Specialty Crops for Pacific Island Agroforestry (http://agroforestry.net/scps)

Farm and Forestry Production and Marketing Profile for

Ginger

(*Zingiber officinale*)

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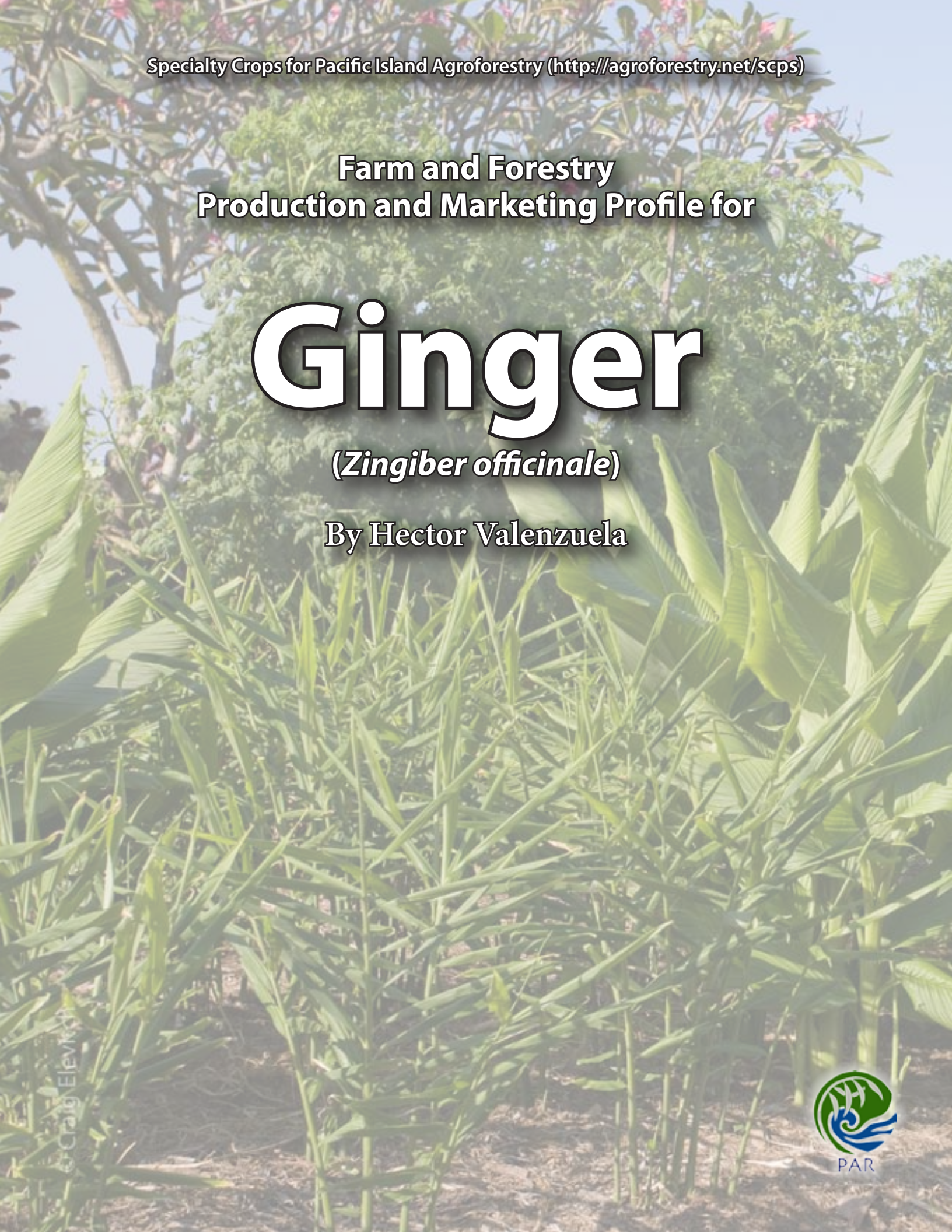

PAR

USES AND PRODUCTS

Ginger is used throughout the world as a spice or fresh herb in cooking and a variety of other value-added products including flavoring in candies, beverages, liqueurs, ice cream, baked goods, curry powder blends, sauces, and various condiments. Ginger is also used in traditional medicine to treat several ailments including nausea, motion sickness, migraine, dyspepsia, and to reduce flatulence and colic. Young rhizomes that are harvested early are also used in pickles and confectionery.

Scale of commercial production worldwide

According to the United Nations Food and Agriculture Organization (FAO), global production of ginger in 2008 was over 1.4 million metric tons (MT), with major production in India, China, Indonesia, Nepal, and Nigeria. Major importing countries to the U.S. in 2007 included China, Brazil, Thailand, Costa Rica, and Nigeria.

