Banana Production in Hawaii
August 1999

PRODUCTION FACTS

In 1997, total statewide acreage devoted to banana production reached a record high at 1,590 acres, of which 1,020 acres, or 64% were harvested. Three-hundred additional acres are anticipated for the 1998 growing-season. Bananas locally produced contributed to 44% of Hawaii's fresh market share in 1996. This figure is expected to increase in 1997 & 1998 with the increase in acreage and harvested fruit.

Total harvested yields amounted to 13.7 million pounds in 1997, which was valued at 5.2 million dollars. The farm price of bananas averaged 38.0 cents per pound and produced a yield of 13,400 pounds per acre. (1)

There are three associations affiliated with the banana industry in Hawaii. The Hawaii Banana Industry Association (HBIA), Oahu Banana Growers Association (OBGA), and the Big Island Banana Growers Association (BIBGA) are active participants in the development of the banana industry in Hawaii. The HBIA is the sole statewide industry association and has recently become a partner in the EPA's Pesticide Environmental Stewardship Program (PESP). (2)

PRODUCTION REGIONS

Bananas are grown throughout the Hawaiian Islands. In 1997, there were 170 farms within the state. Seventy-two percent of the total number of farms resides on the islands of Hawaii and Oahu. (1)

BANANA CULTURE

Flower development is initiated from the true stem underground (corm) 9 - 12 months after planting. The inflorescence (flower stalk) grows through the center of the pseudostem. Fruits mature in about 60 – 100 days after flowers first appear, depending on the season and cultivar. Commercial banana production practice limits fruit development to 1-2 pseudostems per mat at any given time.

Once the primary stalk is harvested, a vegetative daughter plant takes over as the producing unit and the granddaughter is allowed to develop. Bananas can also be propagated through suckers, or corms and by tissue culture.

There are many different types of cultivars being grown in Hawaii. However, the Cavendish (Williams, Valery, Chinese, Grand Naim) and Brazilian (Dwarf Brazilian, Brazilian) varieties appear to be the preferred cultivars among island growers. Statistics show 34% of the total acreage under Brazilian production, with Cavendish production making up the 66% difference.

Bananas are best grown in well drained soils and are generally tolerant of low soil pH. Since liming can result in releasing or fixing other nutrients, soils should not be limed to pH greater than 6.0-6.5. Majority of the farms on the island of Hawaii depend on rainfall for irrigation, while growers on the remaining islands rely on drip irrigation lines. (1,3,4,5)

I. INSECTS

A. THRIPS

Elixothrips and *Hercinothrips* are common insect pests in commercial statewide banana production. Their piercing and sucking mouthparts damage flowers, fruit, leaves and stems. Feeding on the leaf tissue of plants result in a silvery discoloration which over time turns dark brown. Hawaiian Flower Thrips, *Thrips hawaiiensis*, feeds only on flowers of host (Takahashi 1936). Flecked, spotted or deformed flowers are a direct result of the Hawaiian flower thrips'

feeding damage. Control treatments for the Hawaiian Flower Thrips are under investigation at this time. In 1996, the banana rust thrip, *Chaetanaphothrips signipennis*, was collected in Hilo, Hawaii. Banana damage caused by this pest varies according to host plant. However, thrips feeds on the pseudostem as well as fruit of banana plantings. Thrip feeding on leaf sheaths result in dark, v-shaped marks on the outer surface of leaf petioles, while fruit damage is characterized by a water soaked appearance. Damaged tissue turns bronzed or rust colored with age. Many young fruits exhibited dark or smoky 'curly cue' feeding tracks on the surface. Characteristic oval shaped red-dish "stains" was observed on mature fruit where fingers touched. Majority of the damage detected is the result of two larva-feeding stages. (4,6)

CONTROL

CULTURAL CONTROL

Polyethylene Bags: To avoid additional losses and insect damage, majority of the fruits produced locally in Hawaii are covered with a polyethylene bag prior to harvest. Growers in Central America utilize polyethylene bags treated with insecticides. Unfortunately, these bags are not registered for use within the State of Hawaii. Preliminary research on the efficacy of these bags indicated they were effective in controlling insects and lowering damage levels. The registration status of these chemically treated bags for use in Hawaii is unknown. (3)

DIAZINON (CLEAN CROP DIAZINON 500AG) is applied to 1,000 acres per year at a rate of 0.5 lbs ai per 100 gallons of water. It is registered under a 24 (c) Special Local Needs label to control banded greenhouse thrips (*Hercinothrips fermoralis*) on banana in Hawaii. It is applied directly to fruit bunches prior to bagging. The label allows for a 28-day pre-harvest interval (PHI).

