding their pollen before the stigmas are receptive) and adapted to cross-pollination by bumblebees and hummingbirds.

In describing the pollination of one species of passionfruit, he says: "In the first stage of anthesis, a large insect

when sucking the nectar, receives pollen on its back from the downwardly dehiscent anthers. In the second stage the styles have curved downwards to such an extent that the now-receptive stigmas are lower than the empty anthers. It follows that the older flowers are fertilized by pollen from younger ones."

Passionfruit flowers open and close at definite times of day, *P. edulis* opening in the early morning.

A study was made of the floral movements and pollination of *P. edulis* under the climatic conditions of the central part of the coast of New South Wales. The stigmas were fully receptive from the time of flower opening until early afternoon of the same day. By noon the next day they had completely lost their receptivity.

Anthesis occurred before 1 p.m. on the first day of flower opening in 10% of the flowers and before 4 p.m. in 50% of the flowers.

In Hawaiian studies of pollination in relation to fruit-set problems with *P. edulis* f. *flavicarpa*, fruit set, size of fruit and quantity of juice yield were found to be related to the amount of pollen applied to the stigma. Self-incompatibility and some cross-incompatibility appear to be the chief causes of failure to set fruit. Male sterility seemed to cause a difference in response between reciprocal crosses:

When used as a male parent, there was no fruit set on the subject plant; as a female parent it set fruit with its reciprocal pollinator.

In general, seedlings of the yellow passionfruit appear to be completely self-sterile and cross-pollination between flowers of different vines seems necessary for the setting of fruit.

Field observations indicate that cross-pollination is done mainly by the carpenter bee (*Xylocopa sonorina*), the honeybee (*Apis mellifera*), both of which are nectar feeders, the hover fly (*Eristalis arvorum*) which with the honeybee is a pollen feeder, and hummingbirds.

In Hawaii it was found in an ecology study of the pollinators of passionfruit that the foraging activity of *Apis mellifera* and *Xylocopa sonorina*, the two most important species, was correlated with the time of opening of the flowers.

Akamine and Girolami, working in Hawaii on the yellow passionfruit, showed that fruits from flowers cross-pollinated by hand, are larger and yield more juice than flowers pollinated naturally and that the number of pollen grains placed on the stigma influences the fruit-set percentage, size of fruit, number of matured seeds and juice yield.

Also significant was the finding that ungerminated pollen grains burst on contact with water if the pollen tubes have not grown. This may account for failure in pollination during rain. The period from pollination to maturity is 60–80 days.

Propagation

Passionfruit may be propagated by seeds, cuttings or air layers. Where this fruit is grown for commercial purposes, the usual method is by seeds which are readily available as they are extracted from the pulp during processing. When a particular form or horticultural variety is desired, propagation is by cuttings or air layers.

Seed

This method is fairly easy. Seed selected should be from vines yielding abundantly, with high-quality fruit.

Seeds should be removed from the ripe fruit. They may be planted at once without separation from the pulp, but removing the pulp and washing the seeds may slightly hasten sprouting.

If planting is to be delayed, seeds should be washed, dried at room temperature, and may be stored for three months or more at a temperature of about 55 °F. Temperatures below 55°F tend to delay sprouting. Freezing kills the seeds.

Artificial rapid drying ($\frac{1}{2}$ to 2 hours) at temperatures of 108 °—140°F with forced draft was found in studies to be

harmless to germination if the seeds were planted within a few days after drying.

Seeds artificially dried and then stored at room temperature for two days produced high germination. A drying temperature of over 150°F was found to affect germination adversely.

Drying the seeds by direct exposure to the sun also is harmless, provided the seeds are planted within a few days after drying. However, sun drying should not be used if seeds are to be stored afterward for an extended period.

Seeds should be sown in flats of a light, fertile soil, and shaded. In California this is done in March. If placed in a warm environment, 70°, germination percentage will be high. Electric bottom heat used in the seed bed maintains this temperature. Sprouting begins in 2—3 weeks and maximum germination occurs in 1—3 months. The older the seed, the longer germination takes.