Most ginger imports to Pacific island nations come from Fiji. Fijian ginger is preferred in the Pacific because of its flavor. Hawai'i's ginger is also in demand because of its excellent quality.

BOTANICAL DESCRIPTION

Preferred scientific name

Zingiber officinale Roscoe

Family

Zingiberaceae

Non-preferred scientific names

Zingiber mioga Rosc. (Japanese ginger, a different species)
Amomum zingiber
Zingiber blancoi Massk.

Common names

Chinese: *geung*
Cook Islands: *kopakai*
English: ginger
Fiji: *cagolaya ni vavalagi*
Hawaiian: *'awapuhi Pākē*
India: *adrak*
India: *inchi*
Japan: *shoga*
Java: *san gurng, gung guung, san geong, atjuga*
Niue: *poloi*
Solomon Islands: *papasa*
Spanish: *jengibre*
Thailand: *khing*
Vietnamese: *gung*

Brief botanical description

Ginger is an herbaceous perennial, grown as an annual for its spicy underground rhizomes or stems. The plant has fibrous roots that emerge from the branched rhizomes. Closely grouped, unbranched, pseudostems or aerial shoots are produced from the rhizomes. The pseudostems reach a height of 50–120 cm. The simple, lanceolate, and smooth leaves are alternate and about 25 cm long. Ginger is asexually propagated from portions of the rhizome. The flowers of ginger are usually sterile and rarely set seed.

Left: Mature plant after flowering. Right: Washed and air-dried rhizome, ready for sale.

DISTRIBUTION

While the origin of ginger is uncertain, it is indigenous to the tropics, and some consider it to be a native of Southeast Asia. Ginger has been grown in India and China since ancient times, and by the first century traders had brought it to the Mediterranean region. Today ginger is grown in most warm parts of the world. Hawai'i and Fiji have been important producers in the Pacific.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

Ginger is a warm-season crop adapted for growth in tropical and subtropical regions. It can be grown in areas that experience light frosts as long as the rhizomes are not exposed to freezing temperatures. Best growth occurs under moist conditions and temperatures of 25–28°C. Growth efficiency declines with temperatures above 30°C and below 24°C. Ginger grows well in full sun, but is also adapted to partial shade when grown in intercropping systems. Vegetative growth is promoted with long day lengths, and rhizome enlargement is promoted under shorter day lengths. Day length response varies among different ginger varieties.

Soils

Ideal pH is 5.5–6.5. Ginger requires a deep (25–40 cm), rock-free, sandy loam soil, high in organic matter with adequate drainage that allows for proper hilling of the crop.

GROWTH AND DEVELOPMENT

In Hawai'i ginger is normally planted in March. The crop may be harvested from December to May of the following year. The quality of the rhizomes that are harvested after May of the following year may be slightly reduced, compared to those harvested earlier in the year.

It takes about 6 weeks for shoots to emerge after ginger is planted. Vegetative growth is maximized until flowering begins in September–October. Flowering marks the beginning of rhizome maturity and increasing fibrous tissue development. Rhizomes are already somewhat large at the young stage and in Hawai'i the foliage does not begin to yellow until January of the year following planting.

AGROFORESTRY AND ENVIRONMENTAL SERVICES

In tropical regions ginger is often interplanted in agroforestry systems, such as between rows of coconut, fruit trees, or rows of crops that are trellised such as bitter melon (*Momordica charantia*), or beans. Ginger is adapted to agroforestry systems because it is moderately tolerant of shade.

Table 1. Elevation, rainfall, and temperature

Elevation range	**lower:** sea level **upper:** 1,500 m in tropical areas. In Hawai'i it has been grown at up to 600 m.
Mean annual rainfall	**lower:** 1,500 mm (lower yields) **upper:** 6,500 mm (under excellent drainage, ditches built around the perimeter of the field, and with proper hilling)
Rainfall pattern	Preferable steady rainfall during growing season, with drier period at the end of the growing season prior to and during harvest. Excessive rainfall and waterlogging may result in soil-borne diseases.
Dry season duration	Preferable 1–2 months prior to and during harvest.
Mean annual temperature	**lower:** 21°C **upper:** 30°C Best growth occurs when soil temperatures are about 25°C.
Maximum temperature of hottest month	35°C. The mean maximum may be around 28–30°C.
Mean minimum temperature of coldest month	21°C. Growth will not resume until soil temperature at a 15 cm depth is greater than 20°C.
Minimum temperature tolerated	0°C (if rhizomes are protected by soil, but rhizomes may go into dormancy).

