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Papaya Production in Hawaii

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Site selection

The three major environmental factors to consider in selecting a site to grow papayas are temperature, moisture (rainfall and soil drainage), and wind. The hermaphrodite papaya plant preferred for commercial orchards is more sensitive to the growing environment than the female papaya plant, and therefore selection of a suitable site is critical. Another condition to consider is the amount of sunlight the site receives to support plant growth and fruit production. Insufficient sunlight results in low yields and fruits with inadequate sugar and encourages plant diseases affecting papaya production.

Temperature

The temperature of the site is the most important factor. Commercial papaya production in Hawaii is generally limited to low-elevation areas where the minimum temperature is above 60°F. Temperatures below 60°F cause carpeloidy, which results in "cat-face" deformity when floral stamens develop abnormally into fleshy, carpel-like structures. Even at low elevations, fruits formed during cool winter months can express carpeloidy. Cool growing conditions also cause reduced sugar content and delay in fruit maturity. Thus, commercial operations are generally limited to elevations under 500 feet and to higher elevations only on the leeward sides of the islands, such as the Kona region of the island of Hawaii. High temperatures (90–95°F) may induce "female sterility," in which normally hermaphroditic papaya plants produce male flowers, resulting in poor fruit set and production.

Moisture

A minimum monthly rainfall of 4 inches (100 mm) and an average relative humidity of 66 percent are suggested as "ideal" for papaya growth and production. In low-rainfall areas irrigation should be provided via drip-type or mini-sprinkler irrigation systems.

Papaya requires good soil drainage. Where soil drainage is restricted, papaya is susceptible to fungal root diseases. The plants are severely affected by waterlogging and can be killed when subjected to puddled conditions for even a few hours. The Puna area is well suited to commercial papaya production because its *'a'ā* lava soils are extremely porous. Elsewhere in Hawaii on mineral soils, papaya requires either good soil drainage or low rainfall to allow for proper soil moisture management.

Wind

Papaya plants must be protected from wind. Plants exposed to constant wind develop deformed, crinkled leaves. When wind stress damage is excessive, the plants have reduced growth, fruit set, fruit quality, and productivity. Wind-blown dust can cause sap bleeding that harms fruit appearance. In coastal regions, salt spray carried by wind can desiccate leaves and kill papaya plants. Winds of 40 mph (64 km/hr) can uproot papaya trees growing in mineral soils, especially when accompanied

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fleshed cultivars are adapted to a wide range of climatic conditions, while the yellow-fleshed cultivars have more exact climatic requirements. For example, 'Waimanalo' is adapted to hot, dry locations and when grown in cooler locations has low brix (a measure of sugar content) and a high incidence of fruit carpeloidy during winter. 'Kapoho' requires uniform, mild temperature and rainfall and produces small fruits when grown under hot, dry conditions. 'UH SunUp' and 'UH Rainbow' were developed to resist infection by papaya ringspot virus, which is highly prevalent in the major papaya producing areas on the islands of Oahu and Hawaii.

The cultivars 'Sunrise', 'Sunset', 'Waimanalo', and 'Kapoho' have been inbred for many generations and are genetically stable, reproducing true to type from seed.

The cultivars 'UH SunUp' and 'UH Rainbow' can be planted only with seed obtained under a license agreement with the Papaya Administrative Committee (PAC). Farmers wishing to receive certification training for this license should contact the PAC or the nearest CTAHR Cooperative Extension Service office. Special precautions are needed with these two cultivars to maintain the virus resistance, as described in CTAHR publication NPH-2, *Production requirements of the transgenic papayas 'UH Rainbow' and 'UH SunUp'*.

These commercial cultivars produce harvestable fruits about 10–12 months after planting, with the exception of 'Kapoho', which takes about 14 months. 'Sunrise' has the shortest shelf life and must be marketed in a timely manner. 'Kapoho' and 'Sunset' have the best shelf life, and 'Waimanalo' is intermediate in this character. Fruits of most commercial papaya cultivars are typically harvested at the "color-break" stage, but harvest of 'Sunset' and 'UH SunUp' should be delayed until the quarter-ripe to half-ripe stage because brix development is slower in these cultivars.

