

Guam

Cucurbit Guide

A Guide to production and IPM practices
for Melons, Cucumber, and Squash on Guam



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FOREWORD

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The Guam Cucurbit Guide is comprehensive in nature and carefully designed to provide Guam's cucurbit growers, agriculture extension agents, agricultural students, and home-owners with a comprehensive manual covering all aspects of cucurbit production. This publication incorporates information from a number of sources as it relates to extension activities on Guam. The sources include compendiums, cucurbit guides and fact sheets from U.S. Land Grant Universities; historical data from the Guam Agricultural Experiment Station; and current research and surveys conducted by faculty of the College of Agriculture and Life Sciences. Since cucurbits are worldwide in distribution, fundamental information on growth requirements, cultivated varieties, diseases, insects, weeds, and nutrients will be of interest to all growers. Even though the production/protection practices in this guide were designed for Guam, the fundamental principles can be applied elsewhere. The goal of this publication is to empower any cucurbit producer with enough general and specific information to enhance learning and encourage sound production practices on Guam and elsewhere.

This guide is designed to be user-friendly and to provide information at various levels of interest. At the initial level, the guide's photo plates can be used as a quick visual reference to many of the insects, weeds, and diseases which are common to cucurbit crops. The unit entitled **Trouble Shooting Cucurbit Problems** indexes symptoms, signs, and plant injuries to various causes with associated page and plate numbers. Detailed information on diagnosing problems using technical equipment (i.e., hand-lens, stereomicroscope, or compound scope) and control recommendations can be found in the **Management of Plant Pathogens** unit. Other units include **Cucurbit Management**, **Postharvest Handling**, **Weed Management**, **Management of Insects and Mites**, and **Management of Animal Pests**. To assist growers in applying the principles of integrated pest management, an **IPM Watermelon Pest Survey Form** is provided at the end of the **Management of Insects and Mites** unit. This form advises growers on how to sample their field for insects and when to spray. **Pesticide Safety** is also covered in the guide. Individuals needing assistance in determining a farm budget for cucurbits will find **Developing Budgets for Cucurbits** of value. The unit on **Food Nutrition** provides nutritional information and gives a few recipes.



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Trouble Shooting Cucurbit Problems

Robert Schlub, Extension Plant Pathologist

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The causes of poor plant health can be placed into four major groups. One is due to infectious agents such as viruses, bacteria, fungi, nematodes, and parasitic plants. These are commonly referred to as plant pathogens. Another cause is due to organisms that are mobile such as insects, mites, snails, and mammals, which are referred to as animal pests. Weeds make up the third group. All other causes of plant health problems are placed in the final group, which we call unfavorable factors.

It is important to know the difference between symptoms, injury, and signs in order to diagnose plant problems. Plant pathogens and unfavorable factors generally cause plant symptoms; whereas, animals generally cause plant injury and leaf signs. A symptom is the appearance of a plant when it is

subjected to a stress condition. Yellowing, stunting, spotting and wilting (drooping of leaves) are plant symptoms. Plant injury refers to plant tissue that is missing or damaged due to feeding by insects and other animals. Signs are indications that something is present or was present. Insect signs include presence of feces (droppings), shed skins, or sticky wet excrement. Signs of plant disease include fungus structures and bacterial ooze. To identify the main causes of observed symptoms, injuries, and signs covered in the guide, refer to Table 1. If pests such as maggots, flies, beetles, bugs, caterpillars or snails are seen, then refer to the unit on **Management of Insects and Mites**, and **Management of Animal Pests** for identification. If weeds are crowding out your crop, refer to the **Weed Management** unit.

Table 1. The causes of symptoms, injury and signs associated with unhealthy cucurbit plants starting with the likeliest.

Seedling	Likely Causes
Broken at the soil line	A1, A13
Rotted at the soil line (damped-off)	D5, C9, D2, D8
Leaf tissue bitten away	A12, A13, A3, A4, A5
Leaf spots, blotches, or specks	D1, D2, D9, A6, A16
Yellowish coloration	C9, C3, C7
Wilted	C6, C9, D5, D8, D11

Stems or Vines	Likely Causes
Gnawed near the soil surface	A1, A3, A12, A9, A13
Brown sticky sap	D9, D8, A8
Rotted near the soil surface	D9, D8, D5, C9
Areas of dead tissue	D9, D1, D12, D8, A13
Stunted	D11, C4, C6, D13, C2
Weak or shriveled	D8, C6, D11, A8, C5, C8
Dead or distorted tips	A14, A2, D13, D1, D12
Thin yellow intertwining vine	D6

Fruits and Flowers	Likely Causes
Aborting of flowers and fruits	C5, C8, C12, C9, A14
Few fruits	C10, C8, D13, D11, C12, D4
Spots on fruit	D7, D9, D1
Irregular areas of discoloration on fruit	D2, A8, D13
Flower end of fruit rotten	D3, C12, C8, D7
Fruit eaten	A11, A4, A9, A13, A12
Moldy or rotten fruit	D7, D5, D9, D2
Misshapen fruits or sunken areas	C10, D13, A8, A7
Bitter fruit	D13, C5
Watermelon partially hollow	C8, C9
Small holes in fruits or flowers	A7, A8

Roots	Likely Causes
Blackened and rotten	D5, A12
Areas of swelling	D11
Poor development	C5, C9, D5, C6, A12

Table 1 (continued)

Leaves	Likely Causes
Holes surrounded by green tissue	A12, A5, A3
Holes/spots surrounded by yellow-brown tissue	D1, D4, D12, D9
Yellowed areas or grayish dust	D10
Curled leaf surface	A10, A2, D13, A14, C5
Mosaic	D13
Yellowing of older leaves	C3, D10, C7, C1, C4
Slow growth with purplish veins	C4
Young leaves yellowish, green veins	C1, C2
Sticky surface	A2, A15
Paper thin patches	C11, A3, A6
Fine silky webbing	A10, A3
Tunneling in the leaves	A6
Wilted	D8, D9, C6, C9, D11, A12
Silvery leaves	A14, A15, A16
Silvery trail	A13
Tissue eaten from leaf margin or growing tip	A3, A13, A9, A12, A11
Large brown areas	D9, D1, D12, D4, A6
Tiny white dots or specks on upper leaf surface	A16

Animal Pests	Page	Plate
A1 Ants	<u>41</u>	
A2 Melon aphids	<u>38</u>	<u>17</u>
A3 Caterpillars	<u>39</u>	<u>19</u>
A4 Birds and chickens	<u>43</u>	<u>24</u>
A5 Cucumber ladybeetle	<u>40</u>	
A6 Leafminers	<u>40</u>	<u>21</u>
A7 Leaf-footed bug	<u>40</u>	<u>22</u>
A8 Melon fly	<u>37</u>	<u>16</u>
A9 Rats and mice	<u>43</u>	
A10 Mites	<u>41</u>	
A11 Wild pigs or deer	<u>43</u>	
A12 Pumpkin beetle	<u>37</u>	<u>15</u>
A13 Snails and slugs	<u>43</u>	<u>23</u>
A14 Melon thrips	<u>39</u>	<u>18</u>
A15 White fly	<u>39</u>	<u>20</u>
A16 Fleahopper	<u>41</u>	
Unfavorable Factors	Page	Plate
C1 Deficiency: Fe—Iron	<u>13</u>	
C2 Deficiency: Mg—Magnesium	<u>13</u>	
C3 Deficiency: N—Nitrogen	<u>13</u>	
C4 Deficiency: P—Phosphorus	<u>13</u>	
C5 Deficiency: K—Potassium	<u>13</u>	
C6 Deficiency: Water	<u>6</u>	
C7 Deficiency: Light	<u>5</u>	
C8 Excesses: N—Nitrogen	<u>13</u>	
C9 Excesses: Water	<u>6, 16</u>	
C10 Poor pollination	<u>7</u>	
C11 Leaf abrasion	<u>11, 12</u>	
C12 Weather/time of year	<u>6</u>	
C13 Poor seed quality	<u>6</u>	
Plant Pathogens and Diseases	Page	Plate
D1 A = Anthracnose	<u>26</u>	<u>2</u>
D2 BFB = Bacterial fruit blotch	<u>32</u>	<u>13</u>
D3 Blossom-end rot	<u>29</u>	<u>8</u>
D4 CLS = Cercospora leaf spot	<u>27</u>	<u>3</u>
D5 D = Damping-off and RR = root rot	<u>29</u>	<u>9</u>
D6 Dd = Dodder	<u>33, 45</u>	<u>29</u>
D7 FR = Fruit rots	<u>29</u>	<u>8, 9, 10, 11</u>
D8 FW = Fusarium wilt	<u>31</u>	<u>12</u>
D9 GSB = Gummy stem blight	<u>27</u>	<u>4</u>
D10 PM = Powdery mildew	<u>29</u>	<u>7</u>
D11 RK = Root knot	<u>32</u>	<u>14</u>
D12 TLS = Target leaf spot	<u>28</u>	<u>2, 5</u>
D13 V = Viruses	<u>28</u>	<u>6</u>

Growth Requirements and Development

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Growing any crop successfully starts with an understanding of the crop's basic biology and cultural requirements. It is the growth requirements and developmental stages of cucurbit crops that ultimately determine cultural and pest management strategies.

Cucurbit crops are generally uniform in their environmental and cultural requirements. Given their tropical origins, cucurbits thrive extremely well in Guam's climatic and soil conditions. Most are vining with sprawling laterals, usually with tendrils which are borne at the leaf axils. Flowers, which are also borne on laterals, are usually bright yellow, with the exception of some gourds. Flowers are either perfect, staminate (male) or pistillate (female) (Fig. 1). Laterals are typically indeterminate (grows indefinitely) and may reach lengths of 12–15 m (40–50 ft). The compact or bushlike plants are

modern cultivars of cucumber, gourd, pumpkin, and squash. Some of these are determinate (growth stops when terminal bud flowers). Cucumbers will produce edible fruit within 35–40 days from planting (date of maturity). Some muskmelon, cantaloupe, and honeydew varieties require 70–95 days from planting. Watermelon can be harvested 75–85 days from planting.

The botanical name for the fruit of a cucurbit is a pepo. The pepo is a fleshy, indehiscent, berrylike structure, and is the product of an inferior ovary. Generally, the pepo has a relatively thick rind. Some of the fruits of the cucurbits are among the largest in the plant kingdom. Pumpkins weighing 227 kg (500 lb) or more are not unusual. Watermelons on Guam may weigh 9–22 kg (20–50 lb), depending on the variety selected.

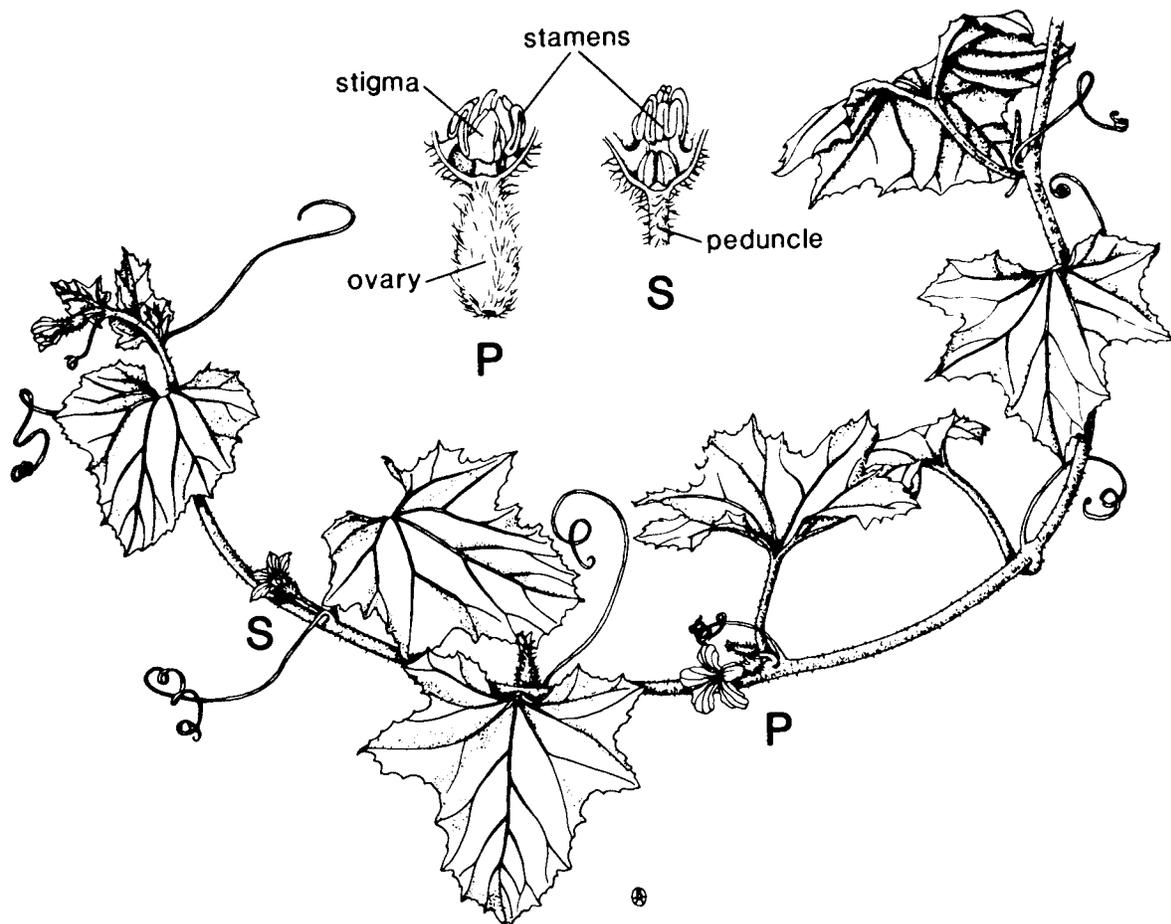


Figure 1. Cucurbit vine and flowers as typified by a honeydew melon (*Cucumis melo*). Perfect flowers (P), having male and female parts, and staminate flowers (S), having male parts only, are borne singly on slender peduncles. The ovary develops into a mature, seed-bearing fruit after successful pollination and fertilization. (Courtesy of APS Press)

Guam possesses all the essentials needed for a successful cucurbit crop, which include favorable light, soil/nutrients, water, and climate.

Growth Requirements

Light

Plant growth depends on the production of carbohydrates within the plant's green tissues. The process known as photosynthesis uses the energy from the sun in combination with water from the soil and carbon dioxide from the air to make carbohydrates (sugars). Through the process of respiration, these carbohydrates in the presence of oxygen are broken down, releasing chemical energy necessary for living cells. Excess carbohydrates are stored for later growth, maintenance, and tissue repair. A plant has two light components: one is the intensity of the light (highest being at noon in a sunny spot) the other is the day length (for those located north of the equator the summer months have the longest days). Guam has day lengths ranging from 11 hours and 19 minutes in December to 12 hours and 56 minutes in June. Although the difference in seasonal day length is small, some plants display photoperiodic responses in their development. Chayote is a short-day plant and initiates flowering when day length is slightly under 12.5 hours. Cucurbits in general are day neutral but may produce more female flowers with shortened days. Cucurbits require high intensity sunlight which is only accomplished in full sunlight. Over a 16 year period on Guam, the average percent possible sunshine was lowest in the months of August, September and October (46%) and highest in March, April and May (67%). Reduced light intensity may promote male flowers and a greater number of days to harvest.

Soil/Nutrients

Soil fertility is essential for a successful crop. It is possible to grow plants without soil such as in an aerated mineral solution (hydroponics) or in an artificial media, but the cost is high and the process requires a high level of care and expertise. Soil serves three main functions: (1) to supply nutrients, (2) to supply moisture, and (3) to provide anchorage for the plants' roots. Nutrient availability depends on soil type (sandy, loam, or clay), mineral content, organic matter content, and soil pH (acidic or alkaline). If the nutrient level is not adequate for good crop production, then fertilizer must be added to the soil. Fertilizers may be inorganic (man made) or organic (originating from plants and animals). Sludge, manure, bone meal, fish meal, and wood ashes are types of organic fertilizers. Most organic fertilizers are generally low in nitrogen and have to be added in large quantities or supplemented with inorganic nitrogen (N) fertilizer when growing cucurbits. Even dry chicken manure, which is perhaps the island's best

inorganic N source, contains only 4.5% N. Manure is generally low in phosphorus; therefore, fresh manure, should be reinforced with super phosphate at 23 kg (50 lb) per ton of manure. Manure is a good source of organic matter for the soil, increasing the water and nutrient-holding capacity of the soil.

On a pound-for-pound basis, inorganic fertilizers provide greater quantities of plant nutrients than organic fertilizers. Additionally, inorganic fertilizers provide nutrients in forms that are more readily available, thus increasing a plant's capacity for growth and high yields.

There are 16 elements (nutrients) that are essential to plant growth. Three of the 16, carbon (C), hydrogen (H) and oxygen (O) are supplied by water and air. The remaining 13 elements are categorized into three groups. The first group, referred to as primary elements, includes nitrogen (N), phosphorus (P), and potassium (K). The second group, referred to as secondary elements, includes calcium (Ca), magnesium (Mg), and sulfur (S). The third group, referred to as trace elements, includes copper (Cu), manganese (Mn), boron (B), and molybdenum (Mo). The primary elements (N-P-K) are needed in greater quantity than secondary and trace elements. However, the presence of all elements for plant growth is essential. Because of the greater need for the primary elements, most inorganic fertilizers sold on the market contain all or some of these elements.

An inorganic fertilizer which contains all three primary elements (N-P-K) is said to be complete. An incomplete fertilizer does not contain one or two of the three primary elements. The amount of primary elements is expressed by a series of numbers such as 10-30-10, 10-20-20, 16-16-16, 21-0-0, and other similar sets of numbers. The first figure is the percentage of nitrogen (N) in the mixture; the second refers to the percentage of available phosphoric acid (P_2O_5); and the third figure is the percentage of water-soluble potash (K_2O). The fertilizer requirements for a field should be based on the crop's nutrient requirements and soil test results.

The functions of the primary elements:

Nitrogen (N) gives dark green color to leaves; improves the quality and quantity of leaves; promotes rapid plant growth; and increases protein content of food crops (**Caution**—excessive application of nitrogen may suppress flowering and fruiting).

Phosphorus (P) stimulates early root formation and growth; hastens maturity of plants; stimulates seed germination, flowering and fruiting; and gives added hardness to plants.

Potassium (K), or potash, increases the plant's resistance to diseases; promotes plant growth, fruit quality and color; aids in protein production; and provides for the formation and movement of starches, sugar and oil.

Water

Nearly all plant functions require water. Cucurbit stems, roots, leaves, flowers parts, fruits, and buds all owe their shape to the water content of their cells. Some cucurbits contain up to 95% water at maturity. Even slight losses in cellular water of leaves will cause them to droop and wilt. Water is essential for photosynthesis, transporting of carbohydrates and minerals, and cooling the plant. Only about 1% of the water taken up by a plant becomes an integral part of the plant. Water loss is mainly due to transpiration (evaporation) from the leaves, via the stomata (small openings or breathing pores). It is not unusual for large leaf cucurbits to wilt some during the day then quickly recover at night. The rate of transpiration increases when the temperature is high, winds are brisk, and humidity is low. Windbreaks can be used to reduce the rate of transpiration, thereby reducing irrigation costs. Controlling foliar pathogens can also reduce transpiration since many cause destruction of leaf tissue and dysfunction of stomata. Moisture stress can also be reduced by increasing the water uptake from the roots. The majority of cucurbits have most of their roots in the top 5–25 cm (2–10 in) of soil. To encourage deep, healthy roots in watermelon, squash, and pumpkin, which may reach 1.2–1.5 m (4–5 ft), watering should be slow and long and soil should be a deep, sandy loam. Moisture stress should be avoided because the plant will stop growing until favorable conditions return. Moisture stress after fruit set may lead to early vine decline and fruits which are smaller and possibly misshapen.

Too much water can also be a problem. Excess water increases the chance of disease from soilborne organisms. It will also decrease root growth due to reduced respiration brought on by lower oxygen levels. Although sugars move from the leaves to the roots, oxygen is not transported in the case of cucurbits; therefore, their roots must obtain oxygen by absorption through root hairs and outer cellular layers, which is not possible under waterlogged conditions.

Climate

With its relatively uniform high temperature (average monthly highs-lows of 30–22° C (86–72° F), high annual rainfall (2,500 mm or 100 inches) and high humidity (65–100%), Guam's climate is nearly ideal for tropical cucurbit varieties. A distinct dry season accompanied by dry winds occurs between

the months of January and May, necessitating irrigation on the shallow well drained soils of Northern Guam. Wind induced stress can be reduced by using windbreaks and by not trellising.

Cucurbits are warm season crops with mean optimum temperatures of 18–30° C (68–85° F). The large cucurbits require 60–120 days before harvest. Cucumbers may be ready in 30–60 days because immature fruits are harvested.

Development

Seed Storage and Germination

Germination is the activation of the embryo (small plant within the seed) which leads to the rupture of the seed coat and the emergence as a seedling. Before seed germination can commence, several conditions must be met.

First, the seed must be viable. It is recommended that seed be purchased from seed companies in order to be assured of high quality seed. The percentage of viable seed in a package is indicated by the company. The germination percentage should be 90% or better. Seed lose viability over time so purchase only what you need for the season. Seed may be stored for up to three years if proper temperature and moisture conditions are met. The storage temperature in Fahrenheit plus the percent relative humidity should not exceed 120, and the temperature component should not contribute more than half the total.

For example, *a storage unit with a temperature of 40° F with a humidity of 75% is adequate for seed storage because (40 + 75) is less than 120 and 40 is less than 1/2 of (40 + 75).*

You can lower the temperature by placing the seeds in the refrigerator above 1.7° C (35° F). Ideally the storage RH should be around 25% and a temperature of 5° C (41° F). Humidity is best controlled by purchasing seeds in moisture-resistant packaging and not opening the package until needed. Seeds sealed in cans store the longest. Once you open your can of seeds, take out what you need for the moment. The remainder can be stored in a zip-lock freezer bag in the refrigerator.

Seeds will not germinate unless certain temperature and water conditions are met. Seeds germinate best at temperatures of 24–35° C (75–95° F) and in moist soil. Under these conditions, the process of germination begins immediately. Within 5 to 14 days, the hypocotyl (seedling stems) arches and pulls the cotyledons (seed leaves) through the soil surface. Afterwards, the cotyledons open and the first true leaves expand. Eventually the cotyledons wither and fall to the ground. Any seedling that

does not germinate normally should be discarded to maximize yield and crop uniformity to minimize the possibility of seed-borne diseases.

Seedling Development

Upon germination of a vining cultivar, the seedling grows vigorously, developing a branching vine growth habit accompanied by a massive root system. Lateral growth of roots generally exceed vine length. Cucumbers will yield well in shallow soils if the proper level of water is constantly maintained. Watermelon, squash, and pumpkin prefer deeper soils.

The seedling stem develops into the main stem. The main stem forms one or more lateral branches near the base of the stem, which will eventually nearly equal the main stem in size and development. Vines are typically indeterminate in length (grows indefinitely) and can reach 15 m in length. Some compact dwarf varieties (bush forms) are determinate. Tendrils are borne in leaf axils and may be branched. They are not formed on bush-type squash and pumpkin. Tendrils serve to anchor the plant and straw/grass mulch is recommended to be placed around the plant for that purpose. The tendrils also aid in support of cucurbits when grown on a trellis.

Flowers and Fruit Set

Fruits develop from the female part of a flower (pistil) (**Fig. 1**). In most cases, seeds develop only after the pistil is fertilized by pollen from the male part of a flower (stamen). The transfer of pollen

from the stamen to the pistil is accomplished by bees. Pollination begins in the morning after the flowers open. Very hot, windy, or rainy weather can shorten the time available for pollination. A flower that has both male and female parts is said to be perfect (hermaphroditic). If it only has one sex, it is imperfect. Imperfect flowers are either male (staminate) or female (pistillate). A plant with only male and female flowers is said to be monoecious. A plant with some perfect flowers and male flowers is said to be andromonoecious. Those with mainly female flowers are said to be gynoeceous. The "PF" hybrids which produce predominantly female flowers are often shipped with male plants for pollination purposes. Cultivars bred for greenhouse production are parthenocarpic and require no pollination for fruit production. In fact, pollination of these cultivars causes off-shaped fruits.

Flower blossoms appear 1.5–2 weeks after emergence. The first blossoms that appear are usually male, followed 4–7 days later by female blossoms. Bee activity is critical at this point, a factor one must consider if pesticides are being used. Proper fruit set is dependent upon pollination by bees. Poor pollination results in small, crooked or constricted fruits. Depending upon the cultivar selected, harvest can be expected 20–70 days after fruit set. In order to keep production going as long as possible, fruits must be picked when they reach a desired size; otherwise the plant will stop setting new fruits and the harvest will be cut short.

Cucurbit Management

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The causes of poor plant health can be placed into four major groups: animal pests, plant pathogens, weeds, and unfavorable factors. In this unit, we will concentrate on eliminating unfavorable factors through proper management. With proper managerial practices, growers will be able to supply their carefully chosen crops with all their basic needs, thereby, ensuring that they get off to a good start. Plants that are vigorous are less likely to be damaged by plant pathogens, animal pests, weeds, and unfavorable factors.

Successful production of cucurbits on Guam requires selection of management practices which are appropriate for the resources and tropical climate of the island. These management practices should promote optimal growth and production while also ensuring the grower adequate economic returns and conserving natural resources. The following section covers several management considerations for growing cucurbits, including variety and site selection, site preparation, fertilization and liming, soil test interpretation, and cultural recommendations.

Cucurbit Crop Selection

A good way to insure the success of your crop is by selecting a crop variety which is suitable for the tropical climate and soils of Guam, has good disease and insect resistance, and is acceptable to your intended market.

Guam's climate is characterized by a relatively uniform high temperature of approximately 27° C (80° F), high annual rainfall (2,500 mm or 100 inches) and high humidity (65–100%). A distinct dry season occurs between the months of January and April. Winds are also strongest during the dry season and can adversely affect crop growth. Preferred cucurbit varieties on Guam should therefore be tolerant of

humid tropical conditions and resistant to diseases commonly found on Guam (see **Management of Plant Pathogen** unit). For a list of current recommended varieties for Guam, contact the Guam Cooperative Extension at the University of Guam and request a copy of the Guam Cucurbit Variety Guide.

Besides suitability for the tropics, variety selection should be based on a number of different factors which encompass market preference and farm resources. Factors people use for selecting cucurbits in the market include size, shape, texture, color and taste. Be aware of market preferences or your own preferences and select the appropriate variety. If space is a limiting factor, bush or dwarf varieties should be selected. If you want to save seeds from mature fruit for your next years crop then you need open pollinated or standard varieties. If you want maximum yields and disease resistance then the hybrid varieties are the better choice. In general, hybrid varieties are more expensive and some require more care during the germination period than standard varieties. Other good ways of selecting varieties include asking successful growers what varieties they grow, obtaining a list of varieties recommended by the Guam Cooperative Extension, checking local markets to see what people are selling and checking seed catalog descriptions.

Seed company catalogs are often free upon request. The Guam Cucurbit Variety Guide has names and addresses of some of the seed companies used by local growers.

The following is information on some cultivated cucurbits you may see growing on Guam, grouped according to their botanical similarities. Information on maturity and quality indices can be found in the **Postharvest Handling** unit.

Causes of Poor Plant Health

Animal Pests	Plant Pathogens	Unfavorable Factors	Weeds
<ul style="list-style-type: none">• Insects• Mites• Slugs• Pigs• Deer• Chickens	<ul style="list-style-type: none">• Bacteria• Fungi• Viruses• Nematodes• Parasitic Plants	<ul style="list-style-type: none">• Bad Weather• Poor Seed• Poor Maintenance• Poor Soil• Poor Pollination	<ul style="list-style-type: none">• Narrow-leaved• Broad-leaved

Watermelon

Botanical name: *Citrullus lanatus*
 Chamorro name: chandiya

Watermelons are commonly grown for their sweet fruits. Most are monoecious and contain seeds which vary from white to dark brown. Seedless types, which are sterile hybrids, are also available but are not yet popular with island growers due to the expense of the seeds and the increased degree of care necessary for high yields. The fruits are spherical to cylindrical and range from 1.4–45 kg (3.1–99 lb), with 9–12 kg (20–26 lb) the most common on Guam. The rind varies from white to green and may be solid, striped, or mottled. It can be thick or thin and either brittle or flexible. The flesh at maturity can be white, yellow, orange, pink, or red. Flesh texture can be fine to coarse and fibrous. Seedlings sprout in 7–10 days with harvest beginning in 75–90 days. Approximate time from pollination to market is 30–45 days. Watermelons are ready for harvest when the tendrils wither at the point of attachment and when the color of the lower part of the melon changes from a greenish-white to a creamy yellow. Watermelons should be sweet, but if too sweet they will not transport well. Watermelons should be cut from the vine and kept in the shade.

Cucumber

Botanical name: *Cucumis sativus*
 Chamorro name: kamba

There are open-pollinated, hybrid and bush cucumber varieties. Cucumbers are also characterized as slicing or processing. Slicing types are the ones most commonly grown on island for the fresh market. They are longer, smoother and more slender than the processing (pickling) varieties. Cucumbers can be selected to have skin which is rough or smooth, with and without spines, and light to dark in color. The cucumber's thin skin promotes fruit desiccation and rot. Size selection can vary from 15–38 cm (6–15 in) long to 2.5–6.4 cm (1–2.5 in) wide. Seedlings sprout in 5–10 days, with harvest beginning in 30–60 days. Approximate time from pollination to market is 15–18 days. When fruit has reached the firmness, color and size typical of the cultivar, it should be picked. Fruit can be removed from the vine by turning it parallel to the runner and then giving it a quick snap, but cutting it free with a sharp knife will eliminate the chance of damaging the vines. To extend the harvest, the fruit should be harvested every two to three days. Odd-shaped or over-mature fruits should be discarded.

Melon

Botanical group: *Cucumis melo*
 Chamorro names: melon-bastos
 melon-fino
 pepino

Other names or types: cantaloupe
 muskmelon
 honeydew
 oriental/hybrid melon

The melons are widely grown in the tropics. They are medium-sized with a netted, deeply wrinkled or scaly surface. Flesh is usually orange or sometimes green with an aromatic or musky flavor. They are usually andromonoecious. Oriental melons or hybrid melons have small fruits 1–2 kg (2.2–4.4 lb) with the skin varying from smooth to fine netting with a wavy to smooth surface and coloration possibilities of white, yellow, green or brown. Flesh is sweet with possible colors of light green, yellow and orange. Seedlings sprout in 5–7 days, with harvest beginning in 65–85 days. Approximate time from pollination to market is 30–45 days. At maturity, cantaloupe can be easily pulled from the stem, leaving a clean stem scar. This condition is called the “full-slip” stage. During the peak of harvest season, a field needs to be picked daily. Melons for storing should be predominantly green in color rather than tan or brown skinned which indicates over-ripeness. Honeydew and oriental melons are more difficult to harvest because they have to be cut from the vine. When the fruit is ripe, the skin will lose its greenish tinge and turn to the color characteristic of that cultivar. Those that are fuzzy as immature fruit will become smooth and develop a waxy feel at maturity. Fruits in the field are subject to damage from pumpkin beetles and fruit rots.

Bittermelon

Botanical name: *Momordica charantia*
 Chamorro name: atmagosu

Other names or types: bitter cucumber
 balsam pear

It is grown throughout the tropics and can be found growing in the wild. Bittermelon fruit are cucumber-shaped, 15–20 cm (6–8 in) long, dark to yellowish green and white with a very warty (bumpy) surface. Fruits are harvested in the immature stage 1.5 to 2.5 weeks after fruit set.

Summer Squash

Botanical group:	<i>Cucurbita pepo</i>
Chamorro name:	kalamasa
Other names or types:	pumpkin (Jack O' Lantern) acorn squash scallops marrow zucchini squash

They are an annual herb with a bushy or more commonly trailing growth habit with monoecious corolla yellow or orange flowers. Fruits vary in size from spherical to elongated, stem hard and 5-sided, no cork at point of fruit attachment, flesh white or yellow with a coarse texture. Seedlings sprout in 5–7 days. Approximate time from pollination to market is 3–4 days for zucchini, 5–6 days for yellow summer straightneck squash. The summer squash type is ready for harvest 5–7 weeks after planting and picked over a period of several weeks every 3 to 5 days. Pumpkins are ready for harvest after 2.5 to 3.5 months and usually harvested only once. Fruits may remain in the field until the vines are dead; however, the longer they remain in the field the greater chance of loss due to fruit rot.