Factors to consider when interplanting ginger with trees include shade levels (optimal level is probably about 25% shade), compatibility with the roots of the intercrop, and possible competition for nutrients.

In Kerala, India ginger was effectively used as an intercrop with the multipurpose tree *Ailanthus triphysa*, which is used in woodworking. Ginger is also intercropped under betelnut palms (*Areca catechu*) in India. Also in India ginger yields were increased compared to monoculture yields when intercropped with poplar (*Populus deltoids* 'G-3 Marsh'). However ginger yields were decreased when poplar trees were planted at very high densities, of 5 m × 3 m, resulting in over 53% shade (Jaswal et al. 1993). In China, while the yields of some intercrops such as beans and corn were decreased in agroforestry systems with *Paulownia elongata*, ginger yields were 34% greater than in the ginger monocultures (Newman et al. 1998). In the Philippines ginger has traditionally been intercropped with cash crops such as mung bean (*Vigna radiata*), sweetpotato (*Ipomoea batatas*), cabbage (*Brassica oleracea*), and sweet corn (*Zea mays*).

When intercropped with palms, sun loving short-season cash crops may be used as the first crops in a rotation, planted before the palms have fully developed. Shade-tolerant crops such as ginger may be planted as the second or later crops in the rotation, when the palms have grown and

reached a stage where they are providing more moderate levels of shade.

To maintain nutrient and moisture balance, leguminous hedgerows such as *Sesbania* spp., pigeon pea (*Cajanus cajan*), Sunn hemp (*Crotalaria juncea*), or *Leucaena* spp. may also be considered in agroforestry systems with ginger. The hedgerows may

- serve as windbreaks
- provide moderate levels of shade
- moderate temperatures on farms that experience hot temperatures
- attract beneficial insects by providing shade, sources of water and nectar
- contribute prunings that may be used as mulch for weed suppression and to conserve moisture.

Because ginger is often grown on sloping land to improve drainage during the rainy months, intercropping or agroforestry systems may be important to conserve fertility and valuable topsoil by helping to reduce erosion rates and nutrient runoff during ginger production.

PROPAGATION AND PLANTING

Ginger is asexually propagated from portions of the rhizome. The ginger plant does not produce true seeds. About 2,000 kg of rhizome "seed pieces" are required to plant a hectare of ginger, using seed pieces of 115–230 g in size. Each seed piece should at a minimum contain 3–4 eyes or nodal sections. The size of the seed piece does not affect final yields when ginger is planted early in the season. However, larger seed pieces may result in greater yields when ginger is planted late in the season.

CULTIVATION

Variability of species and known varieties

Worldwide over 25 varieties of ginger are grown. Most varieties have not been properly characterized. Varieties differ in the size of the rhizome, flavor, aroma, pungency, color, and fiber content. Two main types are grown in Hawai'i. The primary commercial variety is referred to as the Chinese type. This variety has large rhizomes, light yellow flesh, a slightly bluish core, and it is less pungent. The Japanese variety, which is grown on a smaller scale in Hawai'i, has a deep yellow flesh color, a strong pungent flavor, and reaches a height of 45–90 cm. Popular varieties from other regions are referred to as Indian, Jamaican, Canton, Malay, Fijian, and African. Several popular varieties are grown in China.

Basic crop management

For an adequate success rate at plant establishment, it is important to establish the crop in a weed-free bed with proper soil texture. Proper soil fertility and moisture levels during the growth of the crop will be key determinants of crop quality and yields. Nutrient amendments provided by the application of organic or synthetic fertilizers may be applied to complement the natural fertility of the soil. Organic mulches, and rotations with green manures, or other cover crops can also improve and complement the fertility of the soil. An irrigation system, such as drip irrigation, may be

Left: Cutting healthy rhizome for seed. Right: Rhizome selected for seed in air-drying shed.

necessary to maintain proper soil moisture during the production cycle.

The planting of cover crops or leguminous green manure species prior to planting ginger may help to improve soil tilth, and legume green manures may provide additional nitrogen for the following ginger crop. Potential green manure crops include pigeon pea, Sunn hemp, cowpea (*Vigna unguiculata*), and soybean (*Glycine max*). If nematodes are a problem in the area, this may preclude the use of cover crops that host nematode species. For instance if the fields have a history of root-knot nematode infestations, then cover crops that also host root-knot nematodes are discouraged.