When two true leaves develop, during May and June in California, the seedlings should be planted in pots or polyethylene sleeves and kept in the lath house. They may be planted out in the field at about 3—4 months after sowing, when about 1' tall. Blossoms appear the following May with fruit ripening from mid-July to mid-September. The young vine produces about 10—15 fruits the first year (about one lb.), but production increases thereafter and may come up to 10 pounds per vine. Seedlings show considerable variation in fruit production, color, fragrance, flavor and quantity of juice.

Cuttings

Cuttings from young, newly mature wood with 2—3 internodes, may be rooted in about one month and ready for setting out in 90 days. The most desirable cutting material is that portion of the stem from the first fully expanded mature leaf, back to the area of the fully extended branch. The best period to obtain cutting material is when the vines are actively growing, after the summer and winter crops.

Because of the length of the internodes each cutting should have no more than three nodes — the most desirable number. Thickness should be that of a pencil, about $\frac{3}{4}$ ". The basal part of the cutting should be right at the node and the terminal part should be slightly above the node. The branch should be cut slightly above the first bud. A leaf or portion of a leaf should be left intact on the terminal. The lower two-thirds of the cutting should be buried in the rooting medium.

Although passionfruit cuttings root easily in sand with no bottom heat required, root growth is improved with warmth, high humidity and a moist but porous medium. A good rooting medium can be made from equal parts of porous soil, builder's sand, wood shavings and vermiculite. A glass cover will maintain humidity and warmth.

Air Layering

In air layering, roots form on the aerial portion of the plant where the stem has been girdled or slit at an upward angle. Then that portion is enclosed at the point of injury with a rooting medium which is maintained continuously moist. This procedure is most successful in regions of high humidity.

Air layers are made in the spring on wood of the previous season's growth or in the late summer of partially hardened shoots. Very young stems or old wood should not be used and the completed layer should be supported to prevent the vine from breaking at the layered zone. Care should be exercised not to break the brittle stem. Layers root in 4—8 weeks.

The first step in air layering is to girdle or cut the bark of the stem at a point 6"—12" or more from the tip end of the stem. A strip of bark about 1" wide is completely removed from around the stem to induce adventitious root formation above the cut. It is desirable to scrape the exposed surface to ensure complete removal of the phloem and cambium in order to retard healing.

Another procedure is to make a slanting cut about 2" long up and to the center of the stem, keeping the two surfaces apart by sphagnum moss or a piece of wood. Application of a root-promoting compound, such as indolebutyric acid, to the exposed wound has been beneficial.

About two handfuls of slightly moistened sphagnum moss are placed around the stem to enclose the cut surfaces. Stem tissue may decay if the moisture content of the sphagnum is too high.

An 8"—10" square of polyethylene film is wrapped carefully around the branch to cover the sphagnum moss completely and the ends folded with the fold on the lower side. The two ends must be twisted so that no water can seep in from outside. Electrician's waterproof tape, budding rubbers or florist's ties serve to wrap the ends securely.

The entire air layer should then be supported by tying to a nearby untreated branch or to a stick or cane attached to the parent plant.

The time to remove the layer from the parent plant is best determined by observing root formation through the transparent plastic film.

The rooted layer should be potted into a suitable container and placed under warm, humid conditions. Placing the rooted layers under light mist for several weeks, followed by gradual hardening off, is probably the most satisfactory procedure. Rooted cuttings and air layers should be transferred from the propagation bench to individual containers for hardening off. In transplanting, take care not to injure the delicate roots. When well-established, the plants should be set out in the field.

Container Plants

Rooted cuttings often fruit in pots at the age of two years.

Tubs and pots are very suitable for this vine, since the root restriction causes better flowering. It should be potted in February or March in a 7" pot and kept in a moist, shady atmosphere. The foliage may be misted but the plant itself should be only lightly watered until it has become wellrooted. *Passiflora* can ultimately be kept growing for years in an 18"—24" pot if the topsoil is replaced each spring with fresh compost.

The best potting medium is one that consists of two parts fibrous loam, one part peat moss, one part leaf mold and a good amount of builder's sand for proper drainage.

Planting Sites

In New South Wales passionfruit vines are frequently planted among the trees in some young citrus orchards. As it begins to bear very early, growers are able to make considerably more from the crop than from the citrus until the citrus trees begin to produce a commercial crop, which they do after about the 4th or 5th year. Generally, the passion-fruit vines are most productive before they have attained four or five years of age, after which they begin to lose vigor and gradually cease to be very profitable or die out and are consequently removed.