Chayote

Botanical name:	<i>Sechium edule</i>
Chamorro name:	chaiote
Other names or types:	vegetable pear mango squash

This is a vigorous, monoecious, climbing herb common in the tropics. Unlike most cucurbits, which are annuals and many-seeded, chayote is a perennial with a single seed. A day-length of less than 12.5 hours is required for flowering. Fruits are pear-shaped, with longitudinal furrows, in white or green skin. They weigh from 0.2–1.4 kg (0.5–3 lb) and contain a single seed. The plant is propagated by cuttings or by placing a whole fruit on its side. The soft coated seed is protected by the surrounding fruit from which it may derive nutrition during the germination process. Fruit for seed should be carefully handled and not stored below 10° C (50° F). It grows well in loose, well-drained soil high in organic matter.

Wax Gourd

Botanical name:	<i>Benincasa hispida</i>
Chamorro name:	kondot
Other names or types:	white gourd white pumpkin Chinese watermelon

It is a vigorous, annual, hairy, climbing herb, growing to several meters in length. Their young leaves and fruits are eaten as vegetables while mature fruits are used in preserves and pickles. Fruits are large

(7–10 kg or 15.4–22 lb) spherical to oblong, hairy at first, then usually becoming bald. At maturity they are dark green, covered with a waxy deposit which is easily removed. The flesh is white with a spongy center. The gourd is preferred as a cooked vegetable but may also be served raw like a cucumber.

Bottle Gourd

Botanical name:	<i>Lagenaria siceraria</i>
Chamorro:	tagu'a, kalabasa
Filipino:	upo
Other names:	vegetable gourd calabash gourd Chinese squash

Lagenaria siceraria is one of the earliest domesticated plants and has a pantropical distribution. Its origin is believed to be in Africa, with remnants from Japan dating back to 6000–4000 BC. The vegetable gourd is a climbing vine with 5-angled heart-shaped leaves. The flowers are white and the fruit is variously shaped, smooth, green and sometimes mottled. Seed is woody and germination is accelerated after warm water soak. Young fruits of all ages are edible and may be picked, including the ovary of the flower. Continuous picking of young fruits prolongs crop duration and as many as 20 pickings may be possible. Young fruits should be consumed within 2 weeks after harvest. Longer storage causes rapid loss of water, leading to loss of hairs and shine of the fruit surface. The long, green mature fruit is peeled, then diced and boiled to provide a watery, relatively tasteless vegetable. Bottle Gourd is similar to sponge gourd with respect to propagation, cultivation, and pest and disease issues.

Sponge Gourd

Botanical name:	<i>Luffa acutangula</i>
Chamorro name:	patola
Other names or types:	angled loofah silk gourd Chinese okra
Botanical name:	<i>Luffa cylindrica</i>
Other names or types:	smooth loofa dishcloth gourd vegetable sponge

Both species are annual climbing vines with tendrils, and monoecious in flowering habit. However, perfect flowers of the angled loofah have been reported. Distinguished by their shape, smooth loofah have long cylindrical shaped fruits 3–50 cm (1–1.5 ft) in length and 8–12 cm (3–4.5 in) in diameter. The angled loofah fruits are about the same size as smooth loofah fruit, have a distinct widening from point of attachment, and have 10 raised ridges running lengthwise. Plants should be trellised and planted in sandy soil rich in organic matter. For the best

shaped fruits, the pistillate flowers should be hand pollinated. Though both species can be eaten as immature fruits, it is generally the angled loofah that is picked green and is used as an ingredient in chop suey or curry dishes. Shoots, flowers, and young leaves may be cooked and eaten as greens. Smooth loofah is valued for its fiber. The mature fruit is left on the vine until it is dry, removed and then submerged in water for 7–10 days, which results in the disintegration of the outer walls and pulp. Washing removes seeds, skin, and pulp from the fibers. If fibers are not white, they may be bleached with hydrogen peroxide and then dried. Sponges are used for cleaning, filtering, and bathing.

Site Selection

Selection of sites for growing cucurbits is dependent on several factors, which include soil characteristics, slope, wind exposure, access to water for irrigation, and site availability. Cucurbits grow best in low clay, well-drained soils which have a slight acidic or slight alkaline pH between 5.5 to 7.5. Among the cucurbits, watermelon is best adapted to acidic conditions and can grow well down to a pH of 5.0. Deep soils are preferred by all cucurbits but cucumbers and bittermelon will tolerate shallow soils.

A total of 17 soil types have been characterized by the USDA Soil Conservation Service on Guam. These can be grouped into three large categories based on the soils' parent material: bottom lands (4%), volcanic uplands (35%) and limestone uplands (61%). These three categories are subdivided into 8 major soil groups (**Plate 1**). Of these, agriculture production is mainly suited to four soil types. The Inarajan-Inarajan variant soils are well suited for watermelon production and require minimal watering during the dry season (**Plate 1-1**). Watermelons are also commonly grown on Akina-Togcha-Ylig soils (**Plate 1-3**). Soils in low lying areas and high in clay may reduce cucurbit growth due to lack of sufficient oxygen in the root zone. Steep slopes are difficult to cultivate and without adequate management are susceptible to soil erosion. Liming to increase the pH may be necessary for maximum production. Irrigation is generally necessary on Guam soils, and the soil being shallow makes it more suitable for cucumbers (**Plate 1-4**). Phosphorus and micronutrient deficiencies may occur in some of the high pH limestone uplands soils. Shallow soil depth and rockiness reduce the capacity of the soil to hold plant nutrients and water, thereby requiring more frequent fertilization and irrigation. Pulantat-Kagman-Chacha are moderately suitable for melons and cucumbers (**Plate 1-8**). For further information on the characteristics and locations of the soils of Guam, contact the Pacific Basin office of the U.S. Natural Resources Conservation Service

and obtain a copy of the Soil Survey of the Territory of Guam. This publication contains detailed descriptions of the different soils and maps of their locations on Guam.

Proper site selection can reduce wind damage. Typhoons and tropical storms constantly threaten Guam but generally are more likely to occur during the rainy season. Large barriers such as trees, buildings, and hills can offer some protection from high winds. High winds also bring damaging salt spray, so being located away from the shore is important.

To reduce the buildup of plant diseases, insect pests, and nematodes, avoid planting the same cucurbit crop in the same field over several successive seasons. Crop rotation which includes a leguminous green manure, such as sunn hemp, has the added benefit of adding nitrogen and organic matter to the soil.

Site Preparation

A good first step after clearing a site for growing cucurbits is to submit a soil sample for testing to the Soil and Plant Testing Laboratory at the University of Guam. The routine soil test will give you information on the acidity of the soil (pH), the organic matter content, and the amount of available plant nutrients for plant uptake, including phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). This information will assist you in your discussions with your extension agent in determining the amount and kind of fertilizer to apply to your field and whether lime should be applied to increase soil pH. For detailed information on soil sampling and submission of a sample, contact the Guam Cooperative Extension at University of Guam for a copy of the Sampling Soils pamphlet.

For routine sampling of an area of uniform soil texture and cropping history, the following steps should be taken:

1. With a spade or trowel, make a hole in the soil to the depth at which you cultivate (10–25 cm or 4–8 in).
2. Place the sample in a clean plastic bucket.
3. Repeat the above procedure 9 to 10 times at different areas in your field.
4. Mix thoroughly in the bucket.
5. Take out approximately one pint of soil from the bucket and place it in a clean plastic bag. Write your name and field identification on the outside of the bag with a permanent marker.
6. Record your field identification so you will be able to remember which area the sample came from.
7. Bring the sample to the College of Agriculture and Life Sciences building at the University of Guam and fill out a soil submission sheet.

The objectives of soil tillage are to prepare a seedbed, incorporate soil amendments and organic residues, clear weeds and possibly to shape the soil. Shaping the soil is used to improve drainage, control erosion, and to provide a bed for irrigation lines. Dependent on the equipment available to you, several tillage operations can be done. Initial plowing is usually done with a moldboard plow or disc plow. Rototilling can be done with a small rototiller or a tractor-mounted rotovator. A disc is often used to break up heavier clods and prepare a finer seedbed. Rototillers are also often used on Guam for cultivating weeds between the planted rows during the growing season. Formation of raised ridges, beds, or hills can also be beneficial in order to improve drainage and increase soil aeration. Unexposed military ordnance from WWII are still in the soils of Guam so care should be taken whenever new land is to be put into production.

A potential drawback to frequent use of tillage is destruction of soil structure, increased compaction, spread of soilborne plant pathogens, and greater soil erosion. To lessen compaction, tillage operations should be avoided when the soil is still wet. In addition, rototilling a soil when it is very dry can shatter soil aggregates which are important for good root growth. To minimize the detrimental effects of soil disturbance, some growers follow a practice of minimum or conservation tillage. This practice reduces the frequency of tillage and tries to maintain crop residues on the soil surface. Difficulties with this practice are the increased need for pesticides to control weeds and increased insect problems.

During site preparation, weed control can also be initiated by tillage or spraying of herbicides. Physical methods of weed control include use of organic or polyethylene plastic mulches. A mulch is applied to the soil surface to block weeds from emerging and has the additional benefits of increasing soil moisture retention and reducing erosion. Special equipment is available for laying down plastic mulches over the seedbed. Application rates of organic mulches, such as grass, paper and crop residues, will depend on the physical properties of the material. Under Guam's environmental conditions, physical degradation of these materials can be rapid, and, therefore, their effectiveness should first be tested before they are used on a large-scale.

Cucurbit plants are sensitive to wind damage, especially as seedlings. Even the normal occurring trade winds which blow easterly to northeasterly across Guam can occasionally cause damage. Wind damage is caused by the drying effects of wind on leaves and the physical abrasion that occurs when plant tissue rub against each other or against the soil. If wind is a problem then physical barriers/windbreaks

against the wind can be erected perpendicular to the direction of the wind. Several objects can be used as windbreaks, including a row of trees, hedges, tall grasses or a wall of shade cloth or plastic secured to rebar. If you plan to use a living windbreak then be sure to plant the windbreak in advance of planting your cucurbit crop so that the windbreak will be established well before planting.

Fertilization and Liming

A good fertilization plan for cucurbits starts with an analysis of the pH, organic matter content, and amount of available plant nutrients in the soil. Samples can be submitted to the Soil and Plant Testing Laboratory at the offices of the Agricultural Experiment Station or Agriculture and Natural Resources located at the University of Guam. Nutrient recommendations are based on soil test results, crop to be grown, soil type, and field history. Analysis of plant tissue from a prior healthy cucurbit crop is very helpful in diagnosing nutrient problems, particularly micronutrient deficiencies such as iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu). Symptoms plus plant and soil analyses together with a general knowledge of crop needs should be used to determine crop nutrient needs. Visual nutrient deficiency symptoms are only reliable for diagnosing plant nutrient deficiencies or toxicities under test conditions or when a particular crop is highly sensitive to them. The generally accepted deficiency symptoms of plants grown under test conditions are contained in **Table 2**. Under field conditions, symptoms are not as distinct. A particular symptom can be caused by any one of several nutrient disorders or as well as other conditions. Yellowing and interveinal chlorosis of young, newer leaves, could be due to S deficiency or it could indicate a deficiency of one of the metal micronutrients, Fe, Z, M, or Cu. Certain herbicides, diseases, and insects can cause similar symptoms. Refer to the unit on **Troubleshooting Cucurbit Problems** for further information.

Other factors, which will affect the amount of fertilizer to apply, include soil type and method and type of fertilizer being applied. With the exception of Inarajan and Togcha soils, Guam's soil environment is not suitable for optimum production of cucurbit crops and therefore yield is likely to be the same at 80% and 100% of optimum nutrient levels (**Table 3**). There are several methods of applying fertilizer. For phosphorus (P) fertilization, the method that is recommended for Guam is banding (localized placement of the fertilizer in a band). Banding lessens the chance that P will be bound by the soil and made unavailable to the plant. Place fertilizer in a band about 8 cm (3 in) beside and 8 cm (3 in) below the seed. If the band is placed too close to the seed, seedling

roots can be damaged. If drip irrigation is used, place band between the seed-row and the drip-line. For transplants, fertilizer should be placed 10–13 cm (4–5 in) below the seedling. To prevent burning the plant, exercise care at all times so that the fertilizer does not come in contact with leaves, stems, and roots. In broadcasting (uniformly distributing the fertilizer over the field), the fertilizer needs to be worked into the soil prior to planting. Fertilizer applications must be made throughout the season because nitrogen (N) readily leaches out of the root zone. Depending on the soil, potassium (K) will also leach; therefore, as a general recommendation, the crop's N and K requirements should be divided among several applications. The number of appli-

cations can also be reduced if a controlled-release fertilizer is used. These fertilizers are generally more expensive than conventional ones and some have been shown not to offer much of an advantage on the Yigo silty clay soil series or the Guam cobbly clay loam soil series.

Other application methods include foliar sprays (spraying of the fertilizer on the leaves) and fertigation (mixing fertilizer with the irrigation water). These methods vary in efficiency with which they provide certain nutrients to the plant. For example, foliar spraying of micronutrient fertilizers is recommended for deficient plants in high pH soil. Application of micronutrients to the soil is best accomplished by adding a chelated form of

Table 2. Common symptoms associated with nutrient deficiencies and excesses.

Symptoms Due to a Deficiency of Nutrients		
N	Nitrogen	Mature leaves yellowish green to yellow but not wilted with young leaves remaining green. In cucumber, light in color and pointed at the blossom end. More likely to occur in sandy soils with low humus and during periods of high rainfall. Cantaloupe are small light colored and thinskin with small seeds.
P	Phosphorus	Stunted growth. Seedlings have leaves and petiole veins which are reddish-purple in color with remaining tissue a dark green color.
K	Potassium	Leaf scorch where yellowing spreads inward from the leaf tip and edges. Young leaves become cupped. Cucumbers may develop a small stem end with puckered or crinkled fruits and slow plant growth. Cantaloupe develop gritty flesh and a bitter taste.
Mg	Magnesium	Weeks before harvest, plants are small and appear weak. Deficiency is more common in low pH sandy soils or when Mg concentrations are less than 70 ppm. The leaf veins remain green while the remainder of the leaf turns yellow. Young leaves curl, turn brittle and dry up. Most common in melons.
Ca	Calcium	Misshapen fruit water-soaked and necrotic lesions on blossom end referred to as "blossom end rot." Leaf margins stop expanding and leaves cup downward. This disorder is most common in watermelon and some squashes.
Fe	Iron	Light yellow color of interveinal area of younger leaves while the vein retains a dark green color. Condition is more common on soils with pH greater than 7.5.
Mo	Molybdenum	Most likely to occur on melons grown in dark soils with pH less than 6.0. Symptomatic leaves located near the crown of the plant are light green with a slight yellowing between veins.
Symptoms Due to Excess Nutrients		
Mn	Manganese	Most severe on melons and watermelons. Associated with heavy soil with acidic pH of 5.8 or less. Crown leaves of affected plants with heavy fruit load have a pale green cast. Leaves have tiny (pinhole) lesions surrounded by yellow halos.
N	Nitrogen	Can contribute to blossom-end rot. Intensifies Mg deficiency and results in excess foliage and poor fruit set. Increases severity of wilt-inducing pathogens.
P	Phosphorus	Excess P may cause micronutrient deficiencies, especially Fe or zinc.
K	Potassium	Intensifies Mg deficiency.

the micronutrient or an organic manure. Micronutrients, if applied as salts, which is how N, P, and K are normally added, are often transformed to forms which are unavailable to the plant due in part to soil pH and soil components. For example, if the inorganic iron salt, ferric sulfate, is added to the calcareous soils of Northern Guam, much of the iron changes into a form which is unavailable to the plant.

Many types of fertilizers and organic amendments which are suitable for use with cucurbit crops are available on Guam. The fertilizer analysis is indicated on the label as three numbers such as 16-16-16. These indicate the % nitrogen (N), % phosphorus pentoxide (P_2O_5) and % potassium oxide (K_2O) in the fertilizer material. Fertilizer recommendations are usually reported in these same terms (Table 3). To determine how many pounds of actual fertilizer to apply, divide the recommended pounds of N, P_2O_5 , or K_2O by the appropriate fertilizer analysis term. For example,

For 150 lb N, you could apply $150 \div 0.10 = 1,500$ lb of 10-30-20 fertilizer.

For 300 lb P_2O_5 , you could apply $300 \div 0.30 = 1,000$ lb of 10-30-20 fertilizer.

For 220 lb K_2O , you could apply $220 \div 0.20 = 1,100$ lb of 10-30-20 fertilizer.

Several factors may affect your selection of a fertilizer, including availability, nutrient content, particle size, form, and solubility. Fertilizers which will be used in fertigation should be soluble in water. Avoid placing a large amount of solid fertilizer close to the plant due to potential salt injury. Generally, cucurbits can be expected to respond to a complete fertilizer containing N-P-K. Fertilizer requirements depend on a number of factors such as farm practices, soil type, crop density and season; therefore, fertilizer recommendations should be considered only as a guideline. The response to fertilization will be greatest at lower levels with decreasing benefits and eventual harm at excessive levels. Conservative levels of N-P-K should be used if no soil analysis data is available such as 112–168 kg N, 168–252 kg P_2O_5 , and 112–168 kg K_2O /ha (100–150 lb N, 150–225 lb P_2O_5 , and 100–150 lb K_2O /acre). To convert pounds of P_2O_5 to pounds of P, multiply P_2O_5 lb by 0.44. To convert pounds of K_2O to pounds of K, multiply K_2O lb by 0.83. Continuous application of fertilizer may lead to a buildup of P in the soil which can only be determined with a soil test. With experience and additional information, you can fine-tune your individual fertilizer requirement. When soil analysis and data are available, then the general guidelines in Table 3 should be followed. If a heavy rain follows application, then additional

fertilizer will be needed since N and K tend to leach. Supplement with additional applications of N and K at 56 kg/ha (50 lb/acre) only if nutrient deficiencies develop (Table 2). Excess amounts of nutrients may also lower quality or impair development (Table 2).

For the home garden, a balanced fertilizer such as 5-10-10 or 10-10-10, may be applied at 224 gm (8 oz) per hill. If planted in rows, apply 5 lb per 100 ft row. One to two side-dressings of ammonium sulfate (21-0-0) at 28–56 gm (1–2 oz) for every 2 m (6 ft) or hill may be needed during the season. Excess vine growth and inferior fruit will result if excess nitrogen is applied and in some cucurbits if the soil's organic matter is greater than 10%.

Soil Test Interpretation

Routine analysis should be done before each season and special tests need only be requested if you suspect that the soil may be deficient or be in excess of a specific nutrient (Table 2). The routine soil test at the University of Guam includes analysis of the soil water pH, available phosphorus, and exchangeable potassium, calcium, magnesium and organic matter. Special tests include total nitrogen, phosphorus, nitrate, ammonium nitrogen, aluminum, zinc, iron, manganese, copper, sodium and boron. Electrical conductivity for soluble salts and particle-size analysis is also available. For cucurbit production, it is recommended that the producer have particle-size analysis done at least once in order to determine the texture class. The soil texture (such as clay, silty clay, or sandy clay loam) will influence fertilizer, irrigation, and variety choices.

Cucurbit crops vary in their soil pH preference; however, the ideal range for all cucurbits which allow for maximum nutrient availability is 6.0 to 6.8.

Watermelon	pH 5–6.8
Cucumber	pH 5.5–7.2
Melon.....	pH 6.0–6.8
Summer Squash	pH 5.5–6.8

Soil test analysis is important in determining the necessary rates for fertilization. Recommended fertilization rates based on University of Guam soil test results for N, P, and K are shown in Table 3.

Soil salinity is mainly the result of the accumulation of fertilizer in the soil and salt spray from the ocean. Though cucurbits are only moderately sensitive to salts, some yield reduction can be expected when soluble salt concentration reaches 512 ppm with severe losses above 2,049 ppm.

If nutrient deficiency are suspected then further analyses are needed. For optimum level of soil nutrients routinely and not routinely tested for, refer to Table 4.

Table 3. Granular fertilizer recommendations for cucurbit crops based on University of Guam Soil and Plant Testing laboratory results for N, P, and K.

When Test Shows N (ppm)	< 9%	> 9%			
	Organic Matter	Organic Matter			
Add N lb/acre	120	100	80		
Add N kg/ha	135	113	90		
When Test Shows K (ppm)	< 50	50–100	101 – 150	151 – 190	> 190
Add K ₂ O lb/acre	180	125	50	20	10
Add K ₂ O kg/ha	202	140	56	22	11
When Test Shows P (ppm)	< 10	10 – 30	31 – 60	61 – 90	> 90
For High Clay Soil					
Add P ₂ O ₅ lb/acre	200	180	160	100	20
Add P ₂ O ₅ kg/ha	224	202	179	112	22
For Low Clay Soil					
Add P ₂ O ₅ lb/acre	100	80	60	25	10
Add P ₂ O ₅ kg/ha	112	90	67	28	11
Unknown Clay Level					
Add P ₂ O ₅ lb/acre	180	150	130	90	15
Add P ₂ O ₅ kg/ha	202	168	146	101	17

- Add 10% more fertilizer if applied by broadcasting. Reduce by 20% if plastic mulch and drip irrigation is used.
- Apply all P₂O and half the N and K₂O at transplanting; side dress at flowering with the remaining.
- For sustained production over a long period, add additional N at 22 kg/ha (20 lb/acre) every two weeks after first harvest. Apply additional fertilizer if nutrient deficiencies develop.
- Organic matter determined by the Walkley-Black method; phosphorus extracted with 0.5 M sodium bicarbonate (Olseon method); potassium, calcium, and magnesium by 1 N ammonium acetate.
- High clay refers to soil with a textual class name of clay. All others are referred to as low clay.
- If N-P-K values are unknown use the highlighted values in the dotted box.
- To convert lb/acre to 100 ft rows with 100 cm spacing, multiply lb/acre by 0.008. For 130 cm row spacing, use (0.01). For 200 cm rows, use (0.015). For example: (150 lb/acre)(0.08)=1.2 lb/100 ft rows for rows spaced 100 cm apart.

Table 4. Recommended levels of soil nutrients for optimum production of cucurbits on Guam.

Nutrient	ppm in Soil
Calcium	801–1200
Magnesium	101–200
Iron	2.5–5
Manganese	1.0–5.0
Zinc	0.5–5.0
Copper	0.1–0.6
Boron	0.5–2.0

• If soil values are outside the indicated optimum levels, consult your agricultural extension agent for micronutrient fertilizer recommendations.

Tissue Analysis

To determine if nutrients are being absorbed properly, a tissue analysis is required. Tissue analysis is highly dependent on the crop, tissue being sampled and stage of growth. For collection and handling of tissue samples, the following procedure should be followed:

1. Check with your local extension agent or the University of Guam's Soil and Plant Testing Laboratory to determine for your particular crop which plant part to sample, when it should be sampled, and how many samples to collect. Special quarantine procedures are required if

you are submitting samples from outside the island of Guam.

2. Cut or pick the appropriate plant part, dust off any soil or foreign matter and place it in a paper bag. If the sample is placed in a plastic bag, it must be refrigerated in a few hours to prevent rotting. Record field location, the date, presence or absence of nutrient symptoms, plant part sampled, and crop growth stage. Some of this information will be later transferred to the submission sheet.
3. Mark your name and field location on each bag using an indelible marker.
4. Drop off your sample at the offices of the Cooperative Extension Service or the University of Guam Soil and Plant Testing Laboratory. Fill out a submission sheet and pay any fees.

For an example of a tissue analysis for cucumber, refer to Table 5.

Table 5. Recommended tissue nutrient ranges for cucumber.

Nutrient	Sufficiency Range
N %	4.0–5.5
P %	0.25–1.0
K %	3.5–4.5
Ca %	1.5–4.0
Mg %	0.3–1.2
S %	0.3–1.0
B, ppm	30–100
Cu, ppm	8–20
Fe, ppm	50–300
Mn, ppm	50–400
Mo, ppm	0.8–3.3
Zn, ppm	25–300

- Collect leaf samples from at least 20–30 plants.
- Nutrient content of leaf tissue may be affected by the growth stage of the plant. Sample the 5th leaf from tip (omit unfurled leaves) during small fruit to harvest stage.

Jones, Jr., J.B., B. Wolf and H.A. Mills. 1991. Plant analysis handbook: A practical sampling, preparation, analysis, and interpretation guide. Micro-Macro Publishing, Inc. Athens, GA.

Planting

Cucurbits can be transplanted or direct seeded. Depending on the variety, seeds germinate in 7 to 14 days after planting. Seed germinate best at 24–35° C (75–95° F). Use of transplants reduces the risk of a poor crop stand due to poor seed germination, insects, damping-off diseases, birds, heavy rains, slugs, and weeds, but it has greater labor and space requirements. For transplants, seeds are planted 1.3 cm (0.5 in) deep

in cups (2 seeds/6 oz cup) or trays (2 seeds/5 cm [2 in] square) in a synthetic potting soil mix. After most of the seedlings have germinated, the plants should be thinned to one per cup by snipping the less desirable plant off at ground level. Transplants are usually field ready after the second set of leaves have fully developed. Select only the healthiest seedling for transplanting. This is particularly important in the case of seed-borne diseases (see Disease Management unit for more information).

Seedlings should be “hardened” prior to transplanting. This can be done by gradually increasing the seedling’s exposure to full sunlight and wind conditions. Watering the seedling with a high phosphorus water soluble fertilizer after thinning will increase root growth and reduce transplant shock. You can make your own starter solution by using a water soluble 5-10-10 fertilizer at a rate of 0.22 kg/19 L (0.5 lb/5 gal). Some individuals commonly use a 19-19-19 foliar fertilizer at 497 ml/20 L (2 cups/5 gal). If a slow release fertilizer is used, only one application is needed within the first 4 to 6 weeks. The Cooperative Extension Service in Hawaii obtained good results using 4–5 cups of 14-14-14 Osmocote to 50 qt or 25 lb (0.9–1.2 L or 11.3 kg) of All Purpose Sunshine Mix potting soil.

Transplants are spaced according to the vine growth or the cultivar selected. In general, the longer the growing season, the longer the laterals will grow. Allow one to two transplants per hill. For watermelon, it is suggested that one transplant be allowed per hill. This practice will result in larger yields and minimize competition for nutrients, water and light.

For direct seeding, it is recommended that 3–4 seeds are planted in each hill. Seeds should be planted 2.5–7.2 cm (1–3 in) deep and thinned out after 2–3 sets of leaves have developed, allowing only 1–2 plants per hill. Select only the healthiest and hardiest plants.

Those cucurbits that produce vines also produce tendrils. A straw or grass mulch is recommended for placement around the larger cucurbits as a mooring area for the tendrils to attach themselves. The mulch also serves to suppress weeds and conserve soil moisture. At blossom, bee activity is critical for pollination, a factor one must consider if pesticides are being used (see the Management of Insects and Mites unit).

Some of the major considerations in planting a field are summarized in [Table 6](#).

Irrigation and Drainage

The process of applying supplemental water to a crop for satisfactory or optimum production is called irrigation. Irrigation is mainly used to supplement

natural precipitation in order to save a crop from dying or to maximize its yield. If salt accumulation is a problem, then irrigation is used to leach salts from a crop's root zone

Irrigation and drainage requirements of cucurbits depend upon the crop, soil type and depth, climate, and the season. Irrigation needs on Guam are highest during the dry season from January to June. For optimum yield, irrigation may be needed even during the rainy season on most shallow soils. This is because most cucurbits are very sensitive to water stress during their fruiting period and the shallow soil zone can only hold a relatively small amount of water, usually not enough to last between rainfall events.

Drainage

Drainage is the process of removing excess water / salts from the root zone of a crop to assure its survival and optimum growth.

Cucurbits need not only water and nutrients in the soil for proper plant growth but also an adequate supply of oxygen. Under waterlogged conditions, the water puddling on the soil surface restricts oxygen

to the roots. To create conditions in the soil under which plants can obtain adequate amounts of oxygen, drainage is needed. Plants cannot withstand waterlogging for more than 24–72 hours. Some plants, like rice, are able to transport oxygen or oxidized compounds from the leaves to the roots, enabling them to grow successfully in standing water.

Drainage is not a problem on most shallow soils overlying coral reef limestone in the northern part of Guam. However, improved drainage may be needed during the rainy season on low-lying, clay soils located in the southern Guam watersheds. Poor drainage inhibits root growth by reducing oxygen, increasing root rots, and interfering with cultural operations.

Methods of Irrigation

There are five main methods of irrigation. Furrow irrigation requires level to gently sloping fields. This method may be unsuitable on uneven fields, steep slopes, and on soils with high percolation rates. Overhead high pressure and low pressure sprinkler systems may not be suitable in Guam's high wind environment. Moreover, these systems are only cost effective for farms above a certain acreage.

Table 6. Recommended amount of seed, plant spacing, training and fertilizer side dressing for cucurbit crops.

Crop	Amount of Seed/100 ft*	Between Rows **	Between Plants	Training for Optimum Yield	Side Dressing***
Watermelon****	7.1 gm 0.25 oz	244 cm 96 in	150 cm 59 in	–	14 day intervals to fruit set
Cucumber	7.1 gm 0.25 oz	152 cm 60 in	30 cm 12 in	1 fruit/lateral	14 day intervals to fruit set
Melon****	3.5 gm 0.13 oz	183 cm 72 in	70 cm 28 in	3–4 fruits/plant	at 12 inch runner stage and fruit set
Bittermelon	14.2 gm 0.5 oz	152 cm 60 in	25 cm 10 in	Trellis	15 day intervals after fruit set
Summer squash	14.2 gm 0.5 oz	100 cm 39 in	70 cm 28 in	–	12 days intervals
Chayote	32 seeds	150 cm 59 in	100 cm 39 in	Trellis	At mid season and fruit set
Wax gourd	7.1 gm 0.25 oz	152 cm 60 in	70 cm 28 in	1 fruit/lateral	14 day intervals to flower
Sponge and Bottle gourds	10.6 gm 0.38 oz	150 cm 59 in	100 cm 39 in	Trellis	14 day intervals to flower

* The amount of seed can be cut in half if transplants are grown from only one seed per cup or tray division.

** Row spacing should be increased when a crop obtains the majority of its water from soil reserves and not from irrigation.

*** The frequency of side dressing should be doubled during the rainy season.

**** Watermelon and melon, under increased spacing, will grow larger but the risk of sun damage also increases. If planted in hills, double plant spacing and thin to 2 seedlings per hill.

Low pressure, low flow sprinkler systems are also susceptible to effects of the high wind conditions on Guam, which adversely affect the distribution efficiency of these systems. The most widely used irrigation method for cucurbits on Guam and Micronesia is drip or trickle irrigation which is the slow, frequent, precise application of water through small orifices or emitters directly to the root zone of the growing plants. A well designed drip irrigation system can achieve water application efficiency, a ratio of the amount of irrigation water retained in the root zone depth to the amount of water applied, in excess of 95%. This method improves water use efficiency, and is amenable to fertigation (application of fertilizer/chemical via injection equipment) and automation. Figure 2 shows the components and layout of a fertigation system suitable for small farms on Guam and Micronesia. The most common drip line used for cucumbers and other cucurbits in the region are drip-tapes. Drip tapes are thin (4–15 ml thickness), collapsible, plastic tubes with small orifices and are precision manufactured. They are generally available in 1.1, 1.9, 2.3, 3.8, 5.7 L/min flow rates per 30.5 m of tape (.3, .5, .6, 1, 1.5 gal/minute flow rates per 100 feet of tape). The orifices are commonly spaced from 5–91 cm (2–36 in) apart. The drip tapes operate usually between 8–15 psi pressure. Under high pressure, they are likely to burst. On the shallow soil of northern Guam, 5–10 cm (2–4 in) drip spaced drip lines are recommended. It is desirable to have two drip lines per row on these soils, particularly after flowering initiation. To achieve the high application efficiency from drip irrigation systems, they must be designed for your soil and crop. It is suggested to get help from your agricultural extension specialists for further guidance and information. A higher level of skills and maintenance is required of drip irrigation as compared to other methods.

Irrigation Scheduling

Irrigation scheduling, when and how much water to apply, is one of the most difficult tasks a farmer has to perform. Scheduling depends upon three interacting factors, namely crop, soil, and climate. Most of these factors continually change with time. The crop factors include the type of crop, its stage of growth, and root growth characteristics. The soil factors are soil type, depth, and water holding capacity. The rainfall distribution pattern, daily air temperature, relative humidity, wind speed, and solar radiation are some of the climatic factors.

