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# FRESH BASIL PRODUCTION GUIDELINES FOR HAWAI'I

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and Janice Y. Uchida

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Cover Photo: Sweet basil plant.

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# FRESH BASIL GUIDELINES FOR HAWAI'I

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## INTRODUCTION

Basil (*Ocimum basilicum*) is a popular herb grown for the fresh market or for its aromatic leaves which are dried and used as a spice or flavoring. This herb, a member of the mint family, is a native of central Asia and northwest India. It is a perennial adapted to warm growing conditions, but is frequently grown as an annual. It is most commonly used in tomato dishes, pesto, and as a flavoring in soups, salads, minced beef, and sausages. North America imports about 2000 tons of basil every year. Basil is produced commercially in Egypt, France, Hungary, Israel, Mexico, Indonesia, and the United States. In Hawai'i, basil is grown on about 55 acres with an estimated annual farmgate value of $1.2 million. Many types of basil are available varying in size, leaf shape, flavor, and in leaf color (ranging from green to purple). Product quality is determined by appearance (color and absence of decay or insect damage), flavor, moisture content for the fresh market, and volatile oil content and total insoluble ash content for the processing market. Basil markets include local hotels and restaurants, local wholesalers and retailers, mainland produce wholesalers, and processors of pesto and other products using basil. Basil for export from Hawai'i is mainly grown during the winter months.

## CULTURAL PRACTICES

### Propagation

Basil seed should be obtained from a reputable source to ensure that the seed is true to type. Basil is direct seeded or transplanted into the field when about 6 in tall. When direct seeding, over-seed for an 80 to 90 percent expected germination rate. Optimum temperature for germination is 70°F (20°C), but the seeds will germinate well between 65 to 85°F (15 to 30°C) in about 7 days. The soil should be worked well to allow for proper germination. Seed to a depth of ¼ in. Basil can be grown year-round in Hawai'i in well-drained soils at elevations below 700 ft (250 m), and from May to October at higher elevations.

### Spacing

Rows are spaced 24 to 36 in apart and plants are spaced 6 to 24 in apart in the row depending on culture. Basil can also be planted in beds with a spacing of 24 to 36 in between bed centers. Three rows are planted per bed with a spacing of 12 in between rows. In large scale operations, basil may be planted at a high density for once-over harvesting. In smaller operations, basil is planted at a lower density and harvested over a long growing season.

### Mulches and Windbreaks

Basil requires adequate soil moisture throughout the growing season to maintain quality and yields. The field may be mulched with organic material between the rows to help control weeds and conserve moisture. A mulched field will also reduce the amount of soil splashing onto the leaves, which simplifies the washing of foliage at harvest time and helps reduce the incidence of certain diseases.

High winds can damage foliage and cause rapid moisture loss in the field. The use of windbreaks may be beneficial under high-wind conditions.

### Fertilization

Fertilizer practices vary depending on the previous crop and on the fertility of the soil. Use soil tests to determine the levels of available plant nutrients in the soil. Over-fertilization will diminish the quality of sweet basil at harvest and may increase the soluble salt content of the soil to undesirable levels. Plants overfertilized with nitrogen often show dark discolorations in the cooling rooms after harvest. Preplant fertilization rates of 120-120-120 lb/acre of $N\text{-}P_2O_5\text{-}K_2O$ are recommended for soils deficient in these nutrients. Basil does best when soil pH is between 6.0 to 7.5. N may also be side-dressed at the rate of 20 to 30 lb/acre soon after the first harvest. Experiments in Indiana showed that ammonium sources of N decrease petiole and stem yields and leaf content of essential oils when compared to nitrate-N sources. Growers who plan to market basil

labeled as "organic" should check federal and/or state guidelines for organically grown produce.

## PESTS

Basil is a specialty crop with only a few pesticides registered for use on the crop. Therefore, growers should develop and follow a pest management program to minimize the incidence of pests and diseases in their field. Growers should also follow strict measures during and after harvesting to ensure that live insects and mites do not infest shipments. Field plantings of basil generally have a healthy population of beneficial arthropods such as parasitic wasps, spiders, and other general predators which can help keep pest populations to moderate levels. Growers should learn to recognize both pests and beneficials and regularly monitor their populations. The early detection and management of pests can often prevent major problems. Growers producing basil for export should pay particular attention to insects that are quarantine pests or are likely to remain on harvested basil, and remove them before export.

Growers should also be careful that their product is not contaminated with pesticides that are not registered for use on basil. Properly labeled shipments and record keeping help to protect the industry as a whole and to identify the source of contaminated products.