Planting sites buffeted by high winds should be avoided unless adequate windbreaks are provided before the vines are planted. Winds not only damage the vines, but make it more difficult to train the vines to the trellis.

Spacing

Vines are set out at various distances depending upon the topography or slope and contour of the field but studies in Venezuela indicate that the highest yields are obtained when vines are set 10' apart each way. Actually, the more vines per acre, the closer the spacing in the row, the heavier will be the first-year crop. Then the first pruning will consist of merely removing alternate vines.

Rows should run north and south so that plants may get sunlight from both sides and do not shade one another.

Trellising

Although the passionfruit has been shown to be more productive if allowed to climb a tall tree, trellising is recommended for many reasons.

Large crops are obtained on trellises 7'—8' tall or taller. Such a tall trellis with a wire attached near the top of the posts and two other wires each attached near the ends of cross-bars a foot or more below the top of the posts tends to give the best spread of vines and the greatest convenience of working in the planting but is expensive especially for a short-lived planting.

In rocky or gulch areas it is often possible to use standing trees to guy the trellis wires. In some circumstances heavy cables are stretched between trees to support lighter wires at right angles to the cable. In other locations, rather tall trees have been used and the wires guyed to shorter trees or posts, giving a tent-like appearance. However, a standard trellis has the advantage of giving early returns, greater yield, accessibility for fertilization and harvesting; also more leaf surface can be exposed to the light.

In constructing the standard trellis, it is desirable to use at least eight or nine gauge heavy wire. To withstand the weight of the vine and tension on the wire, the wire should be placed on top of the cross-arm or post and stapled securely or holes drilled through the cross-arm and post and the wire strung through the holes. It is then possible to adjust the tension of the wires which is not possible when wires are stapled.

If a wide spacing of 20' or more is used between posts, the cross-arms must be mortised into and securely nailed or bolted to the post. Greatest strength and stability, with very little loss of surface, are attained when the wires are tied directly to the end post, rather than securing the wires to a cross-arm on the end or strainer post.

With the yoke trellis, the cross-member at the end of the trellis should be sufficiently sturdy to support the strain that will be placed on it. A 20' length of trellis 3' wide is required to support a minimum weight of 300 lbs. of vine and fruit.

The posts should be about 10' long, the end posts at least 3' in the ground and firmly braced to support wire tension and vine weight. Inside posts need not be planted so deeply.

A vine offers considerable wind resistance after having become established on a trellis so this must be securely constructed to prevent both vine and trellis from being blown over by a strong wind.

Posts may be almost any material adequate for supplying strength for five or more years and may be 10" butts for

anchor posts, 6" butts for internal posts and 2" x 4" or more for cross-arms.

All wooden posts must be treated to prevent decay, especially the portions in contact with soil. Creosote, which is toxic to plants, should not be used. Copper naphthenate may be brushed onto the wood in two applications about 30—40 minutes apart, then the wood permitted to dry completely.

Training

Some kind of temporary support at each plant is necessary to train it to get a good hold on the wires of the trellis, after which it takes care of itself and needs no other support. The principal objective is to get the vine to the trellis wires in the simplest, quickest and least expensive manner.

If the young vine is supported in an upright position, with a strong wire or light pole to grasp, it usually will grow quickly to the trellis wire with a minimum of lateral branching. A terminal branched portion of bamboo, inverted and hung over the trellis wire, provides an excellent support for the vine and eliminates the necessity for frequent tying.

Four to six laterals may be trained in both directions onto the overhead wire, and the sooner they come to a horizontal position on the trellis the more quickly they will flower and fruit.

Pruning

Generally, pruning is done while the vine is dormant and consists of removing any growth that is weak or trailing on the ground, and shortening strong canes by about one-third. Regular pruning is necessary because the fruit is borne on new shoots arising from old canes. This pruning encourages new growth and removes unproductive wood.

A spur should be left at the base of each cane to replace the old cane after it has borne fruit for a year or two. This pruning is done when the vine begins active spring growth. Vigorous vines branch freely and branches that trail on the ground should be removed.

Severed stems and pruned branches should be allowed to become dry and brittle so that they can be disentangled easily from the vine.

In Australia and New Zealand, purple passionfruit vines in commercial plantings usually are pruned to facilitate spraying or to force new growth.

