

**Farm and Forestry
Production and Marketing Profile for**

Vanilla

(Vanilla planifolia)

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USES AND PRODUCTS

The highly aromatic, cured pod (or “bean”) of the vanilla orchid (*Vanilla planifolia*) is the primary product. Vanilla owes its properties to vanillin, a compound that is formed during pod maturation and in the curing process. Vanillin is believed to be one of most popular scents in the world. Natural vanillin is expensive by weight, but when used as a flavoring it is affordable.

Vanilla is used extensively to flavor ice cream, chocolate, beverages, candies, cakes, puddings, custards, and many other confections. In Hawai‘i, chefs add it to seafood dishes and other non-dessert dishes. Commercial products include:

- Whole cured vanilla beans
- Extractions (usually in a minimum 35% alcohol)
- Powder of ground, cured beans
- Paste (minimum 12.5% ground cured beans with sugar syrup, starch, or other ingredients)
- Seeds

As an aromatic, vanilla is included in products such as perfumes, cosmetics, lotions, detergents, fabric softeners, air fresheners, aroma therapy, and many others. It is also widely used in rubber manufacture and in the fabrication of other items with unpleasant odors.

While the traditions surrounding vanilla are filled with references of the ritualistic and healing powers of this spice, there are few well documented studies to verify these characteristics. Recently, some evidence of anticarcinogenic (interference with cancer formation) and anticlastogenic (promotion of chromosome repair) activity of vanillin has

been found. The anticlastogenic effect of vanillin has been documented in the protection that it provides to cells that are exposed to ultraviolet (UV) radiation and X-rays. When vanillin was added to cell cultures, mutation was significantly reduced following exposure to radiation. This study clearly provides evidence that there are antimutagenic properties of vanillin.

In addition, there is evidence that vanillin has strong antimicrobial properties (Bythrow 2005). This may open doors for the use of vanillin as a natural food preservative. Whether synthetic vanillin can be used in this way needs to be tested.

SCALE OF COMMERCIAL PRODUCTION

Lubinsky et al. (2008) estimates that 5,000–10,000 metric tons (MT) of vanilla beans are produced annually with about 95% derived from *V. planifolia*. In 2006, Madagascar and Indonesia accounted for about 81% of the vanilla produced worldwide. Tonga produced 144 MT and French Polynesia (Tahiti) produced 50 MT (Lubinsky et al. 2008). The U.S. is the largest importing country.

The scale of annual worldwide commercial production varies greatly with the weather conditions in the Indian Ocean and in Indonesia. Political turmoil can also affect production. When the weather is poor, such as with strong hurricanes, or following other natural disasters such as earthquakes, the production in Madagascar and Indonesia is greatly affected. The world supply crashes and prices increase.



Left: Beans in the process of curing to develop optimum flavors and aroma. Right: Well labeled bottles of extract (foreground) and vials of single beans (background).



Left: *Vanilla tahitensis* has smaller and more pointed leaves compared with *V. planifolia*. Middle: *V. planifolia* growing on physic nut (*Jatropha curcas*). Right: Two clusters of *V. planifolia* buds, one with two open flowers.

BOTANICAL DESCRIPTION

Preferred scientific name

Vanilla planifolia Jacks.

Family

Orchidaceae

Subfamily

Vanilloideae

Non-preferred scientific names

Vanilla fragrans Salisb.

Common names

English: vanilla, “Bourdon” vanilla, “Madagascar-Bourbon” vanilla, and “Mexican” vanilla (Lubinsky et al. 2008)

French Polynesian: *tumu vanira*

French: *vanille*, *gousse de vanille* (idiom)

German: *vanille*, *vanilleschote* (idiom)

Italian: *vaniglia*, *baccello di vaniglia* (idiom)

Portuguese: *baunilha*, *fava da baunilha* (idiom)

Spanish: *vainilla*, *mantecado*, *vaina de la vainilla* (idiom)

Related species

Over 100 species of *Vanilla* are reported (Bory et al. 2008). Most of the cultivated vanilla is *Vanilla planifolia* although lesser amounts of *Vanilla tahitensis* and *Vanilla pompona* are also grown. *Vanilla tahitensis* is known as “Tahitian” vanilla and *V. pompona* produces “West Indian” vanilla. Other species have importance to the vanilla industry, as some may have characteristics that could provide viral or fungal disease resistance, higher productivity, or increased vine strength.

BRIEF BOTANICAL DESCRIPTION

The vanilla plant is a fleshy vine, which produces elongate leaves and aerial roots at the nodes. The vine or stem is green and also photosynthesizes along with the leaf. One or two aerial roots are formed at each node, enabling the plant to take up water and nutrients and allowing the vine to climb on supporting trees or other structures. Healthy vines grow for many years and can reach lengths of more than 60 m. In nature, vines grow far into the canopy of trees. Flowers are formed on short branches or racemes, with few to many flowers per cluster. The flowers are about 6 cm to 8 cm in length, wavy, pale yellowish green to green with three sepals and two petals that are pale yellowish green to green and with a third petal that is modified into the lip. The lip surrounds the column, which bears the pollen masses (pollinia) and the sticky stigma. Pollination requires the pollinia to be placed on the sticky stigma. The fruit is a long capsule, which is known as a “bean” and when mature contains thousands of tiny black, round seeds.