Special horticultural techniques

Proper soil and bed preparation are essential for ginger production. Prior to planting, soils are typically plowed to a depth of 45–60 cm. Lime is incorporated to adjust the pH and furrows are prepared in rows spaced about 150 cm apart. A hand tiller is often used to cut the furrows to a depth of 30–45 cm. Fertilizer or organic amendments are placed at the bottom of the furrow and incorporated prior to seeding. The ginger crop, as it grows from the bottom of the furrows, is hilled 3–5 times during the growing season, resulting in raised hill/beds, allowing for the proper development of the rhizomes. Hilling of the ginger row, which is done at 6 week intervals, allows for the rhizome to grow vertically. Hillings are often done by hand, even in commercial operations. Commercial growers fertilize ginger about three times during the growing cycle, beginning with shoot emergence and ending at the time of flowering, which marks the beginning of the rhizome maturing process. Late in the season, commercial growers increase the ratio of potassium fertilizer, with the goal of improving the glossiness of the rhizomes at harvest.

Advantages and disadvantages of growing in polycultures

Because ginger tolerates partial shade and has a year-long growing season, it is amenable to polyculture systems. Field arrangements in polycultures should be amenable to hilling of the ginger crop during the growing season. Hilling ginger with equipment may be problematic in polyculture systems. When both polycultures and mechanical tilling are desirable, farmers may consider planting the companion crops in alternate beds. By using an alternate bed arrangement, growers may still be able to till and hill the ginger beds during the growing season.

Growers should not intercrop or rotate ginger with solanaceous crops such as tomatoes, peppers, and eggplant, as these crops may help to build up levels of bacterial wilt in the field. Ginger may be rotated with grain crops such as corn or upland rice. Other possible crops for use in rotation

Top: Planting seed in prepared field in Hāmākua, Hawai'i. Middle: Field just after a hilling was carried out in Hāmākua. Bottom: Ginger crop maturing on the slopes of Mauna Kea, Hawai'i.

or intercropping include green onion, soybean, sweet corn, sweetpotato, and cabbage.

Intercropping and agroforestry systems are increasingly being recognized as low-input production systems that can help the small farmer reduce the risk of significant crop losses caused by pests, inclement weather, or unexpected down turns or competition in the produce market. Intercropping systems also provide several ecological services, such as improved nutrient cycles, and in some cases, reduced disease, weed, and pest levels in the farm.

Because so little research has been conducted with intercrops and such systems are very location specific, there are very few specific recommendations for the best crop combinations that can be utilized in ginger production. Farmers should select companion species that are known to be adapted to their particular location. Companion species should also be compatible based on their growth rate, canopy and root architecture, and incidence of pests attracted to each individual crop.

PESTS AND DISEASES

Susceptibility to pests/pathogens

Insect control in ginger is important because they may assist in the spread of diseases as well as damage the foliage and rhizomes. The Chinese rose beetle, *Adoretus sinicus*, is a serious pest of ginger in Hawai'i. Other pests include the lesser corn stalk borer (*Elasmopalpus lignosellus*), which damages shoots and stems during the dry season and the Ginger maggot (*Eumerus figurans*), which feeds on injured roots. Nematodes that affect ginger include root-knot (*Meloidogyne incognita*) and lesion nematodes.

Important diseases of ginger include bacterial wilt (*Rolstonia solanacearum*), bacterial soft rot (*Erwinia sp*.), *Fusarium* yellows and rhizome rot (*Fusarium oxysporum* f. sp. *Zingiberi*), and *Pythium*.

Preventing and treating problem pests and diseases

Soil-borne diseases are the principal limiting factor in ginger production. Two key techniques to manage diseases in ginger include 1) the use of clean seed material to prevent dissemination of bacterial wilt, *Fusarium*, and nematodes; and 2) planting in fields that are free of diseases. The use of clean seed will prevent the dissemination of bacterial wilt into new fields. Hot water treatment consisting of exposing seeds to a constant 50°C temperature for 10 minutes is effective in controlling nematodes. Hot water treatments are not effective for disease organisms that are already present inside the rhizome.

Bleach can also be used to surface sterilize the seed by dipping in a 10% bleach solution for 10 minutes (1 part commercial bleach to 9 parts water).

The use of rotations is necessary to prevent the build up of diseases. The use of organic amendments in the form of compost or organic mulch applied to build soil quality, organic matter, and promote microbial activity in the soil may also assist in suppressing soil diseases in ginger. Proper drainage and drainage diversion ditches are necessary to prevent the runoff of infected water sources into fields that are down slope from an infected field.

Planting ginger in intercropping systems may also assist in preventing the build up of foliage pests, and may promote the development of beneficial organisms. It is important that the crops used in rotation or in intercropping systems with ginger are not hosts to some of the same pests and diseases, such as nematodes or bacterial wilt.

DISADVANTAGES OF THIS CROP

A key problem with ginger production is that it is a relatively long-term crop, taking 10–12 months from planting to harvest. In terms of risk management for farmers, planting shorter season cash crops in intercropping systems with ginger may help to alleviate the risks of having a ginger crop occupy a large tract of land without any returns for almost a year.