In South Africa, they are pruned to maintain an environment which discourages infestation and encourages healthy growth, and to facilitate cultural practices. However, unpruned vines of purple and yellow passionfruit have been shown to consistently out-yield those which have been pruned.

The evidence on pruning is conflicting. Although in the literature there are frequent admonitions against severe pruning, some growers do practice severe pruning of established vines in spring, cutting each shoot of the preceding year back to a stub with 2—4 or 5 buds to start all new shoots close to the wires. Others merely cut out the shoots that trail to the ground and thin out shoots where they become thick enough to lodge abscised mature fruit. This method is better suited to plantings where the fruit is permitted to fall for harvest.

In Ceylon, pruning all shoots to stubs with two or three nodes in the fall months of January or February, soon after the crop was off, was reported to cause heavier yield than any less severe pruning or no pruning at all.

On the other hand, in some experiments in South Africa, certain types of pruning seemed to reduce yield. Possibly in Ceylon, where fruit-setting tends not to be very good, the severe pruning caused some of the shoot growth and flowering to be in seasons more favorable for setting.

In Hawaii it has not been determined whether or not the commercial yellow passionfruit requires periodic pruning. For short-lived plants trellising and pruning are expensive, as is the rather long harvesting period with rather frequent gathering of fallen fruit.

Insect Pests

Beneficial insects as pollinators have already been discussed. There are also harmful insects associated with passion-fruit. This entails solving the problem of eliminating the injurious insects without destroying the beneficial insects.

One approach to this problem is through the proper timing of spray applications. The flower of the commercially grown yellow passionfruit opens during the afternoon hours and closes at night. Observations have shown that insect pollinators are most active during the period when the flowers are in bloom. Therefore, less damage to the pollinating insects might result if spray applications were confined to the early morning hours when pollinators are inactive.

Also, since exposed pollen grains burst upon contact with water, becoming non-functional, it is imperative that any spraying for insect or disease control be done only when the flowers are closed but preferably when the plants are not flowering at all.

Fruit Flies

The most troublesome pests are fruit flies:

Oriental fruit fly (*Dacus dorsalis*)

Melon fly (*Dacus cucurbitae*)

Mediterranean fruit fly (*Ceratitis capitata*)

Generally, the Mediterranean fruit fly is found at high elevations. The Oriental and the melon flies seem to prefer lowlands.

Fruit flies usually puncture the immature passionfruit while the rind is still tender. A woody area develops around the puncture as the fruit enlarges. If the fruit is undeveloped at the time of puncture, damage may be sufficient to cause it to shrivel and drop off. If the fruit is well-developed, it may grow to maturity.

At the time of ripening, the area around the puncture has the appearance of a small woody crater which, while it does not impair juice quality, does disfigure the fruit. The oviposition scars on ripening fruits generally do not contain living larvae, which seem to develop better in immature than in mature fruit.

The main objective in fruit fly control is to destroy the gravid females which usually breed elsewhere but lay eggs in the orchard. An important step, then, is to eliminate nearby overripe fruits on which the adults feed and breed.

Fruit fly adults may be destroyed with various insecticides. One is Malathion, which is sprayed at three pounds of a 25% wettable powder per 100 gallons of water. Absolute caution should be exercised in making applications and every precaution taken to do so as safely as possible.

Fruit fly adults may be destroyed also by use of bait sprays made with 3 lbs. of Malathion and 1 lb. of yeast hydrolysate per 100 gallons of water.

Because the adult fruit flies roost on plants that are not necessarily host or crop plants, applications should be made not only on the passionfruit vines but on all nearby vegetation which might harbor the flies.

Frequency of application depends on the population. When adults are numerous, applications twice weekly may be necessary when young fruit is present.

Above all, it is helpful to contact the **USDA** representative in your area for advice and assistance. (See also following section on biological controls.)

Mites

Several mites are also serious pests:

Spider mites (*Brevipalpus phoenicis*); *Tetranychus telari us*;

the broad mite (*Hemitarsonemus latus*).

Mites are generally most damaging in areas of low rainfall and during prolonged dry seasons.

Presence of the spider mite is indicated by scattered reddish patches on the lower surface of the leaf, along the midrib and veins, as well as on the surface of the fruit.