DISTRIBUTION

Native range

For years there has been high interest in the origins of the vanilla that is grown in many parts of the world. In recent chromosome and DNA studies, plants collected from commercial operations throughout the world (Mexico, Central America, Caribbean, South America, Madagascar, and Indonesia) were discovered to be very similar genetically. These studies showed that cultivated vanilla from different parts of the world were all *V. planifolia*. Within Mexico and the Papantla region, there is a greater variation in the *Vanilla* genus, and since genetic variation is typically greater

at locations closer to the origin of a species, this region is considered the center of origin of all cultivated *V. planifolia*. Researchers believe that *V. planifolia* originated from the Papantla region of Mexico and cuttings were taken to other parts of the world such as Madagascar (Lubinsky et al. 2008). The relationship between *V. planifolia* and *V. tahitensis* has been investigated. In some older literature, *V. tahitensis* is believed to be a hybrid of *V. planifolia* and *V. pompona*. Currently, the combined results of several molecular analyses such as UPGMA (Unweighted Pair Group Method with Arithmetic mean) clustering reveals that *V. planifolia* and *V. tahitensis* specimens are more closely related to each other than to *V. pompona* (Besse et al. 2004). Similar results were obtained by microsatellite markers (Bory et al. 2008), RAPD (Random Amplification of Polymorphic DNA), and ISSR (Inter Simple Sequence Repeat) also support this finding.

Current distribution worldwide

Vanilla is grown pantropically in Mexico, Central America (Costa Rica, Guatemala, Belize), the Caribbean (Jamaica, Trinidad, Tobago, Puerto Rico), South America (Ecuador, Brazil, Paraguay), Africa, India, Madagascar, Reunion Isles, Mauritius, Seychelles, Southeast Asia, the Pacific region (Indonesia, Vanuatu, Fiji, Niue, Tonga, Cook Islands, Samoa, French Polynesia, Hawai'i), and in other countries (Lubinsky et al. 2008). *V. pompona* is grown in Paraguay and in the Philippines, while *V. tahitensis* is primarily grown in French Polynesia.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Warm tropical climates are ideal, with annual rainfall of 1,500–2,500 mm per year. A prolonged period of drought, or low temperatures (<14°C) for more than a few days can negatively impact production. A shady growing environment is required. Many tropical forests and agroforest environments will support the growth of vanilla vines.

Climate

Elevation range

Sea level to about 1500 m

Mean annual rainfall

1500–3000 mm evenly distributed throughout the year. Irrigation is necessary during dry seasons, especially for young vines.

Rainfall pattern

Rainfall patterns vary among regions. In Hawai'i, spring and summer rains allow for good growth, with less water needed during the fall, which stimulates flower production. The dry season (less than 50 mm of rainfall per month) should not

be longer than 2 months. For vegetative growth, a brief daily shower or a weekly soaking rain with temperatures in the 24–28°C range is ideal.

Temperature

Mean annual temperature should be 21–32°C, although the vines will tolerate short periods below 14°C (night) and above 32°C.

Soils

In the forest or field, vanilla grows in well drained, loose organic matter. Vanilla plants do not tolerate standing, stagnant, or waterlogged or compacted soils.

PROPAGATION AND PLANTING

Propagation

Vanilla is usually propagated from stem cuttings. The size of the cuttings is dependent upon the amount of plant material that is available. Each node will make a new plant but generally at least two or four nodes are used per cutting. The cuttings are planted in containers kept in a moist, shady environment. New shoots grow from the nodes in 2–3 months. Establishment is faster for longer cuttings. If 2–3 m vine sections are used, plants will flower in less than 2 years.

Long cuttings can be planted directly in the field, as long as moderate shade is available. The roots at the severed end are buried in mulch at the base of a support post or tree. Twine is used to hold the roots and vine on the support. Some nurseries offer long cuttings for establishment of new fields, but these are usually expensive.

Freshly harvested fruits or beans have seeds that are viable. Like most orchids however, these seeds must be planted in agar and nurtured for many months before tiny plants are formed. Establishment of these plants from agar to pot culture can be difficult and takes 6 years or more before vines are large enough for fruit production.

Vanilla plants are also propagated commercially via tissue culture, which has the advantage of producing material that is disease free.

Planting

After new shoots have grown to 30–60 cm, the plants can be transplanted to the field or greenhouse. The plants must be kept moist and fertilized at least once a month with a balanced granular N-P-K fertilizer (10-10-10). Plants provided with water can grow rapidly in temperatures of 23–27°C. At lower temperatures (15–22°C), growth will be slower. Moderate rainfall occurring throughout the year for the first 1.5–2 years will help cuttings to establish and thrive. New growth is regularly secured to the support and kept at a convenient height for hand pollination.