Increased competition from China, and other global markets is also creating a challenge for small-scale producers of ginger. Farmers need to identify niche markets, and focus on producing a high-quality crop in order to compete with inexpensive foreign imports.

Bacterial wilt, a soil-borne disease, is a major limiting production factor in many regions. Once a field is infected with bacterial wilt, it may take many years before ginger can be grown there again. To prevent bacterial wilt incidence in their fields, growers need to follow strict sanitation practices (including tractors, machinery, and hand tools), conduct proper rotations with non-hosts, add organic amendments routinely, and clean the seed prior to planting (heat or bleach treatment).

Potential for invasiveness

Edible ginger is not known to be an invasive species.

COMMERCIAL PRODUCTION

Postharvest handling and processing

"Young ginger" refers to the rhizome harvested at an early stage after only 5–6 months of growth. Young ginger is a specialty product, valued for its low fiber content, and it is often pickled. Care should be taken to keep young ginger out of direct sunlight after harvest because it dehydrates quickly. For early harvest, growers may want to consider trimming the foliage of the plants 2–3 weeks prior to harvest to promote senescence and development of a protective abscission

layer between the rhizome and the pseudostem. This will minimize product injury during the harvest and handling process. Young ginger is sometimes sold with 15–20 cm of the stems and leaves still attached to the rhizomes. Young ginger, which normally commands a 50% greater price than mature ginger, may represent about 5% of the total ginger sold on a commercial farm.

Mature ginger is normally harvested after the foliage has turned yellow and dried down completely. At full maturity, the rhizomes are firm and glossy. Growers can promote an earlier senescence by trimming the foliage 2–3 weeks prior to the desired harvest date. After harvest, rhizomes are cleaned of soil and debris using water sprayed at high pressure. The rhizomes may also be cleaned with a soft brush or coconut fiber, and are then air-dried on screen racks. To allow all the exposed tissues to heal and become firm, the rhizomes are normally allowed to air cure under well ventilated conditions for a period of 3–5 days. Once cured, the rhizomes are graded and packed for shipping. Farmers normally keep 5–10% of their mature harvested ginger as seed for the next year's planting (normally a 1:20 seed to crop ratio).

Fusarium rot (*Fusarium* spp.) is a disease that can infect the rhizomes during the postharvest stages. Symptoms of *Fusarium* include discoloration of the vascular strands, and eventually the entire rhizome becomes brown and dry. To minimize the postharvest spread of diseases such as *Fusarium*, the rhizomes should be properly cured, ventilated, and stored at 12–14°C.

Methods of processing

As a fresh market herb and spice, ginger can be processed into a wide range of products. It is used in flavoring, pickles, herbal medicines, perfumes, beverages, and confectionery. While production for the fresh market may bring greater per weight revenues to farmers, processing products overcomes the issue of storage and the limited shelf life of the fresh product.

As noted above, ginger is harvested at different stages, depending on the product that is desired. The early harvest, from 5 to 6 months after planting, yields tender rhizomes with less fiber for use as candied products. The second harvest about 2 months later when plants are about 85% of their maximum size, yields rhizomes with the highest content of essential oils and oleoresins, used for the preparation of dehydrated products. The fully mature rhizomes obtained at the last harvest are used for drying and for grinding to produce powdered ginger.

Production for syrup and for the confectionery market requires early harvested ginger with a lower fiber content. Ginger that is not processed immediately is often preserved in brine. After it is drained from brine the ginger may be cut, graded by hand, peeled, boiled, and impregnated with sugar syrups to produce ginger syrup. Ginger that is harvested fully mature may also be peeled and dehydrated for further processing into ground ginger, or sold as sliced or whole dried ginger.

Upon extraction, the rhizome yields an essential oil that lacks the pungency of fresh ginger. The oil is used for flavoring and in perfumes. An oleoresin may also be extracted

Left: Harvesting mature ginger. Right: Freshly harvested ginger plant in "young ginger" stage, just after flowers are formed.

that preserves the pungency of ginger and is used for flavoring and for medicinal purposes.

Product quality standards

In Hawai'i ginger is graded according to standards established by the Hawai'i Department of Agriculture. Federal standards also exist in the U.S. for the grading of ginger. Grade A or No. 1 rhizomes should be large and thick, light brown to cream colored, and have a glossy appearance. Rhizomes should be free of bruises or blemishes, decay or injury from pests, or vegetative sprouts. In addition, the rhizomes should be fairly well matured, dry, clean, firm, and of reasonable size (113 grams or 4 oz, minimum). Grades No. 1, 2, 3 for ginger are equivalent to Fancy, Commercial, and off-grade classifications, respectively. In Hawai'i normally about 80% of the production by individual farms is sold as Grade A ginger. Young ginger is bright yellow and brown on the surface, has a glossy appearance, and has no sprouts.

