CHAPTER 3

SUSTAINABLE AND ORGANIC PRODUCTION METHODS
SUSTAINABLE AND ORGANIC PRODUCTION METHODS

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RESOURCES AND RECOMMENDED READING

Use this document in conjunction with the companion website:

Links for New Farmers
http://www.ctahr.hawaii.edu/sustainag/newFarmer/links.asp

hosted by the Sustainable Agriculture Program at the University of Hawaii College of Tropical Agriculture and Human Resources. Extensive additional information and updates are posted there.
SUSTAINABLE AND ORGANIC PRODUCTION METHODS

Agriculture defies simple description and encompasses an extensive range of subjects and methods. By now you must realize that it is impossible to pick up a single book to learn how to produce high quality crops and animals. This section will direct the new farmer to information sources to learn about the biological, chemical and decision-making principles which guide their use of sustainable and organic practices on the farm.

THE PHYSICAL ENVIRONMENT

Beginning farmers must recognize that they work within the limits of an ecosystem. They optimize the fit between the animals and crops that they grow with the limiting features of the physical environment. They will select plants and livestock that are adapted to and will thrive in the localized micro-climate and weather region of Hawaii where they farm.

WATER

Farms require an abundant water supply for growing both plants and animals. Your water supply may largely determine what you can grow. Understand what the water sources are for your farm, where they come from. The most common water sources on Hawaii farms are county water or catchment tanks for rainwater collection. Become familiar with the water rights for the property and the water rates, if applicable. Get the water tested to determine if there is any contamination. Find out how much rainfall the farm receives and the annual precipitation rates. If you will need supplemental water, learn all you can about irrigation systems. Surface, sprinkler, drip or trickle irrigation systems offer lots of different possibilities depending on your crop and climate needs. Investigate how you can conserve water on-site by using methods such as cover cropping, mulching, terracing, and growing drought tolerant varieties.

Water management is a critical factor in maintaining optimum plant health. Learn to recognize the signals of water stress for your crops. Too much water can promote certain diseases such as Phytophthora root rot. Too little water can stress plants making them less resistant to attack from insects and plant pathogens.

CLIMATE

The amount of light (day length), heat, and the weather patterns (wind, rain, temperature, and humidity) will strongly influence what you can successfully grow on the farm.

ORGANIC PRODUCTION HIGHLIGHT

“Organic farming is a production system that avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to support plant nutrients and to control insects, weeds and other pests.”

US Department of Agriculture

NOTE: The use of genetically modified organisms (GMOs), human manures and sewage sludges, and food irradiation are not allowed in organic farming.

Where to Find CLIMATIC DATA

Hawaii Climate Summaries
<http://www.wrcc.dri.edu/summary/climsmhi.html>

Hawaii Crop Weather Reports
<http://www.nass.usda.gov/hi/speccrop/weather.htm>
SOIL

The soil resource on the farm is another major physical feature which will help determine what you can produce. The USDA Natural Resources Conservation Service (NRCS) soil maps help you learn about important soil characteristics and limitations such as drainage, depth to bedrock, and texture. Check this on-line resource for maps for all of the Hawaiian islands to determine the capability grouping for the soils on your farm (<www.ctahr.hawaii.edu/soilsurvey/soils.htm>).

The beginning farmer needs to have a clear understanding of soil properties and processes. An excellent introductory publication, Building Soils for Better Crops, covers soil science fundamentals such as soil organic matter, the soil food web, nutrient cycles, tilth and aeration. Management methods, such as the use of cover crops, crop rotations, compost, animal manures, low and no-till methods to improve soil health are explained as well.

SOIL FERTILITY

In the past, conventional agriculture systems have emphasized meeting the nutritional requirements of plants primarily by applying easily soluble chemical fertilizers to the soil that were immediately available to the plants for nutrient uptake. Initially, yields were astounding. However, over time these farms came to experience serious declines in yield attributed to loss of organic matter, degradation of soil structure, and a depletion of micronutrients. Today, as the soil biological sciences catch up with soil chemistry, we are gaining a more comprehensive understanding of the relationships between soil particles, microbes, insects and plants. As we learn, more “conventional” farmers are embracing the same production principles used in organic and sustainable production systems.

