

BANANA IPM PROTOCOL SUPPORTING DOCUMENTATION

Overview. The Banana Integrated Pest Management (IPM) Protocol was modeled after the National IPM Protocol for Potatoes. The Banana IPM Protocol is supported by guidelines which were defined by a multi-disciplinary team of faculty from the University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources (UH-CTAHR) and the Hawaii Banana Industry Association (HBIA). This program was specifically designed to establish the best management approach for the production of Bananas in the State of Hawaii. Guidelines and point values are used to determine the level of IPM being utilized and are subject to change with new IPM developments.

Point System

Pest management practices are grouped according to five categories: 1) cultural, 2) physical, 3) mechanical, 4) biological, and 5) chemical. Each category is assigned a point value. This point system provides higher value to pest management practices that require active management decisions or reduction of environmental risks.

The system enables the UH-CTAHR IPM Program to determine the level of IPM being utilized while providing growers with a flexible, cost effective and environmentally responsible approach to crop management. To receive 'IPM Verification' the grower must enroll in the program, provide documentation that the Basic IPM level was achieved. This means that the grower has accrued a total of 70% of the total possible points set forth in the Banana IPM Protocol. Pest management practices and the relative credited IPM points for bananas were developed by UH-CTAHR IPM in collaboration with the HBIA.

Five Categories of Integrated Pest Management:

Five terms were used to identify IPM practices. They are:

- **Cultural.** Those practices used in general decisions making on the farm and in pest control.

Scouting and monitoring of fields for pest problems. (5 points)

Establishment of an economic action threshold. (7 points)

Non chemical management. (5 points)

- **Physical.** Those cropping practices used that physically change the farming landscape to control or alter pests. (3 points)
- **Mechanical.** Those farming practices that require mechanical use, cleaning, or adjustment to control or alter a pest. (2-3 points)

Calibration of sprayers. (3 points)

- **Biological.** Those practices used in pest control that are based on biological manipulation, biocontrol measures, etc. Biological decisions receive higher point values due to the promotion and adoption of agricultural practices that minimize risks associated with pesticide use. (3-7 points)

Resistance management decisions involves the rotation of chemicals to effectively control pest populations to prevent jeopardizing new chemicals to pest resistance. (4-5 points)

- **Chemical.** Those practices used in pest control that are chemically based. Examples: herbicides, fungicides, and insecticides. Chemical applications are awarded points due to their ability to provide remedial action to reduce pest populations and severe outbreaks. However, chemical treatments will be credited with points according to their specificity and potential impacts on the environment. (1-4 points)

Choose One:

Broad-spectrum compounds (chemicals that are less specific): (1 point)

Narrow spectrum compound: (3 point)

Reduce-risk or biological compounds: (4 points)

Spot and/or border sprays for weed or host plant pest control. (3 points)

BONUS points are awarded to advanced IPM practices as well as practices which are currently experimental and require additional time before conclusions are drawn.

Calculating Grower IPM Adoption Level

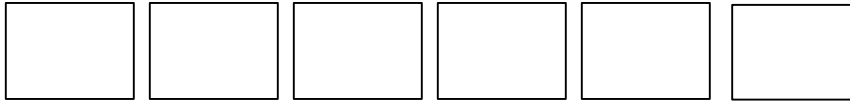
The Banana IPM Protocol does not penalize growers for not having or not-managing pests. To ensure fairness, growers who do not have certain pest problems are not responsible for points under those specific areas of the protocol. These points are deducted from the total possible points available. The grower's score will be divided by the new total possible points and plotted on the IPM adoption continuum. To receive 'verification' the grower must acquire a minimum of 70% (Basic IPM Level) of the total possible points set forth in the Banana IPM Protocol. Total possible points available will vary from farm to farm. An accounting of the production practices of each plantation will be reviewed and verified annually by UH-CTAHR IPM.

Banana IPM Adoption Continuum

Banana IPM Points Available: 225 Points
 Advanced IPM Points Available: 23 Points

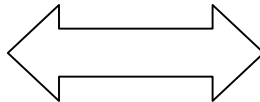
LEVELS OF IPM

No IPM Emerging Basic Established Advanced Optimal



< 50%	> 50%	70%	80%	100%	>110%
< 112.5	> 112.5	157.5	180	225	> 247.5
Points	Points	Points	Points	Points	Points

Chemically dependent
 Low decision-making



Biologically dependent
 High decision making

** Total possible points will vary depending on the pest situation at different geographic locations.

PEST MONITORING AND MANAGEMENT

✓ DO YOU HAVE A PEST PROBLEM?