Most cucurbits require a constant water supply to obtain maximum yield and high quality produce. For example, cucumber requires 40–50 cm (16–20 in) of water from rainfall or irrigation for a 10–12 weeks period from transplant to last harvest. It is susceptible to even mild water stress. Soil moisture tension in the root zone at distance of 15 cm (6 in) from plant hill and 15 cm (6 in) deep should be kept below 25 centibar for high yields in a clay loam soil with an average depth of 25–30 cm (10–12 in). Centibars are units used to measure the force or energy with which water is held in soil. A soil tensiometer is an effective, inexpensive device used to measure soil moisture tension. Flooded soil would have a reading of 0 and soil that has been allowed to drain would have a reading of 10–33 centibars depending on the soil type. A less accurate method of determining how much water to apply is to subtract the total rainfall in the last 24 hours from the average daily water requirement of the crop. On Guam, a daily requirement of 6–25 mm (0.25–1 in) should be used. A tenth of an inch of rain is equivalent to 25,350 L/ha (2,715 gal/acre) of water. Average daily water requirements vary from near zero during the rainy months to 46,765 L/ha/day (5,000 gal/acre/day) during drought periods. During the dry season, the water requirement should be split into 2 or 3 applications per day.

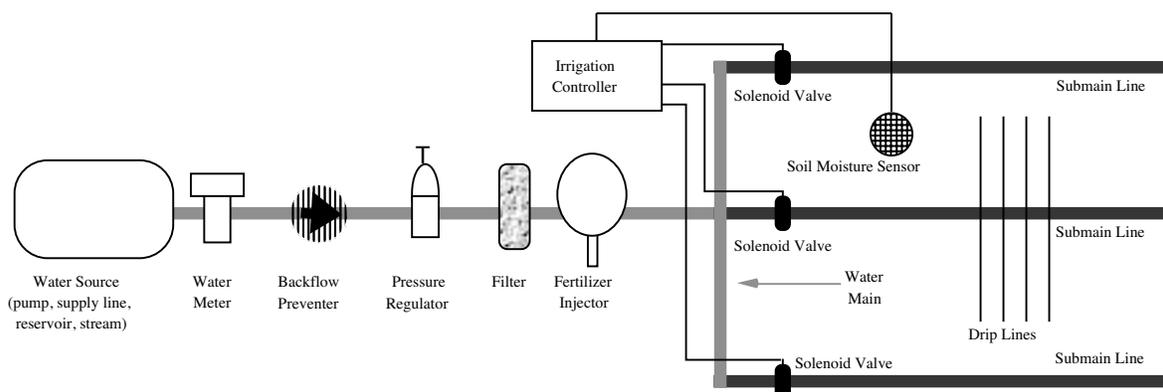


Figure 2. Schematic of a recommended drip fertigation system layout for Guam and Micronesia.

Fertigation

The process of applying fertilizer to a crop via a drip or sprinkle irrigation system is called fertigation. Many farmers, who invest in drip irrigation to make a profit, find the additional cost of fertigation equipment worth the investment. One advantage is that fertilizer is added only in small amounts. Therefore, there is no waste if the crop is harvested early (Table 7). In a test conducted using trellised cucumber in a Guam cobbly clay loam soil with less than 5% organic matter, plants responded to 10–12 split weekly applications of N. Nitrogen was applied at 14 kg/ha/wk (12.5 lb/acre/wk) for the first two weeks and 28 kg/ha/week (25 lb/acre/wk) for subsequent weeks to final harvest. Under certain situations, it may be the only method that can be used to apply fertilizers in a timely manner. Fertigation can be used when fields are too wet for workers or equipment to enter and is generally cheaper because it has lower equipment, maintenance and operational costs than does using traditional fertilizer application equipment. Fertigation is ideally suited for small farm situations on Guam and Micronesia where drip irrigation is used. Equipment used for fertigation can easily be added to any existing drip irrigation system.

The main limitation of fertigation is that only fertilizers that are completely water-soluble can be used because the particles of insoluble or partially soluble fertilizers can clog up the small orifices of the drip lines (Table 7). Many phosphorus fertilizers are not water-soluble.

Table 7. Timing and fertilizer injection rates recommended for cucumbers, beginning at transplanting.

Timing (after transplanting)	Fertilizer Rates (lb/acre/week)
1st to 3rd week	2.5 lb of 20-10-20
4th to 8th week	5 lb of 20-20-20
9th week through harvest	6.25 lb of 20-20-20

- Use only water soluble fertilizer designed for drip-line fertigation.
- Use enough water so that the concentration of N does not exceed 200 ppm or K does not exceed 150 ppm.
- Preplant 800–1,000 lbs/acre 10-30-10

Table and information adapted from 1994 Hawaii Research Extension Series 151 (630 US ISSN 0271-9916) and 1997 Vegetable Crops Update Vol. 7, No. 2.

Equipment Needed and Procedures

A fertigation system's versatility depends on the injector and environmental safety depends on the backflow preventer. Fertilizer injectors enables the fertilizer to enter the irrigation line. There are many different kinds of injectors available on the market. They vary in size, capacity, allowable application rate, power requirements, and the principle of their operation. The two main types, suitable for small farming situations of this region, are venturi injectors (ex: Mazzi injectors) and water-powered injectors (Ex: Dosmatic Plus and Dosatron). Venturi injectors are simpler and cheaper but water-powered injectors offer more flexibility in usage and range of application rate. An additional source for more details on your specific injector may be found in the manufacturer's literature.

A backflow preventer, a device that allows water to flow in a forward direction only, is a must for fertigation. This is needed to prevent contamination of a water source or the water distribution system from chemicals going back into the water supply lines. If your drip irrigation system does not have a backflow preventer, it must be installed before starting fertigation. As an additional precaution to prevent contamination of soil or water, before turning on your system, have it evaluated by your local agriculture extension agent.

The following is a brief general procedure outlining what needs to be done in order to apply fertilizer uniformly, and prevent clogging of the drip lines.

1. **Prepare the stock solution.**
2. **Prime the drip lines to operating pressure.** Priming time will vary depending upon the distance to the farthest point in the field.
3. **Set injector.** Set the injector to the desired proportion of stock solution to water and pressure test the injector.
4. **Start injecting.** When the entire stock solution has been injected, dip the suction tube in a water container. Let it run for a about a minute to rinse the suction assembly.
5. **Flush the system.** Let the system run for a long enough time to flush the fertilizer from the farthest end of drip lines. This practice is important to enhance the uniformity of fertilizer application over the field. It also significantly reduces clogging of drip line by removing chemicals that may otherwise precipitate or crystallize in the emitter pathways and eventually block these pathways.

Management of Plant Pathogens

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A plant disease is a condition of abnormal function within a plant, which is manifested by the production of symptoms. It is the result of the exposure of a susceptible plant to a specific causal agent, which may be either infectious or noninfectious. Infectious agents are of biological origin that infect and spread among susceptible plants (hosts). Examples of pathogens include viruses, bacteria, fungi, nematodes and parasitic seed plants. Environmental factors, poor pollination, and genetics are examples of non-infectious agents. A non-infectious agent does not spread from plant to plant nor does it obtain nutrition from the host plant.

Non-infectious agents are placed in larger groups of plant problems known as unfavorable factors. For more information on unfavorable factors, refer to the units on Trouble Shooting Cucurbit Problems and Cucurbit management.

In this unit, identification and control of diseases commonly found on cucurbits on Guam will be discussed, of which the majority are infectious. There are over 200 known infectious cucurbit diseases; fortunately only a few have been reported on Guam and of those, fewer still are responsible for the majority of the losses (Table 8).

Table 8. Occurrence of infectious cucurbit diseases reported on Guam (**C**=common, **O**=occasional, **R**=rare, **N**=No report) and their relative importance on specific cucurbit crops (1=High, 2=Moderate, 3=Low).

Crop	Bittermelon	Cucumber	Melon	Summer Squash	Watermelon
Disease					
A = Anthracnose	R-3	C-1	C-2	N	C-2
BFB = Bacterial fruit blotch	N	N	N	N	O-1
CLS = Cercospora leaf spot	O-3	R-3	O-3	N	O-3
D = Damping-off (a)	O-3	O-3	O-3	N	O-3
Dd = Dodder	N	O-3	C-3	N	C-3
FR = Fruit Rot (b)	N	C-2	C-2	O-3	C-3
FW = Fusarium wilt	N	R-3	O-2	N	O-1
GSB = Gummy stem blight	O-3	O-2	C-1	N	C-1
Ph = Phyllosticta	N	N	N	N	R-3
PM = Powdery mildew	C-2	C-3	C-3	C-3	C-3
RK = Root knot	O-3	O-3	O-2	O-3	O-2
RR = Root rot (c)	O-3	O-3	O-3	N	O-3
TLS - Target leaf spot	R-3	O-1	O-2	N	R-3
V = Viruses (d)	C-3	C-2	C-2	C-1	C-2

(a) Damping-off caused by *Pythium* spp. or *Rhizoctonia* spp.

(b) Fruit rot caused by *Erwinia* spp., *Pythium* spp., *Sclerotium rolfsii* or *Phomopsis cucurbitae*.

(c) Root rots caused by *Pythium* spp. or *Rhizoctonia* spp.

(d) V=viral symptoms caused by papaya ringspot-w virus and zucchini yellow mosaic virus.

An infectious disease is the result of a host coming in contact with a pathogen in a suitable environment. In an Integrated Pest Management program (IPM), all three factors (host, pathogen and environment) are considered. By avoiding particular crops (hosts), many diseases can be eliminated (Table 9). Chemicals should only be used after a

pest or disease problem has been identified (Table 1). IPM also places importance on maintaining an environment that is beneficial to the crop and detrimental to a given pathogen or pest. Since IPM uses cultural practices where possible as an alternative to chemicals, the risk to the environment from chemicals leaching into ground water and washing into streams is reduced.

Table 9. Literature review of cucurbit pathogens reporting their associated diseases and pathogenicity range for crops commonly grown on Guam.*

Genus	Species	Disease**	Agricultural Host***
<i>Acidovorax</i>	<i>avenae</i> subsp. <i>citrulli</i>	BFB	cucurbits with major losses in watermelon and occasionally melon
<i>Cercospora</i>	<i>citrullina</i>	CLS	bittermelon, chayote, cucumber, melon, sponge gourd, summer squash
<i>Cercospora</i>	<i>echinocystis</i>	CLS	wax gourd
<i>Choanephora</i>	<i>cucurbitarum</i>	FR	cucumber, eggplant, okra, melon, papaya, pepper, sweet potato, summer squash
<i>Colletotrichum</i>	<i>orbiculare</i>	A	cucumber, melon, sponge gourd, summer squash, watermelon, wax gourd
<i>Corynespora</i>	<i>cassiicola</i>	TLS	banana, cucumber, guava, papaya, pepper, pumpkin, melon, snap bean, soybean, summer squash, swamp cabbage, sweet potato, tomato, watermelon
<i>Cuscuta</i>	spp.	Dd	most plans with the exception of corn, some beans and some solanaceous plants
<i>Didymella</i>	<i>bryoniae</i>	GSB, FR	cucumber, melon, summer squash, watermelon
<i>Fusarium</i>	<i>oxysporum</i> f. sp. <i>niveum</i> <i>oxysporum</i> f. <i>melonis</i> <i>oxysporum</i> f. sp. <i>cucumerinum</i> <i>moniliforme</i> var. <i>subglutinans</i>	FW FW FW FW	watermelon only muskmelon only mainly cucumber bottle gourd, watermelon
<i>Meloidogyne</i>	spp.	RK	all cultivated should be considered susceptible
<i>Pythium</i>	spp.	D, FR, RR	all cultivated should be considered susceptible
<i>Phytophthora</i>	spp.	D, FR, RR	all cultivated should be considered susceptible
<i>Rhizoctonia</i>	<i>solani</i>	D, FR, RR	all cultivated should be considered susceptible
<i>Sclerotium</i>	<i>rolfsii</i>	SB, FR	avocado, bean, bok choy, cashew, cabbage, carrot, chayote, corn, cucumber, eggplant, garlic, grape, grapefruit, leek, lettuce, melon, okra onion, papaya, peanut, pechay, pepper, pumpkin, swamp cabbage, summer squash, sweet potato, Honolulu taro, red taro, tangerine, tomato, watermelon
<i>Sphaerotheca</i>	<i>fuliginea</i>	PM	cucumber, lettuce, summer squash, melon, watermelon
<i>Erysiphe</i>	<i>cichoracearum</i>	PM	bittermelon, bottle gourd, chayote, cucumber, eggplant, lettuce, sponge gourd, melon, okra, pepper, pumpkin, watermelon, mango, papaya
PRSV-W or ZYMV		V	all cucurbits

*To simplify the table only one pathogen name is given.

** **A** = Anthracnose, **BFB** = bacterial fruit blotch, **CLS** = *Cercospora* leaf spot, **D** = damping-off, **Dd** = dodder, **FR** = fruit rots, **FW** = *Fusarium* wilt, **GSB** = gummy stem blight, **PM** = powdery mildew, **RK** = root knot, **RR** = root rot, **SB** = southern blight, **TLS** = target leaf spot, **PRSV-W** = papaya ringspot virus strain watermelon, **ZYMV** = zucchini yellow mosaic virus.

*** All common names are not given. Refer to the Guam Fruit and Vegetable Pesticide Guide for a cross-reference of English, Chamorro, Filipino and scientific names. Plants of the same genus should be considered as having the same susceptibility.

IPM Disease Control Strategies

An IPM approach to disease control starts before planting (preplant) when decisions regarding crop, cultivar, planting date, site selection, irrigation, and chemical treatment of seed and soil are made. At the time of seedling emergence, preventative chemical sprays can be initiated. The use of cultural practices such as transplanting, grafting, scouting, trellising, weed control, row covers, and mulching begins at planting. Once symptoms appear, the objective of IPM is to reduce disease loss through the use of chemicals and/or by plant removal and sanitation. After harvest, practices such as crop rotation and residue management are used to reduce the likelihood of disease in the future. The effectiveness of the various IPM practices depends on the disease to be controlled (Table 10). Therefore, it is important to be able to correctly identify the disease. To

aid in disease identification refer to the section on Disease Identification in this unit and the former unit titled Trouble Shooting Cucurbit Problems.

Crop selection: Many diseases can be avoided and others reduced through selection of various cucurbit crops (Table 8 and 9). Crop selection is less effective for diseases such as **D**, **Dd**, **RK**, **RR** and **V** because these pathogens have a wide host range.

Cultivar selection: You can reduce disease losses associated with a particular crop such as watermelon by carefully selecting the variety (var.) or cultivar (cv.) you plant. Varieties are those cucurbit types that are found in nature and generally occur true to type. Whereas, cultivars are the result of cultivation and selection processes of humans and are generally not true to type because most are hybrids. Many cultivars have been screened for their susceptibility

Table 10. Timing and relative effectiveness of management recommendations to control or reduce diseases of cucurbits on Guam (**H** = High, **M** = Moderate, **L** = Low).

	Diseases*												
	A	BFB	CLS	D	Dd	FR	FW	GSB	PM	RK	RR	TLS	V
Preplant													
Crop selection	H	H	H	L	M	H	H	H	H	M	L	H	L
Cultivar selection	M	L	M	L	L	L	M	L	H	L	L	M	M
Chemical Control	L	L	L	M	H	L	L	L	L	L	L	L	L
Planting Date	L	L	L	H	M	H	M	M	M	L	H	L	L
Site Selection	L	L	L	H	H	H	M	L	M	L	H	L	L
Irrigation	L	L	L	M	L	H	L	L	L	L	M	L	L
At Planting													
Chemical Control	M	L	L	H	M	L	L	L	L	L	M	L	L
Transplanting	M	H	M	H	L	L	M	M	M	M	L	M	L
Grafted Seedlings	L	H	L	H	L	L	H	M	M	M	M	M	L
Scouting	H	H	H	L	H	L	L	H	H	L	L	H	M
Trellising	M	L	M	L	L	H	L	M	M	L	L	M	L
Weed Control	L	L	M	L	H	L	L	L	L	L	L	M	M
Row Covers	L	M	L	L	H	L	L	L	L	L	L	L	H
Mulching	L	L	L	L	H	H	M	M	L	L	L	L	L
During Season													
Chemical Control	M	L	M	L	H	M	L	M	H	L	L	M	L
Plant Removal	L	M	L	L	H	L	M	L	L	L	L	L	M
Sanitation	L	H	L	H	H	M	H	M	L	M	M	L	L
After Harvest													
Residue Management	M	M	M	L	M	M	M	M	M	M	M	M	M
Crop Rotation	H	H	H	M	M	M	M	H	M	M	M	M	M

* **A** = anthracnose, **BFB** = bacterial fruit blotch, **CLS** = Cercospora leaf spot, **D** = damping-off caused by *Pythium* spp. or *Rhizoctonia* spp., **Dd** = dodder, **FR** = fruit rots caused by *Erwinia* spp., *Pythium* spp., *Sclerotium rolfsii* or *Phomopsis cucurbitae*, **FW** = Fusarium wilt, **GSB** = gummy stem blight, **PM** = powdery mildew, **RK** = root knot, **RR** = root rot caused by *Pythium* spp., or *Rhizoctonia* spp., **TLS** = target leaf spot, **V** = viral symptoms caused by papaya ringspot-w virus and zucchini yellow mosaic virus.

to diseases by seed companies and research centers. Some cultivars are disease resistant, which prevents the plant from developing a particular disease. Also desirable are cultivars that have disease tolerance, meaning they may become diseased but do not suffer heavy yield losses. Refer to current seed company catalogs, university screening trial reports, and the Guam Cucurbit Variety Guide for further information. Though a variety or cultivar may be given a resistant rating by a seed company, its performance on Guam may be different because of the existence of different strains or races of pathogens and our environment being different from that of the seed companies' trial plots. Cultivars which are reported to have resistance to watermelon mosaic virus (WMV or WMV-1) should be selected to reduce loss from PRSV-W.

Chemical control: A variety of chemicals are used to reduce diseases. Preplant herbicides are used to control weed hosts and **Dd**. Insecticides are used to control insects that create wounds for infection and spread diseases (vectors). Nematocides are used to control nematodes, and fungicides are used to control fungal diseases. Chemically treated seed reduces the risk of early infection caused by the seed-borne diseases **A** and **Gsb**. Seed treatments also give protection against **D**. Fungicides are mainly used

later in the growing season against foliar diseases such as **A**, **CLS**, **Gsb**, **PM**, and **TLS**. Chemicals are less effective against bacterial diseases, **RR** and **FR**, and ineffective against **V**. Fungicides do not cure present symptoms or eliminate pathogens. However, they do reduce pathogen levels, protect the host, and reduce losses. The first spray should be made before symptoms appear if a particular disease commonly occurs in the field. Otherwise, the first application should be applied immediately after the first symptoms appear.

An alternative to man-made chemicals for disease control are biological control agents. These live organisms can be used to destroy specific pathogens or keep them from causing damage. These products are slower acting than chemicals but protect longer. For information on chemical and biological control agent recommendations and safety, refer to the Guam Fruit & Vegetable Pesticide Guide supplement and contact your location Cooperative Extension Office.

Planting date: The majority of cucurbits are planted near the end of the wet season. This is to time flowering, fruit set, and harvest during the drier months (Table 11). Trellised vine crops (bittermelon, cucumber, and gourd) are not susceptible to poor production in the rainy season because their fruit are not in contact with excessively wet soil (Table 11). Excess soil moisture increases **RR** and **FR**. Since

Table 11. Seasonal availability of cucurbit produce on Guam.

Common Name (Chamorro)	J	F	M	A	M	J	J	A	S	O	N	D	
	A	E	A	A	A	J	J	U	U	S	O	N	D
	N	B	R	P	Y	N	L	G	E	C	O	V	E
Bittermelon (Atmagosu)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Cucumber (Kamba)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Gourd, Bottle (Kalabasa/Upo)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Gourd, Spanish (Chaiote)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Gourd, Sponge (Patola)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Gourd, Wax (Kondot)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pumpkin (Kalamasa)	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Pumpkin tips (Puntan Kalamasa)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Honey Dew (Melon Finu)	Yellow	Green	Green	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green
Melon (Pipinu)	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green
Muskmelon (Melon Bãstos)	Yellow	Green	Green	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green
Watermelon (Chandiha)	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green
	DRY SEASON						WET SEASON						

	Indicates Availability
	Indicates Moderate Availability
	Indicates Not Available

water is necessary for most fungal spores to germinate, excessive rain increases susceptibilities of fruits, leaves, and flowers to infection. Splashing rain and runoff spread **A**, **BFB**, **CLS**, **D**, **Dd**, **FR**, **FW**, **GSB**, **PM**, **RK**, and **TLS**.

Site selection: When choosing a site, it is important to consider the crop to be planted, soil characteristics and topography (the lay of the land). Cucurbits grow best under full sun and in well-drained soils which have a pH value in the range of 5.5 to 7.5. **FW** is usually worse in soils with a pH less than 6.5. Poor drainage favors **FR** and **RR**. Poor light favors **PM**. The land should have a gentle slope to aid in removal of surface water. Areas of high wind or salt spray should be avoided. Areas of high infestation of **Dd** should be avoided. Whenever possible, plant on new land or land that has been out of production for a while to avoid **FW**, **RR**, **RK**, and **BFB**. The next crop should not be situated next to areas where diseased plants are standing. For more information refer to the section on site selection in the cucurbit management unit of this guide.

Irrigation: Drip irrigation is better than overhead because it reduces the spread of foliar diseases (leaf diseases). Excess moisture should be avoided, especially in clay soils and soils with a history of **RR** and **FR**. Low to moderate soil moisture (25% saturation) favors **FW**. For more information, refer to the section on irrigation in the cucurbit management unit of this guide.

Transplanting: The use of transplants is beneficial because the plants are protected from exposure to diseases and the grower can easily inspect the seedling for any possible problems. Transplants should be kept away from actively growing fields to reduce infection by pathogens that may become airborne and cause diseases such as **A**, **CLS**, **GSB**, **PM**, and **TLS**. Keeping the transplants away from cultivated fields will also reduce the risk of insects spreading **V**. Field damping-off can be eliminated using transplants grown from high quality fungicide treated seed planted in artificial soil. By using transplants, abnormal seedlings can be discarded prior to field planting, which reduces the chance of loss caused by seed-borne diseases such as **A**, **ALS**, **BFB**, **FW**, and **GSB**. Some viruses are seed transmitted but not **PRSV-W** and **ZYMV**. For more information, refer to the section on planting in the cucurbit management unit of this guide.

Grafting seedlings: The utilization of grafts is commonly practiced in areas of Asia where maximum yields are desired from limited land resources. Grafting is the process of making a plant more desirable by using a piece from another plant. Cucurbits

which produce good fruits can be improved by replacing their root systems with those of *Cucurbita* spp., *Lagenaria siceraria*, or *Benincasa cerifera*, which have roots resistant to **FW**. Grafting offers the grower the normal advantages of using transplants, with the additional advantages of resistance to **FW** and a more vigorous root stem, which is beneficial against **RR**. Roots stock, instructions and supplies for grafting of watermelon, melon, cucumber, and balsam pear are commercially available.

Scouting: Once the seedlings emerge, they need to be inspected for diseases (scouting). Plantings should be scouted regularly (at least weekly) in order to determine if new diseases have developed and to determine the effectiveness of present practices. Chemical sprays are only effective if applied early and for the disease in which they are intended.

Trellising: Trellising is the process by which cucurbit vines are trained to grow onto a latticework of wood, string, or netting. The advantages of trellising are that it allows for easy inspection and picking, uniformity of fruit shape and color, better chemical spray coverage, reduced **FR**, more efficient use of land resources and higher yields. Increasing air-movement decreases periods of leaf wetness resulting in less **A**, **CLS**, **FR**, **GSB**, and **TLS**. The disadvantages of trellising are that it is suitable only for the medium to small vining cucurbits. There are extra costs associated with material and labor, and plants are more prone to wind damage. Damage from high wind can be reduced by temporarily laying trellises on the ground. Rotating cucurbits with another trellising crop can reduce costs by maximizing the use of the trellis.

Weed control: Eliminating alternate hosts for cucurbit pathogens reduces the likelihood of disease by reducing the inoculum in the area. Plants that serve as alternate hosts include weeds and cucurbits that have been allowed to go-to-seed and grow wild. Those diseases that develop on a few hosts such as **FW** and **GSB** do not develop on weeds. All weeds should be considered as possible alternate hosts for at least some of the many **FR** and **RR** organisms. Many weeds, particularly broadleaf species, are host to **RK**. Weeds of particular importance and associated diseases are as follows: *Amaranthus* spp. (spiny amaranthus), **SB**; *Carica* spp. (wild papaya) harbor **SB** and **TLS**; *Commelina* spp. **A**; *Euphorbia* spp. (Spurge), **SB** and **TLS**; *Ipomoea* spp. (morning glory), **SB**, and **TLS**. Wild bittermelon, pumpkin and sponge gourd, which are commonly found growing around fields, should be considered as possible sources of infection for all cucurbit pathogens and removed from the area.

Mulching: Mulching is the process of applying select materials around a crop. Each type of mulch has its particular function. Some function to conserve soil, fertilizer, and soil moisture. Others prevent weeds or create a mooring area by allowing hold fasts for tendrils. Mooring mulches also aid in reducing wind damage. Mulches reduce the spread of **GSB**, **FW**, **RR**, and **Dd** because they reduce soil splashing and soil movement. Mulch can contribute to snail and slug problems by protecting them from the drying effects of the sun. Plastic mulch is an excellent barrier to weeds, **Dd** and many **FR** organisms. Plastics may contribute to disease if not laid properly, thereby creating dips where soil and water may accumulate and lead to increased **FR**. Reflective mulch reduces **V** because it reduces its main vectors, the aphid and white fly. Care needs to be taken with reflective mulch to avoid overheating or burning of some plants. Clear polyethylene mulch is used in soil solarization. Solarization is a process by which pathogens and weeds in the top few inches of soil can be reduced through the heating of the soil by the sun. Solar heating is achieved by placing a sheet of clear polyethylene over moist soil during hot sunny weather. The sheet is then removed when it is time to plant.

Row covers: Row covers are fine mesh materials that are placed over the crop. The mesh is small enough to keep out aphids. Aphids are responsible for the spread of **PRSV-W** and **ZYMV**. When the mesh is laid on top of the plants without a support frame, it is referred to as a floating row cover. This arrangement works fine for watermelon, melon and non-trellis cucumbers. While the cover is in place, other insects such as thrips, pumpkin beetles, leafminers, and adult caterpillars are also excluded. Covering also reduces wind damage. This can be significant on cucurbits grown on plastic mulch due to poor anchorage of tendrils to plastic. To insure proper pollination, row covers are removed when the first female flowers appear. Covers can also be used to protect seedlings from viruses and insects prior to transporting to the field. Refer to the unit on **Management of Insects, Mites and Animal Pests** for more information.

Plant removal: Removing diseased plants from the field as they appear through the growing season is called roguing. Roguing is most effective when the pathogen is slow to spread and when only a few plants are diseased. It is not effective against latent cucurbit diseases. Before entering a field to rogue, the crop's foliage should be dry to reduce the spread of bacterial or fungal pathogens. Roguing should be practiced as early in the season as possible to protect bordering plants from infection and to allow time for bordering plants to fill in the

space once occupied by the pulled plant. Roguing for **BFB**, **D**, **GSB**, and **RR** should only be considered beyond the first two weeks of planting. It is recommended that virus infected plants be placed in a garbage bag for transporting outside the field to reduce the spread of virus infected aphids that may be on the diseased plants.

Sanitation: Equipment and boots should be washed to remove all clinging soil and debris when leaving infested fields to avoid contamination of clean fields with **BFB**, **D**, **Dd**, **FR**, **FW**, **SB**, **GSB**, **RK**, and **RR**. Clean fields should be worked before infested ones. To reduce spreading a disease, it is best to enter a field when the foliage is dry and where the plants are the healthiest. To reduce fruit rots in storage, mature fruits should be wiped free of any adhering soil at harvest and placed in soil-free picking crates. Rags and wash water should be changed frequently. Care should be taken to insure sorting and storage areas are not contaminated with soil.

Residue management: Old plants should be removed or the field should be tilled to work the plant material into the soil as soon as possible after the last harvest. The spread of **A**, **CLS**, **GSB**, **PM**, and **TLS** from old fields to new ones is reduced when fields are tilled or plants are pulled up. Tillage also hastens decomposition, which reduces the buildup of soilborne pathogens **RK**, **FR**, **RR**, and some destructive insects. If **SB** was present during the current planting season, it is important not to allow fruits to rot in the field because the fungus produces its resting structures (sclerotia) in such fruits (**Plate 11**).

Crop rotation: Crop rotation is the process of switching crops grown on a section of land. These crops should be selected for their disease resistant qualities. The seeds of pathogens (propagules) build up in the soil and air when susceptible crops are continually planted on the same soil. Eventually disease can reach high enough levels to make it unprofitable to grow a particular crop. Crop rotation quickly brings down the level of airborne propagules of **A**, **CLS**, **GSB**, **PM**, and **TLS**. Benefits can be seen within a single season of rotation. Soilborne propagules are slower to reduce and may require 2 to 4 years **ALS**, **BFB**, **D**, **Dd**, **FR**, **FW**, **GSB**, **RK**, and **RR**. Since **FR** and **RR** pathogens have a wide range of hosts, it is best to rotate out of cucurbits and away from crops whose fruit may drop on the soil and rot. Even cover crops (a crop grown to protect the soil) can be hosts to **FR**, **RK**, and **RR**. For these pathogens, a period of dry tillage where no plants are allowed to grow will aid in reducing the likelihood of disease. Dry tillage should not be practiced in areas where soil erosion is a problem.

In summary:

1. **Choose carefully** your crop, cultivar, planting site, and planting date.
2. **Scout your field** for diseases, insect vectors, and weed hosts.
3. **Reduce plant pathogens** through sanitation, chemical sprays, row covers, rouging, proper entering and exiting of a field, and crop rotation.
4. **Stay current** on information by listening, reading, and asking questions.
5. **Get help** from a professional whenever in doubt about a causal agent or recommended treatment.

Disease Identification

Many diseases can be easily identified once you know what to look for. On the other hand, some are very difficult to identify and require a plant pathologist with a laboratory. This section is to aid growers and agents in identification of common cucurbit diseases on Guam and to provide information on how they spread (epidemiology). This section is not intended as an authoritative presentation. To keep the complexity of fungal nomenclature simple, identification will be based on the most common occurring spore stage. To aid in disease diagnosis, features as seen with a hand-lens, through a stereomicroscope, and with a compound microscope will be discussed.

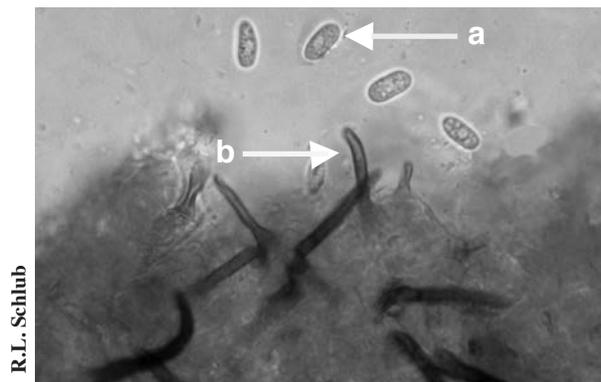
Identification is based primarily on symptoms and signs. A symptom is the visible response of a plant when subjected to a disease agent. A sign is the actual organism. Signs of fungi include the presence of spores (seeds of the fungus), fruiting bodies (a fungal structure containing spores), and mycelium (threadlike filaments of a fungus). The presence of fruiting bodies and spores are critical for positive identification. If diseased tissue is collected with no signs, then the tissue should be placed in a moist chamber to induce the formation of fungal structures. A simple moist chamber can be made by placing two sheets of moist paper towel in a clean plastic bag. The diseased plant tissue sample is placed between the two sheets of paper towel, and the bag is sealed and left at room temperature with ambient light for 24 to 72 hours. Signs of an infectious fungus form quickly, closely followed by the growth of non-infectious fungi (saprophytic fungi); therefore, tissue must be examined daily before the saprophytic fungi overgrow the sample.

Foliar Symptoms**A = anthracnose**

Symptoms produced by the anthracnose fungus first appear on leaves and later may be found on vines and fruit. Infected leaves first show yellowish or water-soaked areas that soon become tan to brown (black in the case of watermelon). On cucumber, the spots are roughly circular consisting of dead brown tissue often surrounded by a yellow to tan halo of dying tissue (**Plate 2A**). These diseased areas (lesions) grow together destroying large areas of foliage. The dry centers of the lesions may tear out or shatter leaving ragged or shot-hole leaves. On cucumber a spot may enlarge to over 2 cm.

Infections on the petiole (leaf stem) and vine result in elongated lesions that appear water-soaked at first and then become tan to black and sunken. Entire vines may be killed by the combination of leaf and stem infections. Young fruits may develop black, sunken spots which result in fruit malformation. Older fruits will usually develop slightly sunken, water-soaked spots which turn black. When moisture is present, the black center of the lesion is covered with a gelatinous mass of spores, which may be pinkish in color. On watermelon, the fruit spots may measure 1–1.5 cm. Gummy exudate is common on lesioned cucumber fruits.