Sustainable and organic systems meet nutritional needs to a great extent by managing soil biology, chemistry, and structure to optimize soil fertility and nutrient cycling. These farmers focus on providing nutritional balance, which will include micronutrients. They farm with the goal of improving the soil habitat to allow beneficial soil microorganisms to flourish. This results in healthy plants which are better able to withstand pest and disease pressures. In addition, by using these methods, many farmers are reporting improved marketability and longer shelf life for their plant products.

To meet their nutrient needs, organic farmers generally rely on animal or plant products and by-products (fish emulsion, blood meal, feather meal, bone meal, alfalfa meal, soybean meal), rock minerals (high-calcium aglime, dolomitic limestone, various rock phosphates, gypsum, sulfate of potash-magnesia, mined potassium sulfate), and rock powders (glauconite/greensand, glacial gravel dust, lava sand, Azomite®, granite meal).
Organic Matter and the Soil Food Web

Much of the farmer's efforts to improve and maintain soil health revolve around increasing and managing soil organic matter levels. Organic matter is important for keeping soil structure loose, to allow for good root penetration and water percolation. It can supply important plant nutrients such as nitrogen, phosphorous and sulfur. Adding organic matter can help reduce excessive soil compaction. In times of drought, organic matter will hold water far longer, reducing stress on the crop. Additions of organic matter often stimulate populations of beneficial soil microbes responsible for nutrient cycling. Some of these soil organisms prey on and reduce populations of damaging nematodes or plant disease organisms. Organic matter improves the ability of soils to retain nutrients.

The most common way to increase organic matter and nutrient cycling in soils is through applying green manures, animal manures, and composting.

Green manures (often nitrogen-fixing legumes) are crops grown primarily for the purpose of being plowed down back into soil to improve soil fertility and structure and are used extensively in organic production. Because they remove a field from production while growing, in the past they have not been popular with local conventional farmers. However green manures are rapidly gaining wide-spread acceptance in Hawaii for breaking disease cycles.

A related practice, cover cropping, can have the same beneficial effects as green manuring. Managing Cover Crops Profitably, a book available from SARE (Sustainable Agriculture Research and Education), gives the new farmer a comprehensive introduction to green manures and cover crops. The University of Hawaii has a tropical cover crop and green manure database with information about plants suitable for local island agriculture (<www.ctahr.hawaii.edu/ sustainag/Database.asp>).

Livestock manures and manure composts are also traditional sources of organic matter and soil fertility. Unfortunately in present-day agriculture, crop and livestock production are frequently segregated, making it difficult to source and costly to haul to the farm fields. Gradually this trend is reversing as it becomes more common for livestock and crop farmers to form partnerships for manure recycling.

Because of the risk of certain bacteria and viruses that can be spread through raw manure, it is good to exercise a bit of caution. Refer to the side bar to familiarize you with the USDA regulations regarding the use of manures on organic farms.

Compost is also a great source for building organic matter. It not only builds organic matter, but also balances pH levels in soil, helps with moisture retention, and breaks up clay soils. It is considered a slow releasing fertilizer with significant amounts of nitrogen, potassium, phosphorus. It is full of micronutrients and large popu-
lations of beneficial microbes. Presently, finding a steady source of finished compost in this state is fairly difficult so many farmers make it themselves. Refer to the side bar for guidelines from the USDA on making composting. Contact your cooperative extension agent to find out about upcoming compost workshops in your area. Also check with local recycling programs such as Recycle Hawaii on the Big Island and Opala on O‘ahu.

For additional information about animal manures and composting, refer to Chapter 5, Animal Production.