Spider mites cause shriveling, yellowing, premature leaf fall and sometimes complete defoliation. A heavy infestation might also cause vine dieback and shriveling and dropping of immature fruit.

Indications of the presence of the broad mite requires a lens for detection. The very minute female white mites can be seen often carrying the smaller males on their posterior ends. Under the lens, eggs with white markings may also be seen sticking to the leaf surface.

An attack by the broad mite can most readily be detected by the symptoms of injury during the period of vine growth since this mite attacks the young terminal leaves, causing them to be stunted, deformed, slender and rugose.

Mites on passionfruit can be effectively controlled with a sulfur spray containing 5—6 pounds of wettable material for 100 gallons of water. Monthly applications serve as a precautionary measure.

Aphids

Severe damage by aphids usually results from their attacks on young plants. Two aphids, *Myzus persicae* and *Macrosiphum solanifolii* are efficient vectors of the passionfruit woodiness virus. These aphids are present in Hawaii but the virus is not.

Woodiness disease has been identified in Australia as cucumber mosaic virus 1. It is thought to be transmitted by aphids and is the most serious threat to the purple passionfruit in Australia and Kenya. Much research has been devoted to combating it.

In this disease, the leaves become leathery and malformed; the fruits gradually decrease in size and the rind becomes thick and hard and little pulp is produced.

Other Pests

The barnacle scale (*Ceroplastes cistudiformis*) has been found in large numbers attacking the passionfruit vine. Heavy infestation results in severe defoliation.

In Florida the stinkbug (*Chondrocerca laticornis*) punctures the yellow passionfruit but only the appearance of the fruit seems to be affected.

Although severe attacks appear to be exceedingly rare, the thrip, *Selenothrip rubrocinctus*, has been observed to attack passionfruit leaves.

The passion vine leaf hopper (*Scolypopa australis*) requires protective measures in Queensland, Australia.

In California, this past season, caterpillars have been destructive of the passionfruit plants, especially attacking new leaf growth.

Since the writer prefers not to use sprays, the recommendation is to hand-pick the caterpillars off the plants or to use biological controls.

Biological Controls

Ladybird beetles or Ladybugs (*Rodolia cardinalis* and *Hiippodamia convergens*) and Praying Mantises (*Mantis religiosa* and *Paratenodera sinensis*) are among the most beneficial insects known to man. They devour many times their own weight in destructive pests.

Ladybugs consume aphids, fruit scales, tree lice, mealybugs, leaf hoppers, thrips, fleas and the eggs and larvae of many plant-destructive insects.

When young, Praying Mantises devour aphids, flies and other small insects. When larger, they consume enormous quantities of beetles, caterpillars, grasshoppers and other damaging insects.

Ladybugs and Praying Mantis egg cases may be purchased from W Atlee Burpee and other nursery products suppliers.

The most startling breakthrough in biological controls is evidence found by a team of Penn State chemical ecologists that *plants control mating in insects*. This contradicts the current theory that female insects manufacture their own sex lures and that each male will respond to a single attractant unique to its species.

Dr. Laurence B. Hendry and his coworkers at Penn State University discovered that the attractants originate in the plants on which the insects feed. He believes the female simply stores the attractants, called pheromones, not changing them in any way. He has found the attractants in plants in concentrations corresponding to the amounts found in females. He also has evidence that males of a single species can be sensitive to as many as 20 different chemicals, depending on their diet.

Dr. Hendry theorizes that the insect is imprinted or programmed, while still in the larval stage, to respond to whatever pheromone is present in its earliest food. Therefore the male and female insects which feed on the same plants as larvae will be imprinted with the same attractant and mate as adults.

Thus, pest-control programs based on sex lures may be the most effective; a field may be sprayed with an inexpensive compound which insect larvae would eat and imprint. Later the same chemical could be used as a sex lure to confuse the males and prevent mating.