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Top left: It is essential to propagate vanilla only from disease-free cuttings. Top right: Tom Kadooka, a pioneer in commercial vanilla cultivation in Hawai'i, shows his propagation benches in Kainaliu, Hawai'i. Middle left: Six-month-old vines. Middle right and bottom left: Progression of vine growth on wood supports in containers. Bottom right: Healthy vines growing on untreated wood poles under shade cloth in other commercial operations.

Organic amendments

Organic matter can be used directly as a growth medium (e.g., coconut husk, banana trunk) or composted (e.g., leaves, twigs, grass trimmings, food waste). Vermicompost (worm compost) can also be a valuable addition to fertility maintenance.

Fertilization

Fertilizer rates depend on the environment. Plant growth should be kept vigorous and leaves a uniform green. Granular N-P-K fertilizer (10-10-10) is often added once per month or a slow release formulation every 3 months. If available, fish emulsion or foliar fertilizer can be applied every 2 weeks. Foliar fertilizers feed the aerial sections of the vine, which is especially beneficial for long vines on supports.

Flowering and fruiting

Flowers form on mature vines after at least 2 years of growth. Flower initiation can be the most difficult part of growing vanilla. Continuous watering and fertilization will keep the plant growing vegetatively without flower formation. Some experimentation may be needed by growers in new environments. In rain-fed outdoor cultivation, a dry period of 1–2 months will initiate flower production. In container culture, growers can reduce water and eliminate fertilizer for 1–2 months during the autumn period (October–December in

Hawai'i). Flowers are initiated and racemes will form 1–2 months later.

A *Melipona* bee is the only insect known to pollinate vanilla flowers in Mexico. In Hawai'i and other areas of the Pacific where *Melipona* are absent, a few beans sometimes form on vines high in trees, suggesting that other insects or organisms also pollinate vanilla flowers, but at a very low rate. For commercial production, flowers must be hand pollinated, preferably in the morning just after the flower opens.

Pollination tips

1. Find the anther with the pollen sacs. Remove the two pollen sacs using a toothpick, small bamboo stick, directly on a fingertip, or another convenient means.
2. Move the rostellum away and place the pollen sac gently on the stigma. The pollen sac will adhere to the stigma.
3. The pollen grains germinate and carry the male nucleus to the female egg nucleus in the ovary. The fertilized ovary becomes the seedpod or vanilla bean.

CULTIVATION

Prepare holes or pits 30–45 cm wide and 60 cm deep. Keep the holes at least 20–30 cm away from the base of support trees. Place a layer of volcanic cinder or rock on the bottom of the hole and fill with loose clay loam soil, organic matter, and compost. The top layer of most forest soils is ideal. Poles



Left: Hand pollination is necessary for production of beans. Right: A bean forms soon after successful pollination.

and other support structures should be surrounded with humus and mulch. However, when using support trees, keep the mulch closer to the vanilla vine and not around support trees. Roots do not penetrate deep into the soil but at least 30–45 cm of sandy clay loam is recommended. As the plant grows, the addition of mulch such as coconut leaves and husks, and other leaves and small twigs at the base of the plants is valuable.

For greenhouse cultivation, the use of well drained, high organic matter potting mixes is recommended. Some growers use commercial potting mixes based on peat or coconut husk (salt free). The field or greenhouse should provide good drainage, even after prolonged rains.

In cultivation, vines must be kept within reach to allow the farmer to hand pollinate the flowers and harvest pods. Thus vines must be kept low for ease of management.

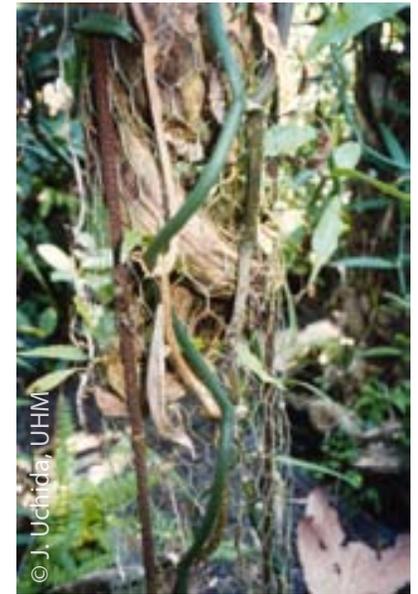
Basic crop management within greenhouses

In many countries, vanilla cultivation has moved from the forest into covered greenhouse structures. A structure with 50–70% shade cloth is commonly used. Irrigation is often necessary for optimal growth and to control flowering. Within the greenhouse, the ground should be kept free from weeds and algae with a synthetic weed mat or a thick layer of sand or gravel.

Planting methods

These methods are applicable to both greenhouses and under living trellis trees.

- Large containers. The containers are filled with an appropriate potting or compost mix. The vines are trained onto a supporting pole. If one vine becomes diseased, the vine can be removed together with the growth medium, allowing for relatively easy sanitation.
- Raised beds. Using lumber or concrete for sidewalls, beds are built about 35–50 cm deep. The beds are filled 20 cm deep with clean rocks or gravel. Plastic piping can be inserted in the medium for vine support. Plants are spaced at least 90 cm apart.
- Cylinders. Cylinders about 8–11 cm in diameter and 2 m tall are fashioned with a wide-mesh wire fence material (e.g., “chicken wire”) and filled with coconut husk and other large pieces of organic matter. Metal bars set in the ground or concrete foundation hold the cylinder vertical. The vanilla vines grow in the organic materials within the cylinder.