Seedling production

Papaya can be either seeded directly or transplanted into the new field. Direct seeding is practiced in the Puna area because of the porous nature of the *'a'ā* soil, which has few fine particles, resulting in poor moisture-holding and nutrient-holding capacity. The seeds are planted in a trench approximately 6 inches long dug parallel to the planting row. About 15–20 seeds are placed in this trench and covered with ½–1 inch of soil. The use of a trench allows separation of seedlings in the hole and reduces plant competition. Germination occurs 10–21 days after sowing.

In soil areas, transplanting allows growers to place a larger plant (4–8 inches tall) into the field. Seeds are direct-seeded into individual cells (2 x 2 inches) placed in full sunlight. The potting media should be sterile and well drained to minimize root rot. Seedlings are transplanted into the field at about 6 weeks of age after being "hardened" in the nursery to minimize transplant shock.

Planting

Planting in "virgin" lands or fields in which papaya has not been grown before is preferred because of low disease and insect pressure. It is becoming increasingly difficult to find such fields.

"Replant" fields in which papaya has recently been grown generally have high levels of *Phytophthora palmivora* spores due to the decomposition of infected papaya fruit, trunk, and root residues. In replant fields in Puna, it is essential that the "virgin soil" technique is practiced. The technique requires the use of ½ cubic foot of "virgin" soil (soil not previously planted with papaya) placed in each planting hole. This soil allows the seedling roots to grow in a fungus-free environment until the seedlings are old enough to withstand fungal infection as the roots extend beyond the "virgin soil" zone. Because *'a'ā* lava fields are so porous, soil fumigation is impractical, and these fields require a fallow period of 3–5 years before planting another papaya crop.

In fields with mineral soils, residual fungi and nematodes can be controlled with soil fumigants. The fumigant is injected under plastic mulch before planting and allowed to volatilize for 2–3 weeks to ensure that seedlings are not damaged when transplanted. Fumigation reduces the population of nematodes and residual fungi and allows young roots to grow free of pathogenic organisms.

In fields that are infested with *Phytophthora*, an approved fungicide may be used to drench the soil in which the seeds or seedlings are planted.

Seeds planted into the ground or flats are prone to damage by mice and rats. Rodent damage can be detected by looking for signs of digging in the soil surface and by the presence of seed remnants. Cutworms, snails, and slugs often attack papaya seedlings.

Table 2. A typical fertilizer schedule for papaya grown on *'a'ā* lands in Puna.

Age (months)	Fertilizer analysis	Application (lb/acre)	Notes
0	0-46-0	100	Treble superphosphate
0	Dolomite	400	Ag 65®
0	14-14-14	25	Osmocote®
1.5	"	25	Osmocote®
3	"	200	granular
4.5	"	300	granular
6	"	300	granular + 0.3% B
7.5	"	300	granular
9	"	300	granular
10.5	"	300	granular
12	"	300	granular + 0.3% B
13.5	16-5-16	300	granular
15	14-14-14	300	granular
16.5	16-5-16	300	granular
18	14-14-14	300	granular + 0.3% B
19.5	16-5-16	200	granular
21	14-14-14	200	granular
23	16-5-16	200	granular
25	14-14-14	200	granular

Continue applications every two months, alternating 16-5-16 and 14-14-14.

A mixture of treble superphosphate (0-45-0, at ½ lb/tree), and minor elements is applied in the hole before transplanting. After planting, top-dress with about ⅒ lb/tree of a complete fertilizer such as 16-16-16. Double this application amount each month until flowering (recommended in an unpublished report by D. Ikehara and R. Yamakawa). After flowering, apply nitrogen at 40–50 lb/acre/month to maintain the N:K ratio in the index tissue between 1:1 and 1:1.5. When applying fertilizer in the irrigation water ("fertigating"), apply weekly to reduce the occurrence of soft fruits.

Plant tissue analysis

Papaya is grown under many different environmental and soil conditions, and therefore it is difficult to have any one fertilizer practice that fits all conditions. Plant tissue analysis is useful in determining the nutritional status of growing plants at different stages of development. This permits modification of fertilizer programs to maximize yield and improve fertilizer use efficiency.

Tissue sampling should be initiated after the plants begin to set fruit. The petiole under the most recently set fruit is collected from five representative plants within a uniform production area. Samples should be taken every two to three months, two weeks after a fertilizer application. Six samplings are usually enough to develop a fertilizer program for a site. Fertilizer program modifications are made by comparing tissue analysis data with "critical" levels developed from research (Table 3). This comparison should be considered in relation to the field's yield data and observations of fruit size and fruit column length.