This revolutionary discovery, that insects take compounds from plants for their reproductive purposes, may also alter insect classification. What previously were thought to be different species, because they were attracted to different pheromones, may turn out to be only a single species feeding on different kinds of plants. Theories of insect evolution, based on the idea that insects from different species will not mate also will be affected. Researchers who have made noteworthy discoveries regarding the use of biological methods of pest and disease control include:

The State University of New York's College of Environmental Science and Forestry at Syracuse; U.S. Forest

Service Station in Delaware, Ohio; University of Missouri scientists who have discovered a remarkable hibernation-controlling hormone in insects; Orono, Maine Research Station; Texas A&M; North Dakota State University; University of Arizona Extension Service; Delaware Extension Service; University of Florida's Agricultural Research and Education Center at Lake Alfred; Division of Biological Control, U.C. Berkeley; Colorado Agriculture Dept., which for the second year is shipping thousands of *Macrocentrus* wasps to the Soviet Union to destroy Oriental fruit fly there.

For further information addresses of the forementioned may be obtained from your Agricultural Advisor, the public library, or from Organic Gardening and Farming, Organic Park, Emmaus, Pennsylvania 18049.

Integrated Control

At U.C. Berkeley, a program of integrated control is being studied under which all of these - natural enemies, cultural practices, resistant-crop varieties, microbial agents, genetic manipulation, messenger chemicals, selective chemical controls such as green soap and water, and even pesticides – become mutually augmentative, rather than individually exclusive.

California's system of pest control is locked to chemical pesticides and it follows that this state also leads in pesticide pollution, dumping hundreds of tons of unneeded pesticides into the environment and costing Californians about \$35 million every year. Other states, and most other nations, generally follow the same pattern of chemical pest control.

Dr. Robert van den Bosch, chairman of the Division of Biological Control, College of Natural Resources, U.C. Berkeley, has done extensive research and can supply further information on this subject.

Diseases

The most serious diseases of the passionfruit are brown spot, root rot and nematodes. Brown spot, caused by the fungus *Alternaria passiflorae* in warm weather, is easily recognized. On the leaf, the first symptoms are minute reddish-brown spots about 1/16 to 1/4" in diameter which, under the humid conditions required for its development, have a water-soaked margin.

Spores or conidia produced by the fungi are readily spread by the wind and germinate on leaf and fruit surfaces, causing the telltale brown spots.

As infection progresses, the spots enlarge, forming a series of concentric rings with premature leafdrop. Symptoms on the fruit are characterized by circular, sunken necrotic areas, about 1/2"– 2" diameter, which, as on the leaves, are reddish-brown. Infection occurs on half-grown to nearly mature fruit but apparently does not impair juice quality. However, it is objectionable from the processing standpoint because the brittle, necrotic rind tissues drop into the juice during extraction.

In Florida and Hawaii, brown spot can be controlled by Daconil 2787(75% WP) or Maneb (80% WP) at the rate of 2 lbs. per 100 gallons of water applied biweekly or Captan, Zineb or copper fungicide.

However, in the writer's opinion, since this is a disease caused by moist conditions, growers probably can minimize fruit damage by picking up the fruit before it can be damaged by fungal spores on the damp soil.

Root rot, the second most serious disease of the passionfruit, is caused by the fungi *Pythium splendens* and *P. aphanidermatum* in Hawaii. In South Africa the fungus has been identified as being of the *Phytophthora* genus.

Symptoms are a general decline in vigor as feeder roots are destroyed by the fungus. Some California vines show these symptoms. *Passiflora edulis*, the purple passionfruit, is highly susceptible to root-knot nematode attacks. Symptoms are severe stunting of the vine which may eventually die. *P. edulis* f. *flavicarpa* seems not to be affected by this disease and is resistant as well to woodiness disease and Fusarium wilt. It is being used in many countries as rootstock for the purple passionfruit.

However, it is evident that maintenance of vigorous, healthy plants by *consistently* good fertilization and cultural practices will reduce or eliminate disease or minimize their effects.

The Commercial Aspect

Only the purple passionfruit (*P. edulis*) and the yellow passionfruit (*P. edulis* f. *flavicarpa*) have been considered, thus far, of value for commercial planting.

The purple passionfruit has been used almost exclusively in commercial production in Australia, New Zealand, South Africa and other countries; the yellow is preferred in Hawaii.

The chief feature about the passion vine is its habit of producing two crops per annum. The summer crop comes in about mid-July to mid-September in California with prices necessarily lower since there is a superabundance of other fruits. The winter crop is ready for picking when other fruits are not so plentiful on the market. The practice of the growers in Australia has been to secure a heavy winter crop by pruning away the summer crop when it is about half-grown in mid- to late spring. This stimulates the vines to throw out fresh fruiting laterals for the winter when prices are higher.