Left: Vanilla grown in cylinders. Right: Close up of a cylinder.

VALUE-ADDED PROCESSING

In some environments, beans are ready for harvest 7 months after pollination but usually require 8–9 months, with more time required in cooler environments. Beans should be checked daily and as soon as part of a bean begins to yellow, it should be harvested with a knife or clipper. If beans are not harvested on time, they will split and their value will be greatly diminished. Harvested too early, the rich flavor and aroma of the bean will not develop during curing.

Processing

Immature beans are uniformly dark green and the tip becomes slightly yellow when the bean begins to ripen. A small amount of reddish-brown liquid called “balsam of vanilla” is exuded under high humidity. Such beans are strongly scented. If left on the vine a few weeks or months, beans dry completely, becoming brittle, with diminished scent.

To optimize development of aroma, beans are carefully harvested, cured, and stored. During the curing process, vanillin is formed by enzymatic action on the glucosides in the beans. High quality, cured beans are at least 16 cm long, fleshy and supple with slightly oily, unblemished and unscarred epidermis, whole (not split), strongly aromatic, and dark brown to almost black. Undesirable beans are hard, brittle, very soft or moldy, thin, brown or uneven in color, or weakly aromatic.

Curing

Several curing methods have been developed using variations of four fundamental processes:

1. Killing or wilting. This process kills the cells, turns the pod brown, and initiates the enzymatic reactions.



Left: Young pods with dried flowers. Middle: Close up of mature beans. Right: Brown mature beans, left too long on the vine for demonstration.

2. Sweating. The sweating process keeps the temperature warm to encourage the enzymatic process. After the sweating stage, the beans are supple and the vanilla aroma develops.
3. Slow drying. In the slow drying stage, the beans are placed in the shade in a well ventilated, clean area to prevent mold growth or contamination with dust. When the beans have lost about two-thirds of their moisture, they are placed in boxes for 3 or more months for the conditioning stage.
4. Conditioning. During this last phase, the beans develop their full aroma and vanillin content.

Bourbon method

The Bourbon curing method was developed on Reunion Island in the Indian Ocean. It is widely used in Madagascar and the Comoro and Reunion Islands. Given the reputation

of the Madagascar vanilla beans for high quality, this method has been widely adopted.

Beans arrive at the curing factory and are separated by size, stage of maturity, and epidermal integrity and quality. Beans are bundled, placed in open net cylindrical baskets, and blanched by dipping into 63–65°C hot water for 2–3 minutes. Small and split beans are immersed for less than 2 minutes. The warm beans are quickly drained, wrapped in dark cotton cloth, and are placed in a box for sweating. In Hawai'i, camping coolers and similar boxes have been used. After 24 hours, the beans are inspected, with uniformly brown beans separated and moved to the sun-drying phase. The heating process is repeated for beans that are not uniformly brown.

The sun-drying phase places the beans on a dark cloth in direct sunlight on a raised surface (table or bench) with good air movement and a clean environment free of insects. After an hour in the sun, the beans are covered with



Left: Sweating a small batch of beans in a plastic bag in the sun. Middle: Beans at the beginning of the sweating process. Right: Beans spread out in the sun for warming after sweating is complete.

a blanket or towel and left in the sun for another 2 hours, then they are rolled inside the blanket to retain heat, and moved indoors. This process is repeated for 6–8 days until the beans are supple. In the third stage, the beans are spread out in an indoor environment with good air circulation, free from insects, dust, and other potential contaminants. Commercially, beans are kept on racks or tables for 2–3 months within large warehouses that are built for this purpose. If the weather becomes wet for more than a few days, the beans can be placed in ovens at 45–50°C.

In the final conditioning phase, beans are grouped by length and straightened by hand. This helps to spread the oil that is released from the beans. The beans are tied in groups of 25–50 with a sturdy string, wrapped in wax paper, and placed in a wax paper lined metal conditioning box. At least 3 months are required for this stage with the beans checked frequently to remove any that develop mold. Beans that are not progressing well are returned to the sunning step. Beans that have lost about ⅓ of their weight or can be bent around three fingers are fully cured and can be bundled for sale.

Product quality standards

Bourbon vanilla is classified by International Standards based on the Madagascar Classes of vanilla as follows:

Grade	Standard
First	Longer than 14 cm, blemish free, supple, full, tan-brown uniform color, good flavor, and moisture content of less than 25%
Second	Longer than 14 cm, some scratches or spots, good flavor, moisture content of 25–28%
Third	Longer than 14 cm, good flavor, some blemishes and spots, red blemishes and moisture content of 30% or more
Fourth	Shorter than 14 cm, broken or cut, have red blemishes, and with moisture content of 30% or more

The standards for Australian vanilla also include the Australian Food Standard Code that requires testing of all beans for bacteria (*Salmonella* and *Escherichia coli*) and chemical residues. For large sales, the seller often provides a representative sample to the prospective buyer for confirmation of the grade.

