

FRESH BASIL PRODUCTION GUIDELINES FOR HAWAII

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INTRODUCTION

Basil (*Ocimum basilicum*), is a popular herb grown for the fresh market or for its dried aromatic leaves which are used as a spice or flavoring. This herb, a member of the mint family, is a native of Central Asia and North West India. It is adapted to warm growing conditions and although it is a perennial, it 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 2,000 tons of basil every year. Basil is produced commercially in Egypt, France, Hungary, Israel, Mexico, Indonesia and the United States. In Hawaii, basil is grown in 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. Quality of the product is determined by appearance (color and absence of decay or insect damage), flavor, and 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 Hawaii is mainly grown during the winter months.

CULTURAL PRACTICES

Propagation

Basil seed should be obtained from a reputable source to assure that the seed is true to type. Basil is direct seeded or transplanted when about 6 in. tall into the field. When direct seeding, over-seed expecting an 80-90% germination rate. Optimum temperature for germination is 70°F (20°C) but the seeds will germinate well between 65-85°F (15-30°C) in about 7 days. The soil should be worked well to allow for proper germination. Seed to a depth of 1/4 inch. Basil can be grown year-round in Hawaii 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 inches apart, and plants are spaced 6 to 24 inches in the row depending on culture. Basil can also be planted in beds with a spacing of 24 to 36 inches between bed centers. Three rows are planted per bed with a spacing of 12 inches 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.

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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 in weed control and to conserve moisture. A mulched field will also reduce the amount of soil splashing onto the leaves which will simplify the washing of foliage at harvest time and help 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 may vary depending on the previous crop and on the current 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. Pre-plant fertilization rates of 120-120-120 lbs per acre of N-P₂O₅-K₂O are recommended for soils deficient in these nutrients.

Basil does best when soil pH is between 6.0-7.5. Nitrogen may also be side-dressed at the rate of 20-30 lbs per acre soon after the first harvest. Experiments in Indiana showed that ammonium sources of nitrogen may 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 with 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 and follow strict measures during and after harvesting to ensure that live insect 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. Learn to recognize both pest and beneficials and regularly monitor their populations. The early detection and management of pest problems can often prevent major problems. Growers producing basil for export should pay particular attention to insects which 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 which 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 insect and mites found on basil grown in Hawaii. Although only a small portion of these cause significant crop damage, growers shipping to the continental U.S. have to comply with strict quarantine regulations which essentially require pest-free shipments. Therefore, growers should also monitor insects which may not be economically important in the growing of the crop, but which could pose quarantine problems later.

Identification of the pests attacking your crop is simplified by classifying them based on the type of symptoms typically seen 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 1/2 inch long and are nocturnal. The chewing type damage may appear as leaves with holes or cause a lace-like appearance when the areas between leaf veins are eaten (Figure 1). Chinese rose beetles 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 Hawaii. The larvae feed on decaying plant material and are not damaging to basil.

Slugs, various species. Slugs are mollusks which thrive during wet weather but can also be troublesome during dry weather in irrigated field and greenhouse basil crops. Slugs are active at night. Their feeding damage appears as entirely eaten leaves or leaves with holes or missing leaf parts, girdling or scraping of the bark, or the entire destruction of small plants (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. Leafminer larvae feed inside the leaf tissue causing 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 inch long. Adult flies make tiny punctures on the upper sides of leaves while feeding and laying eggs. Leafminer populations in Hawaii are usually kept below damaging levels by a number of beneficial parasites. The population of beneficial parasites in a field may be significantly reduced when broad-spectrum type insecticides are applied. Because biological control does not provide total leafminer control, grower/shippers must carefully inspect the harvested basil to avoid noncompliance with quarantine regulations.

Beet armyworm, *Spodoptera exigua* (Hubner). The destructive stage of the beet armyworm is the larva or caterpillar which causes a chewing type of damage on basil. The younger leaves are most commonly infested with more than one of the small, recently hatched caterpillars. The caterpillars grow to about 1 1/4 inch long and are light green with pink to red stripes on its sides. The caterpillars develop into moths which are active at night.

Pinkwinged 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 a typical chewing type of damage to the leaves. Grasshoppers are more of a pest in home gardens than in commercial plantings where they are of minor importance.

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, are capable of flying. Brasilian leafhoppers are sucking type insects which can cause leaf scarring, sometimes confused with the mines of leafminers. Several leafhoppers species attack basil. These insects generally cause no significant in-field damage even with high populations levels. However, leafhoppers have resulted in noncompliance with quarantine regulations, especially with the eggs and small nymphs which are not easily detected. 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 and cause significant problems on basil grown for export. Thrips are small, slender insects which in the adult stage, generally have wings with hair-like fringes. The banded greenhouse thrips is very common on basil and can usually be found on the lower leaves of established plants. Their feeding leave 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. Because 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. Whitefly immature stages, which tightly attach to the leaf under sides, have caused problems with basil grown for export.