Commercially, passionfruit is grown more extensively in Hawaii than elsewhere and is cultivated especially for its acidic juice. The yellow passionfruit plants are said to be more vigorous than the purple. However, the yellow are more frost-tender and self-sterile; hand-pollination of this form is often needed.

In harvesting commercial groves, the fruit is permitted to fall and is picked up frequently enough to avoid spoilage. The rind is so tough, that for delivery to the processing plant, it can be raked into piles and picked up with a fork, if none of the fruit has been on the ground long enough for bad flavors to penetrate.

If not being processed for juice, syrups or jellies, the fruit to be sold fresh is marketed weekly. Color, shape and size are considered in grading fruit, with any badly colored fruits sorted out and packed separately.

Uses

In many tropical countries, passion-fruit is a popular item on the menu.

As an addition to a fruit salad, there is no flavor that can surpass it and when eaten fresh with cream, it is said to rival the most delicious of strawberries.

It is used in jellies, refreshing drinks, juices, sherbets, confections and trifles.

The plant is used medicinally in most countries where it is grown.

In the West Indies, Mexico and South America and in Indonesia the passion-fruit root has been used as an emetic and diuretic. In Indonesia also, the leaf is used as a vermifuge and an emetic.

In Italy, the plant is used as an antispasmodic and sedative.

In Mauritius, a tincture and an extract of the plant are used as a remedy for insomnia and to counter the nervous manifestations of menopause.

In Brazil, pulp of the fruit is used as a digestive stimulant and tonic.

In Madeira, the fruit is used as a remedy for gastric carcinoma.

The leaf is reported to have given positive antibiotic readings.

Analysis of Contents

The fruit and its pulp, as well as the shell, have been the subject of chemical analysis, the striking thing being the relatively high mineral content.

The dry pulp, in percentages, yields the following:

*Ash 2.43%
Protein 9.9%
Fat 7.0%
Fiber 26.0%
**Acids 9.5%
Reducing sugars 25.5%

Non-reducing sugars ... 5.4%

***Starch 14.3%

*The dry pulp yields **2.43%**ash; the shell yields 8.820/0 ash; the whole fruit yields **4.76%**ash.

The total acids assay **93%~96% citric acid and **4%~7%** malic acid.

***The fruit starch is almost pure amylopectin and it has assayed as high as **20%** from the rind calculated on a dry basis.

The rind is a very good source of high quality pectin, an excellent jellying agent, which probably accounts for the rapid thickening of the fruit juice in concentration.

The seed yields 18% of a fixed oil which has been the subject of considerable study.

The yellow passionfruit is superior to the purple as a source of Vitamin A and the reverse is true with respect to Vitamin C.

Analysis of the fruit per 100 grams shows the following contents:

Moisture 78.4 gm
Nitrogen 0.131 mg
Carotene 0.013 mg
Fiber 4.5 gm
Ash 0.51 mg
Thiamine 0.037 mg
Calcium 15.1 mg
Riboflavin 0.032 mg
Calories 23
Phosphorus 22.5 mg

Niacin 0.800 mg
Iron 1.39 mg
Ascorbic Acid 43.0 mg

Hybridization and Varieties

In most countries where passionfruit is grown commercially, some variety selection has been undertaken, although commercial plantings generally are based upon seedling progenies of individual vines which have been selected according to yield, disease-resistance and hardiness.

Seedlings of the hybrid types are within broad limits, with many of them possessing the delicious flavor of the purple passionfruit and approaching the qualities of large fruit size and productivity of the yellow passionfruit.

In Hawaii, there has been discovered what seems to be a natural hybrid between *Passiflora edulis* and *P. edulis* forma *flavicarpa*.

In Queensland, Australia, the cross has been made artificially to combine the most desirable qualities of both parents.

While most, if not all, Californians who grow passionfruit have raised these from seedlings, much thought is being given to developing hybrids and selecting varieties especially where this fruit is being or may be grown for commercial purposes. As a matter of fact, *Passiflora edulis* forma *flavicarpa* in many areas was selected over *P. edulis* for the former's wilt- and nematode-resistance and has been adopted as a rootstock. The chief problem with *P. edulis* f. *flavicarpa*, however, is its inability to withstand frost.