SOIL TESTING

Farmers using sustainable and organic production methods often use soil and plant tissue test results to help them determine what they need to grow crops. The farmer will apply organic or chemical fertilizers based on the uptake rates for their crop. Since nutrient and mineral requirements vary from crop to crop, the farmer must become familiar with each plant’s nutrient requirements and match them to their soil conditions. Consult your local extension office to obtain information about nutrient and mineral requirements for the crops you wish to grow. Again, a clear understanding of nutrient cycles, especially for nitrogen and phosphorus, is vital for successful sustainable and organic production.

With our state’s current emphasis on diversified agriculture and market expansion, there are many information gaps on the nutrient needs of the new varieties and exotic tropical crops being grown. You may need to do some small test plots and experiment with fertility rates at your own farm. With experience you will come to recognize optimal plant health by observing plant color, stem structure, and overall plant vigor.

The University of Hawaii Agricultural Diagnostic Service Center (ADSC) lab conducts standard chemical analyses of soils, plant tissue, water and nutrient solutions (as well as plant disease, feed and forage, and insect identification analyses). Fertilizer recommendations from ADSC are calibrated to the soils of Hawaii. Micronutrients are generally measured through plant tissue analyses. Organic farmers will need to adjust standard ADSC recommendations since they will not be appropriate for organic fertilizer application rates. Consult with your extension service professionals for assistance in understanding test results and recommendations.

Several mainland laboratories now offer soil testing services for biological parameters, which is still a relatively new field within the soil sciences. There are also “alternative” soil testing labs which base their recommendations on a different soil fertility system (known as the Albrecht system, cation nutrient balancing, the CEC or base saturation approach). Be sure to ask if the recommendations from these mainland labs are calibrated and accurate for Hawaii soil conditions.
**KNOW YOUR PLANTS AND ANIMALS**

We are assuming that you have read the section on direct marketing and are now very “akamai” (Hawaiian for smart, clever, expert) about selecting the diverse range of crops and animals that you plan to grow (based, of course, on what you can sell). If you don’t have access to property, now would be the time to research the optimal environment to grow your agricultural products. If, however, you already have land, you should match your choice of crops and livestock to your physical environment.

When considering what to grow, learn everything you can about the biology of the species. Nothing can take the place of the farmer’s thorough knowledge of the life cycle, nutritional needs, water requirements and pest problems of their crop. You’ll need to know the lowest and highest temperatures that can be tolerated, how many days to harvest, the pH, moisture and fertility requirements. There are volumes of information available from the Cooperative Extension Service, the educational outreach agency of the land grant University of Hawaii. Look to other major universities located in similar climatic areas, such as the Universities of Florida and California, for additional sources of information. Seed companies also usually provide cultural information about their products.

To match plants and animals to your local environment, look into the origin of the species, where it grows naturally, and how it performs commercially. Compare this with the crops and animals already being raised in your area. Ask older farmers what they used to grow and what they are growing now. Make sure you can source healthy, locally adapted stock.

Crops that are in excellent health and well adapted to the local environment are more able to withstand insect damage and disease. You decrease your risks of pest damage by selecting the right plants and animals for your property. (With more experience, you may try to push the limits of your ecosystem to get a price premium for a product that is more difficult to grow in Hawaii.)

**PEST MANAGEMENT**

Farmers around the world invest considerable time and energy to protect their crops from disease and pests. In the recent past, pest control was considered to be synonymous with pesticide use. Over time, the folly of relying too much on pesticides became apparent. Pest species began to develop resistance to the pesticides. Pest resurgence (a rebound of the pest species, often to higher levels than before) occurred because natural enemies which had once held pest populations in check had been killed. Secondary pest outbreaks began to become a problem. Pollinator species such as honey bees, leaf-cutting bees, alkali bees and bumblebees were damaged, with resulting crop declines. Pesticide residues began to be observed in air, soil, water, as well as in the food supply and accumulated in the human body.
A new approach to pest control was developed and is widely used today, embraced by both conventional and organic farming communities, and replacing the chemical “silver bullet” approach. Integrated pest management (IPM) emphasizes monitoring and identifying pests and natural enemies, preventing pest outbreaks, and using the least toxic materials available to manage pest species.