### Insect, Mite, and Mollusk Pests of Basil

More than 30 insects and mites are found on basil grown in Hawai'i. Although only a small portion of these cause significant crop damage, growers shipping to the continental United States have to comply with strict quarantine regulations which require pest-free shipments. Therefore, growers should also monitor insects which may not be economically important in the growing of the crop, but may pose quarantine problems later. Identification of the pests attacking the crop is simplified by classifying them based on the type of symptoms typically observed in the field.

### Chewing-Type Damage

**Chinese rose beetle**, *Adoretus sinicus* Burmeister. Chinese rose beetles cause heavy damage to basil when population levels are high. Adult Chinese rose beetles are brown, about ½ in long, and are nocturnal. The chewing-type damage may appear as leaves with holes or with a lace-like appearance when the areas between leaf veins are eaten (Figure 1). Chinese rose beetles

**Figure 1. Chinese rose beetle damage to basil.**

leave small, dark-colored particles of frass which are excreted on the plant while feeding. Chinese rose beetles feed on a wide variety of ornamental and food crops in Hawai'i. The larvae feed on decaying plant material and do not damage basil.

**Slugs**, various species. Slugs are nocturnal mollusks which thrive during wet weather but can also be troublesome during dry weather in irrigated field and greenhouse basil crops. Their feeding damage appears as entirely eaten leaves or leaves with holes or missing parts, girdling or scraping of the bark, or the destruction of entire seedlings (Figure 2). Slugs leave a shiny slime trail as they move about. They hide during the day under plants, rocks, mulch, pottery, fallen leaves, or in loose soil.

**Celery leafminer**, *Liriomyza trifolii* (Burgess). The leafminers infesting basil are yellowish larvae (maggots) of tiny flies. Leafminers feed inside the leaf tissue creating tunnels or mines within the leaf. Leafminer populations have usually been relatively light on basil and have not resulted in significant in-field crop losses. However, because leafminer larvae live and feed inside of the leaf tissue, they cannot be dislodged by shaking or rinsing the harvested basil. In the case of basil grown for export, the leaves containing live larvae must be plucked off before packing. The adult fly is mostly black with some yellow and is about $1/16$ in long. Adult flies make tiny punctures on the upper sides of leaves while feeding and laying eggs.

Leafminer populations in Hawai'i are usually kept below damaging levels by a number of beneficial parasites. Beneficial parasite field populations may be significantly reduced when broad-spectrum type insecticides are applied. Since biological control does not provide total leafminer control, growers/shippers must carefully inspect the harvested basil to ensure compliance with quarantine regulations.

**Beet armyworm**, *Spodoptera exigua* (Hubner). The destructive stage of the beet armyworm is the larva or caterpillar which causes chewing-type damage on basil. The younger leaves are commonly infested with more than one of the small, recently hatched caterpillars. The $1\frac{1}{4}$-inch-long caterpillars are light green with pink to red stripes on their sides. The caterpillars develop into nocturnal moths.

**Pink winged grasshopper**, *Atractomorpha sinensis* Bolivar. Basil may be attacked by several grasshopper species. The pink winged grasshopper commonly feeds on basil and other herbs. Both nymphal and adult stages cause typical chewing-type damage to the leaves. Grasshoppers are more of a pest in home gardens than in commercial plantings where they are of minor importance.

**Figure 2. Slug damage to basil.**

**Sucking-Type Damage**

**Brasilian leafhopper**, *Protalebrella brasiliensis* (Baker). Brasilian leafhoppers commonly infest herbs such as basil, perilla (shiso), and mint (Figure 3). The adults are black and yellow, while nymphs are light green. Both stages are capable of hopping or jumping when disturbed but only the adult, with its fully developed wings, is capable of flying. Brasilian leafhoppers are sucking-type insects that can cause leaf scarring, which is sometimes confused with the mines of leafminers. Several other leafhopper species attack basil. These insects generally cause no significant in-field damage even with high population levels. However, the presence of leafhoppers, especially the eggs and small nymphs which are not easily detected, can result in noncompliance with quarantine regulations. Other leafhopper species cause typical "hopeburn" symptoms due to toxins injected while feeding on the foliage.