B. BANANA FRUIT PIERCING MOTH

The fruit-piercing moth, *Othreis fullonia*, is a serious pest in localized areas in Hawaii. It was first reported in Hawaii on Oahu in 1985, and by 1986, it was present on Kauai, Hawaii, Maui and Molokai. Unlike most moth and butterfly pest, the caterpillar stage does not severely damage plant foliage. Instead, the adult moth punctures and feeds on ripening fruit and creates opportunities for fungal and bacterial infections to enter. High moth populations may result in premature ripening and fruit drop. The fruit piercing moth will continue to be a pest of home grown bananas which are tree ripened. In most commercial areas, natural enemies of the banana fruit piercing moth keep populations below economic threshold levels. (4,7)

C. BANANA ROOT BORER

The banana root borer, *Cosmopolites sordidus*, is a continuing problem for commercial and home growers. The larvae of this pest bores through the corn, suckers and roots of existing and decaying planting material. Large number of larvae and extensive feeding can result in root destruction, slowed plant growth, reduced fruit production, and, sometimes, toppled plants. The root borer was first reported in Hawaii on the island of Oahu in 1981and has since spread to Hawaii, Kauai, Maui and Molokai. The adult weevil is a nocturnal insect that feeds and breeds at night. There are no known beneficial parasites within the state. Instead, field sanitation and hot water treatment practices are being used to manage this pest. (4,8)

D. CHINESE ROSE BEETLE

The Chinese rose beetle, *Adoretus sinicus*, was introduced to Hawaii before 1896 and is now a common pest on all major banana-producing islands in the State. The greatest damage is not created by the larvae, but by the beetle itself. The larvae primarily dwells in the soil and leaf litter surrounding the plant crop. The adult beetle is nocturnal and feeds primarily on leaf and inter-veinal tissue. Chinese rose beetles are commonly detected on younger plants. The introduction of parasites to control this pest turned out unsuccessful. Currently, there are no known chemical controls to alleviate this problem. (4)

E. BANANA LEAF ROLLER

Since the introduction of parasites by the State of Hawaii Department of Agriculture, the banana leaf roller is not considered a serious pest of commercial banana production. However, with the loss of several registered pesticides, the banana leaf roller may threaten young and newly planted acres. (3)

F. BANANA SKIPPER

The banana skipper, *Pelopidas thrax,* was first reported on Oahu, Hawaii in 1973 and established itself on all islands by the year 1975. Rolled leaves originating from the mid rib of banana plants are a good indicator of banana skipper damage. Since 1973, six parasites have been identified and continue to minimize damage caused by this pest. Due to the effective biological control of the banana skipper, chemical treatments are uncommon. (4)

G. COCONUT SCALE

The coconut scale, *Aspidiotus destructor,* was first detected on Oahu in 1968 and is now present on the islands of Kauai, Hawaii, and Maui. This pest is classified as an armored scale and is usually found on the under side of leaves. Scales can also attach themselves to petioles, peduncles and fruits. Their piercing and sucking mouth parts extract plant juices which leads to discoloration and yellowing of plant tissue. Currently, the coconut scale is a sporadic problem in Hawaii that affects only the underside of banana leaves. Introduction of natural enemies will be considered if and when outbreaks of the coconut scale warrants it's use. (4)

H. SPIRALING WHITEFLY

The spiraling whitefly, *Aleurodicus dispersus,* was first reported in Hawaii on the island of Oahu in 1978 and by 1981 was detected on all major banana-producing islands. Whiteflies are sap sucking insects that damage and discolor plant leaves and tissue. Similar to aphids and mealybugs, whiteflies excrete honeydew that may lead to black sooty mold. Insects that inhabit banana plantings to obtain honeydew tend to protect whiteflies from natural predators. In addition, whiteflies are commonly known to transmit various plant diseases. In 1979, the spiraling whitefly was considered a serious economic pest. Since then, five natural enemies were introduced into Hawaii from the Caribbean to control this pest. By July 1981, the spiraling whitefly was considered under control. However, since spiraling whiteflies have virus vector capabilities it is an on-going concern for many island growers. (4)

I. BANANA MOTH

The banana moth, *Opogona sacchari* (Bojer) also called *Opogona subcervinella* (Walker), is a pest in Hawaii's banana orchards. Eggs are laid on senescing flowers and on decaying leaves, pseudostems or fruit. The larvae feed on detritus and decaying plant material. They are often found feeding on healthy tissue at the interface with decaying plant parts. The removal of flowers and application of insecticidal bunch treatments prior to bagging appears to greatly reduce damage larval damage.