**INTEGRATED PEST MANAGEMENT**

According to the US Environmental Protection Agency (USEPA), IPM is a series of pest management evaluations, decisions and controls. In practicing IPM, growers who are aware of the potential for pest infestation follow a four-tiered approach. The four steps include:

1. **Prevention**: As a first line of pest control, IPM programs work to manage the crop to prevent pests from becoming a threat. In an agricultural crop, this may mean using cultural methods, such as rotating between different crops, selecting pest-resistant varieties, and planting pest-free rootstock. These control methods can be very effective and cost-efficient and present little to no risk to people or the environment.

2. **Monitor and Identify Pests**: Not all insects, weeds, and other living organisms require control. Many organisms are innocuous, and some are even beneficial. IPM programs work to monitor for pests and identify them accurately, so that appropriate control decisions can be made in conjunction with action thresholds. This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used.

3. **Set Action Thresholds**: Before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken. Sighting a single pest does not always mean control is needed. The level at which pests will become an economic threat is critical to guide future pest control decisions.

4. **Control**: Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk. Effective, less risky pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control such as trapping and weeding, or physical barriers such as sticky tapes. If further monitoring, identifications and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.
PREVENTING PEST OUTBREAKS

The strategies used by successful farmers for pest control are sequential - they first use preventive measures to keep pest populations low.

- **Site Selection**: Select a site that is pest free, and choose plant species and varieties particularly well suited to the site. Assess adjacent areas for pest problems as well.

- **Resistant cultivars**: Plant pest resistant cultivars and varieties. Plant breeders and genetic engineers are producing a new array of plants with resistances to insects, plant pathogens and nematodes.

- **Sanitation**: Use good sanitation to prevent infecting your crops and livestock. Use disease-free seed and vegetative pieces (tubers, rootstock, etc.) for initial planting. Clean equipment that is transferred between sites to prevent spreading pathogens, weeds, and nematodes. Be sure your irrigation water is clean. Remove unharvested crops which might provide shelter and food sources to unwanted pests.

- **Habitat**: Modify the habitat to make it unfavorable for pest species. Areas adjacent to your crops may provide food, shelter, and alternate hosts that allow pest species to survive. Plants that can harbor pests should be replaced with plants that shelter beneficial organisms.

- **Cover crops**: Cover crops can suppress weeds and provide food and shelter to beneficial insects, mites and spiders.

- **Crop rotations**: Alternate the sequence of crops grown in a field to prevent populations of soil-borne plant pathogens and nematodes to build up.

- **Planting and harvesting dates**: In certain cases, the planting and harvesting dates for the crop can be adjusted to favor crop growth and avoid seasons with large pest outbreaks.

- **Proper irrigation and water management**: Pest outbreaks can be triggered by improper water management practices. For example, certain root and crown diseases can be aggravated by excess water. Certain weeds favor areas with poor drainage.

- **Soil drainage**: Prepare the land properly. When tilling and cultivating the soil, be sure to use methods which reduce soil compaction and provide good drainage.

- **Fertilizer and soil amendments**: Over fertilization (especially with nitrogen) may attract or enhance development of pest species.

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**INCREASING BIODIVERSITY**

“Ideally, agricultural landscapes will look like patchwork quilts: dissimilar types of crops growing at various stages and under diverse management practices. Within this confusing patchwork, pests will encounter a broader range of stresses and will have trouble locating their hosts in both space and time. Their resistance to control measures also will be hampered. As plant diversity intensifies above ground, diversity builds in the soil. Through a system of checks and balances, a medley of soil organisms helps maintain low populations of many pests. Good soil tilth and generous quantities of organic matter also can stimulate this very useful diversity in pest-fighting soil organisms.”

‘Naturalize’ Your Farming System: A Whole-Farm Approach to Managing Pests
LEAST TOXIC PESTICIDES

Since pests are controlled most effectively when their populations are low, experienced farmers act before pest problems reach devastating levels. This is accomplished by setting an “action threshold” - a pest population level where some form of control must be taken to avoid economic or aesthetic damage to the crop.