**Banded greenhouse thrips**, *Hercinothrips femoralis* (O. M. Reuter). Several thrips species infest

**Figure 3. Brasilian leafhopper damage to basil.**

and cause significant problems on basil grown for export. Thrips are small, slender insects which generally have wings with hair-like fringes in the adult stage. Banded greenhouse thrips are very common on basil and can usually be found on the lower leaves of established plants. Their feeding leaves whitish scars or a silvered appearance on the leaves. The fecal spotting left by thrips is also noticeable. Live thrips in harvested basil can be easily overlooked because of their small size and cryptic habits. Since it is difficult to identify immature thrips to the species level, the presence of live thrips in basil shipments has been of great concern to the local fresh herb export industry.

**Silverleaf (sweetpotato) whitefly**, *Bemisia argentifolii* and **greenhouse whitefly**, *Trialeurodes vaporariorum* (Westwood). Both whitefly species infest basil. The nymphs and adults feed on plant sap and produce a sticky substance called honeydew which can serve as a substrate for sooty mold. Immature whitefly stages, which tightly attach to leaf undersides, have caused problems with basil grown for export.

**Other Pests.** Other pests which cause sucking-type damage to basil foliage include: the southern green stink bug, *Nezara viridula* (Linnaeus); the broad mite, *Polyphagotarsonemus latus* (Banks); and the red and black flat mite, *Brevipalpus phoenicis* (Geijskes).

## Diseases of Basil

Information on basil disease etiology, epidemiology, and control is very limited. Although basil is plagued by many diseases, no fungicides or bactericides are currently registered for this crop in Hawai'i. Therefore, growers must rely on early disease recognition and use cultural practices such as the use of windbreaks and rain shelters to prevent and manage diseases. By recognizing the first symptoms of disease, growers can remove diseased plants and continuously monitor fields for signs of pathogen recurrence or spread. For disease control: (1) use clean seed; (2) grow the crop in disease-free soil; (3) maintain disease-free fields; (4) rotate basil with non-susceptible crops such as oats, buckwheat, and sunhemp; (5) sanitize or remove diseased leaves or plants to reduce field inoculum levels; (6) control moisture since high humidity or free water on plants strongly favors disease; (7) increase the spacing between plants to improve air movement and reduce leaf wetness periods; and (8) increase the organic matter in the soil which will enhance microbial activity and favor pathogen reduction. Laboratory analysis is recommended to identify the causal agent(s) when diseases are encountered.

## Leaf Spots

Various organisms cause leaf spots on basil in

Hawai'i. Some of these are new causal agents. Research on the identification, pathogenicity, and spread of the following organisms has been initiated.

***Colletotrichum* sp.** This fungus causes dark leaf spots, defoliation, tip dieback, stem lesions, and occasional loss of entire plants (Figure 4). At times, dead tissue within leaf spots falls away, producing holes in the leaves. Like most leaf spot fungi in the tropics, it is especially troublesome during wet and humid weather. Fungal spores are produced on diseased plant parts, splash to healthy leaves or plants, and initiate new spots.

***Cornyespora cassiicola*.** This fungal pathogen produces numerous, small, gray to black specks or leaf spots on basil. Small spots coalesce and produce larger diseased areas. Older leaves are lost following heavy spotting. Stem lesions are light brown to brown.

**Bacterial pathogens.** Bacteria cause water-soaked, dark, angular, or irregular leaf rots, and brown to black, wet stem rot. When dry, diseased areas are brittle and easily cracked. Bacterial diseases are extremely severe during wet weather and cause stem rots. Quality and total production is greatly reduced. Postharvest losses are also very high.

***Aphelenchoides* sp.** (foliar nematode). These microscopic roundworms cause angular leaf rots during wet weather. Spots are large, water soaked, and black. *Aphelenchoides* sp. swim in the thin film of water covering the plant surface in high humidity or rain. This nematode penetrates the leaves through stomates, then feeds and multiplies in the internal leaf tissue.

**Wilt, Die-Back, or Decline**

*Fusarium* sp. causes a major production-limiting disease in commercial farms and in home gardens. Early signs of this fungal disease include slow growth and yellowing of the young shoots. Advanced symptoms include wilting, die-back, and discolored stems (Figure 5). Infected plants may show a darkened discoloration of the stem beneath the bark. Longitudinal slices in the stem will reveal this symptom. Under moist conditions, a light white to pink, cottony growth can be observed along the infected stem areas. *Fusarium* can persist in