J. SUGARCANE BUDMOTH CATERPILLAR

The sugarcane bud moth caterpillar, *Decadarchis flavistriata*, is a localized pest in Hawaii. This caterpillar is known to feed on decaying flowers and cause fruit scarring. Many growers have adopted the practice of removing all flowers prior to bagging to reduce sugarcane budmoth damage. At present, the sugarcane budmoth caterpillar is not considered a serious pest problem in Hawaii. (3)

CONTROL

BIOLOGICAL INSECTICIDE

Bacillus thuringiensis (DIPEL 2X) is applied to fruit bunches prior to bagging to minimize damage caused by the sugarcane budmoth caterpillar. Dipel 2X is applied to less than 100 acres per year at a rate of 0.03 lbs ai per acre. Although this product is rarely used, growers need this product and new alternatives to manage serious outbreaks.

II. MITES

The piercing and sucking mouthparts of mites damage plant tissue and fruit. Recently, there has been an increase in damage caused by mites. However, there are no miticides registered in the State of Hawaii for mite control on bananas.

III. DISEASES

A. BANANA BUNCHY TOP VIRUS

The banana bunchy top virus (BBTV) was first discovered on Oahu in 1989. Since then, the disease has been detected on the Kona area of Hawaii and in 1997 identified on the island of Kauai. It is a serious problem for banana growers statewide. Common symptoms of BBTV include 'morse code' streaking on leaves, dot/dash patterns on the lower midrib and leaf blade, distorted fruit, erect and narrow leaves, marginal chlorosis/necrosis, and a 'stack up' of leaves at the apex of the shoot, giving it a bunched, rosette appearance. The banana aphid, *Pentalonia nigronervosa* has been identified as the sole vector of this disease. Adoption of recommended banana aphid management practices is strongly urged. Once the area has been contaminated with the BBTV, eradication of the disease is difficult and the possibility of finding a cure is slim. Prevention is the key. Infected planting material and the failure to destroy diseased plants also attribute to the spread and transmission of the BBTV. The Hawaii Department of Agriculture continues to educate growers and strives to control the spread of this serious disease of bananas. (9,10,11)

CONTROL

CULTURAL CONTROL

Disease Free Planting Material: All newly planted fields should use sterile stock, free of the banana bunchy top disease. By using BBTV-free planting material, temporary prevention of the BBTV is possible.

Crop Residue: Once BBTV contamination occurs, all diseased material should be sprayed for aphids and immediately destroyed. A delay in destruction will result in the spread and build-up of infectious pathogens. One single infected sucker can threaten the entire plantation. Therefore, the entire mat should be removed and destroyed. (11)

Horticultural Oil: Horticultural oils are used as an alternative to chemical pesticides. Oils such as, Volck Supreme and Clean Crop Superior are used to suffocate aphids and other soft bodied pest. These oils are low in toxicity to plants and have little impact on the environment and human well-being.

Soapy Water: Soapy water is used to kill aphids that dwell in leaf pockets and the pseudostem of plantings. Rather than applying pesticides, many homeowners utilize this non-toxic method to reduce aphid populations.

Wind Breaks: Wind breaks can stop or slow the flight of incoming, viruliferous aphids into a banana field, reducing the chance of a new field becoming infested with aphids and BBTV. (12)

DIAZINON (PRENTOX DIAZINON AG500) is registered under a 24 (c) Special Local Needs label for preventative control of aphids on banana. It is a violation to apply this product on fruit bunches and trees bearing fruit. Prentox Diazinon AG500 is applied to 1,200 acres per year at a rate of 0.5 lbs ai per acre.

GLYPHOSATE (ROUNDUP ULTRA) is also registered under a 24 (c) Special Local Needs label. It is injected at a rate of 0.01 lbs ai per 2-3 inches of pseudostem diameter to destroy BBTV infected material. The total number of acres treated with Round-Up Ultra for pseudostem destruction is not presently known.