Product storage requirements and shelf life

Ginger storage life is maximized if rhizomes are harvested at the proper stage of maturity, are cured properly and are free of diseases, nematodes, and bruises. If possible, ginger should be pre-cooled with forced-air or room cooling. Recommended storage conditions include temperatures of 12–13°C and relative humidity (RH) of 85–90%. Storage at 65% RH leads to dehydration and wilting. Storage temperatures below 12°C will cause chilling injury resulting in tissue softening and breakdown, decay, and skin discoloration.

Research in Hawai'i showed that the proper storage conditions described above prevented decay, physiological breakdown, sprouting, and surface discoloration for up to 6 months. Healthy rhizomes may be stored for as long as 6 to 8 months. With proper ventilation ginger may also be stored for shorter periods of time under ambient temperature, but yield and quality losses from shrinkage will be greater than under cold storage (Akamine 1969).

Ginger can be compatibly stored together with crops that require conditions of 13–18°C and 85–95% RH, such as cassava (*Manihot esculenta*), dry onion (*Allium cepa*), jicama (*Pachyrhizus erosus*), potato (*Solanum tuberosum*), pumpkin (*Cucurbit* spp.), sweetpotato, taro (*Colocasia esculenta*), and yam (*Dioscorea* spp.).

Recommended labeling and packaging

In the U.S., ginger is typically packed in 6.8 or 13.6 kg fiberboard cartons, or in 1.7 kg cartons with film bags.

Labeling and packaging is important because they are representative of the value and quality of the product. Packaging and labeling should be considered as key ingredients of the farm's marketing program and brand identity.

Each box should be properly labeled on a side or the top. The label may contain the name of the producer or produce dealer, address of the packer, name of the commodity, grade, and net weight, measure, or count. For marketing purposes, additional information may be placed on the labels or attached to the product such as specific variety, a logo with a brand name, region of origin, certifications (e.g., organic), nutritional traits, and even recipes.

SMALL SCALE PRODUCTION

Ginger is well adapted for production levels ranging from a few plants grown in a kitchen garden to small-scale production. Because it is a labor intensive crop, many small farmers may only be able to handle small-size plots for ginger production, ranging from a few 30 m long rows to 0.25 ha plots. Some farmers may be able to grow small plantings of ginger for sale to local restaurants, hotels, or for direct sale to consumers in the local farmers' market. Small farmers may also explore the possibility of forming a cooperative for sale of bulk volumes through a wholesaler or local distributor. For small farmers, it is always a good idea to identify potential buyers prior to planting a crop and to start with small plots. As they gain more experience and develop better relationships with their buyers, the planting areas can be expanded.

Adding value

Value added ginger products increase market opportunity for farmers. A certified community kitchen can be used to prepare a range of processed ginger products. Small-scale facilities may be amenable to the production of several processed products such as pickled, dehydrated, or candied ginger, instant tea, cookies, and wine (made from ginger peels).

Household use in the Pacific

Ginger is a popular garden and commercial crop grown and consumed on many islands of the Pacific. Commonly used as a spice in home cooking, it also is in high demand by local restaurants and health food stores, with organically grown ginger becoming increasingly popular. Certified organic ginger may be a new local and export market expansion opportunity for local ginger growers.

Statistics on ginger production and trade are scant in the Pacific. A USDA report on American Samoa indicated annual import volumes of 1,800 kg fresh ginger at a value of US$16,000. Local production of ginger and sale at farmers markets in American Samoa was recorded at about 70 kg, at a value of about $4/kg.

In 2007 Hawai'i produced about 1.3 million kg, which was less than 50% of the volume produced in 2003. Reported ginger yields in Hawai'i for 2007 were about 35 MT/ha. Total Hawai'i production has decreased over the past few years

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Value-added products that can be produced for local markets include flavored candies made from coconut or macadamia nuts and syrup.

because of drought, increased disease pressure, and because of greater competition from China.

Medicinal and nutritional value

Early Chinese and Sanskrit writers reported ginger's medicinal properties. It continues to be widely used today as an herbal medicine in Asia and the Middle East. Early writers in Europe also recited its benefits with respect to helping with digestion, vision, joints, gout treatment, and as an aphrodisiac. The ancient Chinese believed that ginger was a natural internal cleansing and purifying agent, an antidote for nausea, morning sickness, indigestion, and flatulence. Modern science has confirmed that ginger does help to relieve the effects of morning sickness.