Close examination: On close examination of an old leaf spot with a hand lens, fruiting bodies of the fungus appear as dark brown to black dots often clustered along leaf veins (**Plate 2C**). Under moist conditions, the dots may appear pinkish. The stereomicroscope reveals that the black dots are actually clumps of small black bristles (setae) (**Plate 2D**). Individual spores cannot be seen but en masse appear as a clump in the middle of a crown of setae. Under the compound scope, the setae appear dark, 3 to 4 times the length of the conidia, which are unicellular, transparent, and oblong (4–6 X 13–19 μm) (Fig. 3). Conidia are sexual spores (seeds of a fungus) formed at the end of conidiophores (stalks on which conidia are produced).



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Figure 3. Conidia (a) and seta (b) of a cucumber *Colletotrichum* spp. which causes anthracnose = A.

Epidemiology: The anthracnose fungus survives from season to season on diseased plant residue and on a few weed hosts. Rain dislodges the conidia from their fruiting bodies and splashes them to adjacent plants, while providing moisture for the spores to germinate. Under wet conditions and Guam's high temperatures, spores germinate and penetrate the host within 72 hours. Symptoms occur within 96 hours. Lesions increase in size more rapidly and spore production is greater on older versus younger leaves. Farm workers and equipment entering wet fields are a source of spread. Transmission by seed and wind have also been reported. Disease development that occurring later than 50 days after seeding is unlikely to affect yield.

CLS = *Cercospora* leaf spot

The fungus *Cercospora* is mainly a leaf pathogen infecting older leaves and causing spots 0.5–10 mm in diameter. Occasionally it infects petioles and stems. Leaf spots are irregularly circular with white to tan centers and dark margins. On wax gourd, the spots are often found toward the leaf margins and with a yellow halo (**Plate 3A**). Heavy infection causes the leaf to yellow and drop early.

Close examination: On close examination of a leaf spot with a hand-lens, the fungus appears as hairy black clumps with white silvery threads (**Plate 3B**). Under the stereomicroscope, they appear as small bundles of black sticks, many of which have attached silvery threads (**Plate 3C**). The silvery threads may be nearly the length of a leaf hair. Under the compound scope, the conidiophores are 4–5.5 × 50–300 μm, medium brown, in groups of 3 to 10, mostly straight, multicellular with conidia attachment scars often visible (**Fig. 4A**). The conidia are indistinctly multicellular, clear, long (50–220 μm) with a narrow pointed tip (1–2 μm) and a wider base (3.5–5 μm) (**Fig. 4B**). Conidia are borne on the tips of the conidiophores and are pushed aside as the conidiophores continue their indeterminate growth. This creates distinct attachment scars on the side of the conidiophores. Growth of long whiplash conidia are common when tissue is incubated in a moist chamber.

Epidemiology: It survives mainly on crop debris. Spores are spread by wind, rain splashing and wind-driven rain. Infection requires free water and is favored by temperatures of 26–32° C. Under Guam's climate, new infections would be expected every 7 to 10 days.

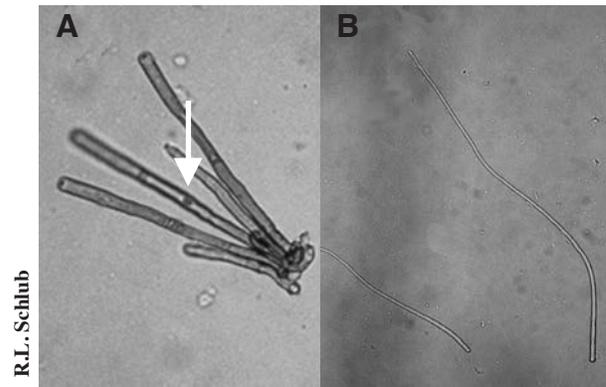


Figure 4. **A.** Clump of conidiophores with visible conidia attachment scars characteristic of the *Cercospora* leaf spot = CLS fungus. **B.** Conidia are long, whiplash in shape, and are indistinctly multicellular when non-stained.

GSB = gummy stem blight

The fungus disease, gummy stem blight, is an important disease of melons and watermelon on Guam. The name gummy stem is derived from the fact that it causes a blight on the leaves (rapid killing of the leaves) and stem lesions that may form a gummy exudate. The rapidly expanding leaf spots are brown on melon (**Plate 4A**), tan on cucumber, and black on watermelon (**Plate 4B**). Only occasionally does **GSB** cause damage on cucumber where it usually infects the margins of older leaves. On melon and watermelon the leaf blight is very rapid, often making it difficult to find the fungus's fruiting bodies needed for identification (**Plate 4C**). Infected stems first develop water-soaked lesions, which later appear tan with a gummy exudate. Diagnosis of **GSB** as the cause of a stem lesion should be based on the presence of the fungus fruiting bodies and not on the presence of gummy exudate (**Plate 4D**). Gummosis is not always associated with **GSB** infection. Gummosis may be caused by factors other than **GSB** (**Plate 12B**). Infected vines usually wilt after mid-season. Infection of the crown will cause total plant failure. Infection of the fruit commonly referred to as fruit black rot starts out as small, water-soaked spots, which may develop into larger gummy exuding spots and eventual fruit rot.

Close examination: Examination of a leaf spot, stem lesion, or fruit spots with a hand-lens reveals pimple-like small fruiting bodies called pycnidia (**Plate 4C**). Under the stereomicroscope, the pycnidia appear roughly spherical in shape (120–180 μm) with an opening at the top (ostiole) (**Plate 4E**). The mature pycnidia may be black and protrude through tissue layers while the younger spots are tan and often covered with a layer or more of plant tissue. Under moist conditions, a ribbonlike mass of gelatinous spores (cirrus) exudes from the ostiole. Viewing the cirrus under the compound scope reveals

translucent, oval shaped, one or two celled conidia, (6–13 μm X 3–5 μm) (Fig. 5). The sexual spores of the fungus are also commonly seen and appear in club-shaped asci (sacks). The asci are formed in a ball-shaped fruiting body (perithecium 140–200 μm). Each ascus contains 8 spores, approximately 60–90 μm x 10–15 μm in size.

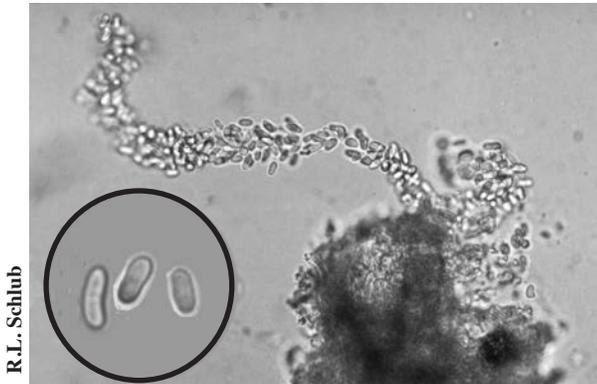


Figure 5. Conidia of a *Didymella* spp., the cause of gummy stem blight = **GSB**, oozing in a cirrus from a pycnidium.

Epidemiology: Wounding, beetle damage, aphid feeding, and **PM** predispose plants to infection. Infected cotyledons (seed leaves) are a source of inoculum for crown infection at the soil line. High relative humidity and moist soil conditions are important for infection, which occurs within hours. Symptoms can occur within 3 to 10 days after infection. Conidia are spread by water-splashing and the ascospores by wind. The fungus survives in diseased plant residue and possibly seeds. The fungus may survive in fields in the absence of host plants for 2 years. To avoid fruit rot caused by the **GSB** fungus, fruits should be handled carefully, cooled where possible, and sanitary practices should be followed.

TLS = target leaf spot

The fungus disease target leaf spot, also called *Corynespora* blight, is a leaf, petiole and vine disease of cucurbits. The first symptoms appear as angular yellow leaf spots. They look very similar to anthracnose but generally the spots are smaller, do not spread as rapidly, and do not usually have halos (**Plate 2B**). Spots may enlarge to over 2 cm, at which time the centers may fall out, creating a shot-hole appearance. On melon, the leaf infection may be rapid and look similar to gummy stem blight. Also on melon, it commonly causes a light tan stem lesion surrounded by a dark margin (**Plate 5A**). Vine death may result from stem lesions early in the season on both cucumber and melon.

Close examination: On close examination of a leaf spot with a hand-lens, the fungus appears as thin, short hairs. It may be very thick under leaf folds and other protected areas. The color of the hair can range

from tan to black. Under the stereomicroscope, the long multicellular, transparent, thick walled conidia shimmer on top of their darker conidiophores (**Plate 5B**). Under the compound microscope, the conidia are large, appear multicellular with a prominent dark basal scar. The conidia vary in length from 40–220 μm , in shape from straight to curved and in shade from transparent to pale brown (Fig. 6). Conidia form at the conidiophore's tips and are usually single but may form short chains. The conidiophores also vary, ranging from flexible to straight, pale to mid brown, 110–850 μm in length with a thickness of 4–11 μm . They are smooth, multicellular, with multiple cylindrical proliferations at their tip.

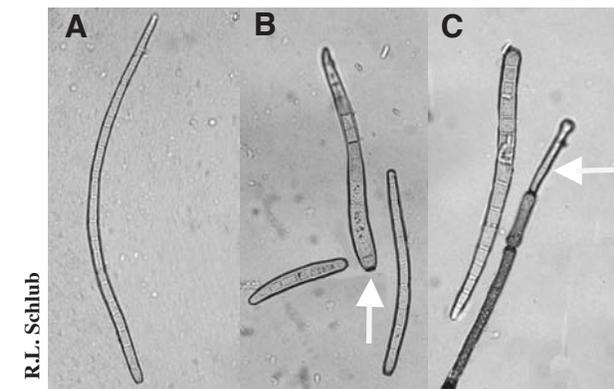


Figure 6. **A, B.** Conidia vary in length and shape, and are distinctly pseudoseptate with dark basal scars. **C.** Conidiophores of the fungus which cause **TLS** are multicellular with multiple cylindrical proliferations at their tips.

Epidemiology: It survives between cucurbit crops on plant residue and on non-cucurbit hosts. Spores (conidia) are produced under humid conditions and are airborne. On Guam, cucurbits at the transplanting stage have been observed with **A** but not with **TLS**. Outbreaks of the disease are often sporadic, skipping one or more seasons.

V = viruses

There are several viruses that may infect cucurbits; however, on Guam **PRSV-W** (papaya ringspot virus strain watermelon) and **ZYMV** (zucchini yellow mosaic virus) are the predominate ones, based on a survey of watermelon farms. Papaya ringspot virus strain watermelon has also been abbreviated as **PRV-W**. Determining whether or not a plant has **PRSV-W** and /or **ZYMV** can be confusing since their symptoms may mimic damage caused by pests and other diseases. Virus symptoms are most conspicuous and severe on new growth and young plants where they cause a light to dark colored mottling (mosaic) and puckering (**Plate 6A**). The puckering leaves may be confused with aphid and mite damage; therefore, samples must be examined for these insects. Stunted plant growth and poor fruit set may

be confused with a nutrient deficiency; therefore, fertilization records should be reviewed. A common leaf deformation caused by V is shoestringing (narrowing of leaf lobes), which is most severe on bittermelon, muskmelon, watermelon and squash (**Plate 6B**). Infection of older mature foliage and plants cause less conspicuous symptoms and the plants may even appear healthy.

Close examination: Viruses are too small to be seen with the ordinary microscope. They do not produce any fruiting bodies.

Epidemiology: PRSV-W and ZYMV are primarily spread by aphids and secondarily by workers. Aphids acquire viruses by feeding on infected crops or wild cucurbits, later infecting healthy plants when they feed again. Workers spread the viruses when equipment, hands and clothing contaminated from sap of infected plants comes in contact with healthy plants. Based on experimentation conducted on Guam, PRSV-P, a common virus disease of papaya, does not infect cucurbits. For further information, read about aphids in the Management of Insects and Mites unit.

PM = powdery mildew

Powdery mildew is a widely occurring fungus disease of cucurbits. It is so named because it produces a whitish, talcum-like fungal growth. Symptoms usually develop first on older shaded lower leaves, and on the under surface. The fungus rapidly spreads to the upper leaf surface, petioles and occasionally to stems. In severe infections, leaves will develop spreading yellowish blotches, which eventually causes the leaf to wither and die (**Plate 7A**). Fruits are not infected but often of poor quality due to increased sun exposure, hastened maturity, and poor plant growth.

Close examination: With a hand-lens, fine white threads of the powdery mildew fungus (mycelium) can be seen growing on the leaf surface. Viewing a young lesion under the stereomicroscope reveals chains of transparent conidia arising from transparent mycelium (**Plate 7B**). Under the compound scope,



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Figure 7. Conidia and conidiophores of a powdery mildew = PM fungus.

chains of barrel shaped conidia (25–37 μm \times 14–25 μm) can be seen on short erect conidiophores (**Fig. 7**).

Epidemiology: Although high humidity favors spore survival and infection, a wet surface is not necessary for spore germination, which can occur in 2 hours. Leaf infection is favored by the tissue being very young or very old. Within 3–7 days of the initial infection, symptoms appear and new spores are formed. Spores (conidia) are wind dispersed and can be viable for 7–8 days. Resistant cultivars and fungicides are used to manage powdery mildew.

Symptoms on Fruits, Stems or Roots

FR = fruit rots, RR = root rot, and

D = damping-off

Blossom-end rot is not an infectious disease. It is mainly a disease of watermelon and squash brought on by a deficiency in calcium within the cells that form the fruit. Symptoms first appear as small, light brown spots at the blossom end of immature fruit. As affected watermelons grow, these spots can enlarge rapidly to form dark, sunken, leathery areas. Such spots allow easy access for organisms that will then rot the fruit. Environmental conditions that interfere with the uptake of water and availability of nutrients contribute to this disease. Such conditions include water stress (especially wide fluctuations), excess salinity, and root damage from infectious diseases. Excess nitrogen fertilizer can also contribute to blossom-end rot in non-calcareous soil (soil that do not contain high levels of limestone) (**Plate 8**).

Belly rot is a fungus disease that invades fruits which are in contact with the soil. On Guam, it commonly occurs on watermelon. Water-soaked, tan to brown lesions develop on the underside of cucumber fruits, often toward the blossom end. Older lesions are sunken and crusty in appearance with the fruit remaining firm.

Close examination: Under a hand-lens or stereomicroscope only threads (mycelia) of *Rhizoctonia solani* are seen. An important characteristic is the darkening to near black of the mycelia with age and occasional appearance of small, superficial sclerotia (tightly packed mycelium). These small sclerotia (0.2–0.5 mm diameter) are white at first, turning brown to dark brown and rough with maturity. Under the compound microscope mycelial strands are strongly stainable, thick, colorless when young, darken with age and exhibit right angle branching with cross walls forming near their constricted bases. Mature hyphal cells are brown, 5–12 μm wide and up to 250 μm long.

Epidemiology: The pathogen survives as mycelium and as sclerotia (non-spore resting body) in soil and plant residues. Movement of contaminated plant tissue and soil by wind, rain splashing, water and

machinery are means of spread. Since the fungus is soilborne and has a wide host range, the potential for diseases is always present. This fungus can also cause **D**, **RR** as well as crown rot.

Pythium cottony leak is most commonly seen on cucumber fruits which are in contact with the soil. Infection occurs most often at the point of soil contact, where it causes a watery, soft rot. The fungus quickly grows over the area and produces a mass of white cottony mycelium (**Plate 9A**). It may also cause a crown rot of young plants (**Plate 9B**).

Close examination: Most cucurbit pathogenic *Pythium* species produce spherical shaped spores (oospores and sporangium) which are just visible with a hand-lens or stereomicroscope but are easily seen under low magnification of a compound microscope (**Fig. 8A**). When examined under the compound microscope, it can be seen that a young mycelium is 5–10 μm wide, transparent, lacks cell walls and often exhibit cytoplasmic streaming (**Fig. 8B**). Sporangia may be filamentous or spherical, or may resemble enlarged mycelium. *Pythium* sporangia range in size from 7.5–12 \times 12–28 μm with spherical sporangia being 12–26 μm in diameter. A quick test for *Pythium* is to place several pieces of diseased tissue on several cucumber slices in a moist chamber for 48 to 96 hours. If *Pythium* is present, some of the pieces will yield cottony *Pythium* mycelium, quickly followed by the production of spores.

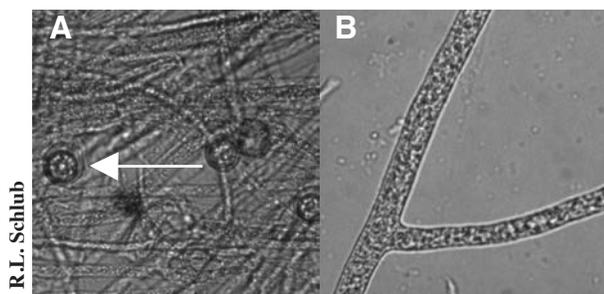


Figure 8. **A.** Oospore of a *Pythium* spp. that causes cottony leak of cucumber. **B.** Hyphae are transparent and have no cross walls.

Epidemiology: Some *Pythium* species are always present in the soil so there is always the possibility of disease. Disease is most severe in flooded fields during the rainy season and when fruit is in contact with the soil. Spores are spread by running water, splashing rain and equipment. Since *Pythium* quickly rots fruit in storage and easily spreads in wash water, it is recommended to change wash water frequently and treat water with 40–60 ppm chlorine or use a commercially prepared fruit wash preparation. Several *Pythium* species are responsible for **D** and **RR**.

Black rot or *Didymella* black rot, a fruit rot of mainly squash and pumpkin, is caused by the same

organism that causes **GSB**. Symptoms of black rot are most common where fruits are in contact with the soil. Large Halloween pumpkins are more susceptible than pie types. Black rot starts as irregular circular fruit spots often near the blossom end that are faded green or yellow, later gray to brown and finally black due to the fungus's fruiting bodies. The fungus penetrates the rind and causes a dry rot.

Close examination: Refer to **GSB** in the section on Foliar Symptoms.

Epidemiology: Refer to **GSB** in the section on Foliar Symptoms.

Choanephora fruit rot is primarily a pathogen of blossoms and young fruits of summer squash. At first, dense growth of the fungus appears as white needles; later the needles appear capped with small purplish black balls (**Plate 10**).

Close examination: Under a hand-lens, conidiophores (modified hypha which bears conidia) of *Choanephora cucurbitarum* can be seen capped with a ball. Under the compound microscope, it can be seen that the conidiophore is non-branching and has a spherical head which is covered with several small balls covered with conidia; these are light brown to red-brown, oval to elliptical, with striations and measuring 15–25 μm \times 7–11 μm .

Epidemiology: The fungus survives from season to season due to special thick-walled spores and its ability to grow on dead plant matter. It is transmitted by bees, cucumber beetles, wind, rain and splashing water. Recommended practices include crop rotation, planting during the dry season, and avoiding overcrowding of the crop.

SB = southern blight is a fungus disease that is mainly restricted to melon fruits lying in contact with the soil and partially buried vines. The presence of rhizomorphic cords (many mycelia threads woven together into a readily visible white web) and sclerotia are the main diagnostic features of **SB**. Mycelial growth on fruit, which resembles a fan (**Plate 11**), may precede the formation of sclerotia by a week or two. **SB** sclerotia are about the size of mustard seed (1–2 mm) are white at first, then turning orange, reddish or brown and are bound together by mycelial strands (**Plate 11**). When an infected fruit is picked up, the portion surrounded by mycelium strands normally remains attached to the ground.

Close examination: Southern blight is caused by a fungus, *Sclerotium rolfsii*, which appears mainly as white mycelial strands. Under the compound scope, the mycelium appears coarse, has clamp connections (bridge-like swelling at cross walls) (**Fig. 9A, B**), and consist of cells 2–9 \times 150–250 μm .

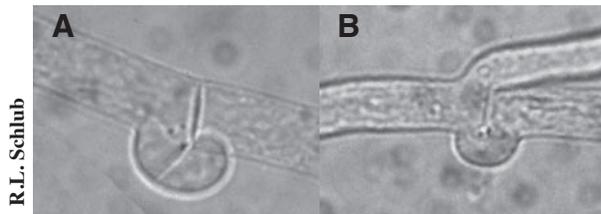


Figure 9. A. Bridge-like hyphal connection (clamp connection) characteristic of the southern blight = SB fungus. B. Hyphal branch arising from an area of a clamp connection.

Epidemiology: The fungus persists in the soil as resting bodies (sclerotia) which, under warm wet conditions, give rise to mycelia of the fungus. Once the *S. rolfsii* starts to grow, it will grow on plant tissue, preferring dead or dying material. Epidemics usually follow heavy rain, at which time melons in contact with the ground, are easily invaded, especially if the skin has been punctured by insects, damaged by sharp stones, or are in contact with old vines or leaves. Sclerotia produced on organic matter and dying plants serve as inoculum for the next crop. Cultivators and other farm equipment spread sclerotia and infected plant matter within a field. Spread may also occur from infested transplant soil and runoff water. After each harvest, the crop should be tilled under to hasten its breakdown. Sclerotia lose viability in soil but will persist in infected tissue for months. With melons, it is best to avoid a dense canopy, organic mulches, and excess watering at harvest.

FW = Fusarium wilt

Cucurbits are affected by a number of different *Fusarium* species that cause various symptoms such as wilt, crown rot, root rot, fruit rot, and stem lesions. Since the *Fusarium* fungus lives in the soil, any plant part that comes in contact with the soil is susceptible to infection which can occur at any stage of growth. **FW** is the most serious of the *Fusarium* cucurbit diseases on Guam and will be the main focus of this section. Wilt is the symptom used to describe a plant that is drooping from lack of water without any outward sign of infection. Such plants will show what appears to be normal midday drooping but are slow to recover and eventually may die. Plants that are not killed show yellowing, stunting, and poor fruit development. Symptoms are most severe during droughts and fruit formation. **FW**, unlike most wilts, does not affect the entire plant at once. At first only a few vines will show symptoms (**Plate 12A**). A reddish-brown discoloration of the water conducting tissue is evident when a dying plant is cut in half near the crown. After the death of the plant and during wet periods, white pinkish mold may be seen on the stems.

Another *Fusarium* disease seen on Guam is a crown and vine rot of cucumbers. It is not a true wilt disease because it causes a decay of the outer tissues on which the fungus readily produces spores. Infection of the crown causes a rapid soft decay, whereas vine infections are slower and often result in streaks of dead tissue within the stem with occasional formation of gummy exudate (**Plate 12B**).

Close examination: *Fusarium* mycelium is white and sparse under normal field conditions. The fungus is a prolific spore producer, which may appear as a salmon-pink crust (**Plate 12C**). Under moist conditions, there is an abundance of cottony mycelium and little spore production. Under the stereomicroscope tufts of tightly packed macroconidia may be seen. Under the compound microscope the typical *Fusarium* macroconidia can be easily seen (Fig. 10). They are multicellular, curved, with a apex and foot cell (a constricted area where the spore was attached during formation). *F. oxysporum*, which causes **FW**, have macroconidia which measure 27–60 × 3–5 μm, have 3–5 cross walls, and have a somewhat hooked apex and a conspicuous foot. *F. solani*, which is the most frequently reported cause of crown and stem lesions, has 3 celled macroconidia that measure 44.5 × 5.1 μm and 4 celled ones that measure 51 × 5.3 μm, with a rounded or slightly pointed apex, and a conspicuous foot.

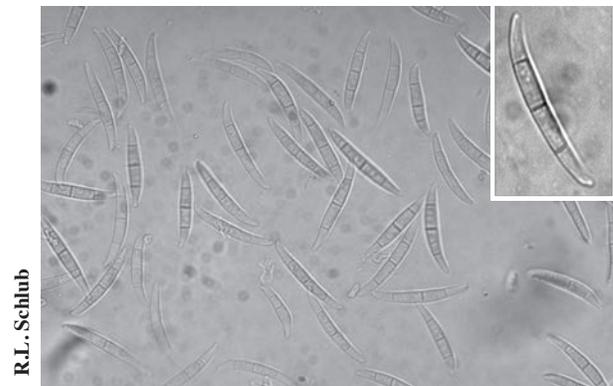


Figure 10. Macroconidia of a *Fusarium* spp. isolated from cucumber.

Epidemiology: *Fusarium* survives in the soil as thick spores (chlamydospore) on crop residue, and on weed hosts. The fungus can persist in the soil for many years. With proper management practices, disease can be greatly reduced but not eliminated. Movement of infested soil by wind, rain, equipment, and man is the main means of spread. There are a number of different form of species of *F. oxysporum* that can cause **FW**. This means, the watermelon wilt pathogen will not cause wilt of cucumbers or melon. **FW** of watermelon is most severe in light, sandy soils with a pH of 5.5–6.5 with low to moderate soil moisture. It has been reported that high nitrogen

levels increase infections, whereas high potassium levels reduce it. Nitrogen fertilizer in the form of NO_3 is recommended over NH_4 . Moisture stress and over crowding should be avoided.

BFB = bacterial fruit blotch

The main symptom of bacterial fruit blotch is the production of blotches on fruit (irregular areas of discoloration, usually superficial). On watermelon, bacterial fruit blotch appears as dark olive green areas on the upper surface of the fruit (**Plate 13A**). Initial infection may start out as small 1 cm spots and may, in 7–10 days, quickly cover most of the fruit's surface. Infection is limited to the rind so fruit can be eaten but are often not marketable due to rotting caused by secondary infections.

Leaf infections appear as small dark brown angular areas that can easily go unnoticed. Watermelon seedlings show infection on their seed leaves (cotyledons) as areas of water soaking (tissue appears wet, slightly darker and may appear translucent) (**Plate 13B**). These later give rise to small brown to gray areas surrounded by yellowish tissue. Infection on the seedling stem will result in the collapse of the seedling. Seedlings from infected seed usually show symptoms within 7 days, and by 3 weeks nearly all infected seeds will have shown symptoms.

Close examination: The **BFB** bacterium is a small, simple, one celled rod-shaped organism that is able to move by whipping a tail like structure called a flagellum. Bacteria are very small ($0.3\text{--}1.0 \times 0.6\text{--}3.5\mu\text{m}$) and not easily seen individually; however, they can be seen en masse (ooze). Bacterial ooze can be seen by cutting a lesion in half, placing a drop of water on the cut surface, covering with a cover slide and observing through a compound microscope set at low power (**Fig. 11**) or stereomicroscope.

Epidemiology: The bacterial disease **BFB** was first

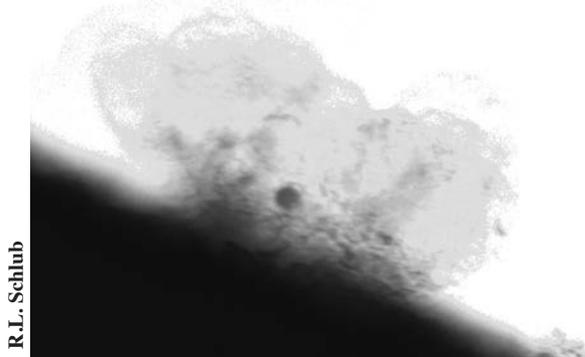


Figure 11. Bacterial ooze pouring from a lesion into surrounding water creating a clouding effect.

found on Guam in 1987 and has occurred sporadically ever since. The original source of the epidemic was thought to be infected commercial seed. Though

seed companies today test their seed for contamination, most will not guaranty disease-free seed. The amount of infected seed in commercial seeds today is less than 1 in 10,000. **BFB** is caused by a bacterium, which is splashed from plant to plant and enters through tiny natural openings called stomata. Bacteria will quickly spread among transplants if overhead watering is used. Infected plants will either show symptoms very early or none until harvest. Most outbreaks of **BFB** can be eliminated by removing any abnormal seedlings, by not using overhead watering for transplants, and by always purchasing seed from a reputable company. The pathogen may survive from season to season on volunteer plants arising from infected rotted fruits as well as in wild cucurbits growing in the area. Since infected rind may also pose a possible threat, infested fields should be rotated out of watermelon production for at least three planting seasons, thereby allowing complete decomposition of the rind. Losses have occasionally been reported on melons.

RK = root knot

Root-knot nematode is a microscopic roundworm which feed on plant roots and belongs to the species *Meloidogyne*. Damage is usually associated with patches of stunted, yellowish plants that are prone to mid day wilting. Symptoms of infected plants include yellowing, reduced size and number of leaves, and poor fruit quality and yield. Infected plants often show symptoms of potassium deficiency. The diagnostic symptom is the presence of knots or swellings on the roots. Symptoms are first seen on feeder roots where they cause a swelling within the root and not on the surface (**Plate 14**). Heavy infection may lead to plants with large, severe, malformed roots and few small feeder roots.

Close examination: If a knot is sliced in half, the light colored, pear shaped females may be seen with a hand-lens ($0.44\text{--}1.3$ mm long \times $0.33\text{--}0.7$ mm wide). Nematodes are best viewed under a stereomicroscope or a compound microscope's low power. The male is shaped like a typical worm ($1.0\text{--}1.5$ mm). There are many harmless nematodes that may look like adult males or juvenile root-knot nematodes. To distinguish parasitic nematodes from the harmless ones, one needs to examine the head of the nematode and look for a stylet or spear. The hollow stylet is quite visible and is used by the nematode to puncture and extract the contents of plant cells.

Epidemiology: In the absence of a crop or weed hosts, the nematodes survive as eggs and in pieces of infected root tissue. A single female deposits 500–1,000 eggs in a gelatinous matrix. They hatch and go through several juvenile stages. The life cycle is complete in 21–28 days. **RK** nematodes can

not move far on their own but can be spread easily through water runoff and soil clinging to farm equipment. Symptoms are usually most severe in drought-prone, well-drained light soils. Nematode damage may also increase levels of **FW** and **RR**.

Dd = dodder

Dodder is a common parasitic plant related to morning-glory. On Guam, there are two types, *Cassytha filiformis*, which is native to Guam and *Cuscuta campestris*, which was introduced to the island. *C. campestris* is the bigger pest on Guam. It is a thin, yellow, leafless, vine that intertwines with its host plant (**Plate 29**). The vines have infection pegs (haustoria) that penetrate the leaves and stems of the host plant and feed off the host plant's sap. If left unchecked, the vines will form a dense mat that produce small white flowers, which will give rise to thousands of extremely small, hard seeds. These may survive in the soil for years. **Dd** is mainly spread when seeds infest hay, crop seed, water, farm machinery, and animals moving from one area to another. For more information on **Dd**, refer to the Weed Management unit.

Management of Insects and Mites

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“Integrated pest management”, IPM for short, makes use of good farming practices to reduce the size of the bite that pests and pesticides take out of your profits. Most experienced growers know that pests can be allowed to get to a certain level without really affecting production. This is particularly true of pests which feed on leaves rather than fruits. The core IPM is a sampling plan which you use to estimate pest levels in your field. You then use the estimates to help you decide whether or not you need to spray.

Sometimes it is better not to spray. Often, insect pests are kept at low numbers by beneficial insects which feed on them. These “good guys” only feed on the pests, and will not eat your crop if the pests are absent. Unfortunately, these beneficial insects are often easily killed by insecticides, much more so than the pests you are trying to control. Killing all insects leaves your field open to re-invasion by the pests. A field that contains no insects is not a healthy field. For this reason, so called “preventive sprays” may actually pave the way for pest invasions.

Quite a few pest problems have been caused by over-use of insecticides. For example, in Hawaii and the Marianas, a small fly called the serpentine leafminer (**Plate 21**) is a major pest of vegetable crops that are sprayed heavily. This fly has become resistant to insecticides and has survived daily pesticide applications. In fields where pesticides are not often used, the fly is killed by tiny wasps barely visible to the naked eye. Heavy pesticide use kills the wasps, but only some of the flies. Without the wasps in the field, fly populations quickly build up to levels that will destroy the crop. Similar situations can occur with melon thrips (**Plate 18**) and whiteflies (**Plate 20**). IPM can help maintain a “balance of nature” by preserving these natural enemies in your fields, and actually provide better insect control with fewer pesticide treatments.

Watermelon IPM in the Pacific Islands

Many farmers currently spray their crops on a weekly basis whether pests are present or not. This practice is not desirable from a health or environmental standpoint, and costs more than spraying only when needed. To spray as needed, you need to know what the important pests are, how many of them

are in your field, and how many of them there must be before you really need to spray. Generally, few pests will not affect your yield much if at all, and spraying these low numbers is a needless waste of your money. However, at other times the pests will be numerous enough to damage your crop, and not spraying may cost you money. How do you know when to spray and when not to? This is the purpose of the Watermelon IPM sampling program we present here. It has been designed and tested by scientists in the Pacific region. It will require an investment of your time, but the rewards should more than offset the investment. To use the Watermelon IPM program, you will have to look for pests in your crop every week, estimate their numbers, and then make spray decisions based on the numbers. Once you know what you are doing, the Watermelon IPM sampling program takes about 20 minutes a week in each watermelon field.