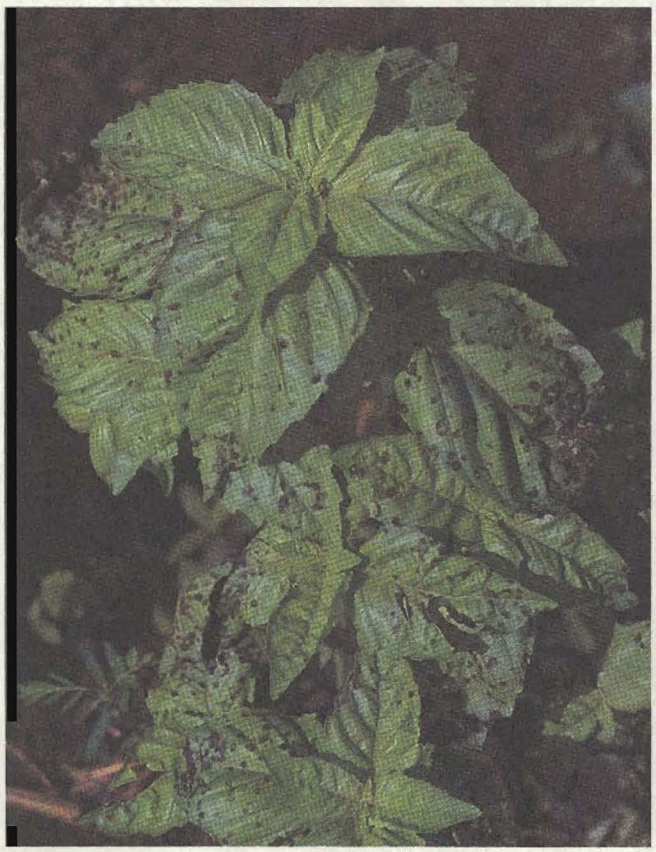

**Figure 4. Leaf spots caused by *Colletotrichum* sp.**

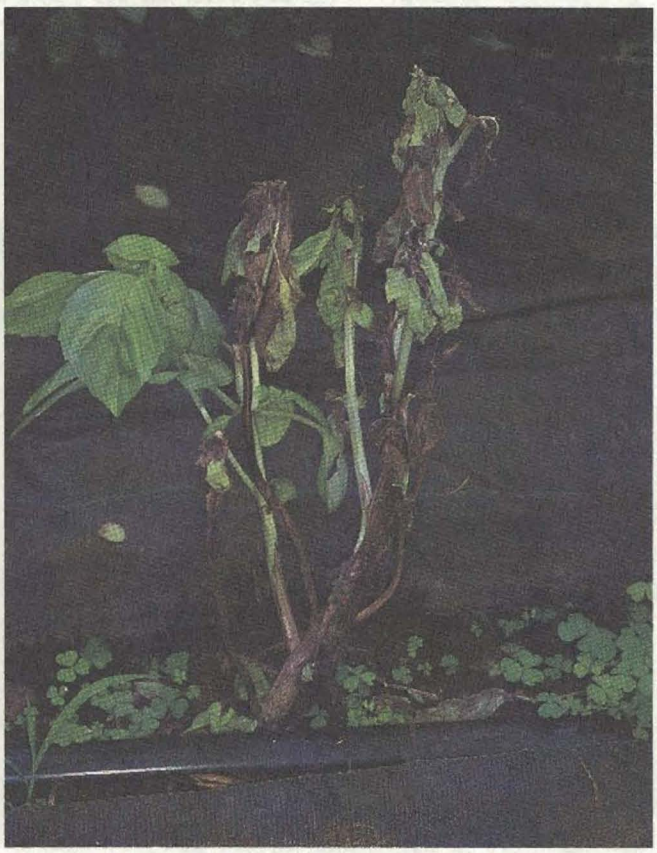

**Figure 5. *Fusarium* disease of basil.**

the soil for many years. Thus, growers must prevent contamination of their farms or new fields. The spread of *Fusarium* can be reduced by quick removal of all diseased plants and leaves. Do not bring infected plants or soil onto the farm from contaminated areas. Avoid planting in wet, poorly drained areas.

Other soilborne pathogens such as *Rhizoctonia solani*, *Pythium* spp., and *Phytophtora* sp. have been associated with diseased plants. Further research is needed to establish their roles in root disease.

**Decline Caused by Nematodes**

Basil is very susceptible to root-knot nematodes, *Meloidogyne* spp. These microscopic roundworms damage the roots and impede a plant's ability to absorb water and nutrients from the soil. As a result, affected plants may show symptoms of nutrient deficiency, wilting, and yield decline. Galling and root rot occur on plants that are heavily infected (Figure 6). Growers should check with agricultural chemical representatives, county extension agents, or plant disease specialists for chemicals that are registered for soil treatments for nematode control. The addition of organic matter such as chicken manure (1 lb per hill) may improve soil conditions and reduce the effect of nematodes and other pathogens. Other cultural practices for disease control include rotation with non-susceptible plants and soil solarization. Soil solarization techniques employ a clear plastic sheet placed over tilled soil for 6 or more weeks. The plastic cover helps to retain heat in the soil, reducing nematode numbers. Soil solarization is effective only if there is sufficient sunlight to allow accumulation of heat beneath the plastic cover.