Product storage requirements and shelf life

Stored in airtight containers and kept below 20°C, cured beans will last for 1–2 years. Other products with longer shelf life include vanilla paste (ground cured vanilla with sugar syrup); honey-infused with vanilla (whole cured beans placed in honey); vanilla powder (ground cured beans); vanilla powder or seeds mixed with coffee; vanilla extracts; and cured beans in alcohol (e.g., vodka).

Recommended labeling

Labeling should include the country of origin, grade, promotional material, and contact information. Labeling is crucial for regions that are establishing a unique identity or brand for their product. Many Pacific island nations have government agencies that help communities to grow, process, and market new crops. Individual growers should also develop their own labels for the retail market. Promotion of the source location (e.g., “Grown in Hawai‘i”) can enhance product value and market potential.

AGROFORESTRY AND ENVIRONMENTAL SERVICES

In several Pacific island communities, it is common for vanilla to be grown under coconut palms. Since coconuts may not provide enough shade for the vanilla plants, other types of shade trees may need to be planted to protect the vanilla plants. This practice is being used in Papua New Guinea, Vanuatu, Fiji, Tonga, Samoa, and Tahiti. In Tahiti, *Tecoma* trees are commonly used as the support plants while in Tonga, it is physic nut (*Jatropha curcas*). In addition, nitrogen-fixing trees such as *Gliricidia sepium* are excellent support plants. Such support trees can also provide trimmings for mulch, composting, and animal fodder. Other potential support trees are citrus, mango, bamboo, neem (*Azadirachta indica*), *Ficus* spp., *Plumeria alba*, jackfruit (*Artocarpus heterophyllus*), and areca nut palms (*Areca catechu*). The type of support tree selected varies with the environment (Anadaraj et al. 2005).

Support plants can help prevent erosion, and, when planted densely along the contour, contribute to terracing slopes. The fibrous roots help to retain soil and moisture. In some areas, another cash crop is grown with the vanilla, such as vegetables or other plants that will not compete with the vanilla for light. These can be grown as a border around the field or between the rows of trellised vanilla.

Recommended planting density

Depending on the type of support tree used, they are grown in rows that are 1–2.5 m apart and 2.5–3 m between rows. Depending on the species selected, 1,500–2,000 support plants can be grown per hectare and one to three vines can be planted per support plant.

Advantages and disadvantages of polyculture

Advantages of polycultures such as vanilla growing on support trees include suppression of rapid disease spread and reduced movement of insect pests. Support trees also provide shade, add organic matter, and reduce soil erosion. In general, support trees cost less than large greenhouse structures. The shade provided to the working environment is also comfortable for employees and enhances the physical and



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Top left: Vines growing on physical nut cuttings in agroforestry of bananas, coconuts, and other species on Tongatapu, Tonga. Bottom left: Young vines establishing on physical nut cuttings, interplanted with taro on Savai'i, Samoa. Right: Young vanilla vine planted under a neem tree.

psychological environment. Disadvantages include some competition among the support plants and vanilla vines for nutrients, water, and space. Support trees also require pruning, which is additional field maintenance cost for a grower. The biggest disadvantage maybe that the support trees can harbor slugs, snails, insect pests, and are nearly impossible to clean if the crop becomes infested with a pathogen. Also, support trees may encourage mosquito populations.

Special horticultural techniques

Commercial production begins with disease free plants that are trained on a support tree or artificial trellis. If support trees are used, they need to be planted 3–6 months before the vanilla. A cluster with about 10 beans will usually form mostly long beans (which have the highest market value) depending on the environment and the health of the vanilla crop. Many growers pollinate all flowers and are happy with shorter beans in the early crop cycle.

PESTS AND DISEASES

Pests

Occurrence of pests depends on the region. Pests include slugs and snails, which are common in many forests and ecosystems with support trees. These pests feed on the tender shoots, floral buds, young beans, and roots of vanilla vines. They have been reported from Africa, the South Pacific, India, and are likely to occur everywhere in moist environments. Insects such as the Lamellicron beetle (*Hoplia retusa*) and the ashy-gray weevil (*Cratopus retuse*) produce holes in flowers, preventing bean formation. The sucking bug (*Halyomorpha* sp.) infests young shoots and floral buds and kills them (Anandaraj et al. 2005). Scales and thrips can also cause damage. However, most insects can be controlled with appropriate insecticides, with availability varying by country. Chicken, snakes, and crabs have been reported to cause damage to vines also. Many of these pests also spread viral diseases.

Diseases

Diseases are caused by viruses, fungi, bacteria, and nematodes. Viruses and fungi cause the most serious problems for vanilla.

Viruses

Six viruses have been reported for vanilla, although not all are severe. Both *Cymbidium mosaic virus* (CyMV) and *Odontoglossum ring spot virus* (ORSV) are common on ornamental orchids in many parts of the world. Vanilla vines can be infected with CyMV, but show virtually no symptoms and remain highly productive, or the virus can be associated with chlorotic and necrotic flecks on leaves (Grisoni 2004). In French Polynesia and in Reunion, 44% and 32% of the plants, respectively, were infected with various potyvirus with CyMV present at both locations and ORSV, a tobamovirus, found on Reunion only (McGrath 2008).