The Watermelon IPM sampling plan is designed to allow you to determine current pest levels and compare these to “action levels.” Action levels can be defined as a “best guess” for the level at which a pest is starting to nibble at your profits. Treatment of your field is recommended if the current level you observe when sampling is higher than the action level. The work involved in sampling should pay off by reducing the time, labor, expense, and health risks associated with unnecessary insecticide applications, thereby increasing your profits. In addition, growers participating in other IPM programs have expressed a sense of satisfaction with being more in touch with their crop and understanding it better. Another advantage is that IPM tends to reduce insecticide use. These chemicals not only kill pests and beneficial insects but are also toxic to other organisms, including fresh water and marine life. Insecticides can and do end up in groundwater or pass through into sensitive reef ecosystems. Insecticides need to be applied judiciously to keep them from contaminating the island’s water sources.

Designing Your Field to be Pest Resistant

There are things you can do even before and at planting to lower the risk of crop loss due to pests.

—When you buy seeds, select varieties which are resistant to plant diseases such as *Fusarium*, anthracnose, and gummy stem blight in watermelons, and anthracnose and powdery mildew for cucumbers and cantaloupes. These diseases are common in the region, especially in fields which have previously been planted with melons or other cucurbits.

—Before planting, destroy wild cucurbits (wild pumpkin, bittermelon, wild luffa) on your farm. These wild plants harbor pests and diseases that can move into your field.

—Use transplants rather than direct seeding. Seeds planted in artificial soil in trays or pots are protected from seed rotting organisms. Poor seed that result in diseased or misshaped seedlings, can be identified early and not used in production. The growing season and period of harvest is shorter when transplants are used; thereby, reducing the time diseases and insects can become established. When grown under fine mesh screening (floating row covers), seedlings are protected from insects and insect transmitted diseases.

—The field application of floating row covers provides an additional insect free period. Experiments at the University of Guam and elsewhere have shown that these are effective at delaying insects and a mosaic virus from attacking the crop until after flowering. Row covers may also speed up the growth of the plant, resulting in earlier harvest dates.

—If you are using plastic mulch, try to use white or silver mulches instead of black. We have found that mulch which reflect sunlight are very effective in keeping aphids and thrips off young plants. Several experiments have shown that highly reflective mulch protect plants from getting mosaic virus vectored by aphids. Even in the absence of insects, plastic mulches may increase yields as much as 30% by warming the soil and possibly preventing nutrient leaching.

Note: If you use a floating row cover, you must remove it when the plants start flowering. Cucurbits are pollinated by bees. The bees must have access to the flowers or you will not get a crop.

Watermelon IPM Pest Survey

Survey methods are designed to find out if you need to spray. A detailed explanation and instructions of how to conduct an Watermelon IPM field survey is described below. In addition, a Watermelon IPM pest survey form is found within this unit.

Yellow Sticky Traps

On islands with melon flies, yellow sticky traps can be used to detect the flies and give you an early warning of their presence. Using traps, eliminates the wait for the appearance of damaged fruits to determine whether or not to spray. You should put out at least five traps: one near each corner of your field and one near the center.

Traps should be fixed to the top of two foot bamboo or wooden stakes driven into the ground between rows. The sticky material used to coat the traps may have to be replaced several times during the growing season. A material call Tack-Trap®, specifically designed for traps, will last most of a growing season if a thick coat is applied. You should remove any melon flies you count on the traps, so you know how many new flies have come into your field since the last sampling date.

Traps are available commercially or you can make your own. To make your own, get some large bright yellow plastic 8 oz drinking cups and coat them with Tack-trap®. If Tack-trap® is not available, you might experiment with breadfruit or jackfruit sap.

Although the main purposes of the yellow sticky traps is to detect melon fly, you will also catch pumpkin beetles, winged aphids, thrips, and whiteflies. Thrips are very small and difficult to see, so you will probably not notice these. You will also catch a great many other flies that are not crop pests. Record your counts of melon flies on the Watermelon IPM Pest Survey Form. This form can be copied as needed. Recording counts for the other insects collected from yellow sticky traps is optional. Sometimes heavier insects such as pumpkin beetles and melon flies slip off the traps, so check the ground underneath each trap.

Plant Inspection

Inspecting your watermelon crop for pests is the most common way of conducting a pest survey. For each pest there is a different method of sampling and a different threshold level to be reached before spraying is recommended. In order to get a representative sample of these pests it is necessary to sample 20 different sampling stations (Fig. 12) that you have pre-selected throughout the field. Once you get used to the sampling routine, it should take about fifteen to twenty minutes to complete a field survey. You should survey your field at least once a week or earlier if you think damage is occurring.

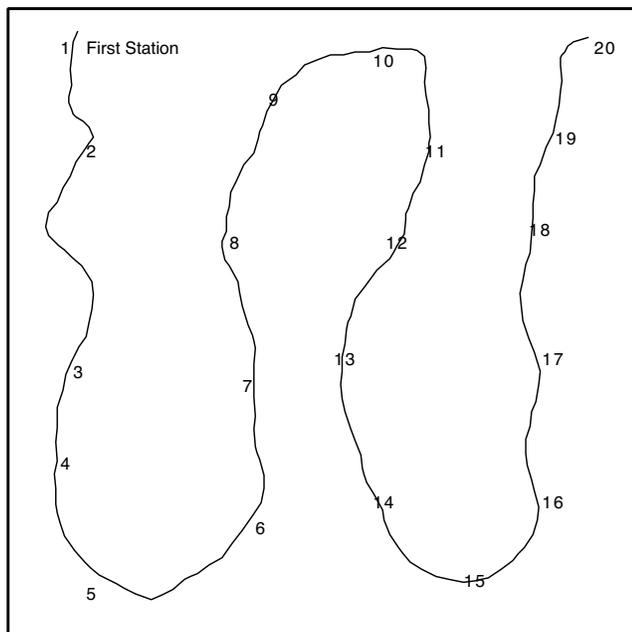


Figure 12. Represents a possible path a grower may have walked while randomly choosing twenty sampling stations.

Survey Form Instructions

Refer to the **Watermelon IPM Pest Survey Form**, at the end of this unit, when reading through the following instructions.

Specific Instructions

Melon fly. If the total number of melon flies collected in one week divided by the number of traps is greater than 2, then you should spray. For specific insecticides that are labeled to control melon flies on watermelon and other cucurbit crops, contact your local extension entomologist.

Leaf-footed bug. It is only necessary to sample once a week in order to determine whether to spray or not. If two or more leaf-footed bugs are found in a 6.1 m (20 ft) of row, then spraying is recommended. For specific insecticides that are labeled to control leaf-footed bugs on watermelon and other cucurbit crops, contact your local extension entomologist.

Sampling Stations

1. **Cross-out a sampling station number** on your Watermelon IPM Pest Survey Form when you arrive at each new sampling station in your field. Remember it is necessary to sample 20 different sampling stations, spread throughout the field, before any management decision can be made.
2. **Record pumpkin beetles** found if your island has pumpkin beetles (Mariana Islands, Yap, Palau, and American Samoa). At each sampling station, look at three adjacent plants and search for yellowish orange beetles. These beetles are quick to fly, so you need to be looking at the plants you approach. Examine the tops of the leaves, then brush the plants and wait a moment. This will cause any beetles that are hiding to fly up. For

each beetle seen on a plant, check off one symbol.

3. **Record aphids and caterpillars** found. At each sampling station, choose a leaf somewhere near the middle of the vine closest to you. Carefully search the underside of the leaf for aphids. If you see six or more wingless aphids on the leaf, mark a symbol in the section for wingless aphids. If you see one aphid with wings, mark a symbol in the section for winged aphids. If you see a caterpillar, mark a symbol in the section for caterpillars.
4. **Record thrips** found on vine tips. At each sampling station, you need to start looking for thrips as soon as vine tips are formed. To do this, pick up the vine tip nearest to your foot and shake it vigorously inside a white plastic cup. If thrips are present, you will see tiny, skinny, yellowish or brown insects running around in the cup. If you see any, check off one symbol. Note: we are not counting individual thrips, just the presence or absence of thrips.
5. **Virus diseases.** Early virus symptoms are difficult to identify and should be confirmed by a specialist. Carry a roll of flagging tape to tie on suspect plants when you do your sampling. This will make it easy for you to locate them again. In addition, you may want to place any suspected leaves into a sealed plastic bag and bring them to your local Cooperative Extension Agent for their confirmation. Refer to the unit on Disease Management for more information.

At the end of your field survey, fill out the other information asked for on the form (date, observer, notes, etc.).

Deciding Whether or Not to Spray

The symbols on the survey form tells you if treatment for a particular pest is recommended. Please note that young plants that have not flowered have different needs for protection than older plants. Thus, you will find different levels triggering recommendations.

If your field contains young plants that have not flowered you will use the square (□) symbol to determine if treatment is recommended. If any of the star (☆) symbols are marked, regardless of plant age, you need to treat for that pest.

The information you gained from the pest survey will help you make an informed decision about when treatment is really needed. At the bottom of the survey form, write down your decision and the reason you decided to treat or why you decided not to treat.

In Summary:**Before flowering, you should spray if one or more of the following conditions occur:**

1. **Melon fly traps:** if the total number of melon flies collected in one week divided by the total number of traps is more than 2.
2. **Leaf-footed bugs:** 2 or more bugs per 6.1 m (20 ft) of row are seen.
3. **Pumpkin beetles:** 6 or more beetles are seen.
4. **Aphids:** 8 out of 20 leaves (one leaf per sampling station) have 6 or more wingless aphids, or winged aphids are found on 2 or more leaves.
5. **Caterpillars:** 7 or more caterpillars in a 20 leaf sample (one leaf per sampling station).
6. **Thrips:** 6 out of 20 vine tips have thrips (one tip per sampling station).

After flowering, you should spray if one or more of the following conditions occur:

1. **Melon fly traps:** More than 2 flies per trap per week when left in the field for one week
2. **Leaf-footed bugs:** 2 or more bugs per 6.1 m (20 ft) of row.
3. **Pumpkin beetles:** 11 or more beetles are seen.
4. **Aphids:** 13 out of 20 leaves (one leaf per sampling station) have 6 or more wingless aphids, or at least one winged aphid is found on 11 of 20 leaves.
5. **Caterpillars:** 7 or more caterpillars in a 20 leaf sample (one leaf per sampling station).
6. **Thrips:** 6 out of 20 vine tips have thrips (one tip per sampling station).

We recommend that you take a blank photocopy of the Watermelon IPM Survey Form into the field every time you survey your crop for pests. Your completed survey form and the treatment used should be kept in a loose leaf notebook as a permanent record of pest levels, treatment decisions, and actions taken.

Please Note: Pesticides are labeled for specific crops. Always read the label to ensure that the pesticide you intend to use is registered for the crop you are planning to spray. For specific product recommendations, contact your local extension entomologist.

Pest Descriptions & General Treatments

Pumpkin Beetle

The pumpkin beetle (*Aulacophora similis*) (Plate 15A) damages plants in two ways. Adults eat leaves and flowers and can kill young plants if beetles are abundant. Adult beetles cut semicircular holes in the leaves (Plate 15B). These odd shaped holes are characteristic signs of damage caused by pumpkin beetles. Pumpkin beetles lay their eggs in the soil around the plant. In 10 to 14 days, the eggs hatch into small larvae (Plate 15C) that burrow into the soil and feed on the roots. If there are many adults

present when plants are young, enough larvae may be produced to kill the plants before the fruit is ripe. Larvae also feed on the underside of fruit lying on the ground. Such feeding scars the skin of the fruit, and in the case of cantaloupe makes holes through the rind that allows diseases to enter (Plate 15D). Because the beetle larvae live underground, the damage they cause cannot be seen until it is too late. Their underground habits also make them difficult to control. For this reason, adults must be monitored and controlled. If adults are controlled while the plants are young, there should be no problems with the larvae.

Pumpkin beetles are found on the Marianas Islands, American Samoa and the Western Caroline Islands (Yap, Palau and some of the western atolls). In the Western Carolines, there are also several other beetles with similar shapes but different colors which attack cucurbits. Their biology and treatment is similar to that of pumpkin beetles. For farmers growing luffa, the beetle *Aulacophora quadrimaculata*, which is orange with black spots, will be commonly observed on the crop.

General treatment: University of Guam researchers have found that pumpkin beetles often congregate at fixed locations within a field. You should note which sections of your field the beetles seem to favor. Experiments have shown that spraying alternate rows is just as effective in controlling beetles as spraying the whole field. Beetles from unsprayed parts of the field will eventually be killed when they land on sprayed plants. If you follow this recommendation, you will use less insecticide and maintain beneficial insects in unsprayed parts of the field. In experiments at the University of Guam, carbaryl (Sevin®) has been showed to be effective against adult beetles. However, it is important to contact your local Cooperative Extension Service for the latest updates on pesticide recommendations.

It is very important to plow down old fields as soon as they are harvested to avoid increasing beetle problems throughout the season. The larvae have a long developmental time (approximately six weeks) and large numbers of adult beetles will emerge from old fields beginning about harvest time and continuing for several weeks thereafter if the roots and fruits are left undisturbed.

Melon Fly

The melon fly (*Bactrocera cucurbitae*) is a medium size fly with a yellow body and black markings on its wings (Plate 16). Adult female melon flies attack both young plants and mature fruits. The female has a pointed abdomen with which she pierces or "stings" the plants to lay her eggs inside. The eggs hatch into maggots. Young plants are sometimes

stung on the stem. Occasionally, a bacterium is introduced into the wound and quickly spreads along the vine, killing that part of the plant. If newly-formed fruits are stung, they are often aborted by the plant. Melon flies will occasionally lay eggs in mature fruits, making them unmarketable due to the maggots that develop. Melon flies are known from the Mariana Islands and from Hawaii, but have so far not reached the Carolines or Samoa.

Hover flies, are sometimes mistaken for melon flies. These medium size flies with a yellow and black body are often found in cucurbit fields. However, these are “good guys” because their young hunt and kill aphids. Hover flies differ from melon flies in that they do not have dark markings on their wings. As their name suggests, they are often seen hovering as they search your field for aphids.

General treatment: Even low numbers of melon flies can cause significant damage to cucumbers and watermelon. Bittermelon is highly favored by melon flies and flies can cause severe damage.

Melon flies are not often seen flying around the field. For this reason, we rely on yellow sticky traps to tell us how many are around (a detailed description regarding sticky traps can be found in this section under Watermelon IPM Pest Survey - Yellow Sticky Traps). On these cups, if 0–2 flies per cup are caught during a week, then 2–6% of young watermelons are likely to have melon fly punctures. If 2–7 flies are caught, then 20–50% of the young fruits will have melon fly punctures.

In Hawaii, melon flies in watermelon are controlled indirectly. Melon flies prefer to spend their resting time on tall plants. Tall plants are planted every 5 or so rows in a watermelon field and sprayed with a mixture of protein hydrolysate (to attract the flies) and malathion. The flies feed on and are killed by the malathion. This treatment keeps flies in Hawaiian watermelon patches at very low levels. In Hawaii, corn can be used as a trap crop. However, in the Marianas the Asian corn borer makes it very difficult to grow corn. Other tall plants such as wild cane windbreaks might be substituted. Unfortunately, trellised cucumbers and bittermelon are too high to be effective trap crops and must be sprayed directly.

Melon Aphid

The melon aphid (*Aphis gossypii*) (Plate 17A) is a small, soft bodied insect that sucks plant sap. They are usually found on the underside of leaves. These insects have a very unusual life cycle. In the tropics, all aphids are female and do not mate. Unlike most insects, which lay eggs, adult female aphids give birth to babies which look like miniature adults. Most aphids spend their whole lives on a single plant in a colony of relatives. However, when colonies get very large or their home plant is under some sort

of stress, adults with wings are produced. These adults will fly off and establish colonies on new host plants. Melon aphids are common throughout the tropical Pacific region and the world.

Very high numbers of aphids may suck enough sap out of a plant to affect its growth. Leaves which are home to large colonies become crinkled (Plate 17B). Lady bugs and hover flies are very effective at feeding on aphids, and will often clean up infestations. However this often happens too late, after significant aphid damage has already occurred on the crop.

Aphids are also a major pest problem because they vector viral diseases, meaning they can move mosaic virus from plant to plant. A watermelon plant will start to show virus symptoms about 2 weeks after being fed upon by an infected aphid. One problem with spraying for aphids is that the insecticides cause those that are not killed instantly to move around more than usual. This creates an additional problem because each time they move and feed, they can transmit mosaic disease to another plant. Treating aphids with insecticide may actually increase problems with mosaic disease if sublethal dosages are used.

One of most interesting relationship that aphids share is with certain ant species. Ants alone can be a problem in a grower’s field independently of aphids, feeding on roots and stems of young seedlings, but there are many times a grower will see both aphid and ant living side by side. A substance called “honeydew” is secreted out of the aphid and the ant feeds upon this substance. Indirectly, ants utilize aphids as a food source and will protect aphids from other insects which may feed directly on the aphid. Eliminating the aphid population will also reduce ant activity in the field.

General treatment: Since winged aphids have the ability to fly into newly planted fields it is advisable that a grower spends time inspecting newly planted fields every couple of days, for winged aphids and early colony establishment. It is very important that aphid colonies are not allowed to get established early in the planting cycle. Aphid control is best if total colony establishment is kept to a minimum. Insecticidal soap usually is not very effective against aphids in the field situation, and may kill lady beetle larvae which are predatory against aphids.

Viruses

Cucurbit viruses are submicroscopic microbes frequently spread by aphids and which cause disease in cucurbits. Plants are usually inoculated with a virus by winged aphids which have recently fed on diseased plants. The virus spreads throughout an

infected plant and in about two weeks the leaves become deformed and mottled (**Plate 6A**). If a plant becomes infected at an early stage, it will be stunted, and fruit production will be poor. Refer to the unit on Management of Plant Pathogens for more information.

General treatment: Unfortunately, there is no cure for virus-infected plants. Once diseased plants are identified, they need to be immediately spot-treated with an insecticide to kill all the insects on them, and then clipped off at the base of the stem the following day. If you simply pull diseased plants and leave them in the field, the virus-infected aphids living on them will simply move onto healthy plants and continue to spread the disease. The best strategy for dealing with virus problems is prevention and delaying initial infection in the field. Here are some tips that can help prevent aphids from carrying virus into your field from adjacent areas. These tips will also help to prevent other pest problems.

1. Use transplants. Seedlings can be protected from aphids carrying virus by growing them under fine mesh netting.
2. Plow old fields under soon after harvest.
3. Remove wild pumpkin, bittermelon, and papaya from your farm. These plants can be a source of the virus and of melon aphids.
4. Use reflective mulch (white or shiny silver). Experiments at the University of Guam and Hawaii have shown that reflective mulch greatly reduces the number of aphids and other pests landing on young plants, reduces virus infection, and increases yield. Contact your extension agent to ask about the availability of reflective mulch.
5. Use floating row covers. In watermelons, cantaloupes, and possibly cucumbers grown on the ground, floating row covers will prevent aphid infestations until the covers are removed at flowering time. Floating row covers also help prevent infestations of other insects.

Melon Thrips

The melon thrips (*Thrips palmi*) (**Plate 18**) is a very small insect that is often found on vine tips and on the leaves of older cucurbit plants. They feed by scraping away the surface of the leaves. Feeding damage by thrips causes the leaves to look silvery and eventually dry up and die. Hot and dry weather conditions seem to favor extremely high thrips populations in many cucurbit crops. Due to their very small size, most growers do not realize they even have a thrips problem until it is too late. Most growers will need extra help determining the presence of thrips in their fields. It is advisable that growers contact their local Cooperative Extension Service for assistance in determining early thrips invasion.

General treatment: If present, thrips are not easy to control with insecticides. Experiments at the University of Guam and Hawaii have shown that using insecticides may sometimes result in increased numbers of thrips compared to untreated controls. Predatory mites and minute pirate bugs, which normally eat thrips, are killed by these insecticides. Because predators of thrips are common in many fields, it is important only to treat fields when thrips numbers exceed threshold damage. Preventative treatments may actually cause an outbreak by killing natural enemies. For current updates on treatment for thrips contact your local cooperative extension agent.

Caterpillars – Larva

In the Marianas, there are three common caterpillars. The cucumber moth caterpillar (*Diaphania indica*) is the most common. Young caterpillars are green with white median stripes and feed on leaves making small holes. When mature, the caterpillar will roll up the edge of the leaf where they feed and pupate. Prior to pupating, they turn brown. The adult moth has pearly white wings, which are edged by a broad brownish-black band. When present in high numbers they may feed on the skin of the fruits. Several parasites attack the larvae and pupae, so they only occasionally reach numbers that require treatment. The green semi-looper (*Chrysodeixis eriosoma*) (**Plate 19A**) is also green with white stripes, but it is larger than the cucumber moth and moves with a looping movement. The cluster caterpillar (*Spodoptera litura*) (**Plate 19B**) is black with small blue and yellow spots along the sides. Green semi-loopers and cluster caterpillars are rarely abundant enough to significantly damage leaves but their feeding does cause scarring of the fruit. Cluster caterpillars and green semi loopers occur throughout Micronesia and Samoa, but cucumber moths have not been definitively identified at all locations.

General treatment: In general, pesticide treatments used to control other pests will also keep the caterpillars in check; therefore, spraying solely for caterpillars is rarely needed. Cucurbits are able to compensate for a certain amount of injury to the leaves, and no yield losses are observed as long as the number of cucumber moths present is less than one per 2 leaves (that is 10 cucumber moths in a 20 leaf sample). If treatment is needed, we suggest that one of the *Bacillus thuringiensis* preparations be used (such as Dipel®). These materials are specific for caterpillars, effective against these pests, and not damaging to natural enemies.

Whitefly

There are several species of whiteflies that infest cucurbits; however, the silverleaf whitefly (*Bemisia argentifolia*) is the most problematic for the Mari-

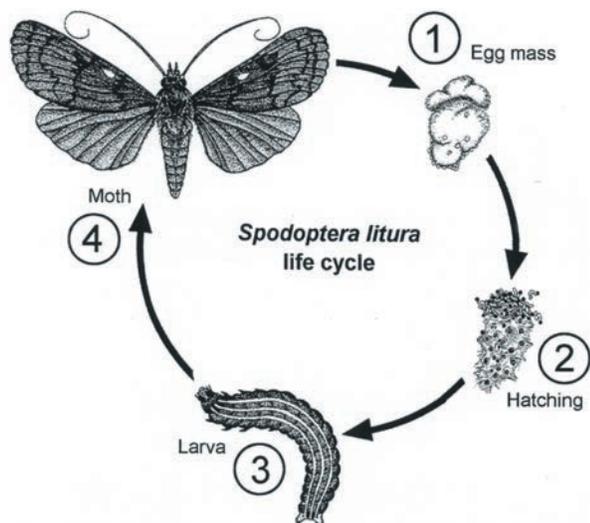


Figure 13. *Spodoptera litura* life cycle.
Courtesy of Land Grant Institutions of the Pacific and ADAP Project.

anas. The adult resembles a tiny white moth (**Plate 20A**), hence the name whitefly. In actuality, it is not related to the moth but instead to the aphid. The immature stages (**Plate 20B**) appear as being covered with a snowy-like substance. They cling tightly to leaves and are very difficult to see without a hand lens. Whiteflies feed by sucking sap from the leaf. When feeding on zucchini, they cause the leaves to turn silver, hence, their name silverleaf whitefly. In comparison to watermelons and cucumbers, cantaloupes and musk melons are the two most sensitive crops to white flies. Moderately high infestations can result in total crop loss.

General treatment: Because this is a new pest, complete IPM recommendations have not yet been developed. In Guam, two parasites of the nymphs are known, and parasites have been introduced to Saipan. When farmers quit spraying on Guam, the whiteflies often become less abundant, suggesting some control by natural enemies. Natural enemies can maintain control as long as they are not killed by pesticidal sprays. Whiteflies show resistance to most of the insecticides registered for use on cucurbit crops. The only sprays that are moderately effective are light horticultural oils such as Sun Spray. For current updates on treatment for whiteflies contact your local cooperative extension agent.

Leafminers

Leafminers (*Liriomyza sativae* and *L. trifolii*) are tiny flies about the size of a pin head. The adult flies are black and yellow. The larvae are yellow maggots which mine between the top and bottom surfaces of leaves (**Plate 21**).

General treatment: We do not recommend treating for leafminers. They are resistant to almost every insecticide known, and can become resistant to new insecticides within a single crop cycle. Plants can also tolerate numerous mines in leaves without yield being affected. The most effective control method is to not interfere with the several species of tiny wasps which kill leafminer larvae and pupae. If unharmed by insecticides, these wasps can maintain excellent control of leafminer populations, and will keep populations low. In the Marianas and Hawaiian Islands, problems with leafminers often indicate that too much pesticide is being used in the crop. The most effective parasitic wasps have been introduced to Hawaii, Guam, Pohnpei and American Samoa. Elsewhere, effective controls agents are lacking and government entomologists should be consulted about biological control possibilities in these areas.

Leaf-Footed Bug

The leaf-footed bug (*Leptoglossus gonagra*) (**Plate 22**) is a fairly large insect which is black with red spots on its underside. They are often referred to as stink bugs. The immature stages are similar but lack wings. Eggs are laid in rows on the stems of plants. These insects have piercing sucking mouthparts and suck juices out of various parts of the plant which may cause deformation of the affected parts. If present in high numbers leaf-footed bugs can kill vine tips and deform the fruit.

General treatment: Leaf-footed bugs are generally kept at very low levels in the Marianas by a tiny wasp which attacks the eggs. Occasionally they may be abundant in bittermelon. The egg parasite has greatly reduced the pest problem on Pohnpei where the leaf-footed bug was extremely common. Island agencies should consider introducing the parasite when the pest densities exceed one bug per 20 feet of row. No impact studies on yield have been made for these bugs. However, sprays are probably not necessary if there is less than one bug per 10 plants. The leaf-footed bug only attacks cucurbit plants grown on a trellis. On islands with moderate rainfall, cucumbers can be grown on the ground. This is not practical on islands with high rainfall due to severe fruit rot problems.

Cucumber Ladybeetle

The cucumber ladybeetle (*Epilachna cucurbitae*) only occurs in the South Pacific region, i.e. American Samoa. It does not occur in Micronesia or Hawaii. The larvae are yellowish and very spiny. Adults are a dull brownish orange with many small black spots. Both adults and larvae feed by scraping the undersides of the leaves, leaving distinctive marks.

General treatment: These ladybeetles should not be confused with the beneficial species which eat aphids. The beneficial species are red or pink

with few large black spots, and their larvae are black with pink or red spots. A pupal parasite of the cucumber ladybeetle was recently introduced into American Samoa. Parasitized pupae can be recognized in the field because they are much darker than healthy pupae. It is hoped that this biocontrol agent will maintain numbers of cucumber ladybeetles below treatment thresholds. However, if the pattern seen elsewhere is followed, occasional outbreaks of the pest may still occur. No data exists on the level of damage cucumbers can tolerate without causing yield loss, but it seems likely that they can tolerate at least as much damage as caused by melon worms. Therefore no control is recommended unless the number of leaves with larvae or adults exceeds 5 out of 20 leaves.

Fleahopper

The black garden fleahopper, *Halticus tibialis* Reuter, is common throughout the region. It is usually a minor cucurbit pest and a small amount of damage should be tolerated by producers. The adult fleahopper is winged, black, about 2 mm long, and has characteristic orange lines on the forewings. The eggs are inserted in leaf tissues. The life cycle is completed in six weeks. Both nymphs and adults of the fleahopper feed by sucking sap from the leaves. Feeding and toxin from its saliva cause white lesions at the feeding sites. White dots or specks on the upper surface of leaves due to feeding damage and black dots of excreta on the leaf surface are characteristic evidence for the presence of this pest. The hind legs are large and strong and help the insect in jumping. If present in a field, any disturbance of the leaves will set the insect hopping at which time they are easily spotted.

General Treatment: The black garden fleahopper will always be present in cucurbit crops because it commonly feeds on weeds (morning-glory and Bdens) and on numerous crops (eggplant, cabbage, cucurbits, beans, sweet potato, okra, tomato, and corn). Severely damaged cucurbit seedlings should be uprooted and replanted with healthy seedlings. Weeds adjacent to your cucurbit fields should be inspected for fleahopper damage and signs of infestation and removed if present. If fleahopper numbers become a problem, chemical sprays can be used. The crop should be sprayed in the morning when fleahoppers are less active on the leaves.

Mites

The broad mite (*Polyphagotarsonemus latus*), spider mite (*Tetranychus truncatus*), and flat mite (*Brevipalpus* spp.) can be major pests of cucurbits during some seasons where weather is very hot and dry. Although related to insects, mites along with spiders, are actually arachnids and have 8 legs. Mites are

very small (0.3–0.5 mm) and require a hand lens or microscope to observe their presence. Mites penetrate plant tissues by using their chelicerae (mouthparts) to withdraw fluids from leaf cells. Feeding results in the destruction of chlorophyll resulting in pale, stippled leaves. Leaves which are infested with broad mites normally curl up and may cause bud and flower drop under severe infestations. The fruits that survive these severe infestations will have a corklike surface. Some cucumber varieties are very sensitive to this pest.

General treatment: The use of approved miticides can result in effective control measures. On Guam there was an introduced predatory mite (*Metaseiulus* sp.) that has shown to be effective against the broad mite. There are also some of the indigenous predatory mites that can be effective in reducing plant feeding mite populations. Because predators of mites are common in many fields, it is important only to treat fields when mite numbers exceed threshold damage. Preventative treatments may actually cause an outbreak by killing natural enemies.

Ants

There are many different kinds of ant with various colony or nesting preferences: buildings, rotten wood, soil, pavement, lawns, and gardens. Ants are social insects that have three castes (queens, males, and workers) and live in colonies or nests. The workers are the most commonly encountered in the garden as they forage for food and water. When desirable items are found many species will recruit ants from the colony to help gather the food and return it to the colony.

Some ants share an interesting relationship with aphids. Ants alone can be a problem in a grower's field independently of aphids, feeding on roots and stems of young seedlings, but there are many times a grower will see both aphid and ant living side by side. A substance called "honeydew" is secreted out of the aphid and the ant feeds upon this substance. Ants utilize aphids as a food source and will protect them from other insects which may feed directly on the aphid. Eliminating the aphid population will also reduce ant activity in the field.

For the Guam farmer, fire ants (*Solenopsis geminata* (F.)) can be a nuisance because they can bite and cause damage to plants. They frequently build their nests under drip irrigation lines. Ants may feed on germinating seeds, stems of young plants and blossoms. Damage to seedlings is usually greatest during hot dry days. Besides aphids, ants also contribute to damage caused by mealy bugs and scale insects because they are often involved with distribution, establishment and protection of these insects.

Integrated Pest Management (IPM) Watermelon Pest Survey Form

Field: _____ Date: _____ Time: _____ Observer: _____

Yellow Stick Trap Sampling

<p>Melon Flies: Number of melon flies: <input style="width: 30px; height: 20px;" type="text"/></p> <p><i>Spray if the total number of melon flies collected in one week divided by the total number of traps is more than 2.</i></p>	<p>Number of Traps: <input style="width: 30px; height: 20px;" type="text"/></p> <p style="text-align: center;">Spray if $\frac{\square}{\triangle} > 2$</p>
<p>Notes (Pests other than melon fly associated with traps):</p> 	

Plant Inspection

In order to get a representative sample of these pests it is necessary to sample **20** different sampling stations that you have pre-selected throughout the field.

<p>Leaf-footed bugs: Number of bugs found in 6.1 m (20 ft) row: <input style="width: 30px; height: 20px;" type="text"/> <i>If 2 or more leaf-footed bugs are found then you should spray.</i></p>
<p>SAMPLING STATIONS: Cross out a number for each station sampled.</p> <p style="text-align: center;">1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20</p>
<p>PUMPKIN BEETLES: Mark one shape for each beetle seen on 3 adjacent plants.</p> <p style="text-align: center;"> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="checkbox"/> </p>
<p>WINGLESS APHIDS: Mark one shape if you see 6 or more wingless aphids on a sample leaf.</p> <p style="text-align: center;"> <input type="radio"/> <input type="checkbox"/> </p>
<p>WINGED APHIDS: Mark one shape if you see 1 or more winged aphids or more on a sample leaf.</p> <p style="text-align: center;"> <input type="radio"/> <input type="radio"/> <input type="checkbox"/> </p>
<p>CATERPILLARS: Mark one shape for each caterpillar seen on a sample leaf.</p> <p style="text-align: center;"> <input type="radio"/> </p>
<p>THRIPS: Mark one shape if you shake any thrips from a vine tip.</p> <p style="text-align: center;"> <input type="radio"/> </p>

Treatment not necessary Treatment necessary only before flowering Treatment necessary

Observations (Crop growth stage / Beneficial insects seen / Problems):

Treatment Recommendations (Chemical / Rate / Date / Reason for application):

Management of Animal Pests

Manuel Duguies, Extension Veterinarian

Pests other than insects and mites can cause serious damage to cucurbits. These pests include slugs, snails, rats, mice, chickens, birds, pigs and deer. The following control measures may reduce the damage caused by these animals. The proper use of baits, traps, barriers, dogs and guns will be discussed. The cost and effectiveness may vary due to the size of the field, its location and the pest population in the area.