Other Pests. Other pests which cause sucking type damage to basil foliage include:

Southern green stink bug, Nezara viridula (Linnaeus)

Broad mites, Polyphagotarsonemus latus (Banks)

Red and black flat mites, Brevipalpus phoenicis (Geijskes)

Diseases of Basil

Information on basil disease etiology, epidemiology, or control is very limited. Although basil is plagued by many diseases, no fungicides or bactericides are currently registered for this crop in Hawaii. Growers, therefore, must rely on early disease recognition and use of 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, recommended cultural practices include: 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) sanitation or the removal of diseased leaves or plants, to reduce field inoculum levels; 6) moisture control, since high humidity or free water on plants strongly favors disease; 7) increase the spacing between plants to improve air-movement and reduction of leaf wetness period; 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 first encountered.

Leaf Spots.

Various organisms cause leaf spots on basil in Hawaii. Some of these are new causal agents and research on identification, pathogenicity, and spread of these organisms has been initiated. These include the following organisms:

Colletotrichum sp. This fungus causes dark leaf spots, defoliation, tip dieback, stem lesions, and sometimes loss of entire plants (Fig. 4). At times, dead tissue within leaf spots fall away, producing holes in the leaves. Like most leaf spotting 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.

Corynespora cassicola. 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 also cause stem rots. Quality and total production will be greatly reduced. Post harvest losses are also very high.

Aphelenchoides sp. (foliar nematode). These microscopic round worms 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 (Fig. 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 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 Phytophthora 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 round worms damage the roots and impede the plant's ability to take up 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 which are heavily infected (Fig. 6). Growers should check with agricultural chemical representatives, County Extension Agents, or Plant Disease Specialists for chemicals which 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 six or more weeks. The plastic cover retains heat in the soil and reduces nematode numbers. Soil solarization is effective only if sufficient sunlight is received to accumulate 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 with basil but is currently a severe problem in many other crops grown in Hawaii such as tomato, pepper, lettuce, and chrysanthemum. Infected plants may have dark colored, ring-like spots on the leaves, especially on younger leaves.

Post harvest 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 post harvest losses. Avoid harvesting from fields with known bacterial pathogens present. Select clean leaves from tips-only and avoid harvesting from branches near the base of the plant.

Weeds

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

HARVEST AND POSTHARVEST PRACTICES**Product Quality**

Hawaii relies on the high quality of its horticultural products to maintain competitiveness in the local and export market. High quality, including rich flavor and attractive dark green or purple foliage, is achieved by proper

cultural and post-harvest 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 non-acceptable cultural and postharvest management practices which may have an effect on the quality of your product.

Harvest Operation

Basil is ready for harvest about 30-35 days after planting. Usually, 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 your buyer for desirable product characteristics (stem length, etc.). Basil fields are picked daily when plants are rapidly growing. Regular harvesting prevents flowering and seed setting and encourages vegetative growth. Basil will grow about one inch per day under proper environmental conditions. During the picking operation hold the tips from the petiole to minimize contact with fragile foliage tissues. Leaves are easily bruised, which will later show up as black, water-soaked creases in the harvested product.

Handling and Packing

Fresh basil is very tender and is easily damaged by rough handling, desiccation and chilling. In order to help ensure and maintain product quality, minimize bruising when harvesting 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 which are not strongly adhered to the plant. It is important to drain off the free water before packing the product. Basil may be packed in bulk or packed in twelve bunches to the pound in polypropylene bags placed in paper cartons, sometimes lined with moist paper. For the local market, basil is packed in 1-2 oz plastic bags.

Storage and Transportation

The shelf-life of basil is relatively short as compared to other herbs such as rosemary, oregano and thyme, and 30% 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 (5-13°C) and 95% 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 from live insects which will result in noncompliance with Federal and State quarantine regulations.

Other postharvest tips for basil include:

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 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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Captions for Photographs

Cover Photo: Sweet Basil plant.

Figure 1. Chinese rose beetle damage to basil

Figure 2. Slug damage to basil

Figure 3. Brazilian leafhopper damage to basil

Figure 4. Leaf spots caused by Colletotrichum sp.

Figure 5. Fusarium Disease of Basil

Figure 6. Damage to Basil By Rootknot nematode

Figure 7. Chilling Injury of Harvested Basil