Vanilla mosaic virus (VanMV) causes leaf mosaic and severe malformations on *V. tahitensis* and *V. pompona* in French Polynesia. VanMV causes a severe mosaic, blistering, and leaf distortion with over 30% of the fields in French Polynesia infected (Wisler et al. 1987). This virus is serologically related to *Dasheen mosaic virus* (DsMV), extremely common in taro (*Colocasia esculenta*), but has a different host range.

Pearson and Pone (1988) reported another potyvirus in Tonga, the *Vanilla necrosis potyvirus* (VNV) that caused significant losses in the South Pacific in 1988. Wang et al. (1993) reported that the protein coat gene of VNV had a 97% sequence homology with watermelon mosaic virus II (WMV-II) from the U.S. and 93% sequence homology with watermelon mosaic virus from Australia. The name *Watermelon mosaic Virus II Tonga* (WMV II Tonga) was suggested.

Cucumber mosaic virus (CMV) was recently found in vanilla causing leaf distortion and stunting. In French Polynesia, 23% of plants surveyed showed virus-like symptoms and contained CMV. The *Vanilla tahitensis* plants were severely stunted with distortions of the leaves and stems. Flowers were sterile and production was greatly impacted. This virus has an extremely large host range and infects over 800 plant species, with the vanilla isolates able to infect Chenopodiaceae (*Chenopodium*), Cucurbitaceae (cucumber), Fabaceae (mung bean), and Solanaceae (pepper, tomato, and tobacco). CMV is divided into two major subgroups (I and II) and subgroup I is further divided into two groups (IA and IB) by phylogenetic analysis. The *V. planifolia* isolates belong to subgroup IB in India (Madhubala) and subgroup I from French Polynesia and Reunion Island (Farreyrol) for *V. planifolia* and *V. tahitensis*, respectively. An unknown rhabdovirus-like particles or “bullet shaped” virus has also been found in vanilla from Fiji and Vanuatu.

Management of viral diseases

A viral infection means that the entire plant has the virus and it is incurable. Viral diseases must be detected and any plants with CMV, VanMV, or WMV-II should be destroyed immediately and new plantings should be started with virus-free stock plants. Keep all ornamental orchids and crops such as cucumber, mung bean, pepper, tomato and tobacco away from vanilla fields. Older vines should be tested for viral diseases before using for propagation.



Top: Young shoot eaten by caterpillar. Middle: Scales on leaf. Bottom: Slug damage.

For many viral diseases, the virus is present in the sap and movement of this sap from a diseased plant to a healthy plant will transfer the disease. When trimming vanilla vines, wash the clipper or knife between vines and dip in a 20% solution of bleach. If washing the blade is not practical, then the blade should be wiped dry before dipping into the bleach, otherwise sap will prevent sterilization. If any plant is observed with leaf mottling, blisters, or deformity, it should be tested for virus. In general, because there are many unknown viruses, any plant with deformities or blisters should be destroyed.

Vanilla plants that have CyMV can still produce top quality beans with high vanillin content. In Hawai'i, billions of *Vanda* (now *Papilionanthe*) orchid blossoms have been produced on CyMV-infected plants. These plants have no deformities or distortions and are known as symptomless carriers of the virus. It is important to know if vanilla plants are infected to avoid transmission of the virus to other orchids that will show symptoms. However, total field destruction of plants with this virus is not warranted at this time.

Fungal diseases

In general, fungal diseases present the greatest problems to vanilla crops and occur throughout the world. Common pathogens are discussed below.

Fusarium

Fusarium species cause the most destructive diseases of vanilla in the world. Often undiagnosed, these diseases will kill many plants before the problem is recognized. Growers believe that their plants are "in decline." Beginning in the late 1980s, millions of orchids were exported from Southeast Asian countries. This introduced several *Fusarium* species into the orchid trade in Hawai'i, but the diseases they caused were not recognized. On some of the orchids, such as *Cattleya*, *Fusarium* blackens the sheath but frequently does not do more damage.

Fusarium forms an abundance of spores on the surface of diseased tissue, which look gray, grainy, or mealy. These spores splash or are blown to healthy leaves and other plants such as vanilla. The fungus spore germinates when moisture is present. The entire vanilla plant is susceptible to infection, with disease frequently beginning on the aerial roots. Infected aerial roots become brown and die but do not look very different from roots that have died from injury or lack of moisture. *Fusarium* enters the stem from the infected roots and causes stem rot. With time, movement of nutrients and water is inhibited by a section of dead vine and the rest of the vine, although not infected, has pale, off-green leaves. These vines can be used for propagation but only the tips are taken and absolutely no part of propagation material can have a brown spot or blemish of any kind.