Snails and Slugs

Snails and slugs (**Plate 23**) are mollusks and are related to clams, oysters, and other shellfish. Snails have visible external shells. Slugs have internal shells and a fleshy exterior. They must stay moist at all times which is why they hide in damp places and avoid the sun and dry places. They are most active during the night and early morning. They eat young shoots and succulent plant parts. They secrete a mucoid substance on their trails which leaves an objectionable mark on plant leaves.

Desiccants, poison baits and cultural practices are useful methods to control snails and slugs. A desiccant such as salt can be sprinkled or poured as a solution on snails and slugs to kill them. Common molluscicides are commercially available in the form of poisonous baits. These baits are broadcast around the area to be protected and in areas where snails and slugs may be hiding. Baits are most effective when applied on a damp night followed by a dry day. Avoid irrigation for at least 12 hours after treatment.

The removal of any coverings near the field that may provide a shelter for these pests is also helpful. Be sure that snails and slugs are not present when using a mulch for weed control as these may serve as a shelters for them. Remove weeds and grass within 4.6 m (15 ft) of irrigation drip line. This will reduce the chance that snails and slugs will enter your field under the cover of the drip line.

Rats and Mice

Rats and mice can be a serious problem in the field. They nibble on fruits and leaves which can lead to decay and disease. Keeping weeds mowed and the immediate area free of garbage and trash will reduce the likelihood that mice and rats will become a problem. If a problem does arise, a control program must be started before the next cucurbit crop is planted and then maintained until the harvest season is over.

Poison baits, traps and cultural practices can be used to control rats and mice. Rodenticides come in the form of poison baits, of which there are two kinds. A single treatment of a non-anticoagulant bait can kill rats and mice while anticoagulant baits require several feedings by the rodent. Different carriers are used to attract rats versus mice. Poison baits should be placed directly in or near burrows. Different carriers are used to attract rats versus mice. To prevent accidental poisoning, signs should be posted as to their presence and location. Pets should be kept on a leash or fenced away from traps and poison. Fields should be plowed or burned, if permitted, after the last harvest so that food will not be available for rats and mice to eat. Plowing also destroys the tunnels and burrows in the field made by these pests.

Birds and Chickens

The bird population on Guam is so low that hardly any damage is caused by them. Cucurbit fields near residential areas, however may encounter problems with chickens. Chickens like to scratch on newly-tilled soil, eat seeds, eat fruits and damage seedlings. In southern Guam, birds occasionally cause damage to watermelon by picking at immature fruit (**Plate 24**). Birds can also be controlled by providing a barrier or scaring them away. To control damage from your neighbor's chickens, ask that they be caged during the planting/growing season. Installing a net fence and placing guard dogs around the area will also help. Scarecrows with noise and/or guard dogs will help to scare birds away. Placing fruits under a frame with netting will act as a barrier to their feeding.

Wild Pigs and Deer

Wild pigs are possibly the most destructive of all large animals on Guam. They damage crops by eating the fruits of watermelon, cantaloupe and cucumber and by uprooting plants. Wild pigs cause the greatest damage at harvest. Deer eat only the growing tips of plants which usually causes little yield loss once the plants are growing vigorously. Clearing around the perimeter of the field will reduce the chance of this problem because pigs and deer usually do not come into open areas. The footprints of pigs and deer are hard to distinguish because they are both split-hoofed. However, pigs are shorter and they drag their feet forward while walking or stepping, thereby making a longer, less distinct print.

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Barriers, hunting, and repelling are the most common control practices. A strong fence around a field is very effective. A hog wire (chain-linked fence) around the perimeter will prevent animals from entering the field. Be sure the bottom wire is close to the ground to prevent animals from crawling underneath. Fence height should be between 2.1–2.4 m (7–8 ft) for deer and at least 1.2–1.5 m (4–5 ft) for pigs. Shorter fences can have strands of barbed wire not more than 4 inches apart to extend the height of the fence. Fences may be expensive, but provide the most effective control against vertebrate pests. Electric fences are also recommended; they cost less to set up and are easier to install than a regular fence. They have some disadvantages, such as human safety, shorting of wires, high long-term cost, and dependence on a power source. Electric fences should always have a posted warning sign. Dogs can be strategically posted in corners or points where pigs and deer are likely to enter the field. Dogs can be put on a long leash or connected to a long line to allow them to run from one end of the field to the other. Barking will frighten pigs away or at least signal the farmer of something unusual in the field. However, there are reports that posting dogs becomes ineffective as over time pigs learn ways to outmaneuver the dogs. It is unlawful to use dogs to hunt, catch or kill wild pigs and deer. Use of scarecrows with an accompanying sound or noise barrage can also be used.

Farmers may not hunt or trap wild pigs and deer on their land without a permit from the Guam Department of Agriculture. Permits are issued only after inspection. Report any damage to your cucurbit crop to the Department of Agriculture as soon as possible.

Theft and Vandalism

There have been police reports of thefts of fruit and vandalism of cucurbit fields. Pickup trucks or possibly all terrain vehicles are driven into the fields with the intention to destroy the crop or to steal a truck load.

Loss from theft and vandalism can be reduced by reducing accessibility and improving visibility. Inform neighbors and be on the look-out for suspicious activity. Make fields inaccessible by constructing fences and piling up dirt and boulders around the field. Avoid too many entries or exits and provide strong gates for each entry/exit. Clear away brush and install night lights so that the area can be easily monitored. Guard dogs also serve to deter intruders and their barking also serve to alert the owner. Posting signs such as Do Not Enter, No Trespassing and Private Property can also be a deterrent to potential vandals.

Weed Management

Mari Marutani, Horticulturist

James McConnell, Ornamental Horticulturist

All plants are in some way useful but some plants become undesirable and grow out of place. These plants are defined as weeds. Weeds in a farm compete with crops for nutrients, light, and water resulting in losses in the crops' yield and quality. The general characteristics of weeds are

1. They are very competitive and persistent.
2. They are possible alternate hosts for insect pests and diseases.
3. They may interfere with farm operations.

Weeds are often more competitive and persistent than cultivated crops. They often survive even under unfavorable conditions. They possess very effective mechanisms for adapting to the environment and reproduce very effectively. Seed production of weeds is usually prolific. Weed seeds can be disseminated by becoming mixed with crop seeds, by rain or irrigation water, by wind, and by man or animals. Many weeds also reproduce by forming vegetative organs such as rhizomes, tubers, corms, and runners. The seeds and the vegetative organs can become dormant if environmental conditions are not favorable for the plant to development as a weed.

Weed occurrence and severity on Guam depends on the amount of rainfall, wind, physical and chemical properties of soils, and biological factors at the farming site. Important soil factors include moisture content, pH, soil temperature, and availability of soil nutrients. Biological factors include man, animals, other plants, insects, and soil organisms. Man and animals are often responsible for seed dissemination while other plants, insects and soil organisms are competitors for development of a weed and natural enemies for a weed.

Classification of Weeds

On Guam, most weeds are perennials, meaning they are able to live almost indefinitely. Because of Guam's warm climate, many plants continue to survive after a cycle of seed production. Common weeds found in Guam's cultivated fields can be divided into three major groups according to their plant morphology and growth habits. The first group includes plants with broadleaves. Most

broadleaves are dicotyledons (plants with two seed leaves) but some are monocotyledons (plants with one seed leaf). The broadleaf-weeds are further divided into two groups, vines or not vines. Recently vines are becoming more prevalent on Guam. Economic damage by viny weeds can be great, since they are capable of covering the entire canopy of a vegetable crop. Vines use the crops for support, which physically interferes with the crop's development.

Plants in the second group includes species of grasses and sedges with narrow leaves. They are monocotyledons. Grasses and sedges have well-developed fibrous root systems which have advantages in Guam soils. They are quite efficient in the absorption of nutrients in harsh soil conditions. Grasses produce numerous seeds and they also often reproduce vegetatively by stolons and runners. Purple nutsedge (*Cyperus rotundus* L.) in the sedge group is considered the worst weed in some tropical regions. Purple nutsedge can be easily reproduced by tubers and tuberlets and the persistence of these root structures make them permanent residents in a field. Once a field is infested with purple nutsedge, it is almost impossible to eradicate this weed completely from the field.

In the third category, there are parasitic plants which fuse with the stems and leaves of vegetable crops in order to rob them of nutrients and water. One important plant species in this category on Guam is dodder (*Cuscuta campestris* Yuncker). More information on dodder can be found in the **Disease Management** unit of this guide.

Table 12 summarizes a list of common weeds found in cultivated farms on Guam. This classification system will help to identify weeds and to find their control methods.

In cucurbit fields, some weeds have a greater effect on crop production than competition for space due to their ability to serve as a reservoir for plant diseases, insects, mites, and nematodes. Wild bittermelon (*Momordica charantia* L.), as an example, is a host of **PRSV-W** and **ZYMV** which are two of the major virus diseases on Guam.

Weed Control

A successful weed control program for a farm on Guam can be established by following AVRDC (Asian Vegetable Research and Development Center) general guidelines.

1. The aim of a successful weed control program is not weed eradication but to reduce its population to a level that allows for an optimum crop yield.
2. Weed control should be started early in the growing period of a vegetable crop. This allows the crop to effectively compete for nutrient and water resources.
3. Weeds should be controlled before they flower to prevent seed production.
4. Prevent the introduction of weed seeds by using planting materials and soil amendments free of weed seeds; keep the surrounding areas weed-free and by cleaning implements before moving from one field to another.
5. Combine the different weed control methods before, during, and after growing crops to maximize net outcome. Use both short and long term integrated weed control management strategies.

Table 12. Some common weeds in farms on Guam.

Scientific Name	Common Name	Family Name
Broadleaves		
Viny weeds		
<i>Ipomoea indica</i> (Burm.) Merr.	Blue morning glory	Convolvulaceae
<i>Passiflora foetida</i> L.	Wild passion fruit	Passifloraceae
<i>Momordica Charantia</i> L. (Plate 25)	Wild bittermelon	Cucurbitaceae
Non-viny weeds		
<i>Acalypha indica</i> L. var. <i>indica</i>	Acalypha	Euphorbiaceae
<i>Amaranthus spinosus</i> L.	Kulites; Klutes; Spiny amaranthus	Amaranthaceae
<i>Bidens alba</i> (L.) DC (Biden) (Figure 14)	Beggar's tick; Guam daisy	Asteraceae (Compositae)
<i>Boerhavia erecta</i> L.	Dafao	Nyctaginaceae
<i>Cleome viscosa</i> L.	Monggos-paluma	Capparidaceae
<i>Commelina benghalensis</i> L.		Commelinaceae
<i>Conyza canadensis</i> (L.) Cronq.		Asteraceae (Compositae)
<i>Corchorus aestuans</i> L.	Bilimbines chaka; Tuban chaka	Tiliaceae
<i>Euphorbia heterophylla</i> L. (Plate 26)		Euphorbiaceae
<i>Euphorbia hirta</i> L.	Golondrina	Euphorbiaceae
<i>Euphorbia cyathophora</i> Murr.	Dwarf poinsettia	Euphorbiaceae
<i>Mimosa pudica</i> L.	Sleeping plant	Fabaceae (Leguminosae)
<i>Portulaca oleracea</i> L.	Pigweed; purslane	Portulacaceae
<i>Physalis angulata</i> L.	Tomato chaka	Solanaceae
<i>Stachytarpheta jamaicensis</i> (L.) Vahl		Verbenaceae
Narrow leaves		
Grasses (Figure 15)		
<i>Cenchrus echinatus</i> L.	Sandbur	Poaceae (Gramineae)
<i>Dactyloctenium aegyptium</i> (L.) Willd	Crowfoot grass	Poaceae (Gramineae)
<i>Digitaria sanguinalis</i> (L.) Scop.	Large crabgrass; hairy crabgrass	Poaceae (Gramineae)
<i>Digitaria violascens</i> Link	Small crabgrass; smooth crabgrass	Poaceae (Gramineae)
<i>Eleusine indica</i> (L.) Gaertn. (Figure 16)	Goose grass	Poaceae (Gramineae)
<i>Paspalum conjugatum</i> Berg. (Plate 27)	Sour grass; T-grass	Poaceae (Gramineae)
Sedges		
<i>Cyperus rotundus</i> L. (Plate 28)	Purple nutsedge	Cyperaceae
Parasitic weeds		
<i>Cuscuta campestris</i> Yuncker (Plate 29)	Dodder	Convolvulaceae

Physical and Mechanical Control

1. Hand pulling (roguing)—effective, but time-consuming. Use of tools can make this method faster and more effective. Hand weeding is sometimes necessary, especially removing weeds within the rows of the crop.
2. Cultivation—Use of implements which disturb the root system or physically damage the weeds. Most are commonly tractor-drawn.
3. Mulching—Effective for controlling many weeds. A barrier of organic or synthetic material blocks light from soil greatly reducing the germination of seeds and the development of weed seedlings. Mulches also help conserve moisture for the main crops.

Cultural Control

1. Use of competitive vegetable species or cultivars
2. Increased planting densities
3. Thorough land preparation
4. Multiple cropping

Chemical Control

Use of herbicides. There are selective herbicides that kill some plants while not harming others. This method requires less labor than rouging. Further information on chemical weed control methods are discussed in the next section.

Chemical Weed Control

Several types of herbicides (weed killing chemicals) are available. Each herbicide has specific usage and handling regulation.

Contact Herbicides

Contact herbicides kill plant parts which come into contact with the toxic chemical. Usually the effect of these chemicals is immediate. There is little or no movement of these chemicals through the plant. Contact herbicides are rarely selective, meaning that they will kill all plants. The plant tissues exposed to the chemical usually die quickly. Parts of the plant not exposed to the chemical are not damaged and can initiate new growth.

Growth Regulators

Growth regulators are chemicals that affect growth or metabolic processes in the plant. These herbicides are systemic and move through the plant making them effective in killing the whole plant. The chemicals may be absorbed by the roots translocated to the leaves through the xylem (water-moving tissues) or from the above-ground plant parts to the roots through the phloem (food-moving tissues). The plant's response to the chemicals may be delayed with the full effect not occurring for a week or more after treatment. Some of these chemicals, once mixed, have a short effective life with no residual properties.

Growth regulator herbicides which were developed for foliar application may become inactive as soon as they come into contact with the soil.

The rate of application greatly affects the effectiveness of growth regulators. Certain plants may be tolerant of low levels of these chemicals (grasses, for example). Because of this, growth regulator herbicides can often be applied to selectively kill some plants and not others by adjusting the rate of application. However, there are other considerations when selecting an application rate. If the rate of application is too high, the chemical may kill the tissue quickly before it is translocated, making the application less effective. Repeated low application rates may be the most effective. These chemicals are also affected by timing of application. Generally they are not as effective during midday.

Preemergence Herbicides

Preemergence herbicides are usually applied to the soil surface. Water is used to leach the chemical into the upper soil layer where it is absorbed by soil colloids. These herbicides are designed to remain near the soil surface where they are effective against germinating seedlings while not damaging the root systems of established plants. The extent of leaching is affected by the amount of rain, the solubility of the herbicide in water, and the absorption capacity of the soil colloids.

Soil Sterilants

These are chemicals applied to the soil which non-selectively kill living organisms. They are generally applied during field preparation and are not used after the field is planted.

Types of Herbicide Formulations

The major types of herbicide formulations are emulsions, wettable powders, and granules. An emulsion is one liquid dispersed in another liquid, each maintaining its original identity. Without agitation, the liquids may separate. Once thoroughly mixed, little agitation is required. Oil-soluble herbicides are often made for mixing with water as an emulsion. Emulsions often appear milky and are easy to spray.

A wettable powder is made to be applied as a suspension. A suspension consists of finely divided solid particles dispersed in a liquid. Some herbicides are nearly insoluble in both water and oil-like substances. These are usually finely ground to allow them to disperse in a liquid for a period of time. The smaller the particles, the slower the rate of separation. Most wettable powders still require agitation to prevent the settling of the solid particles. Higher density liquids, such as oils, also slow down the rate of separation.

Granules are applied in a dry form. They are generally mixed with carriers such as sand, clay or finely ground plant parts. The advantage to granules is that water and spray equipment is not needed. Granules are bulky and are difficult to uniformly apply.

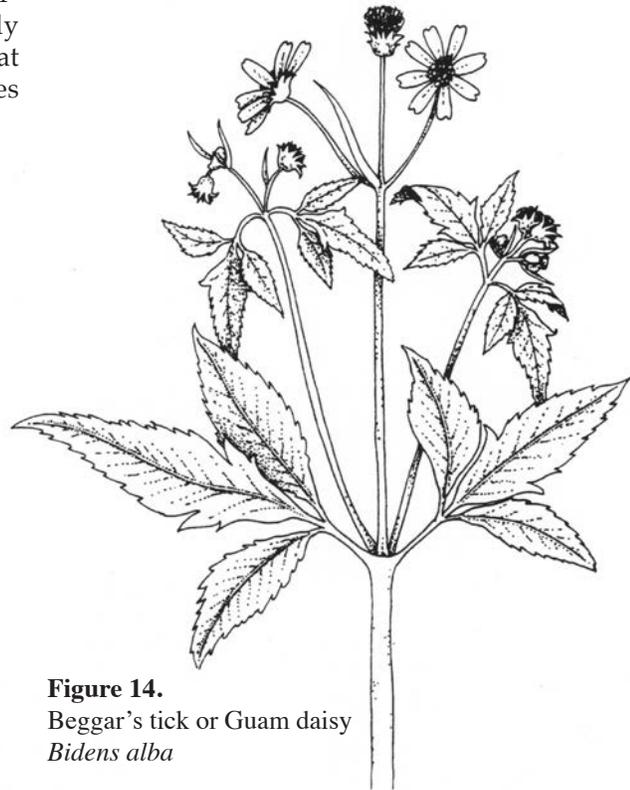


Figure 14.
Beggar's tick or Guam daisy
Bidens alba

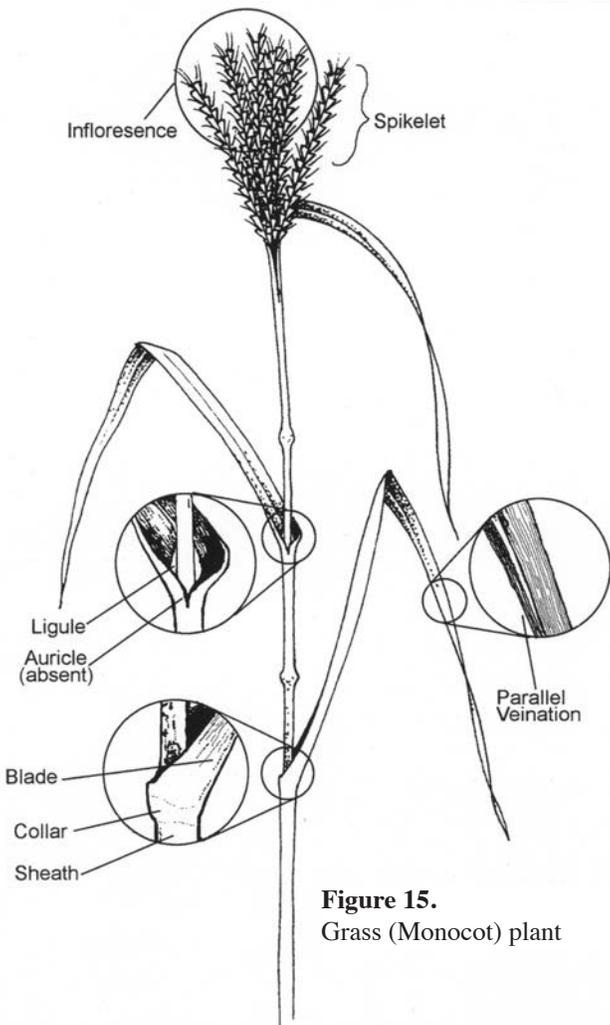


Figure 15.
Grass (Monocot) plant

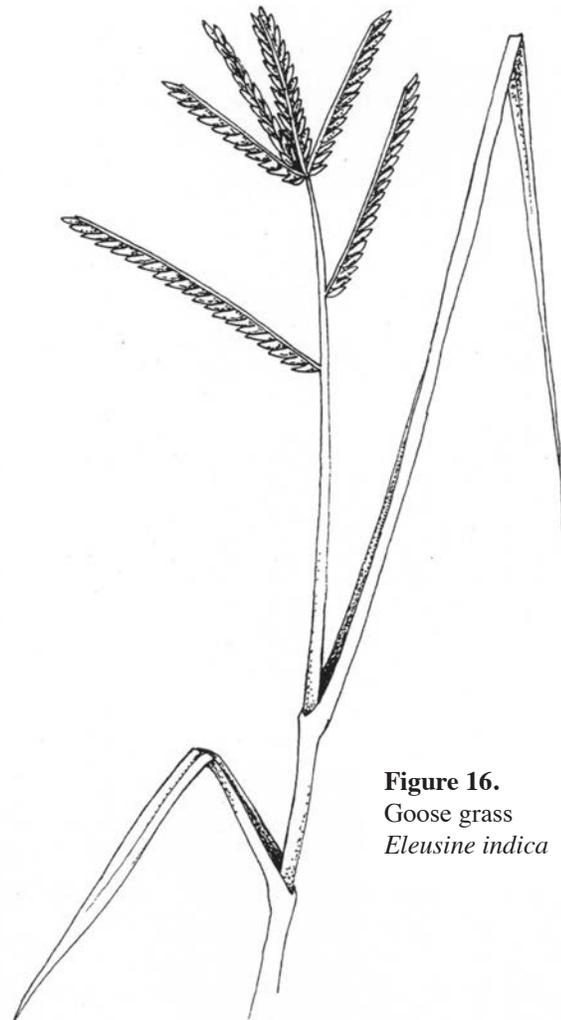


Figure 16.
Goose grass
Eleusine indica

Pesticide Safety

Lee Yudin, Extension Entomologist

Victor Artero, Extension Agricultural Economist

Pesticides are chemical substances used to kill or greatly reduce pests. There are particular classes of pesticides that are specifically used to control different types of pests. For example, Insecticides are used to control insects; Herbicides are used to eliminate weeds; Fungicides are used to prevent or control fungal pathogens; Rodenticides to kill mice and rats; and Molluscicides are used to kill snails and slugs.

Pesticide Poisoning

Pesticides can enter the body in four major ways: oral exposure (when you swallow a pesticide); inhalation exposure (when you breathe in a pesticide); ocular exposure (when you get a pesticide in your eyes); and dermal exposure (when you get a pesticide into the pores of your skin).

Pesticide poisoning most commonly occur in children under five years of age. A simple rule that will help reduce the risk of the number of pesticide poisonings is to **Keep All Pesticides Locked Up**.

Pesticide Safety Tips

- **Identify the pest problem.** If in doubt seek professional assistance for proper identification and control measures. Use the proper pesticide to do the job.
- **Follow label instructions carefully.** The label is meant for your safety. It provides information on protective clothing and equipment, first aid treatment, environmental hazards, general and specific use directions, and other vital information.
- **Restricted-Use** Pesticides are to be applied only by **certified applicators** or those individuals under their direct supervision. The pesticide label states whether or not a pesticide is for restricted use. Read the pesticide label.
- **Wear proper personal protective equipment** when mixing, handling, or applying pesticides.
- **Never** mix, handle, or apply any pesticide **by yourself**. Make sure you have a partner around in case an accident occurs.
- **Never use kitchen utensils** for pesticide measurements or stirring and reuse them for food again.
- **Mix only the amount needed** to complete the job. Storing mixed pesticides over a period of 24 hours is not recommended. Do not exceed the recommended rate.
- **Never smoke** while mixing, handling, or applying pesticides.
- **Never spray** outdoors on a **windy day**.
- **Keep children and pets away** from pesticides and areas that have been treated until it is safe to enter. See the label for specific reentry periods.
- When a pesticide comes in contact with your skin, hair, or clothing, **remove contaminated clothing and cleanse skin and hair with soap and water**.
- When a pesticide comes in contact with your eye, **immediately but gently wash out the eye** with cold water for 15 minutes or more. See a doctor if necessary.
- **Never mix clothing** that you have worn when either mixing, handling, or applying pesticides with family laundry. Always wash these clothing separately.
- After any pesticide use, it is important to **wash your hands and face** before eating, drinking, or smoking.
- Keep pesticide **equipment in proper working order** by cleaning equipment after each use. **Store equipment in a locked shed or building** separate from pesticides.
- **Never store pesticides** near food, feed, seed, fertilizers, or animals.
- **Never transfer a pesticide to a container**, such as a soft drink bottle, that would attract children.
- **Store pesticides properly** by placing in a cool, dry, well ventilated building, under lock and key, and in the original container with proper labels. The storage area should be supplied with detergent, hand cleaner, water, absorbent material (charcoal, sawdust, paper) to soak up any spills, and a fire extinguisher rated for chemical fires.

- **Dispose of empty pesticide containers safely.** Always rinse out empty containers (metal, plastic, or glass) three times. Pesticide labels give proper disposal directions. “Home Use” pesticide containers may be safely disposed of by wrapping them individually with newspaper, tying them securely, and placing them in a covered trash can. For pesticide spills or further questions about pesticide disposal you can contact the Guam Environmental Protection Agency.
- **In case of pesticide poisoning,** refer to the pesticide label immediately for first aid treatment. Then call or go to the doctor or hospital for immediate care. Take the label with you to show to your doctor. Emergency numbers (doctor, hospital, poison center, or 911) should always be clearly posted so anyone can readily call for help.

Categories of Pesticide Toxicity

Here are three key words to watch for on pesticide labels:

DANGER —Highly Toxic. When accompanied with a Skull and Crossbones symbol the toxicity hazard is greatly increased.

WARNING—Moderately Toxic.

CAUTION—Slightly Toxic.

These signal words reflect the immediate hazard of pesticide exposure only. They do not reflect the hazards of long term exposure to small amounts of pesticides that can accumulate in the body over time.

Home gardeners who wish to apply “least toxic” pesticides should look for those products that contain the signal word **CAUTION**. However, the misuse of any pesticide can cause serious health hazards. Read the label for the proper clothing and protective equipment (chemical resistant gloves, boots, eye wear, and respirator) when using any over the counter pesticide.

Pesticide Applicator Training (PAT)

The Guam Cooperative Extension provides educational material and training for those individuals who are required by law to obtain either Private or Commercial certification when mixing, handling, or applying Restricted-Use pesticides. For further information please contact UOG Cooperative Extension Service or Guam Environmental Protection Agency.

Postharvest Handling

Frank Cruz, Extension Horticulturist

L. Robert Barber, Extension Economist

The goal in postharvest handling is to reduce losses after harvest. The quality of all produce at harvest is determined by management practices as well as biological and environmental factors during production. Postharvest practices can only delay the deterioration of quality; they can never improve the quality after harvest!

Losses in quality and quantity of cucurbit fruit occur between the time of harvest and consumption. Shrinkage and external damage are the primary causes of losses in quantity. The deterioration of quality may be due to changes in appearance, nutritive value, flavor, texture, or composition.

The structure, make up and physiology of cucurbit products vary considerably. The specific requirements for maximum postharvest life of leaves, stems, flowers, seeds and fruits, both mature and immature, vary for each product. Maximizing shelf life and quality requires the quick removal of field heat, management of relative humidity and temperature, control of atmospheric conditions, and proper handling.

Quality and Maturity

Quality is defined as the degree of excellence, or the features that make something desirable. The components that determine the quality of cucurbit products are appearance, texture, flavor, nutritive value, safety, and maturity. Appearance includes the size, shape, color, uniformity, gloss, and defects. Texture refers to traits such as firmness and crispness. Flavor relates to the sweetness, sourness, bitterness, and aroma of products. Nutritive value is measured by the protein, carbohydrate, and vitamin content of the products to be consumed. The safety, or presence of natural toxins and contaminants in or on produce, is of concern to consumers and producers as well as to marketers. Which safety and quality component is most important depends on one's perspective. To the producer, appearance and texture as they relate to ease of handling may be most important. Appearance may be more important to one who markets produce, while to the consumer the appearance on the shelf determines whether to purchase or not, but flavor and texture determine if a repeated purchase will be made.

The stage of maturity at which cucurbit products are harvested varies depending on their use and intended markets. Cucurbit products are harvested at either physiological maturity or commercial maturity. Physiological maturity is the stage when

a fruit or vegetable is able to ripen naturally after harvest. That stage does not change for each fruit or vegetable type; for example, cantaloupes are physiologically mature at half slip and honeydews are physiologically mature when the rind becomes waxy. Commercial maturity is the stage when a particular plant part has the characteristics desired by consumers.

Signs that are used to define the various stages of maturity and quality are referred to as indices. Maturity indices incorporate both internal and external characteristics of horticultural products. External characteristics include size, color, luster, rib development, and the presence or condition of various plant structures. Some internal characteristics used to determine the maturity of cucurbits are the sugar content ($^{\circ}$ Brix), firmness, and the accumulation of liquids. To ensure that crops are harvested at the optimum stage, maturity indices are used in conjunction with a time element such as days after planting, days after flowering, or days after fruit set.

Characteristics that are used to distinguish different degrees of quality are referred to as quality indices. **Table 13** lists the major indices and the average days from planting to first harvest for some cucurbits grown in the tropics. Some indices such as sugar content are used as both quality indices and maturity indices. Quality indices such as size and appearance are often a reflection of consumer preference.

Handling to Avoid Damage

Proper handling is the most important key to maintaining produce quality after harvest. Symptoms of damage caused by improper handling while harvesting, sorting, packing, storage, and transport may not become obvious until the produce has reached the retail store or the consumer. Handle all produce carefully to avoid physical damage, disease, and physiological deterioration.

Physical damage such as cuts, scratches and bruises not only reduce the appeal and value of produce, they also provide sites for the invasion of disease causing organisms and the rapid loss of moisture. Damaged fruits and vegetables produce more ethylene and release more carbon dioxide, both of which speed up the deterioration process. Rough handling and improper packing can cause obvious surface bruises or internal bruises which are difficult or impossible to detect while sorting and grading. Bruised and otherwise damaged produce are more susceptible to rotting than undamaged produce.

Disease management starts in the field while crops are being grown and continues through harvesting, handling and marketing. Gentle handling and sanitation are critical to avoiding losses due to disease. Combining mishandled produce with decaying material from the field is an excellent way to start postharvest rots. All harvesting equipment such as baskets and buckets should be cleaned and disinfected regularly. There are no postharvest treatments or chemicals that can overcome low quality due to poor production practices or improper handling.

Mishandling of produce is not limited to rough handling. Exposing produce to undesirable conditions can result in physiological disorders, which quickly deteriorates quality. Produce exposed to direct sunlight or excessively high temperatures, such as those experienced when produce is covered with a tarp and left in the sun, can easily be damaged. Surface burning or scalding, bleaching, softening and uneven ripening

are symptoms of exposure to high temperatures. Produce can also be damaged by exposure to temperatures that are too low. Chilling injury can be initiated at temperatures above freezing. Horticultural produce of tropical origin such as cucumbers, pumpkins and squashes are especially susceptible. Injury due to low temperatures is evident as surface decays, internal browning objectionable flavors and poor color development. Follow the recommended storage temperatures listed in **Table 14** carefully to obtain maximum shelf life and avoid injury.

Water and Moisture

The quality of produce is best at harvest. After harvest, quality can only be maintained never improved. Fresh produce are highly perishable because they are alive. They breathe and give off heat from respiration and lose moisture.

Table 13. Harvest produce at the proper maturity to get maximum quality and shelf life. Maturity indices, quality indices and days to harvest for selected cucurbits grown in the tropics.