If there is a pest outbreak after using preventive measures and the action threshold is passed, the farmer will move to the next strategy, using effective low risk controls to reduce pest populations. For example, mating disruptors, sticky traps, and physical barriers are examples of non-toxic methods to reduce insect pests.

If pest populations continue to escalate and cause unacceptable levels of damage, pesticides are generally used. Most pesticides are chemicals which are intended to damage or kill pest species. Unfortunately, these same chemicals can poison or injure humans as well. Farmers, farm workers, and farm families can be exposed to these products by mouth, by inhalation, and through the skin or eyes. Effects can be acute (with symptoms appearing within 24 hours) or delayed. They may be the result of a single exposure to a chemical, to repeated exposure, or from exposure to a combination of chemicals. Some illnesses which may be traced to pesticide exposure include tumors, cancers, chromosome damage, birth defects, miscarriage, infertility and sterility, and systemic disorders of the blood, brain and nervous systems, skin, lung and respiratory systems, and liver and kidneys.

Federal and state laws strictly regulate the use of pesticides. **General use** pesticides are available to anyone and are considered to be safe if used according to label directions. **Restricted use** pesticides are more hazardous to human health or the environment and are not available for public use. Farmers or ranchers wishing to use restricted-use pesticides on crops on their property must pass a certification exam administered by the Hawaii Department of Agriculture. The exam tests your ability to interpret pesticide labels and to apply label information to pest management problems. You are expected to understand proper handling, calibration, storage, and disposal techniques; first aid and emergency response; and the fate of pesticides in the environment. The University of Hawaii Cooperative Extension Service offers training materials and classes to prepare for the certification exam. Additional information is available at the Pesticide Extension website: <http://pesticides.hawaii.edu/>

There are several criteria for pesticide selection such as toxicity (especially to humans), selectivity (range of organisms it will impact), persistence (length of time it takes to degrade), and mode of action (method chemical uses to kill target organism).

Organic farmers will select the least toxic pesticide permitted under the National Organic Program’s **National List of Allowed and Prohibited Substances**. Currently, there are a variety of organic approved pesticides for sale on the market. Most of them are vinegar, clove oil or lemon based products.
**INSECT MANAGEMENT**

Hawaii’s year-round subtropical climate provides excellent growing conditions for many insect species. Lacking a winter season with temperature extremes and a fallow period, pest populations can rapidly build to damaging levels. The war on insect species is continuous and farmers must be constantly observing their fields and keeping records of what they find. In addition, new pests are constantly arriving on our shores.

Insect identification is complicated because many insects undergo major changes between their immature and adult stages. Farmers need to learn what insect pests and their natural enemies look like throughout their life cycles. Knowledge of their habitat requirements, their mode of dispersal and movement, and the type of damage they do is helpful. There are many resources available to learn some basic entomology.

Plan weekly inspections in the field with a hand lens and a photographic identification key. In the beginning, you may need to hire a trained pest control advisor or scout to help with insect ID.

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**INSECT PEST MANAGEMENT**

for arthropods, insects, mites, spiders

**CULTURAL CONTROLS**
- **site selection** – choose sites and adjacent areas free from insect pests
- **use resistant or tolerant cultivars**
- **habitat manipulation** – destroy sections that harbor pests, enhance areas that provide food and shelter for beneficial insects (field borders, insectaries)
- **cover crops** – select plants to provide habitat for beneficials
- **trap crops** – use to lure pests away from cash crop
- **crop rotation** – alternate pest-susceptible crops with pest-resistant crops to avoid build up of pest populations
- **adjust planting and harvesting dates** – avoid seasons with peak pest outbreaks
- **proper irrigation/water management** – especially avoid water stress
- **fertilizer management** – avoid excessive nitrogen fertilization
- **fallow period** – to reduce insect pest populations in soil (cutworms, root maggots)

**MECHANICAL CONTROLS**
- **soil tillage** – expose insects to birds and predators
- **birds** – chicken, ducks, geese
- **vacuums**
- **barriers** – floating row covers, plastic tunnels, sticky barriers, reflective mulches
- **traps**