Fusarium can survive in dead vine and root tissues for over a year. Thus, all infected vine material should be gathered and burned or discarded. Never add diseased plants to the compost pile. Growers who have *Fusarium* disease should build a small greenhouse and process cuttings as described below and start a new population of clean, healthy plants.

***Colletotrichum* spp.**

Colletotrichum species have been reported to cause rots associated with leaf and stem spots. Spores of this pathogen form on leaf spots and are splashed to healthy tissue. This fungus can reduce plant vigor if many leaves are affected. Wet, cool seasons favor this disease.

***Sclerotium* sp.**

This species rots leaves, stems, and roots, frequently producing a thick mat of white fungal threads. After a few days, tiny, round mustard-seed-like bodies are formed. These are the spores that spread the disease and enable the fungus to survive dry periods without a host. *Sclerotium* is a known wound pathogen, so growers need to check their transplants and new cuttings for symptoms. The white to pink mycelial (thread) mats are a clue to its presence.

***Phytophthora* spp.**

These species cause leaf, stem, floral, bean, and root rots. The leaf and bean rots are frequently black and expand rapidly. White fluffy cotton-like growth is often formed on the surface of rotted tissue in moist weather. *Phytophthora* root and stem rots weaken and kill vines. This pathogen grows rapidly in wet weather and thousands of spores are formed in a few hours. Root rots increase if heavy rains lead to standing water in the field. *Phytophthora* also produces another type of spherical spore called the chlamydospore, that has a thickened wall which allows the spores to persist in soil for up to a year. When plants are replanted in an area contaminated with chlamydospores, the nutrients released by the roots stimulate the chlamydospores to germinate and infect the roots. Infected plants should be gathered, burned, buried deep in the ground, or removed from the field.

Management of fungal diseases

Plants should be carefully inspected for symptoms before purchase. Tissue cultured, virus-free plants may be the best option. New plants that are brought onto a farm should be kept away from any established plants.

Plants should always be propagated using tip cuttings from healthy plants. If using 2–3 node cuttings, growers should select material that is blemish free, as even small rots can indicate the presence of pathogens. Cuttings should be dipped in a 10% solution of household bleach (one part bleach to nine parts water) with a little detergent added, for 30–60 seconds. Cool, clean filtered water can be used to rinse the



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Left: *Fusarium* infection of a young cutting. Middle: Advanced rot or blight caused by *Fusarium*. Right: Phytoxicity damage from use of pesticides.

cutting, although rinsing is not necessary. The bleach will kill spores on the surface of the plant. However, any *Fusarium* or other pathogens living within the plant will survive bleach treatment. A few disease-free plants from which to restart the field are more important than many plants with a few that are contaminated. Contaminated plants insure that the problem will recur.

New fields should be started at least 1–2 kilometers from old diseased fields. Be sure water does not run off from an old or existing field to a new field. Even clean pieces of vine from an old, diseased field should not be introduced directly into a new field. Instead, cut into 2–3 node pieces, surface disinfect in bleach, and root in pots before replanting into the new field.

Pest and disease prevention

Vanilla plants should have good air circulation and freely draining, well aerated growth media. A gentle slope usually ensures good drainage when planted in soil. Areas with potential for standing water should be avoided or drains need to be built. The growth medium should be loose and high in organic matter. Plants should be protected from high winds and direct sunlight.

For commercial operations, certified virus-free plants should be used for the field establishment. Pathogens that may be present on plants propagated from cuttings will disseminate to the tissue-cultured vines. This has happened for growers and tender tissue-cultured plants were killed in high numbers.

Other orchid species should not be grown in the same greenhouse with vanilla. Even orchids that appear to be healthy, such as *Cattleya*, are frequently contaminated with *Fusarium* and other pathogens.

Sanitation

All diseased vines should be removed from the cultivation area, burned, or buried in a deep pit. Items used in the

field such as baskets, gloves, clothing, aprons, and footwear should be washed with bleach. Washing and soaking in salt water will also kill pathogens, reducing the need for bleach treatment. Both prevention and sanitation are sustainable methods to control disease.

Chemicals

In some countries, fungicides are permitted for use on vanilla. In India, carbendazim at 0.2% is sprayed on the plant for *Fusarium* rots, and roots are drenched with 0.2% carbendazim, 0.25% copper oxychloride, or a mixture of 0.25% carbendazim and mancozeb. *Phytophthora* is treated with a 1% bordeaux mixture or mancozeb. Metalaxyl is highly effective for *Phytophthora* but is allowed only in certain countries.

Fungicides registered for orchids may not be allowed for vanilla since systemic fungicides could remain in the vanilla bean after harvest or others may adhere to the bean surface, contaminating it for food uses.

Growers who spray herbicides or weed killers need to be aware that some of these poisons will harm their vanilla plants. Glyphosate, for example, can cause damage when the wind carries a mist of the spray onto the vanilla plant foliage.

Potential for invasiveness

Potential for invasiveness is low. However, vanilla vines do persist after a plantation is abandoned. It has naturalized in several countries but growth is slow and non-problematic.