Table 3. Critical nutrient levels in papaya petiole tissue under conditions of Puna, Hawaii.

	%		ppm
Nitrogen	1.20 – 1.38	Iron	20 –100
Phosphorus	0.17 – 0.21	Manganese	20 –150
Potassium	2.70 – 3.40	Zinc	14 – 40
Calcium	1.00 – 3.00	Copper	4 – 10
Magnesium	0.40 – 1.20	Boron	20 – 50
Sulfur	0.30 – 0.80		

only when thorough coverage of the foliage is achieved.

Nematodes can be controlled by fumigating the soil before planting. For more information on nematodes, see CTAHR publication PD-15, *Plant-parasitic nematodes and their management*.

Papaya diseases

Papaya ringspot virus (formerly called papaya mosaic)
Anthracnose and chocolate spot, *Colletotrichum gloeosporioides* (fruit, petiole, leaf)
Phytophthora, *Phytophthora palmivora* (fruit, stem, roots)
Powdery mildew, *Oidium caricae* (leaves)
Black spot, *Cercospora papayae* (fruit)
Damping off, *Pythium, Phytophthora,* and *Rhizoctonia* spp. (seedlings)
Wet rot, *Phomopsis* sp. (fruit)
Dry rot, *Mycosphaerella* sp. (fruit)
Watery fruit rot, *Rhizopus stolonifer*
Stem-end rot, *Botryodiplodia theobromae*, *Mycosphaerella* sp., *Rhizopus stolonifer*, *Phomopsis* sp. (mature fruit)
Reniform nematode, *Rotylenchulus reniformis*
Root-knot nematode, *Meloidogyne* spp.

Insects

Insects can be a major problem in papaya production. The Stevens leafhopper can be a serious problem when its populations build to high levels, which can occur under dry conditions. Infestation is recognized by the yellowing of terminal leaves and the exudate from feeding wounds on petioles. The phytotoxic reaction of the plant, termed "hopper burn," is characterized by the browning (or "firing") of leaf tips and edges.

The white peach scale is a recent introduction to Hawaii. The insects can form large populations at the base of the trunk, giving it a whitewashed appearance. They may move up the trunk and invade the fruit column. If this pest is on fruit intended for export, it becomes a quarantine concern.

Fruit flies are primarily a problem in fruits allowed to ripen on the tree; they are not a major problem when fruits are harvested mature-green for export sale. Papaya fruits for export need to be subjected to approved disinfestation procedures. Treatments currently approved when conducted in accordance with USDA-PPQ specifications are the vapor-heat, irradiation, and high-temperature forced-air treatments.

Mealybugs and white peach scale are occasional pests on the fruits and may lead to rejection at the packing plant. Thorough spray coverage is important in mealybug control, especially at the stem end of the fruit, near the trunk.

Papaya insect pests

Green peach aphid, *Myzus persicae*
Onion thrips, *Thrips tabaci*
Stevens leafhopper, *Empoasca stevensi*
Mediterranean fruit fly, *Ceratitis capitata*
Melon fly, *Dacus cucurbitae*
Oriental fruit fly, *Dacus dorsalis*
White peach scale, *Pseudaulacaspis pentagona*
Mealybugs
Ants
Whitefly

Mites

Mite infestation can affect both the fruit and foliage. It becomes a significant problem under hot, dry conditions. Mites usually feed on the underside of leaves and on young, developing tissues. Miticides generally kill only adults and nymphs and have little effect on eggs. Timely chemical applications are necessary to control the emerging young, which can become egg-laying adults in 7–14 days. Proper spray coverage is essential to prevent "escapes" from reestablishing their population to destructive levels.

Papaya mite pests

Broad mite, *Polyphagotarsonemus latus* (seedlings, young plants, lower surface of young leaves)
Papaya leaf edgeroller, *Calacarus brionesae*
Red and black flat mite, *Brevipalpua phoenicis* (fruit)
Truckerellid mites, *Tuckerella ornata*, *T. pavoniformis* (trunks of old plants)
Carmine spider mite, *Tetranychus cinnabarinus* (lower surface of mature leaves)
Citrus red mite, *Panonychus citri* (upper surface of mature leaves)
Texas citrus mite, *Eutetranychus banksi* (upper surface of mature leaves)