**BIOLOGICAL CONTROLS**
- **conservation and enhancement of natural enemies** – predatory arthropods, parasitic insects, nematodes, pathogens, vertebrates (birds/bats/fish)
- **augmentation** – natural enemies augmented and released

**CHEMICAL CONTROLS**
- **less toxic insecticides** – mating disruptors
- **conventional insecticides**
- **organic insecticides**
WEED MANAGEMENT

CULTURAL CONTROLS
• site selection – choose sites and adjacent areas free from weed pests
• sanitation – clean machinery, clean irrigation water, weed-free compost and manure
• transplants – use to outcompete weeds
• increase crop density – “close-plant” crop to outcompete weeds
• smother and cover crops – suppress weeds between rows
• mulches – old hay, straw, wood chips to suppress weeds between rows
• living mulch – cereal, clover or vetch crops grown between rows and killed before crop planting to avoid excessive competition with cash crop
• proper irrigation/water management – buried drip tape to minimize water available to weeds
• reduce weed seed bank – no weed allowed to go to seed; off-season weed control

MECHANICAL CONTROLS
• soil tillage – shallow cultivation
• mowing – before weeds set seed, at low soil moisture
• flaming
• stale seedbed – pre-germinate weeds then destroy by cultivation, herbicide or flamer
• solarization – plastic mulch over tilled, moist soil to allow solar energy to kill weed seeds

BIOLOGICAL CONTROLS
• insects
• pathogens
• vertebrates – fish, birds (Chinese weeder geese), cattle, sheep

CHEMICAL CONTROL
• conventional herbicides
• organic herbicides – acetic acid, citric acid, sodium nitrate, corn gluten

WEED MANAGEMENT

Weeds are the great competitors of the plant world. They possess features such as abundant seed production, rapid population establishment, seed dormancy, long-term survival of buried seed, adaptations for seed dispersal and vegetative reproduction, and the ability to invade sites disturbed by people. These properties make them formidable opponents in the battle for survival in your field. Weed control can be one of your biggest expenses.

There are many varied and creative strategies for weed control being currently used -- new types of farm machinery, rotational grazing with weed-eating animals, weed-suppressive cover crops, and modified flame throwers. All successful weed control strategies include preventing weed introduction and reseeding.

INVASIVE WEED?
Before you introducing a new plant to Hawaii, thoughtfully consider the weed description above. Does your new crop have any of these aggressive features? Could this plant some day make it onto Hawaii’s invasive species list? Could your green manure or cover crop jump the fence lines and naturalize in adjacent fields and forests?

Hawaii’s native forests have been badly damaged by invasive plant species, most of which were introduced by earlier generations of farmers, ranchers, horticulturists, and foresters.

Learn more about invasive plants and noxious weed in Chapter 4, The Farm as Habitat: Environmental Topics.

Pest Advisories
Check the Hawaii Dept. of Agriculture website for the latest pest advisories for our state.
<www.hawaiitag.org/hdoa/pl_pa.htm>
PLANT DISEASE MANAGEMENT

Plant pathogens are microorganisms (fungi, bacteria, viruses, viroids, and phytoplasmas). They constantly mutate, resulting in new threats to your crop. Although Hawaii is remote and naturally relatively pathogen free, the local, regional and global movement of seed, plant materials and farming equipment makes new introduced pathogens a constant problem for our agriculture and environment.

Pathogen identification requires specialized knowledge and equipment - you may need assistance from a professional to accurately diagnose them. The Agricultural Diagnostic Service Center (ADSC) has on-staff plant pathologists to help you determine what is causing the problem.

When it comes down to disease, it's all about prevention. The best practices minimize conditions that harbor disease. By incorporating good sanitation practices, appropriate watering techniques, good plant spacing, and being aware of new plant materials and farming equipment making its way on to your farm you can minimize the threats.

As researchers and farmers come to better understand microbiology, promising new methods to control plant disease using biological agents (such as disease-suppressive composts and compost teas) appear to be on the horizon.