SMALL SCALE PRODUCTION AND SPECIALTY MARKETS

Because vanilla can grow in shallow soils and containers, it is an ideal crop for small farms having poor soils. Home gardens and small urban lots can produce a steady supply of beans. Growers can cure, add value in various ways, and sell beans or other products at retail. Because of the high value

of each bean, this can be profitable, especially if the product line is diversified.

Communities can also work together on processing, marketing, and product development. For the export market, small growers may have a greater chance for success by collaborating on processing and marketing as a group.

It is difficult to estimate the comparative values of green and cured beans. For the household producer who is selling vanilla beans directly to consumers, the value of cured beans can be high, especially with high-quality processing and packaging. Good quality beans can be stored for months. For growers who sell green beans to a processor (commodity market), the value is much lower than for cured beans, but the work and time involved in curing is avoided.

Tourists are fascinated by the vanilla vine, and how the beans are produced. A successful model is a facility tour with a re-

tail area for sale of vanilla products as well as other products such as chocolate, coffee, nuts, jellies, and jams.

Some vanilla growers also sell plant materials to new growers. Products include small rooted plants and long cuttings.

Import replacement

Locally grown vanilla could easily replace most of the vanilla imported to the Pacific islands. Since local consumption is a small part of the family food budget, homegrown vanilla would presumably have minimal impact on family economies, unless it is sold or traded.

YIELDS

Expected range of yields per plant

Yields vary tremendously over time depending on the length of the vine used to initiate the crop, environmental conditions, maintenance, and attention to pollination and harvesting. In some Asian countries, the crop produces 500–800 kg/ha/yr of cured beans and the expected crop life is 7 years. In India, 300–600 kg/ha/yr of cured beans are produced in fields up to 12–14 years old, while in Uganda, 400–600 kg/ha/yr of cured beans are produced and the field remains productive for 6–8 years.

MARKETS

Local markets

Vanilla can be sold to local restaurants, retailers, organic produce stores, bakeries, county retail outlets, and at farmers markets. Some vanilla growers also sell small rooted plants and longer cuttings. Plants in small pots generally retail for \$12–15 with higher prices for larger plants. Quality is essential for direct retail sales. Unblemished pods fetch premium prices. Beans that are short or blemished can be made into other value-added products or sold in bulk.

Export markets

The U.S. is the largest market for vanilla and imports more than half of world vanilla production. France, Germany, and the United Kingdom are other top importers.

Branding and labeling possibilities

Several vanilla growing regions have developed their own brand identity. Hawai'i is the only place in the U.S. where vanilla is grown commercially, and the "Grown in Hawai'i" name carries the Hawai'i mystique and a perception of quality. However, delivering consistently high quality and reliable supply are the most important selling features of any specialty crop.



Top: For small-scale production, it is easy to keep an eye out for flowers to pollinate when the plant is situated right outside the home. Bottom: A large number of beans can be produced even on one healthy vine.

Potential for Internet sales

For farmers in Hawai'i and regions with good Internet services, potential for Internet sales is excellent. Vanilla products are generally lightweight, of high value per unit weight, and non-perishable.

ECONOMIC ANALYSIS

Expenses

Costs to establish a vanilla farm vary tremendously. Households and small growers who own their land and use support trees will have the lowest cost. Expenses include cost of support trees, mulch for planting, poultry manure or fertilizer, organic matter, tools, vanilla cuttings, and possibly fencing to keep out animal or human intruders. Labor will likely be provided by the family, including clearing the planting area, preparing the ground, planting the support trees and vines, removing weeds, maintaining the vines, pollinating flowers, harvesting, curing, packaging, and marketing.

For those growers who decide to grow vanilla in greenhouses, infrastructure costs are higher, including ground clearing and grading, greenhouse and vine support structures, organic matter or compost, the vanilla plants, tools (hoes, clippers, etc.), and possibly fencing. The ground must be kept clean, thus sand, gravel, or weed mat should be used. Maintenance includes irrigation, fertilization, crop monitoring and cleanup of diseased plants, placing vines on supports, pollination, monitoring of the pods, harvesting, curing, packaging, and marketing. In general, vanilla has seasonally high labor demands.

FURTHER RESEARCH

Potential for crop improvement

Many aspects of vanilla culture need to be addressed. Agronomic research for growing plants under support trees is needed. The amount of shade and best shade trees for each environment should be identified.

Improving potential for family or community farming

Governments should fund and support propagation of virus-free plants to help small landholders. Disease prevention and availability of fungal free propagation material is extremely important. A program to encourage community development of compost production and vermiculture are also critical. Any other community-based support such as financial aid for initiating a vanilla farm or low interest loans for supplies will help this industry.

Genetic resources

A healthy collection of different species is needed to preserve genetic diversity. Hybrids and cultivars should be identified, collected, and maintained. A breeding program to develop cultivars with viral or fungal disease resistance and high quality beans is desperately needed by this industry.

Policy

Global movement of propagation materials accelerates the movement of pests and pathogens. International regulations need to be developed and implemented to prevent the movement of serious viruses such as the Cucumber Mosaic Virus. New policies could proactively prevent pathogen spread.

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Farm and Forestry Production and Marketing Profile for Vanilla (*Vanilla planifolia*)

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