Crop*	Maturity Indices	Quality Indices	Days to Harvest**
Cucurbits Harvested At Physiological Maturity			
Watermelon	Yellow ground spot, wilted vine tendril, change in ground color	Symmetrical and uniform; no surface defects or soil; sweet, bright colored flesh	70-85
Cantaloupe	1/2 to 3/4 slip; well rounded netting	Well shape and uniform; no surface defects or soil; firm, sweet, bright colored flesh	55-65
Honeydew	Skin creamy with yellow streaks and waxy	Well shaped and uniform; no surface defects or soil; waxy surface; firm, sweet, bright colored flesh	65-75
Pepino	Skin creamy and waxy; ground color fully changed	Well shaped and uniform; waxy surface, firm; sweet, bright colored flesh	55-60
Pumpkins	Dried peduncle; ground color fully changed	Well shaped and uniform; no surface defects or soil; firm, dry flesh	110-140
Wax Gourd	Dried peduncle; skin waxy with bloom	Well shaped and uniform; no surface defects or soil; firm, dry flesh	110-130
Cucurbits Harvested at Commercial Maturity***			
Cucumber Japanese	0.75"-1.0"D x 5"-9" L No seed development; solid flesh	Straight, uniform, free of blemishes and defects; crisp, sweet flesh	33-38
Cantaloupe Standard Slicing	1.0"-2.0"D x 6"-14"L Seeds young and tender; solid flesh	Straight, uniform, free of blemishes and defects; crisp, sweet flesh	35-40
Bittermelon	Skin 'growths' rounded and separated; firm flesh, immature seed	Well shaped and uniform; no surface defects or soil; shiny skin; firm flesh	90-110
Pepino	Skin waxy and tender firm flesh; immature and tender seeds	Well shaped and uniform; no surface defects or soil; shiny skin; firm flesh	25-30

* For further information, refer to the Cucurbit Crop Selection in the Cucurbit Management unit.

** Days to harvest—The average number of days from planting to first harvest vary with variety and season (wet and dry).

*** L = length, W = width or diameter.

Fresh horticultural produce is composed primarily of water. The freshness of produce is measured in relation to its water content. Any water loss results in loss of freshness. Water loss is one of the main causes of deterioration in quality. Slight losses in moisture reduce quality while more severe losses result in significant weight loss; both reduce the marketability of produce. Most produce, especially that harvested before maturity, shrivel even when only a small percentage of its moisture is lost.

The loss of moisture from produce is affected by the relative humidity (RH), air movement and temperature of the produce in the surrounding environment. Water loss is accelerated under warm windy conditions like those experienced while transporting warm unprotected produce in tropical environments. Cooling the produce and the air surrounding the produce will reduce moisture loss. Refrigeration used in cooling produce removes moisture from the surrounding air, making it difficult to maintain high relative humidity levels in storage. Humidifying devices made specifically for use in cold storage facilities designed to hold produce, are commercially available from most reputable refrigeration suppliers. Keeping the floor wet or maintaining open dishes with standing water in storage facilities can also help maintain elevated levels of relative humidity. Both practices can be messy and harbor disease organisms, making it necessary to sanitize the room frequently with disinfectants. Commodity

ties that can tolerate direct contact with water may be sprinkled directly to maintain elevated levels of RH. Produce can also be wrapped in plastic film to help maintain high RH.

Respiration and Heat

All living things, including produce, respire. Respiration is the process that breaks down stored foods (primarily carbohydrates and proteins) into the simple end products required to keep organisms alive. The process uses oxygen and releases carbon dioxide, water vapor and energy in the form of heat. After harvest stored food reserves are utilized for respiration, resulting in reduced nutritive value, reduced weight and reduced flavor. Reduced levels of food reserves accelerate deterioration.

The rate that a product respire determines its post-harvest or shelf life. Immature fruits and vegetative plant parts, like "Japanese cucumbers" and pumpkin tips, have very high respiration rates and a very short shelf life. Cucurbits with high respiration rates and slightly longer shelf lives include pepino, cantaloupes at $\frac{1}{2}$ slip, bittermelon and honeydew. Watermelon and bottle gourd (in Chamorro, referred to as chandiya and kalabasa) have moderate respiration rates and even longer shelf lives. Fully mature fruits with dry flesh such as pumpkins and wax gourd (in Chamorro, referred to as kalamasa and kondot) have low respiration rates and long shelf lives.

Table 14. Storage requirements and ethylene reaction of selected cucurbits grown in the tropics.

Crop	Precooling Method	Optimum Temperature	Optimum Relative Humidity	Ethylene Action*	Shelf Life
Bittermelon	Hydrocool, Forced Air	54–55° F	85–90%	Sensitive	2–3 weeks
Cantaloupe	Hydrocool, Forced Air	32–41° F	95%	Sensitive/Producer	7–14 days
Cucumber	Hydrocool, Forced Air	50–55° F	95%	Sensitive	10–14 days
Chayote	Room Cool, Forced Air	45° F	85–90%	Sensitive	4–6 days
Honeydew	Forced Air	45–50° F	90%	Sensitive/Producer	3 weeks
Pumpkin	Room Cool	50–55° F	50–70%	Sensitive	2–3 months
Summer Squash**	Room Cool, Forced Air	41–50° F	95%	Sensitive	1–2 weeks
Winter Squash***	Room Cool, Forced Air	50–55° F	50–70%	Sensitive	2–3 months
Watermelon	Room Cool	50–60° F	90%	Sensitive	2–3 months

* Ethylene sensitive crops should not be mixed with ethylene producers to avoid damage.

** Soft shell varieties, including zucchini, yellow straightneck and yellow crookneck squashes.

*** Hard shell varieties of squashes, including acorn, butternut and kobocho.

Ethylene and Ripening

Ethylene (C₂H₄) is a simple, naturally produced compound that affects the natural aging and ripening process. Fruits are grouped as climacteric or non-climacteric based on their respiration rate and ethylene production pattern during maturation and ripening. Non-climacteric fruits maintain low respiration and ethylene production rates while ripening. Pumpkins and wax gourd are non-climacteric fruits. Climacteric fruits produce increasingly large amounts of ethylene and have increasing respiration rates while ripening. Cantaloupes and honeydews are climacteric fruits. The ethylene production rate of horticultural produce ranges from very low (pumpkin tips and flowers), to low (cucumber, pumpkin and watermelon), to moderate (honeydew), to high (cantaloupes), to very high (passion fruit). The quality of climacteric fruits deteriorates very quickly after ripening is initiated. The rate of internal ethylene production is not directly related to the produce's perishability.

Ethylene is active in very small quantities; levels of less than one part per million can trigger responses in some plant tissues. Ethylene plays an important role in the senescence of plant organs, i.e., yellowing (death) and dropping of leaves. Exposing most horticultural produce to ethylene accelerates their senescence. The production of ethylene in plant tissues generally increases as the tissues mature. Physical injury, disease, high temperatures, and water stress all cause ethylene production to increase. Elevated ethylene levels in storage can cause rapid deterioration of ethylene sensitive produce. **Table 13** lists the ethylene sensitivity of the main cucurbit crops grown in the tropics. Ethylene production rates in horticultural commodities can be reduced by storing the commodities in an environment with reduced oxygen, elevated carbon dioxide levels, and the lowest safe temperature for that commodity.

Ethylene has both desirable and undesirable effects on harvested produce. Ethylene can be used to promote faster and uniform ripening of fruits harvested at the mature green stage. Exposing non-fruit vegetables such as pumpkin tips and immature fruits like cucumbers to ethylene accelerates their deterioration. Proper management of the factors that affect ethylene production is critical to maximizing the shelf life of all stored produce.

Temperature

The rate that produce respire is directly related to its temperature. The higher the product temperature, the higher the respiration rate. For every 10° C (18° F) increase in product temperature above its optimum storage temperature, the respiration rate at least doubles. Rapid cooling to remove field heat

is especially important for prolonging the shelf life of immature fruits and vegetables and those with high respiration rates such as "Japanese" cucumbers, pumpkin tips, and cantaloupes, respectively. The internal temperature of produce must be brought to its lowest safe level immediately after harvest in order to attain its maximum shelf life (**Table 14**).

Postharvest Technology Procedures

Temperature Management Procedures

Managing the temperature of fresh produce is the most important tool available for extending the shelf life of high quality produce. Good temperature management begins with the immediate cooling of produce after harvest. The energy required for removal of field heat can be minimized by harvesting produce early in the morning before temperatures rise. Field heat can be removed quickly by icing, evaporative cooling, or forced air cooling. Bring produce temperatures down to the lowest practical level but not below the lowest safe level for each type of produce. Follow the recommended storage conditions listed in **Table 14** as closely as possible.

Managing Relative Humidity

Relative humidity control is important to minimizing moisture loss and decay and for uniform fruit ripening. Proper relative humidity levels for storing cucurbits range from 50% to 98% (**Table 13**). Simple practices for maintaining high relative humidity levels include sprinkling with water (the finer the droplets the better), wetting the floors of the storage areas, and covering produce with moist cloth blankets.

Follow these points to ensure the best quality is maintained.

- Harvest early in the morning to minimize field heat.
- Harvest at the proper stage of maturity.
- Field pack if possible to minimize handling.
- Keep produce in cool, high humidity areas.
- Protect produce from sunlight and wind.
- Sort and pack with care; do not over load packages.
- Cool as quickly as possible.
- Stack produce packages carefully; allow for circulation and avoid crushing from over stacking.
- Cover produce with moist cloth to minimize heating and desiccation during transport.
- Deliver produce as soon as possible after harvest.
- Always handle produce with tender loving care.

Developing Budgets for Cucurbits

L. Robert Barber, Extension Agricultural Economist

In any business activity, agricultural or other types, one of the most effective methods of increasing profits and reducing the risk of failure is good planning. A key planning tool for farmers is a crop budget. In many states, the Cooperative Extension Service provides budgets for a wide variety of agricultural enterprises. A budget is usually based on the records of top growers in the state. Such a budget can serve both as a guide to recommended production practices and serve as an estimator of production costs and profits. This tool is especially important for growers that are new to farming. But, for any grower, the most important budget to use in planning is the one that comes from the grower's own past records. The purpose of this section is to provide growers with the information and tools necessary to develop their own budgets for cucurbit crops.

To be useful, budgets must take into account the agricultural practices and yields of the area where they will be used. Frequently, budgets from the U.S. mainland are not directly transferable to tropical island settings, due to differences in scale and production practices. Budgets from the U.S. mainland are designed for large farms with acres as the unit of production. On Guam, it is normal for growers to have plantings that are less than one acre. A standard unit for reporting crop production adopted by the College of Agriculture and Life Sciences, University of Guam is a 100 foot row.

Crop budgets can take many forms. The budget may be just a simple list of expected out-of-pocket costs for the crop or it may involve a detailed breakdown of how each farm expense is allocated to a given planting. Growers, in developing a budget, will benefit from an increased understanding of their costs regardless of the degree of detail and effort put into preparing the budget. The three major components of a crop budget are

1. Estimated costs of the various inputs and activities involved in the production and marketing of the crop.
2. Estimated marketable quantity of crop expected to be harvested.
3. The estimated selling price for the crop.

Given these components a grower can calculate the expected net return and the expected breakeven price.

Estimating Costs

When examining production costs, growers need to understand that there are two different types of costs involved in their farming operations, variable costs and fixed costs. Many of the variable and fixed costs

are for expenses that are shared by multiple crops or enterprises on the farm. These costs are known as whole farm costs, of which only a portion should be charged to a single planting.

Variable Costs

Variable costs are costs that can change during the production cycle. They are directly related to increases or decreases in production. Examples of variable costs are labor, seeds, fertilizer, and packaging materials. When making decisions on which crop to produce and how much to produce, the most important considerations are variable costs, expected yield, and market price. In the short run, the fixed costs will be the same no matter what the grower decides to do.

For many farmers, budgeting is a new concept and frequently all the desired financial records are not available. Receipts are the beginning of a budget; therefore they must be recorded and filed. If filed by date, the date should appear each time the receipt is mentioned in a budget worksheet. To identify the cost of production in cases where records are missing, it is important to structure the process in a manner that is familiar to the grower (**Table 14**). Before the various components of the table are discussed it is necessary to point out that this is only a starting point in identifying variable costs because such a list will change with management practices and equipment.

Labor (the farmer's own or hired) is a primary input in the production process. It is also the input that the farmer can most easily document or recall. The production process should first be divided into logical identifiable stages (field preparation, grow out, and harvest and marketing). The practices occurring during each stage need to be identified. One can then determine the labor and inputs of materials and supplies for the practices at the various stages. Second, the man-hours required during each stage will determine the labor component in the budget.

The worksheet (**Table 15**) will provide reference points for the farmer to use in identifying the purchased inputs (materials and supplies) necessary for the production process. At a minimum, farmers must be able to cover their variable costs. If they cannot, then they may need to switch crops, change farm practices, or pull out of the market.

Fixed Costs

Fixed costs are the expenses that remain the same, during the production period, for any level of production. Examples of fixed costs are land, equipment, and insurance. Many fixed costs are more difficult

to calculate than variable costs because some are spread over many production cycles or years. For example the cost of a tractor must be spread or depreciated over many years.

Another consideration in estimating costs is that most fixed and several variable costs are *Whole Farm* in nature. For growers that produce different crops, costs like tractor fuel and tractor repairs, which are variable costs, or property taxes and rent payments, which are fixed costs, must be allocated among the different crops.

Some fixed costs, such as property tax or rent, are easier to calculate than others because the cost is a set annual amount. Many others, like the cost of a tractor or chilling unit, are a little more difficult to estimate. This is because the costs should be spread (depreciated) over several production periods. A major annual cost to the farm for such items is the loss in value that results from each year of use (the item's depreciation) (Table 16).

Table 15. Worksheet for use in calculating the variable cost portion of a single crop budget.

Practices	Input of Labor			Input of Materials and Supplies				
	Man hours	Wage/Rate	Cost	Item	Unit (example)	Number	Price/Unit	Cost
Field Preparation Stage								
Mowing	_____	_____	_____	Fuel	gal	_____	_____	_____
Plowing	_____	_____	_____	Fuel	gal	_____	_____	_____
Disk/Till	_____	_____	_____	Fuel	gal	_____	_____	_____
Preplant Fertilitization	_____	_____	_____	Fertilizer	(50lb bags)	_____	_____	_____
Install Irrigation	_____	_____	_____	Drip Lines	(100 ft)	_____	_____	_____
Other	_____	_____	_____	Other		_____	_____	_____
Other	_____	_____	_____	Other		_____	_____	_____
Grow Out Stage								
Plant Seeds	_____	_____	_____	Seeds	lbs	_____	_____	_____
Transplant	_____	_____	_____	Transplants	flat	_____	_____	_____
Insect Control	_____	_____	_____	Insecticide	oz	_____	_____	_____
Disease Control	_____	_____	_____	Fungicide	oz	_____	_____	_____
Mechanical Weed Control	_____	_____	_____	Other		_____	_____	_____
Chemical Weed Control	_____	_____	_____	Herbicide	oz	_____	_____	_____
Slug Control Pellets	_____	_____	_____	Pellets	lbs/box	_____	_____	_____
Install Trellis	_____	_____	_____	Poles		_____	_____	_____
	_____	_____	_____	Net	(100ft)	_____	_____	_____
	_____	_____	_____	Rope/Wire	(100ft)	_____	_____	_____
Side-dress application	_____	_____	_____	Fertilizer	(50lbs bags)	_____	_____	_____
Other	_____	_____	_____	Other		_____	_____	_____
Other	_____	_____	_____	Other		_____	_____	_____
Harvest and Marketing Stages								
Picking	_____	_____	_____	Crates		_____	_____	_____
Washing	_____	_____	_____	Other		_____	_____	_____
Sorting/Packing	_____	_____	_____	Boxes		_____	_____	_____
Chilling & Storage	_____	_____	_____	Electricity	kw/hour	_____	_____	_____
Delivery & Sales	_____	_____	_____	Fuel	gal	_____	_____	_____
Other	_____	_____	_____	Other		_____	_____	_____
Total Labor Cost:				Total Materials/Supplies Cost:				
_____				_____				

Table 16. Calculation of annual depreciation cost (**AC**) for three items.

Item	Cost C	Salvage Value SV	Estimated Life (Years) L	Annual Depreciation Cost AC*
Tractor	\$25,000	\$1,000	10	\$2,400
Chilling Unit	\$5,000	\$500	5	\$900
Delivery Truck	\$14,000	\$2,000	□	\$2,000

$$* AC = (C - SV) \div L$$

To use this simple method (Table 16) to calculate the annual depreciation cost (**AC**), one needs to know the cost (**C**) of the item, the estimated life (**L**) in years, and its salvage value (**SV**). The salvage value is the amount of money you could receive for the item if you were to sell it after **L** years. An example of annual depreciation cost (**AC**) is shown below:

$$AC = \frac{C - SV}{L}$$

Example:
Tractor $AC = \frac{\$25,000 - \$1,000}{10} = \$2,400$

Allocating Whole Farm Costs to Individual Plantings

Whole farm costs are those costs that cannot be directly charged to a single planting of a crop or agricultural enterprise. Whole farm costs can be either fixed or variable costs. These costs should be distributed among the farm's different agricultural crops. Calculating the distribution of these costs involves looking at cost of an input (equipment, land, etc.) from a whole farm perspective (Table 17), as opposed to using only a single variable cost approach (Table 15). The steps used in deciding how much of each annual depreciation cost to charge to

a single planting and how to calculate whole farm costs are as follows:

1. Select a production unit that is appropriate for the farm. For small farms, a unit should be a single plant, such as illustrated in Table 17. For large farms, a unit should be a 100 foot row.
2. Estimate the total number of production units (**TU**) for all crops during the year which are dependent on a particular item. For example, the tractor and truck are used for all crops (2,240 units) but the chilling unit is only used for some of the crops (1,000 units).
3. Identify the annual depreciation cost (**AC**) of an item (tractor, chilling unit, or delivery truck).
4. The farm production unit cost (**UC**) is equal to the annual depreciation cost (**AC**) of the item divided by the total production units (**TU**).
5. Determine the number of units in a single planting under consideration (**NU**).
6. Calculate the planting cost (**PC**) by multiplying the number of units in the single planting (**NU**) by the production unit cost (**UC**).

Variable costs, such as fuel for a tractor, maintenance, or electricity, can also be used in determining whole farm costs. When using variable costs, the term (**AC**) is defined as annual costs and not annual depreciation cost. Once all the costs associated with a planting have been determined the marketable harvest and selling price must be identified to determine the profitability of the crop.

Estimating Quantity to be Harvested

Harvest or yield estimates in the US mainland are usually based on a given area such as acres. For island farmers, a harvest estimation based on the average per plant yield times the number of plants in a planting is a more useful due to their small planting size, widely varied production systems, equipment, management skills, terrain, row and plant spacing.

Table 17. Allocating a portion of yearly whole farm costs to a single planting.

Item	Annual Depreciation Cost AC**	Total Production Units in a Year TU***	Production Unit Cost UC****	Number of Units in Single Planting NU	Planting Cost PC*****
Tractor	\$2,400	2,240	\$1.07	40	\$42.80
Chilling Unit	\$900	1,000	\$0.90	40	\$36.00
Delivery Truck	\$2,000	2,240	\$0.89	40	\$35.60

* Items that are used in the production of this single crop planting.

** Since we do not depreciate variable items, **AC** = annual cost when variable items are used.

*** For point of illustration, a single plant was selected as a unit.

**** **UC = AC ÷ TU**

***** **PC = UC x NU**

For the island farmer, the first step in estimating harvest (**H**) is to determine the number of plants in a planting (**P**). To calculate the number of plants in a planting, the grower needs three measurements and the following formula:

$$P = \frac{R \times L}{D}$$

R = the number of rows
L = the row length in feet
D = the distance, in feet, between plants in a row

For example, a grower plants 10 rows of cucumbers (**R**), each row is 100 feet long (**L**), and the distance between plants in a row is 1 foot (**D**). You multiply 10 rows by 100 ft. to give you 1,000 row feet. This would then be divided by the 1 foot to equal 1,000 plants in the planting (**P**).

$$P = \frac{10 \times 100}{1} = 1,000 \text{ plants}$$

The next step in calculating a grower's estimated harvest (**H**) requires an estimate of the expected yield per plant (**Y**). While both the Guam Department of Agriculture and the Guam Cooperative Extension have estimates of average plant yields for many crops grown on Guam, the best estimate to use is one based on the grower's past experiences. To calculate (**Y**), a grower records the total pounds harvested (**T**) for a planting and then divides by the number of plants in the planting (**P**). See formula below:

$$Y = \frac{T}{P}$$

Y = yield per plant
T = total pounds harvested
P = number of plants

Keeping the average plant yield for several crop cycles will allow a grower to calculate an average yield per plant for the farm.

To estimate harvest for a planting (**H**), multiply the farm's average plant yield (**Y**) times the number of plants (**P**) in the proposed planting. In estimating the harvest a grower might want to consider previous production history and use both a high and low estimate.

$$H = Y \times P$$

H = estimated harvest
Y = farm's average plant yield
P = number of plants in proposed planting.

Estimating Your Selling Price

The price a grower is able to obtain for his product depends on many variables, such as product quality, supply of the product on the market, and the grower's ability to negotiate. Many growers remember the prices they have historically obtained for their crops. The Guam Department of Agriculture together with the Guam Cooperative Extension collected farmer selling prices on a monthly basis during the years of 1994, 1995 and 1996. This information is available from the Guam Cooperative Extension. The

Guam Department of Agriculture maintains a list of buyers for many crops and in some cases the prices these buyers are willing to pay. It must be noted that historical prices should only serve as a guide and do not ensure present or future prices. Other growers and potential buyers are excellent sources of current information for the market price.

Frequently in order to make a sale, it is important to look at information other than just the market price. If there are large amounts of the crop in the market channels or if a grower is new to the market or trying to capture a larger portion of the market share, it may be necessary to sell below the market price. In order to determine if it is possible to lower one's selling price without suffering losses it is important to know one's breakeven price.

Breakeven Price

Once a grower has calculated the cost of production for a planting an important factor to consider is the breakeven price. Any financial return above the breakeven price is profit. The breakeven price is the unit price (price per pound or box) that one must obtain in the market in order to cover the cost of production and marketing. This is a very important price to know when the grower is developing a market plan. Knowledge of the breakeven price provides a sense of security for growers in developing a market plan and selling price, especially if the market competition is strong and consideration is being given to lowering one's price.

The breakeven price is calculated by dividing the total cost of production by the total number of units (pounds) produced. For example if it cost \$4,194 to produce 12,600 pounds of cucumbers the breakeven would be \$4,194 ÷ 12,600 or \$0.33 per pound of cucumbers. If the going market price was \$0.79/lb then a grower might feel comfortable dropping his price to \$0.69/lb (10¢/lb below the market price) in order to capture a larger share of the market.

Growers who stay on top of their costs can rapidly adapt to changes in the market place with confidence. Knowing where the farm's most profitable opportunities are allows them to make the best use of their resources and help to ensure their success.

Food Nutrition

Rebecca Pobocik, Nutritionist

Nutrition is important for good health and the cucurbits make for good nutrition. Most people do not eat enough fruits and vegetables. Health and nutrition experts recommend a minimum of five servings of fruits and vegetables a day for all people. This is less than most people actually eat. Because cucurbits are annual garden crops, they are commonly referred to as vegetables and share similar nutritional value. Since we consume the fruit of the cucurbits, it also has nutritional value similar to other juicy fruits. Therefore, cucurbits are good for people to eat.

What are some of the specific benefits that can come from eating cucurbits? Cucurbits are low in energy (or calories) and fat, provide dietary fiber, and contain many important vitamins and minerals. They are low in sodium when not processed. These are the food components that most people need for good health. We want to satisfy our hunger and meet our nutritional needs without gaining too much weight. Cucurbits are perfect for this.

All cucurbits have dietary fiber in them. Fiber is that portion of the food that generally is not absorbed by the human body. There are actually two types of fiber and both have health benefits. Water-soluble fibers occur in higher amounts in fruits (also oats, barley and legumes) and in the body delay the stomach's emptying and lower blood cholesterol. The juicy melon cucurbits are good for this benefit. Water-insoluble fibers are found in vegetables (also wheat and cereals) and in the body increase fecal weight, which alleviates constipation. Cucurbits that are commonly eaten with their skin, such as cucumbers, zucchini, bittermelon, contain this type of fiber. Both types of fiber slow starch breakdown and sugar absorption into the blood. Because of these actions in the body eating the recommended amount of fiber can help control weight, improve intestinal function, reduce the risk of colon cancer, lower blood cholesterol levels, and help control diabetes. What is the right amount of fiber to eat? For most adults, 20 to 35 grams of fiber a day is the right amount. There are approximately 4 grams of fiber in 1 cup of acorn squash, 2 grams of fiber in one cup of cucumbers and zucchini, and 1 gram of fiber

in one cup of cantaloupe and watermelon. Although no one food can provide all of these protective effects, eating the minimum of five servings of fruits and vegetables a day can provide approximately half of the recommended amount of fiber needed for good health.

Vitamins are tiny substances found in food that are essential for life. Many people have dangerously low intake of vitamins A and C, especially in the Pacific region. This is due to low consumption of those foods that supply these vitamins. Pumpkin is an excellent source of vitamin A and cantaloupe and watermelon are also good sources. Pumpkin tips and bittermelon are good sources of vitamin C. These foods should be encouraged in the diet. Both vitamins are important for the body's ability to fight disease. Vitamin A is also important for vision, skin, bone and tooth growth, and reproduction. Vitamin C is also important for strengthening blood vessel walls, scar formation (collagen synthesis), antioxidant, protein usage in the body, and assisting with iron absorption. Eating cucurbits can help keep us in better health because of the vitamins that they contain.

Minerals are substances that our body also need to function properly. The cucurbits contain relatively small amounts of minerals but are a good source of potassium. Potassium is one of the body's electrolytes that helps the body's nerve impulses function properly, keeps the body's fluid balanced, and is needed for muscle contraction. Squash also contains several other important minerals, including iron, calcium and magnesium. These minerals are good for the blood and bones and the body's enzyme systems, respectively.

The best way to retain the vitamins in the cucurbits is to eat them raw or cooked lightly so that they are "tender-crisp." However, the mineral and fiber content remains regardless of how they are cooked. Try to avoid adding a lot of butter or frying them unless you are trying to gain weight. These cucurbits are popular and there are many delicious recipes available. We are presenting a few more recipes for your eating enjoyment.

Recipes

From the Kitchen of Mila Moguel

Watermelon Fizz

Ingredients:

5–6 c. of watermelon (seeds removed)
3 c. diet Seven-up or sprite
ice cubes

Procedure:

1. Slice watermelon and remove seeds.
2. Mix watermelon and seven-up and blend (preferably in a blender until well mixed).
3. Chill.
4. Serve with ice cubes.

Sauted Mixed Vegetables

Ingredients:

1 pumpkin, sliced into 1 inch squares
1 c. okra, cut into 2 or 3 pieces each
1½ c. long beans, cut into 2 inch length
1½ c. eggplant, cut into strips
1 c. bittermelon, cut into strips
1 tbsp. oil
1 tbsp. garlic, crushed
¼ onion, chopped
1 tomato, sliced into small pieces
2 c. broth (from the peelings and head of the shrimps)
salt and pepper to taste or “bagoong”
1 piece of pork (approximately 4” by 3”)
6–8 pieces of shrimp

Procedure:

1. Saute garlic, onion and tomato in oil.
2. Add the pork. Stir constantly.
3. Add the shrimps and stir.
4. Pour the shrimp broth and boil until the pork is cooked.
5. Add the vegetables.
6. Season with salt and pepper or bagoong and continue cooking until the vegetables are done.

Any vegetable in season can be added as desired.

Bittermelon with Beef

Ingredients:

½ lb. tender beef, cut into thin strips
2 c. sliced bittermelon
1 tsp. crushed garlic
2 tsp. cornstarch
salt and pepper to taste
1 cube beef bouillon cube dissolved in 2 c. hot water
2 tbsp. oil

Procedure:

1. Mix salt, pepper and cornstarch with the thinly sliced beef and set aside for 15–20 minutes.
2. Squeeze the sliced bittermelon in a small amount of water and drain.
3. Saute the garlic in oil.
4. Add the marinated beef while stirring constantly.
5. Mix the bouillon into the water until dissolved.
6. Allow the meat to cook and then add the bittermelon. Continue cooking until bittermelon is done.
7. Add salt and pepper to get the desired taste.

Cucumber Salad

Ingredients:

2 c. cucumber, cut into ¼ inch rings
½ c. vinegar
1 tsp. salt
2 tsp. sugar
pinch of pepper, if desired

Procedure:

1. Chill cucumber after slicing
2. Mix the remaining ingredients for the dressing.
3. Pour dressing on the cucumber when ready to serve.

Fish with Cucumber

Ingredients:

- 2 pounds of fish, cleaned and scaled oil for frying the fish
- 3 segments of garlic, crushed
- 1/4 of an onion, chopped
- 1 tomato (big), chopped
- 1 1/2 c. pieces of cucumber, cut into 1/4 inch rings.
- salt and pepper to taste
- 1 1/2 c. broth or boiling water

Procedure:

1. Put some salt on the cleaned fish, let stand for a few minutes and then fry. Drain the oil from the fish by putting them on paper towel or napkin.
2. Saute garlic, onions, and tomato in a tbsp. of oil. Press these ingredients to mash as they cook.
3. Add the fried fish and broth and let boil. Simmer for 5 minutes.
4. Add the cucumber and season to taste.
5. Remove from fire as soon as the cucumber turns bright green.
6. Serve hot.

Candied Watermelon Rind

Ingredients:

- 6 c. watermelon rind
- 1 tbsp. lime powder
- 1 gallon water
- 3 c. sugar
- 4 c. water

Procedure:

1. Thinly slice the skin of the watermelon and cut into 2 inch pieces. When sliced, the pieces of rind should fit into a 6 quart container.
2. Soak in a solution of 1 gallon of water and 1 tbsp of lime powder overnight.
3. Wash the rind and drain.
4. Cook the sugar and water until sugar is dissolved and it reaches the soft ball stage. (The soft ball stage is reached when a drop of syrup forms into a soft ball when dropped in a cup of water.
5. Cook the rind in this syrup for 5 minutes.
6. Remove from fire and place in sterilized jars.

Mongo Beans with Bittermelon

Ingredients:

- 1 c. mongo beans
- 1 c. bittermelon, seeds removed and cut into small pieces
- 1 tbsp. oil
- 2 tbsp. garlic, crushed
- 1/2 c. onion, sliced into small pieces
- 2 cherry tomatoes, cut into small pieces.
- 10 pieces of shrimps, peeled
- 3 c. shrimp broth (from the shrimp heads and peelings)
- horse radish leaves (malunggay)
- salt and pepper to taste

Procedure:

1. Boil mongo beans in enough water and cook until tender. It takes 10 minutes for the beans to tenderize in a pressure cooker. Set aside.
2. Saute garlic, onion and tomatoes in oil.
3. Add the shrimps.
4. Mix in the cooked mongo beans.
5. Add the shrimp broth and season to taste.
6. Add the bittermelon and cook until it is done.
7. Mix in the malunggay leaves. Turn off as soon as the mixture boils again.
8. Serve hot.

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c.	cup	8 oz	236.6 ml
tbsp.	tablespoon	0.5 oz	14.8 ml
tsp.	teaspoon	0.17 oz	4.9 ml

Helpful Resources

The following is a summary of the many institutions, organization and resources available to growers.

College of Natural and Applied Sciences (CNAS) at the University of Guam (UOG)

The Guam Cooperative Extension (GCE) at UOG, funded by United States Department of Agriculture (USDA) and Government of Guam, is responsible for providing the island growers with educational assistance in all aspects of the farm operation through professional advisers, publications, workshops, and certification programs. The Guam Agricultural Experiment Station (AES) conducts research projects that address the needs of Guam's farmers and disseminates this information through the Guam Cooperative Extension (GCE).

<http://www.uog.edu/cnas>

Recycling and Environmental Information Service and the Recycling Association of Guam (REIS)

Housed at CNAS, this volunteer organization is dedicated to educating the public through outreach programs on the benefits of recycling, composting, and organic gardening.

<http://guamrecycling.org>

R.F.K. Library at UOG

The library serves the University of Guam and to an extent the island of Guam by providing up-to-date books, periodicals, internet access and other resources. A section of the library known as the Land Grant Collection and the Government Documents Collection is housed on the library's second floor.

<http://www.uog.edu/student-services/rfk-library/rfk-library>

Small Business Development Center (SBDC) at UOG

Located at the University of Guam, SBDC provides counseling and training programs in a number of service areas, such as feasibility studies, market research, surveys, business plan development, loan packaging, and problem solving.

<http://www.pacificsbdc.com>

Guam Department of Agriculture (DOA)

Provides technical assistance and administers programs mandated by the Guam legislature, such as Forestry, Aquatic and Wild Life Protection, and Plant Protection and Quarantine. Soil and Water Conservation Districts is a DOA sub-activity. It is responsible for registration of farms for disaster assistance and agriculture water rates. Through its monthly newsletter (Agrinews), farm visitation, price surveys and public general business meeting, DOA keeps the farmers current. For a minimal fee, farmers can have their seeds grown-out into transplants. For sale to farmers and the general public, they have a number of fruit trees and landscape plants and often have extra garden transplants.