PLANT DISEASE MANAGEMENT

fungi, bacteria, viruses, nematodes

CULTURAL CONTROLS
• **site selection** – choose sites and adjacent areas free from plant pathogens and pathogen vectors
• **resistant cultivars** – many new transgenic cultivars being developed
• **sanitation** – exclude pathogens with excellent sanitation practices at all points in production (in greenhouse, on equipment, in field).
• **habitat manipulation** – use green manures and composts to enhance beneficial organisms in soil food web and promote disease-suppressive soils
• **cover crops** – select non-host cover crops
• **crop rotation** – alternate non-host crops in rotation to avoid build up of pathogen populations; plant disease-suppressive crops (broccoli, mustards, sudangrass)
• **adjust planting and harvesting dates** – avoid seasons favorable to pathogen outbreaks
• **proper irrigation/water management** – overwatering favors most soilborne pathogenic fungi; overhead sprinkler irrigation favors foliar diseases (survival, dispersal, and disease development); drip irrigation or subsurface irrigation may be preferable
• **soil drainage** – poor soil and bed preparation can favor damping-off (fungi)
• **fertilizer management** – excessive nitrogen fertilization can promote pathogen susceptibility, raised pH levels can reduce symptom expression for club-root disease of crucifers
• **fallow period** – to reduce pathogen populations by keeping field host-free
• **vector control** – weed and insect hosts of viral and bacterial pathogens

MECHANICAL CONTROLS
• **soil tillage** – deep plow infected plant residues
• **solarization** – plastic mulch over tilled, moist soil to allow solar energy to kill weed seeds

BIOLOGICAL CONTROLS
• myco-pesticides
• disease-suppressive composts and compost teas

CHEMICAL CONTROL
• conventional pesticides
• organic pesticides – copper, sulfur, or bicarbonate based fungicides, oils, plant extracts, compost teas
RESOURCES AND RECOMMENDED READING

COMPANION WEBSITE
Use this document in conjunction with the CTAHR website **Links for New Farmers**. Additional information and updates are posted there.

<www.ctahr.hawaii.edu/sustainag/newFarmer/links.asp>

CLIMATE
**Hawaii Climate Summaries** (WRCC, NOAA) <www.wrcc.dri.edu/summary/climsmhi.html>
**Hawaii and Pacific Island Local Climate Summaries** (WRCC, NOAA) <www.wrcc.dri.edu/summary/lcdpi.html>
**Hawaii Crop Weather Reports** (HASS) <www.nass.usda.gov/hi/speccrop/weather.htm>

SOILS INFORMATION

GENERAL
**USDA NRCS Hawaii Soil Survey**: The “Hawaii Soils” site features on-line maps and descriptions of the soils found in the Hawaiian Islands. <www.ctahr.hawaii.edu/soilsurvey/soils.htm>


**NRCS Soil Quality Institute Soil Biology Primer** is an introduction to the living component of soil and how it contributes to agricultural productivity, and air and water quality. The Primer includes units describing the soil food web and its relationship to soil health, and units about bacteria, fungi, protozoa, nematodes, arthropods, and earthworms. <soils.usda.gov/sqi/soil_quality/soil_biology/soil_biology_primer.html>

**Soil Central**: CTAHR webpage with info on soils of Hawaii, soil fertility and chemistry information, soil testing, and other useful links. <www2.ctahr.hawaii.edu/ctahr2001/Soil/>

**Plant Nutrient Management in Hawaii’s Soils**. CTAHR publication containing practical research information on soils, fertilizers, and crop nutrient needs, written for the lay reader for Hawaii’s crops and soil conditions. $14. Available for purchase from CTAHR.

SOIL TESTING


**CTAHR’s Agricultural Diagnostic Service Center** (ADSC): This lab conducts plant disease analyses, feed and forage analyses, insect identification analyses, chemical analyses of soils, chemical analyses of plant tissue, and chemical analyses of water and nutrient solutions.