In several countries investigations are being conducted as to the potential for hybrids between the purple and yellow passionfruit and first-generation selections are being made. In the U.S., in Florida, some vegetatively propagated hybrids of the cross have proven to be vigorous, long-flowering, long-fruiting, *Phytophthora-resistant* and self-sterile, producing large, oval, claret-colored fruit with more seeds than the female parent and juice and pulp of intermediate flavor.

In Australia, New Zealand and South Africa, demand is for the fresh fruit and in these places investigations are focused on the purple passionfruit, whose flavor is better than the yellow. In Hawaii, the vigorous, more productive yellow passionfruit is the focus of research because all of the crop of this more acid form of passionfruit is processed for juice and jelly.

In Australia, first-generation *P. Edulis* x *P. edulis* forma *flavicarpa*, used as the female parent, was successfully crossed with *P. caerulea* and *P. incarnata* and produced a fertile hybrid.

Australian scientists also have developed two purple-fruited hybrids, 3-1 and 3-26, which show tolerance of or resistance to diseases and pests. They are higher yielding than the common purple variety. Hybrid 3-1 is known as Redlands Triangular or Three-Cornered and has dark-skinned fruit. Hybrid 3-26 is known as Redlands Pink and produces high yields of fruit which are well-filled with pulp. Its fruits are sweeter than those of 3-1 having a lower acid content. When grown on *P. edulis* forma *flavicarpa* rootstocks, both hybrids exhibit resistance to *Fusarium oxysporum* f. *passiflorae*, tolerant of the woodiness virus.

Third-generation selections of *P. edulis* x *P. edulis* f. *flavicarpa* were reported by the Queensland Department of Culture and Stock to be high-yielding, consistent in

bearing, with good pulp quality and sufficient resistance to *Fusarium* wilt for commercial purposes. Some of the selections bear the main crop in winter when markets are under-supplied and others in summer, with a third group intermediate in cropping habit. Some selections, unlike commercial *P. edulis*, mature normal, sound fruit even when vines show acute symptoms of virus disease woodiness.

Hawaii Experiment Station researchers have selected six clonal *P. edulis* f. *flavicarpa* and *P. edulis* x *flavicarpa* segregates, four of which showed significant levels of tolerance to brown spot *Alternaria* spp., as measured by the average percentage of marketable fruits. This was more than 75% in three of the clones.

Studies in Hawaii on the mode of inheritance of *Fusarium* wilt disease indicated the possession of a simple dominant gene for resistance. Purple tendril was dominant over green. Fruit skin color appeared to be controlled by a single pair of genes with no dominance. Three color types were recovered among the second generation hybrids of *P. edulis* f. *flavicarpa* and *P. edulis*.

Selection in Hawaii also is for plants that produce fruits with more juice. Fruits of some selections at the Hawaii Agricultural Experiment Station yield as high as 40% of high-quality juice. The 60% —75% of pulp left after the juice is extracted is being studied for use as animal food after dehydration.

The Federal Experiment Station of the **USDA** in Mayaguez, Puerto Rico is also researching first-generation hybrids of edible passionfruit species. Six new hybrids, produced by cross-pollination among 42 combinations of seven species, were found to be vigorous and intermediate between parent species in foliage, flower and fruit characteristics, although unique characteristics also were found. The six hybrids varied in flowering tendencies, pollen sterility, ability to be selfed and back-crossed, female fertility and seed production. A hybrid of *P. edulis* f. *flavicarpa* x *P. alata* produced a fruit superior to those of the parent species.

Netherlands agricultural scientists recognize 20 indigenous *Passiflora* species in the Old World. W.J.J.O. de Wilde presents a key for their identification and describes the species and their distribution. He also proposes one new subspecific combination and one new species.

Nelspruit researchers in South Africa are studying passionfruit hybrids, the properties and characteristics of specific parents, cross-pollination between the purple and the yellow granadilla and grafting for propagation of desirable qualities.

Passiflora seems at the stage of development where all the growers are ready to take advantage of the research which has been done in hybridization and variety selection.

We in the California Rare Fruit Growers can do this as well, and fulfill the purposes of our organization by growing the various kinds of passionfruit, keeping records and sharing our information.