**Tomato Spotted Wilt Virus**

Tomato spotted wilt virus is spread by several species of tiny insects called thrips. This disease is not a major problem in basil but is currently a severe problem in many other crops grown in Hawai'i such as tomato, pepper, lettuce, and chrysanthemum. Infected plants may have dark-colored, ring-like spots on the leaves, especially on younger ones.

**Postharvest Problems From Infected Fields**

Unhealthy fields produce leaves of poor to marginal quality. Leaves harvested from fields with disease problems are rapidly rotted by bacterial and fungal pathogens following packing. A minor field problem involving low levels of bacteria can result in major postharvest losses. Avoid harvesting from fields where bacterial pathogens are known to be present. Select clean leaves only from the tips and avoid branches near the base of

**Figure 6. Damage to basil by root-knot nematode.**

the plant.

### Weeds

High-density plantings and physical or mechanical weed control are the most common practices used to prevent weed problems in basil. Weed control is enhanced with proper field preparation prior to planting. Both plastic and organic mulches may be utilized to minimize weeds in the field. Check with a county extension agent, the Department of Agriculture, or a chemical sales representative for herbicides which are registered for use on basil.

## HARVEST AND POSTHARVEST PRACTICES

### Product Quality

Hawai'i relies on the high quality of its horticultural products to maintain competitiveness in the local and export markets. High quality, including rich flavor and attractive, dark green or purple foliage, is achieved by following proper cultural and postharvest handling practices. Proper field culture is essential to obtain a quality end product. Growers should determine the product characteristics desired by particular market outlets. When growing basil for export, maintain a line of communication with Department of Agriculture personnel to determine acceptable and unacceptable cultural and postharvest management practices which may have an effect on the quality of the product.

### Harvest Operation

Basil is ready for hand harvest from about 30 to 35 days after planting. In Hawai'i, 4- to 6-in shoot tips with two to four sets of true leaves are picked. However, because variations exist depending on the intended use of the product, check with buyers for desirable product characteristics (stem length, etc.). Basil fields are picked daily when plants are rapidly growing or every 3 to 5 days. Heavier picking (tips > 6 in) will delay the timing between harvests. Regular harvesting prevents flowering and seed setting and encourages vegetative growth. Basil will grow about 1 in per day under the proper environmental conditions. During the picking operation, hold the tips from the petiole to minimize contact with the fragile foliage tissues. Leaves are easily bruised, which will later show up as black, water-soaked creases in the harvested products.

### Handling and Packing

Fresh basil is very tender and is easily damaged by rough handling, desiccation, and chilling. To ensure and maintain product quality, minimize bruising when har-

**Figure 7. Chilling injury of harvested basil.**

vesting and packing. Harvested basil is usually dipped in cool water to reduce the temperature and to help dislodge soil particles and some of the insects pests that are not strongly adhered to the plant. It is important to drain off the free water prior to packing the product. Basil may be packed in bulk or packed 12 bunches to the pound in polypropylene bags placed in paper cartons, sometimes lined with moist paper. For the local market, basil is packed in 1- to 2-oz plastic bags.

**Storage and Transportation**

The shelf life of basil is relatively short compared to other herbs such as rosemary, oregano, and thyme. Thirty percent losses during shipment are not uncommon. Basil is susceptible to chilling injury and should not be stored below 40°F (5°C) for extended periods. Basil that has been damaged by cold (chilling injury) turn black and are rendered unsuitable for sale (Figure 7). Store and ship fresh basil at 45 to 55°F (5 to 13°C) and 95 percent relative humidity. Diseases affecting basil in the field will likely reduce the shelf life of the harvested product. Basil for export must be carefully inspected before packing to help ensure that it is free of live insects which will result in noncompliance with federal and state quarantine regulations.

**Other Postharvest Tips for Basil**

- ◊ Harvest early in the morning when temperatures are lower.
- ◊ If packaged in bags to reduce moisture loss, maintain at a constant temperature to prevent condensation.
- ◊ Packages may be perforated for ventilation or may be made of a polymer which is partially permeable to water vapor.
- ◊ Do not store or ship with fruits or vegetables that release ethylene.

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