B. BANANA LEAF STREAK

Banana leaf streak (BLS) disease caused by the fungus *Mycosphaerella fijiensis,* is a destructive disease to banana production in Hawaii. This disease favors warm, wet and humid environments. There are two fungal spores associated with this diseases; conidia (asexual) and ascospores (sexual). These spores are transported by wind currents to new plant host. The fungal pathogens penetrate the leaf tissue and create necrotic lesions, also known as streaks. This streaking effect gives the disease its name, banana leaf streak. This disease is managed through cultural and chemical practices. The use of disease-free varieties, weather monitoring programs and preventative control strategies are encouraged. (13)

CONTROL

CULTURAL CONTROL

Disease Forecasting System: The use and effectiveness of disease forecasting systems are currently being explored. Factors such as weather, disease, cultivar variety, cultural practices, location, soil conditions, and various pest populations are taken into consideration when developing a complex monitoring system. The objective of this forecasting system is to gain a better understanding of the relationship between weather and disease incidence. It is relatively a new approach to disease management. However, it promotes the development and adoption of integrated pest management (IPM) practices. (13)

De-trashing: Removal of severely diseased leaves (or portions of severely diseased leaves) reduces the concentration of airborne spores in the canopy, thereby reducing new infections and disease development. De-trashing also increases airflow and reduces humidity, enabling wet leaves to dry more quickly and increases spray penetration/coverage. De-trashing increases the efficiency of fungicide applications by removing the moot troublesome material (heavily diseased leaves) from the spraying area. De-trashing also increases the penetration of sunlight into the canopy, creating stronger plants and more rapidly drying leaf surfaces. (12)

Site selection and preparation: Better drained soils result in less relative humidity and drier leaves, thereby reducing disease incidence and severity. *M. fijiensis* is dependent upon high relative humidity and abundant free moisture. In addition, plant spacing and density can be managed to decrease relative humidity and duration of leaf wetness, and increase spray penetration and coverage. (12)

AZOXYSTROBIN (ABOUND) is applied at a rate of 0.135 lbs ai per acre. Abound is a relatively new fungicide available to banana growers. Therefore, the total number of acres treated is not currently known.

FENBUCONAZOLE (ENABLE 2F) is applied to 190 acres per year at a rate of 0.09 lbs ai per acre. Environmental conditions and site location cause variations in the number of acres treated per year.

MANCOZEB (DITHANE F-45) is used as a preventative BLS fungicide spray and applied at a rate of 2 lbs ai per acre. Environmental conditions and site location cause variations in the number of acres treated per year. The island of Hawaii is the primary user of fungicides due to the high level of rainfall annually. Dithane F-45 is applied to approximately 700 acres statewide.

PROPICONAZOLE (TILT 250 EC) is registered under a 24 (c) Special Local Needs label. It is applied to approximately 550 acres per year at a rate of 0.1 lbs ai per acre. Environmental conditions and site location cause variations in the number of acres treated per year. The island of Hawaii is the primary user of fungicides due to the high level of rainfall annually.

C. FRECKLE

Freckle is a fungal disease of bananas that affects fruit quality and appearance. It is caused by the fungus *Phyllosticta musarum.* This disease is not a serious concern, except for a few localized areas. (3)

D. PANAMA WILT VIRUS

Panama wilt virus (PWV) is caused by the pathogen *Fusarium oxysporum.* Once the fungus has established itself, it is difficult to eliminate. Disease prevention should include the selection of resistant cultivars, field sanitation and moisture monitoring practices. Varieties that are susceptible to the PWV should be avoided. (3)

E. BANANA MOSSAIC VIRUS

Banana mosaic virus (BMV), also known as cucumber mosaic virus (CMV) affects banana production around the world. Common symptoms of BMV are chlorosis of leaves, mosaic symptoms, and heart rot in bananas. Proper selection of virus free planting material is an effective method of preventing BMV contamination.

IV. NEMATODES

Of the eight different nematode genera reported on bananas in Hawaii, three genera are economically important to commercial banana production statewide. Rootknot, reniform and burrowing nematodes are considered the most damaging nematodes among the eight genera. Nematodes are a major concern for growers especially on the island of Hawaii. These roundworms attack the root system of plants and impair water and nutrient uptake. Fields which are not properly managed for nematodes can result in lower yields and higher crop losses. (14)

CONTROL

CULTURAL CONTROL

Nematode-free planting material is a temporary method of reducing nematode populations. Planting material can be sterilized by hot water treatment or obtaining certified tissue cultured material. Hot water treated material is an effective method of disinfecting planting material of nematodes without significant effects on plant quality. Suckers of uniform size should be held in a 122^{o}F water bath for 10-15 minutes (Trujillo 1964). Care must be taken to balance the soaking time with the size of the corm to ensure sufficient heat to kill nematodes without damaging the corm (14,16)