One hundred grams of edible ginger contain approximately 9 g protein, 6 g fiber, 116 g calcium, 71 g carbohydrate, and 147 IU of Vitamin A (Farrell 1999).

Import replacement

Ginger is a healthy food that is used to add zing to dishes and to moderate strong flavors from meat and fish. It can also be used as a beverage and in tea. Thus, in addition to being sold as a cash crop, ginger also provides diversity to the household diet.

YIELDS

Expected range of yield per plant

Yields per plant range from 2 to 7 kg. Per plant yields of young ginger may be 1–3 kg, but fields grown solely for young ginger may be planted at twice the planting density (plants per unit area) compared with spacing for mature ginger production. Globally, large producers normally reach yields of 40–50 MT/ha, and some growers reach yields of up to 70 MT/ha. Because ginger accumulates a large bulk of its final weight during the later months prior to reaching maturity, early harvests result in lower yields.

Little research information is available with respect to yields obtained under organic farming conditions. However, based on a 4 year study, yields of ginger with the use of several organic fertilizers, including bokashi (specially fermented organic matter), chicken manure, composts, and bone meal, showed that yields with organic fertilizers were comparable to or greater than those obtained with chemical fertilizers (Valenzuela et al. 2005). Under commercial conditions it may be reasonable to expect that yield of ginger under organic conditions may reach 60–80% of the yields obtained under high levels of chemical fertilizer applications.

Recommended planting density

Planting distance between crops in Hawai'i is 120–150 cm between rows and 15–30 cm between plants within each

row. The rhizome pieces that are used as planting material are placed on the bottom of furrows that are 30–45 cm deep. After planting, the seed pieces are covered with 5–10 cm of soil. As the furrow is hilled 3–5 times during the growing season, the initial furrows will eventually be the hills by harvest time. The hills provide an ideal environment to promote the vertical growth of the rhizomes, and also make it more convenient to dig them out at harvest.

MARKETS

Local markets

Local outlets for the sale of ginger include farmers' markets, swap meets, subscription farming (or Community Supported Agriculture), small retail stores, wholesalers, restaurants, hotels, and health food stores.

Export market

The market for ginger exports has become more competitive over the past 10 years, as China has increased its volume of exports to the U.S. As a result of the competition, the area in ginger cultivation in Hawai'i has declined over the past few years. Ginger growers from the Pacific region should focus on producing a quality product for local markets before exploring the possibility of exports.

In 2007 the U.S. imported over 35,500 MT of ginger. China accounts for about 78% of total fresh ginger exports to the U.S., with other major importers being Brazil, Thailand, Costa Rica, and Honduras. In 2007 Japan imported over 85,300 MT, or 12.6% of the world's total imports. Other major world importers include Pakistan, India, and Malaysia. In 2006, Fiji exported over 1,100 MT of ginger at a value of $3.2 million.

Fiji has exported ginger for many years. Imports to the U.S. form Fiji are available from July to December, while imports from Hawai'i and Puerto Rico are from November to May. In recent years, Fiji has increased its shipments of fresh ginger to Australia.

Since the 1960s, Australia has produced ginger for processing, mostly as dried ginger syrup and crystallized ginger. Overall about 55% of the ginger grown in Australia is for processing, while 45% supplies the local fresh ginger market.

Specialty markets

Certified organic ginger is a premium product that may command a higher price, especially if sold to health food stores or to restaurants that cater to the visitor industry. In Hawai'i, value-added products from ginger are increasing in popularity. For instance, in Hawai'i organic ginger-based fruit beverages have increased in popularity over the past few years. For Hawaiian organic ginger to gain in popularity, the local ginger industry may have to develop a marketing campaign to develop a brand identity for organic Hawaiian ginger.

In the Pacific ginger has been identified among the crops that can be marketed as part of the growing organic farming industry. In addition to Hawai'i, other island nations where ginger has been considered a potential crop for organic production include Papua New Guinea, Samoa, and Vanuatu (Vinning 2008). However, there may be additional export or local markets for organic ginger in areas of high tourism, or for sale to health food stores.

In Samoa, an organic market was established in Apia in 2007. Ginger is among the products that have been certified for organic production. Market surveys in Samoa have shown that restaurants, resorts, and local residents have shown interest in organic foods. Organic ginger is also being produced in Vanuatu and in Fiji (Fay Bell 2009). Australia has also begun to market organically processed ginger products

Ginger relatives such as turmeric (*Curcuma longa*) (on left) galangal (*Alpinia* sp.) and may be suitable for new ginger markets where common edible ginger is already supplied in abundant quantities.

with exports to the United Kingdom, Germany, and other European countries.