<http://doag.guam.gov>

Guam Environmental Protection Agency (GEPA)

This regulatory agency is responsible for protecting Guam's land, air, and water resources. GEPA has the authority to enforce the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) on Guam. FIFRA governs the registration of pesticide products and safeguards consumers against fraudulent pesticide products entering Guam. In addition, the Agency is charged with protecting the consumer and the environment for any potential hazards associated with the use, storage, and disposal of pesticides. It is also responsible for Worker Protection Standards and the Endangered Species Act.

<http://epa.guam.gov>

USDA-Natural Resources Conservation Service (NRCS)

An agency of the U.S. Department of Agriculture (USDA); works hand-in-hand with people and organizations, conservation districts, and other agencies to conserve natural resources primarily on private and tribal lands. NRCS provides technical assistance to agricultural producers in the Pacific Basin who request such assistance. NRCS may also administer certain programs that provide financial assistance to qualified producers for the installation of conservation practices.

<http://www.nrcs.usda.gov/wps/portal/nrcs/main/pia/contact/>

Guam Economic Development Authority (GEDA)

Assists growers in obtaining farm loans.

<http://www.investguam.com>

Chamorro Land Trust Commission (CLTC)

Assists qualifying Chamorros in obtaining a dollar per year long term agricultural land leases.

<http://dlm.guam.gov/welcome/chamorro-land-trust-commission/>

Glossary

- action level**—Pest population levels where management decisions (i.e., the use of pesticides) are warranted.
- andromonoecious**—A plant with some perfect flowers and males flowers.
- asexual spores**—Spores that are not the result of sexual union.
- bacterium**—A one-celled microorganism much larger than a virus but smaller than a fungal spore.
- beneficial insect**—Insects that are considered useful to the grower because they feed (externally or internally) on insects that are pests.
- bloom**—Young budding flowers.
- blotches**—Irregular areas of discoloration, usually superficial.
- breakeven price**—The unit price (price per lb or box) that a farmer needs to obtain in the market in order to cover the cost of production and marketing.
- Brix**—A measure of total soluble solids in fruit and vegetable juices; calibrated in terms of pure sucrose (1° Brix = 1% sucrose).
- cirrhus**—A ribbonlike mass of gelatinous spores exuding from an ostiole.
- clamp connection**—Bridge-like hyphal connection.
- climacteric fruit**—Fruits that produce increasingly large amounts of ethylene and have increasing respiration rates while ripening.
- complete fertilizer**—Inorganic fertilizers which contains all three primary elements (N-P-K).
- conidia**—Asexual spores formed at the end of conidiophores.
- conidiophores**—Stalks on which conidia are produced.
- cotyledons**—Seed leaves of the seedling. Eventually they wither and fall off.
- crop budget**—A key planning tool used in agriculture to increase profits and reduce the risk of failure.
- crop rotation**—The process of switching crops grown on a section of land after each harvest
- cucurbit**—A plant belonging to the gourd family, cucurbitaceae, such as watermelon, cucumber, bittermelon, squash, and sponge gourd.
- depreciation**—The decrease in value of buildings, other improvements, and machinery which is caused by wear, tear, and obsolescence.
- desiccation**—Loss of moisture, drying out.
- drainage**—The process of removing excess water/salts from the root zone of a crop to assure its survival and optimum growth.
- epidemiology**—A study of the factors determining the amount and distribution of disease.
- ethylene (C₂H₄)**—The simplest, naturally produced compound which affects plants' physiological processes. It is the natural aging and ripening hormone.
- fertigation**—Mixing fertilizers with irrigation water.
- fertilizer**—Any organic or inorganic material added to soil or water to provide plant nutrients necessary for growth.
- fixed cost**—Expenses that remain the same, during the production period, for any level of production. Examples: land, equipment, and insurance.
- forced air cooling**—The removal of field heat by using refrigerated air which is forced through a produce container. This is accomplished using a force air cooler and specially designed containers. This method is more efficient in removing heat than room cooling.
- fruiting body**—Any fungal structure which contains or bears spores.
- fungus**—Non-green spore producing plants. Most are composed of mycelium. They may grow as a parasite or as a saprophyte.
- germination**—The beginning of growth, formation of a sprout. The activation of the embryo (small plant within the seed) which leads to the rupture of the seed coat and the emergence as a seedling.
- grafting**—The process of making a plant more desirable by combining it with a piece from another plant.
- ground color**—The background color of fruits. Color changes with maturity.
- ground spot**—Spot on fruit in contact with soil. Also called belly spot.
- gynoeceous**—A plant with mainly female flowers.
- hybrid**—Varieties resulting from cross-pollination between plants that are genetically unlike. Seed from hybrid plants should not be saved for future planting.
- hydrocooling**—Using cold water to quickly cool produce. Containers must be waterproof and produce must be tolerant to wetting.
- hypha (pl. hyphae)**—A single branch of fungus mycelium.
- hypocotyl**—The short seedling stem between the cotyledons and the primary root which gives rise to the stalk of the young plant.
- imperfect flower**—A flower that has either male or female parts.
- indeterminate**—A terminal bud that is always vegetative; thus vine or stems grows indefinitely.
- insecticide**—A chemical that is used to control an insect pest.
- integrated pest management (IPM)**—A management system that utilizes all methods of controlling animal pests, plant pathogens, and weeds.

- irrigation**—The process of applying supplemental water to a crop for satisfactory or optimum production.
- lesion**—Well defined area of diseased tissue.
- market price**—The price for a product established by buyers (stores or consumers) and sellers (farmers or stores). Sellers sell at or below market price. Buyers buy at or above market price.
- microbes**—Organisms, such as fungi, bacteria, and virus, that are very small in size and are usually single-celled and infectious.
- monoecious**—Plants that have male and female organs in different flowers on the same plant.
- mosaic**—Symptom of certain viral diseases of plants characterized by intermingled patches of normal and light green or yellowish color
- mulch**—Any material placed on the ground to conserve soil moisture or prevent the growth of weeds.
- mycelium**—Threadlike filaments constituting the body of a fungus.
- nematode**—Wormlike, transparent organism that can often be seen with a hand-lens. They live in water or soil as a saprophyte or a parasite.
- non-climacteric fruit**—Fruits that maintain low respiration and ethylene production rates while ripening.
- nymph**—An immature stage of a developing adult insect.
- open pollination**—Varieties that are the result of normal or natural pollination. The seeds from such varieties are the best kind to collect for seed purposes.
- ostiole**—Opening on the top of a pycnidium.
- peduncle**—Fruit stalk.
- perfect flower**—A flower that has both male and female parts (hermaphroditic).
- pesticide**—A generic term used to describe a wide variety of chemicals which include insecticides, fungicide, herbicides, and rodenticide.
- petiole**—The stem of any leaf.
- pH**—A measure of the acidity or alkalinity of soil or water. The neutral point is pH 7.0. All pH values below 7.0 are acidic and all above 7.0 are alkaline.
- plant disease**—An unhealthy condition that results from an infectious agent (viruses, bacteria, fungi, etc.) or non-infectious agent (environmental factors, poor pollination, genetics).
- plant pathogen**—An infectious agent that can cause a plant disease to develop. Examples include viruses, bacteria, fungi, nematodes, parasitic plants).
- pollination**—The transfer of pollen from the stamen to the pistil. In cucurbits, this is accomplished primarily by bees.
- primary elements**—Nitrogen (N), Phosphorus (P), and Potassium (K).
- pycnidium** (pl. pycnidia)—An asexual, hollow fruiting body, lined inside with conidiophores.
- quality**—The degree of excellence or the features that make something desirable.
- relative humidity (RH)**—The ratio, expressed as percentages (%), between the quantity of water vapor present and the maximum possible at a specific temperature and barometric pressure.
- resistance**—A condition where certain pesticides are no longer effective at controlling a certain pest.
- respiration**—The process that breaks down stored foods (primarily carbohydrates and proteins) into simple end products. It is required to keep organisms alive.
- room cooling**—Placing field or shipping containers of produce into a cold room. Requires adequate air movement around containers. Room cooling is the slowest recommended method for heat removal.
- row covers**—Fine mesh materials that are placed over a crop. The mesh is small enough to keep out aphids.
- sampling**—A method used to provide an estimate of how many pests are in a particular area.
- saprophyte**—An organism that uses dead organic material for food.
- sclerotia**—Small hardened mass of fungal mycelium.
- senescence**—The process that follows physiological or horticultural maturity and contributes to death of tissue.
- setae**—Bristle-like fungus structures usually dark and thick-walled.
- slip**—The natural separation (abscission) of the fruit from its stem.
- soil texture**—The coarseness or fineness of the soil. The relative proportions of sand, silt, and clay particles.
- spores**—Seeds of the fungus.
- summer squash**—Soft shell varieties of squashes, including zucchini, yellow straightneck and yellow crookneck squashes.
- symptom**—The appearance of a plant when subjected to a stress condition. Yellowing, stunting, spotting and wilting are plant symptoms.
- tendrils**—Slender, twining organ found on vines; aids in support of cucurbits when grown on a trellis (Fig. 1).
- threshold level**—The number of insects at which treatment is warranted.
- transplant**—A seedling that was germinated in a seedbed or tray then transferred to the soil.
- trellising**—The process by which cucurbit vines are trained to grow into a latticework of wood, string, or netting.
- variable cost**—Expenses that can change during the production cycle. Directly related to increases or decreases in production. Examples: labor, seeds, fertilizer, packaging materials, and transportation.

virus—An infective agent too small to be seen with a conventional microscope and unable to multiply outside a living cell.

whole farm cost—Costs that cannot be directly charged to a single planting of a crop or agricultural enterprise. Whole farm costs can be either fixed or variable costs. Examples: tractors, chilling units, and delivery trucks.

wilting—Lack of water in the leaves and/or stem causing the plant to droop.

winged aphid—Aphids that are winged and can fly to establish new aphid colonies.

wingless aphid—Aphids that have no wings but still have the ability to produce numerous offspring.

winter squash—Hard shell varieties of squashes, including acorn, butternut and kobocho.

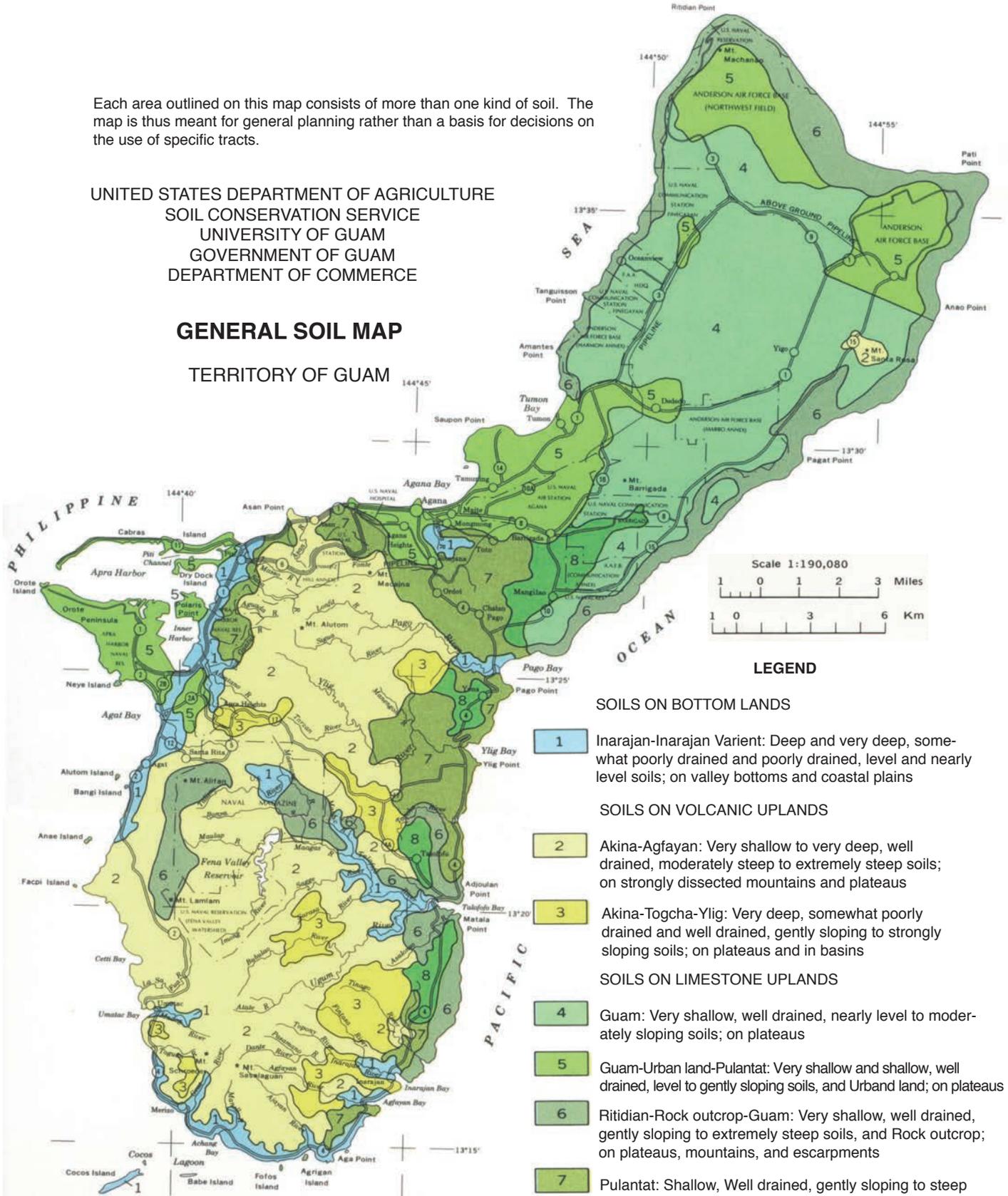
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Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

UNITED STATES DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 UNIVERSITY OF GUAM
 GOVERNMENT OF GUAM
 DEPARTMENT OF COMMERCE

GENERAL SOIL MAP
 TERRITORY OF GUAM



LEGEND

SOILS ON BOTTOM LANDS

- 1** Inarajan-Inarajan Variant: Deep and very deep, somewhat poorly drained and poorly drained, level and nearly level soils; on valley bottoms and coastal plains

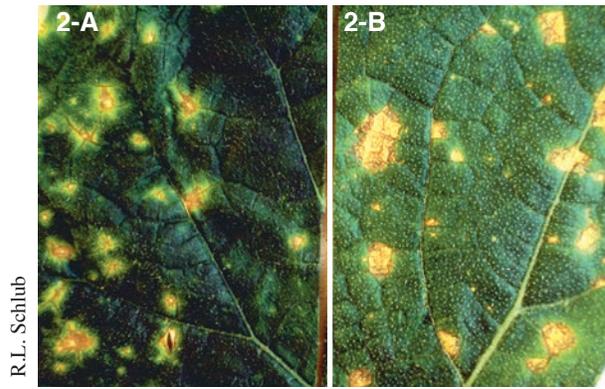
SOILS ON VOLCANIC UPLANDS

- 2** Akina-Agfayan: Very shallow to very deep, well drained, moderately steep to extremely steep soils; on strongly dissected mountains and plateaus
- 3** Akina-Togcha-Ylig: Very deep, somewhat poorly drained and well drained, gently sloping to strongly sloping soils; on plateaus and in basins

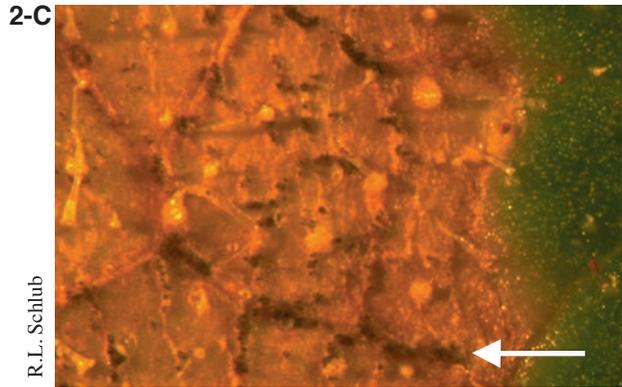
SOILS ON LIMESTONE UPLANDS

- 4** Guam: Very shallow, well drained, nearly level to moderately sloping soils; on plateaus
- 5** Guam-Urban land-Pulantat: Very shallow and shallow, well drained, level to gently sloping soils, and Urban land; on plateaus
- 6** Ritidian-Rock outcrop-Guam: Very shallow, well drained, gently sloping to extremely steep soils, and Rock outcrop; on plateaus, mountains, and escarpments
- 7** Pulantat: Shallow, Well drained, gently sloping to steep soils; on dissected plateaus and hills
- 8** Pulantat-Kagman-Chacha: Shallow, deep and very deep, somewhat poorly drained and well drained, nearly level to strongly sloping soils; on plateaus and hills

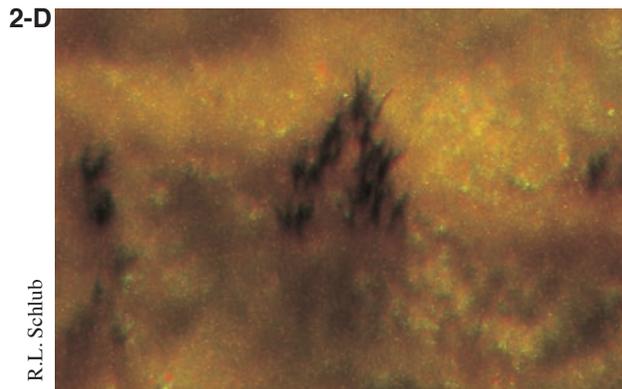
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R.L. Schlub



R.L. Schlub

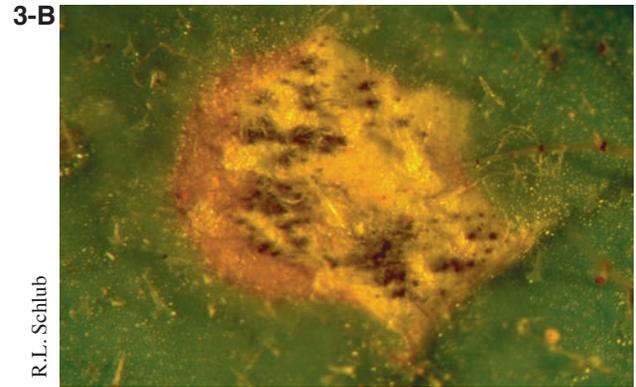


R.L. Schlub

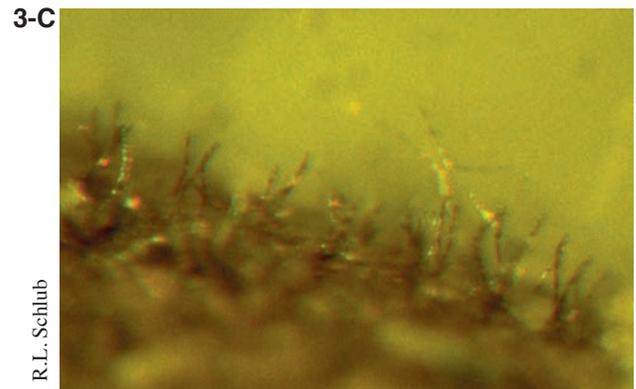
- 2. A.** Cucumber leaf with anthracnose = **A**
B. Cucumber leaf with target leaf spot = **TLS**
C. Anthracnose fungus often clusters along leaf veins.
D. Close-up of anthracnose fungus revealing black bristles.



R.L. Schlub



R.L. Schlub



R.L. Schlub

- 3. A.** Wax gourd leaf with *Cercospora* leaf spot = **CLS**. Occurs on older leaves and rarely on fruit.
B. Fungus appears as dark clumps inside spots with distinct margins.
C. Clumps appear as bundles of black sticks to which are attached long silvery spores.

4-A



R.L. Schlub

4-D



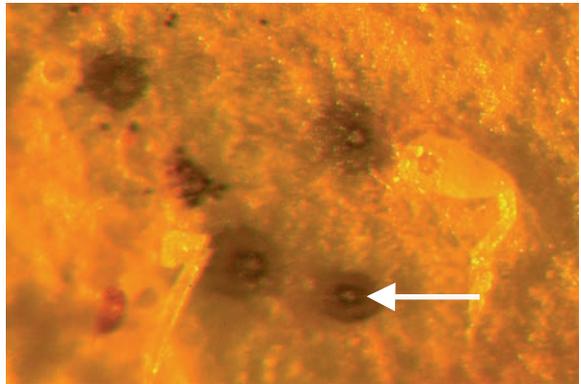
R.L. Schlub

4-B



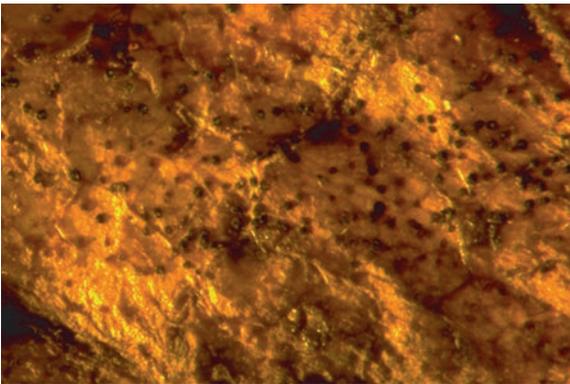
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4-E



R.L. Schlub

4-C



R.L. Schlub

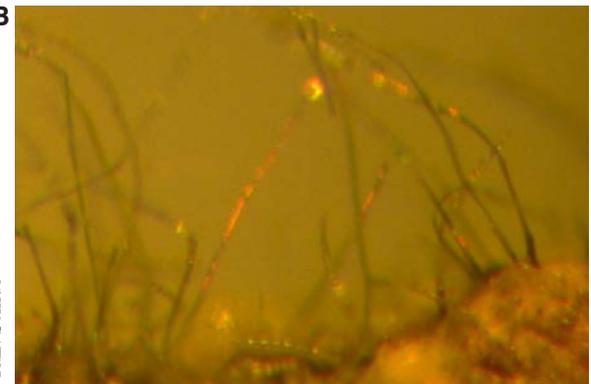
4. Spots often start at leaf margin and expand rapidly.
- A. Melon with gummy stem blight = **GSB**.
 - B. Watermelon infected with gummy stem blight = **GSB**.
 - C. Fungus's fruiting bodies appear as specks which darken with age.
 - D. Stem lesion with black specks of the fungus. Although not pictured here a gummy exudate may develop.
 - E. Specks are ball shaped with an opening at the top.

5-A



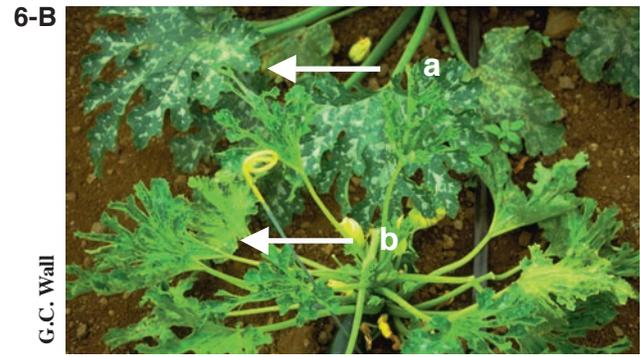
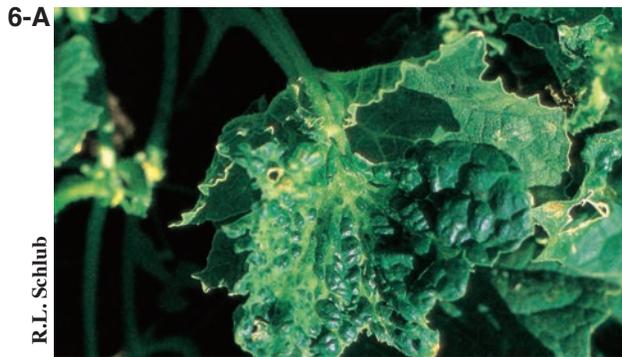
R.L. Schlub

5-B

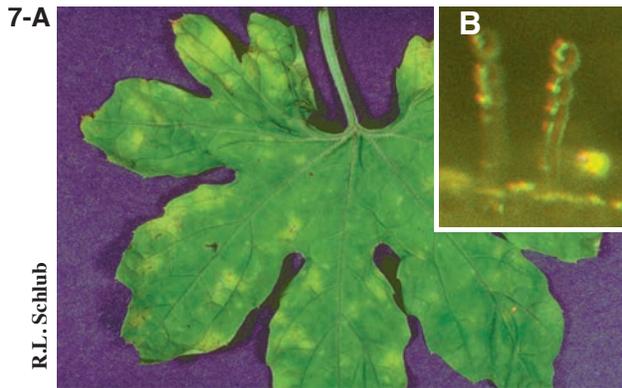


R.L. Schlub

5. A. Melon stem with target leaf spot = **TLS**. Infected area is light in color with a dark margin.
 B. Close-up reveals long hair-like conidiophores to which are attached shimmering spores.



6. A. Melon leaf showing puckering and mosaic symptoms typical of a virus = V.
 B. Healthy zucchini squash plant (a) and one with virus = V showing shoestring symptoms (b).



7. A. Bittermelon leaf with powdery mildew = PM. The yellowish spreading blotches may appear powdery.
 B. Close-up leaf surface reveals chains of transparent spores.



8. Watermelon with fruit rot = FR, disease blossom-end rot.



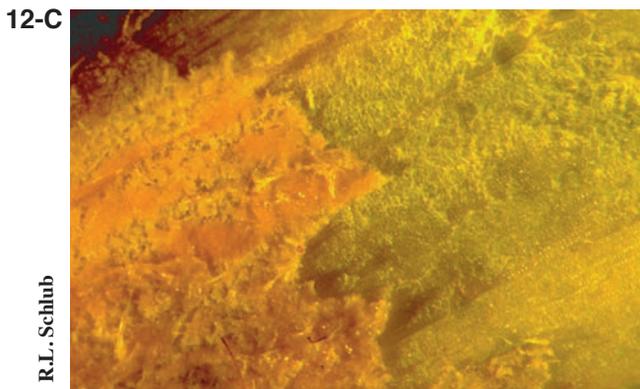
9. A. Cucumber with fruit rot = FR disease Pythium cottony leak.
 B. Cucumber with Pythium crown rot. The same fungus causes damping-off = D of seedlings.



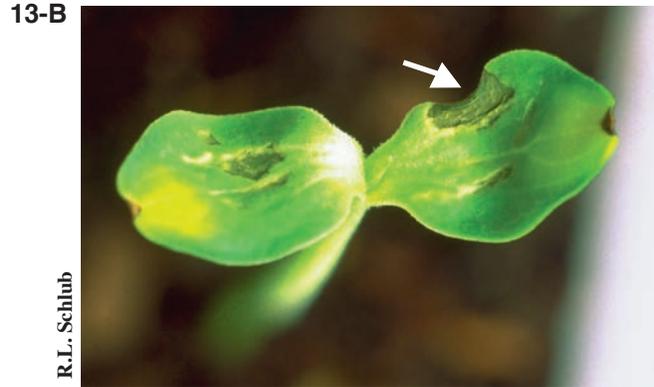
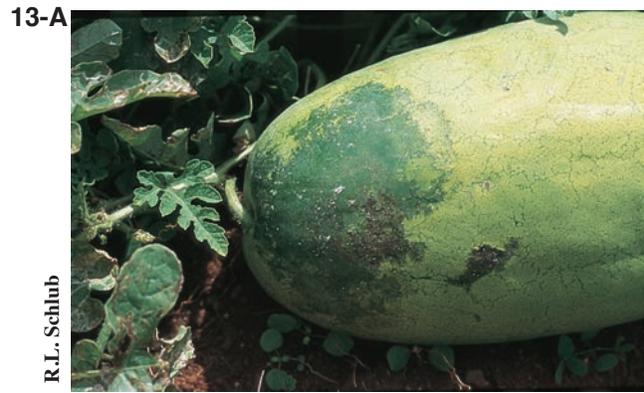
10. Zucchini squash with fruit rot = FR, disease Choanephora fruit rot.



11. Oriental melon with southern blight = SB fruit rot = FR. Diagnostic features include the presence of balls of fungus material and the fungus's fan-like growth.



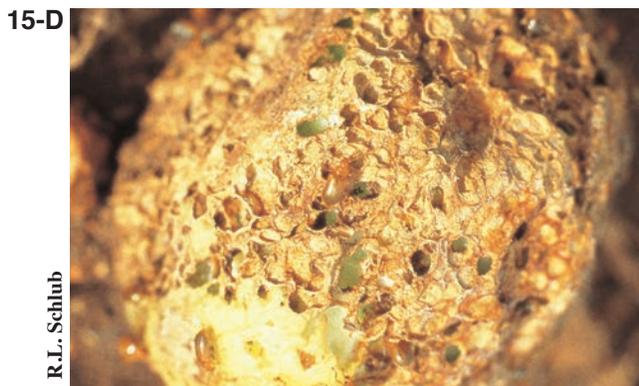
- 12. A.** Watermelon with Fusarium Wilt = FW. Plants often die a few laterals at a time.
B. Cucumber with Fusarium crown and vine rot. Infection occasionally results in a gummy exudate (a) and is often limited to only part of a vine resulting in dead streaks (b).
C. Close up, one may see a salmon-pinkish crust of tightly packed spores.



- 13. A.** Watermelon fruit with bacterial fruit blotch = BFB.
B. Infected area on a watermelon seedling cotyledon.



- 14.** Swellings or knots on feeder roots caused by root knot nematode = RK. Heavy infection may lead to severe, malformed roots and few small feeder roots.



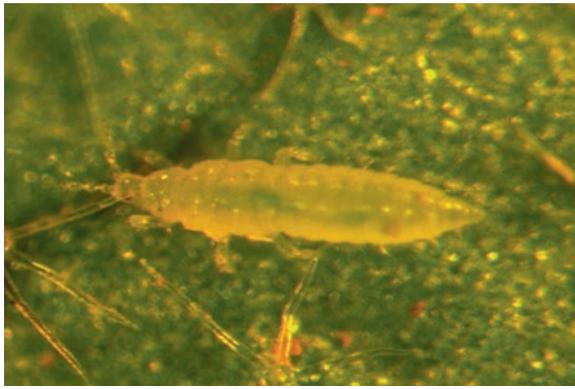
- 15. A.** Adult pumpkin beetle, 6–8 mm ($\frac{1}{4}$ in) chewing on cucumber leaf.
B. An adult beetle cutting semi-circular holes in the leaf.
C. Beetle larvae feeding on young tender roots.
D. Feeding damage on fruit caused by feeding adults.



- 16.** Melon flies, 5 mm ($\frac{1}{5}$ in), are medium size flies with yellow bodies and black markings on their wings.



- 17. A.** Aphids are small, 3 mm ($\frac{1}{8}$ in) soft bodied insects that suck plant sap.
B. Leaves which are home to large colonies of aphids become crinkled.



L.S. Yudin

- 18.** Thrips are very small insects, 1 mm ($\frac{1}{25}$ in). Thrips are found in vine tips and on the underside of leaves of many cucurbit plants. Immature thrips shown above.

20-A



J. McConnell

20-B



L.S. Yudin

- 20. A.** The silverleaf whitefly, 2 mm ($\frac{1}{12}$ in) appear like tiny white moths.
B. The underside of many cucurbit leaves which are heavily infested with whitefly adults and nymphs appears to be covered with a snowy-like substance.

19-A



L.S. Yudin

19-B



L.S. Yudin

- 19. A.** The green semi-looper, 1.3 to 2.6 cm ($\frac{1}{2}$ to 1 in), feeds on the underside of leaves.
B. The cluster caterpillar, last larval instar, 6 cm (2.3 in), is black with small blue and yellow spots along its side.

L.S. Yudin



- 21.** Leafminers get their common names from the tunnel that is produced underneath the leaf surface by feeding larvae.

R.L. Schlub



- 22.** Adult leaf-footed bugs, 3.8 cm (1.5 in), are fairly large insects which are black with red spots on their underside. Commonly found on bittermelon.

R.L. Schlub



23. Slugs are snails that lack shells. They hide in dark, damp places during the day and feed at night. Some species reach 2 to 3 inches in length.

R.L. Schlub



24. Bird damage on watermelon.



25. Wild bittermelon
A broad leaf viny weed
Momordica charantia L.



26. A non-viny weed
Euphorbia heterophylla L.



27. Sour grass or T-grass
A narrow leaf grass weed
Paspalum conjugatum Berg.



28. Purple nutsedge
A narrow leaf weed
Cyperus rotundus L.

J. McConnell



29. Dodder
Parasitic weed
Cuscuta campestris Yuncker



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