Fallow and Cover Crops: Nematode populations can be reduced by fallowing fields for six to eight months using a non-host or bare fallow. The longer the fallow period the greater reduction in nematode populations. Due to the possibility of soil erosion, cover crops are currently being investigated as an alternative to bare fallows and chemical nematicides. Cover crops are used to minimize weeds, reduce soil borne diseases, and nematode populations. Additional research continues to explore the use and feasibility of cover crops in banana production because of the impending threat of losing nematicides through regulatory action. (14)

Crop Residue: The removal and destruction of old banana plantings and living material will stop nematode reproduction and begin reducing nematode population densities. (14)

POST-PLANT NEMATICIDES

ETHOPROP (MOCAP EC) is applied to 400 acres per year at a rate of 6.0 lbs ai per acre. It is used primarily on the island of Hawaii for post-plant control of root knot, reniform and burrowing nematodes. Mocap EC is administered around the base of banana plantings.

FENAMIPHOS (NEMACUR 3) is applied to 400 acres at a rate of 3.0 lbs ai per acre. It is administered post-plant to control root knot, reniform and burrowing nematodes. Nemacur 3 is primarily used on the island of Hawaii.

V. WEEDS

Weed management is an important component in macadamia nut production. Weeds not only compete with the crop for food, water, nutrients and sunlight, but they also provide shelter for insects and host diseases. Weeds can be managed through cultural and chemical means.

CONTROL

AMETRYN (EVIK 80W) is applied to annual broad leaves and grasses. It is applied to 300 acres per year at a rate of 1.5 lbs ai per acre.

DIURON (KARAMEX DF) is applied to annual grasses at a rate of 1.6 lbs ai per acre. Karamex DF is applied to 300 acres per year for pre- and post-emergence weed control.

GLYPHOSATE (ROUNDUP ULTRA) is applied to 900 acres per year at a rate of 0.5 lbs ai per acre. The label allows for a one day PHI.

PARAQUAT DICHLORIDE (GRAMOXONE EXTRA) is applied to 900 acres per year. It is applied at 0.625 lbs ai per acre prior to canopy closure.

REFERENCES

1. Statistics of Hawaiian Agriculture. 1997. Hawaii Agricultural Statistic Service.
2. Per letter received from Richard Ha, President of Hawaii Banana Growers Association.
3. Farmers Bookshelf, University of Hawaii, Department of Horticulture. An Information System of Crops in Hawaii.
4. Knowledge Master, University of Hawaii, Department of Entomology and Plant Pathology. Computer Resource Database.
5. Chia, C. L. 1981. Bananas. Commodity Fact Sheet BA-3(A) Fruit. Hawaii Cooperative Extension Service, CTAHR, University of Hawaii.
6. Extracted from presentation made at the monthly Oahu Banana Growers Association meeting by Dr. Ronald Mau. April 1998.
7. R. Mau. 1985. The Fruit Piercing Moth: A New Pest of Fruits in Hawaii. Proceedings from the 17th Annual Hawaii Banana Industry Association Conference.
8. A. Gettman. 1984. Control of the Banana Root Borer in Banana Planting Stock. Proceedings from the 16th Annual Hawaii Banana Industry Association Conference.
9. S. Ferreira. 1989. Bunchy Top Disease. Proceedings from the 21st Annual Hawaii Banana Industry Association Conference.
10. N. Matayoshi. 1993. The Banana Bunchy Top Program on Oahu. Proceedings from the 25th Annual Hawaii Banana Industry Association Conference.
11. Banana Bunchy Top Virus. 1997. CTAHR Cooperative Extension Service Publication.
12. S. Nelson. 1998. Extracted from Banana Integrated Pest Management Guidelines for 1998 Growing Season. University of Hawaii, CTAHR.
13. S. Nelson. 1994. Epidemiology of Black Leaf Streak. Proceedings from the 26th Annual Hawaii Banana Industry Association Conference.
14. B. Sipes. 1993. Controlling Nematodes in Bananas. Proceedings from the 16th Annual Hawaii Banana Industry Association Conference.
15. Trujillo, E. E. 1964. Clean Banana Rhizomes Certification. Hawaii Farm Science 13(4):8-9.
16. Extracted from Hot Water Treatment Project Proposal submitted by Dr. Arnold Hara. University of Hawaii, Department of Entomology. 1997
17. Takahashi, R. 1936. Tysanoptera of Formosa. Philippine J. Science. 60: 427-458.