Potential for Internet sales

Some Hawai'i growers are selling organic ginger directly to buyers and consumers over the Internet. There is a potential to develop a variety of dried and processed value-added products for ginger that are even more suitable of shipping than fresh ginger rhizome.

EXAMPLE SUCCESSES

Hawaiian Organic Ginger, several locations on Hawai'i Island

Owner Hugh Johnson moved to Hawai'i in 1990 and first grew 0.1 ha ginger together with avocados and pineapples in Puna. The first year was successful, but the following year the crop was devastated by bacterial wilt. From that time on, Hugh has regularly moved his ginger plots from site to site around Hawai'i island.

His main products are certified organic fresh ginger rhizome and turmeric. Ninety percent of the crop is sold through a wholesaler, with the remaining sold directly to customers. Hugh grows several varieties of ginger, including one that he has developed through selection over the years. A part of the business is dedicated to high quality, certified organic seed sales shipped throughout the U.S. Another value-added product is dried rhizome, which accounts for about 5% of the total annual crop.

Hugh Johnson has both open field plots and shade-house container cultivation, such as shown here. The container method may reduce the rate at which pathogens can spread from plant to plant.

Because Hugh sells all the ginger he can produce, the company has a web site is geared toward sharing ginger information, rather than marketing. Despite successes over the years, the expense of production and the losses from pathogens through the years have made his business economically challenging.

Lotus Café, Kaloko, Hawai'i Island

When Howie Simon and his wife Chef Ladda Sai-Laor opened their restaurant in 2005, they discovered they could not buy certified organic ginger dependably and at an affordable price, so they began to grow their own. They cultivate about 110 m^2 each year and all of their annual production of about 450 kg is consumed in their restaurant or used for seed for the next year's crop.

Even though ginger cultivation is labor intensive, it is viable for Lotus Café because the crop is all used in value-added products such as in ginger-vanilla gelato, ginger lemonade, and chutneys mixed with seasonal fruits. Because most restaurants can't afford local, organic ginger, having their own supply allows Lotus Café to distinguish itself by offering dishes crafted using unique ingredients.

Because Howie and Ladda cultivate their own ginger (and many other fruits and vegetables) and sell it only via the

Howie Simon cultivates ginger for his restaurant in Kona, Hawai'i.

dishes they prepare in their restaurant, they have an advantage over farmers who sell ginger at wholesale or even at retail. The restaurant has the advantage of being able to afford to use fresh, organic ingredients.

According to Howie, the challenges of growing ginger include the high labor demand, the need for large quantities of compost, and the risk of disease that could severely limit yields for an entire production season.

ECONOMIC ANALYSIS

Expenses of production

In Hawai'i, field production practices account for about 30% of total production costs and harvesting accounts for about 25%. Overall, 75% of all the income received for growing ginger goes to production costs. Traditionally, a major production cost for conventional ginger farmers consisted of chemical fumigants for the control of soil diseases. However, some key fumigants are no longer on the market and farmers are now focused on planting ginger in disease-free fields. In a Hawai'i study published in 1999, the average profit earned (also referred to as gross margin, or receipts minus production costs) by ginger farmers was about $18,500/ha ($7,500/acre) (Fleming and Sato 1999).

When evaluating production costs and expected profits, another key variable that farmers should consider is risk. An economic analysis conducted in Hawai'i during the 1990s determined that ginger production had a relatively high risk of production compared to other commodities, because of price volatility and potential crop losses due to diseases. However, it should be kept in mind that many Hawai'i growers have relatively high production volumes with sales focused primarily on exports in a highly competitive market.

The economic picture may be different for other Pacific regions, as production volumes will likely be lower, with sales primarily focused on local markets. To establish successful ginger production programs in the Pacific, it is imperative that growers adopt strategies that will prevent the spread of bacterial wilt and other soil pests. Key strategies for disease management include using only clean seed (free of diseases), adopting strict sanitation practices, and preventing the spread of disease organisms from infected fields to new fields (through machinery, humans, or runoff).

FURTHER RESEARCH

Potential for organic crop improvement

Additional research is needed to explore the use of organic practices for ginger production. The use of cover crops, organic amendments, rotations, and other planting arrangements need to be explored to manage diseases and increase on-farm nutrient cycling. There is a need to identify possible crops as intercrops and for planting in rotation systems. New natural farming methods may have potential application for common insect and disease control.

Improving potential for family or community farming

Fresh and value-added market opportunities may be best explored on a community basis rather than by individual farmers.

Genetic resources where collections exist

Most ginger varieties are obtained from local sources and farmers.

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Specialty Crops for Pacific Island Agroforestry (http://agroforestry.net/scps)

Farm and Forestry Production and Marketing Profile for Ginger (*Zingiber officinale*)

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