College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa
1910 East West Road, Sherman Lab 134, Honolulu, Hawaii 96822
Ph: 808-956-6706  Fax: 808-956-2592
Email: adsc@ctahr.hawaii.edu
<www2.ctahr.hawaii.edu/adsc/>

**ATTRA**: **Alternative Soil Testing Laboratories** <attra.ncat.org/attra-pub/soil-lab.html>

COVER CROPS

**Managing Cover Crops Profitably**: USDA’s Sustainable Agriculture Network (SAN). An online pdf version of the book is available online and the second edition can be purchased (book $19, or CD-ROM $10). <www.sare.org/publications/covercrops/covercrops.pdf>

**Sustainable Agriculture in Hawaii: Cover Crop and Green Manure Database** at CTAHR provides information about plants which are suitable for tropical climates. Includes downloadable fact sheets. <www.ctahr.hawaii.edu/sustainag/Database.asp>
**CROP KNOWLEDGE**

**GENERAL**

*UH College of Tropical Agriculture and Human Resources* (CTAHR) has free and for sale publications with a wide range of information. Free publications include downloadable fact sheets on producing fruits and nuts, home garden vegetables, ornamentals and flowers, green manures and cover crops, insect pests, plant disease, weed control, and crop and soil management. For sale publications include production manuals for taro, coffee, tea, onions, corn, and lei plants. 

<www.ctahr.hawaii.edu/ctahr2001/>

CTAHR *Ask the Experts* Database (<http://pdcs.ctahr.hawaii.edu:591/ate/> contains hundreds of questions and answers to a great variety of topics. It includes access points for CTAHR’s *Publications Database, Knowledge Master* (weeds, diseases, and pests), *Pesticide Information Retrieval System* (for commercial users of agricultural chemicals) and *The Farmer’s Bookshelf* (production information about many fruits, vegetables, ornamental plants, and home garden vegetables).

**PEST MANAGEMENT**

**GENERAL**


**PESTICIDES**

*Pesticide Risk Reduction Education Program*, University of Hawaii Cooperative Extension Service (<pesticides.hawaii.edu/epp/pat.html>). Contains on-line training manuals to prepare for pesticide certification exams.

**INSECT MANAGEMENT**

Extension Entomology & UH-CTAHR Integrated Pest Management Program. *Knowledge Master* contains general information on pest hosts, distribution, damage, biology, and management. This website is helpful for pest identification. The management recommendations are for conventional agricultural practices and will most likely need modification for sustainable systems. Contact CTAHR experts directly for more information. <www.extento.hawaii.edu/kbase/default.htm>

**WEED MANAGEMENT**


**ORGANIC PRODUCTION RESOURCES**

Hawaii Organic Farmers Association is a nonprofit organization that provides information and education, farm apprenticeship programs, and organic certification for Hawaii’s farmers. They sell a handbook that familiarizes beginning farmers with the federal rules on organic practices ($15).  

Hawaii Organic Farmers Association (HOFA)  
P.O. Box 6863, Hilo, HI 96720  
Phone: (808) 969-7789 Toll Free: (877) 674-4632  
Email: hofa@hawaiiorganicfarmers.org  
www.hawaiiorganicfarmers.org/


Organic Materials Review Institute (OMRI) <www.omri.org/>

Organic Farming Research Foundation (OFRF) <www.ofrf.org/>
Organic Trade Association (OTA) <www.ota.com/index.html>


LOCAL ASSISTANCE

UNIVERSITY OF HAWAII COOPERATIVE EXTENSION SERVICE (CES)
To locate the CES office nearest to you, contact:

Cooperative Extension Service
3050 Maile Way, Gilmore Hall 203, Honolulu HI 96822
Tel: (808) 956-8397
Email: extension@ctahr.hawaii.edu
Website: <www.ctahr.hawaii.edu/ctahr2001/>

NATURAL RESOURCES CONSERVATION SERVICE (NRCS)
To locate the NRCS office nearest to you, contact:

NRCS State Office
PO Box 50004, Honolulu HI 96850-0050
Tel: (808) 541-2600
Website: <www.hi.nrcs.usda.gov/>