What is a pest? The Banana IPM Protocol has defined a pest to be an organism that causes economic damages or losses which in turn affects the profitability and/ or sustainability of agricultural production systems. The primary goal of the Banana IPM Protocol is to retain or enhance production system yields without providing a negative impact to the environment. The strategy of IPM encompasses the utilization of principles including proper pest identification, continual pest monitoring, establishing an economic action threshold, and the implementation of pest control measures. Therefore, it is important to first identify if an organism is a pest or not. Growers who do not have certain pest problems are not responsible for points under those specific areas of the protocol.

✓ PEST MONITORING:

IPM is an ecologically based system that focuses on minimizing crop losses through the use of multi-disciplinary collaboration of crop production practices and principles. The importance of crop monitoring is to assess the pest situation to determine if the existing population numbers justify control actions. Monitoring of pest and diseases on a routine basis prior to implementation of control measures ensures that pesticide applications are precise and reflect time.

✓ **ESTABLISHMENT OF AN ECONOMIC ACTION THRESHOLD:**

Establishment and enforcement of an economic action threshold is a fundamental component of integrated pest management systems. A pest specific action threshold is the established level a pest population must reach before treatment to control the pest can be initiated without jeopardizing economic loss. Development of pest thresholds are area and season specific and require extensive research and knowledge on the targeted pest's lifecycle and history. Economic action thresholds promote effective pest management, while minimizing risk to human health and our existing natural resources. It will be at the discretion of growers to decide whether to take or to withhold action triggers once economic action thresholds are surpassed.

Banana Rust Thrips Management

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.

- **Install un-treated bags over the bunches as soon as it is allowed by label restrictions.**

To avoid additional losses and insect damage, it is recommended that fruits produced locally in Hawaii are covered with an un-treated polyethylene bag prior to harvest.

- **Apply insecticide spray 1-3 times during flowering.**

To control thrips populations and minimize severe aesthetic damage, insecticide treatments should be applied 1-3 times during flowering. The last application should be made immediately after the male flowers have been removed.

Rind and Green House Thrips Management

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.

- **Installation of untreated bunch covers will prevent establishment of rind and green house thrips.**

To avoid additional losses and insect damage, it is recommended that fruits produced locally are covered with an un-treated polyethylene bag prior to harvest. Installation of bunch covers will minimize additional pesticide treatments to

exposed fruit and prevent the establishment of rind and green house thrips on bunches.

Flower Thrips Management

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. Unfortunately, there are no recommendations at this time.

Banana Root Borer Management

- **Cut and remove all harvested stumps to prevent borer breeding.**
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. Therefore, all harvested stumps should be cut and removed from the orchard to prevent borer feeding and breeding.
- **Minimize plant debris around planting mats.**
The adult weevil is a nocturnal insect that feeds and breeds at night. During the daylight hours, banana root borers hide underneath plant debris and around the soil of banana plantings. Proper field sanitation practices such as minimizing debris matter from around the planting mat area will prevent buildup of pest populations.
- **Apply insecticides when environmental conditions permit.**
When economic action threshold are surpassed, apply approved insecticides to minimize root borer populations as soon as environmental conditions permit. Follow label specifications.

Banana Skipper Management

- **Encourage biological insects that control the banana leaf roller, spiraling whitefly, and banana skipper.**
Due to effective biological control of insects pest such as the banana leaf roller, spiraling whitefly, and the banana skipper chemical treatments are infrequent. To continue minimization of chemical inputs, protection of biological insects are encouraged.

Sugarcane Budmoth Management

- **Remove all flowers prior to bagging to reduce budmoth damage.**
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. Growers are advised to remove all flowers prior to bagging to reduce sugarcane budmoth damage.

Nematode Management

Plant parasitic nematode management strategies should be applied after a harvest rather than calendar based (i.e. not once every 6 months) to protect new roots. Sipes

Banana Bunchy Top Virus (BBTV) Management

- **Monitor fields for BBTV symptoms and aphid populations.**
Banana aphid is the vector of Banana Bunchy Top Virus. Control of this insect in diseased fields helps to reduce the rate of disease spread. Early detection of diseased plants allows eradication of disease, and slows the spread of disease by reducing the amount of inoculum in the field. Nelson
- **Destroy BBTV infected plants and kill aphid populations.**
Destruction of the BBTV-infected plant also kills the infecting virus. The destruction of aphids on the plant prevents viruliferous aphids from spreading the virus to un-infected plants. Nelson

Black Leaf Streak Management

- **Utilize weather forecasting information to time management strategies.**
Timing of management decisions on the basis of weather forecasts increases the efficiency of the operations. For example, do not spray fungicides immediately before, during or after rainfall or when leaves are wet. Spraying when leaves are wet reduces product adhesion to leaf surfaces and dilutes the active ingredient. Do not spray during periods of high wind speed. High winds can reduce fungicide efficacy by preventing or reducing adequate coverage of banana leaves. Nelson
- **Removal of unwanted or unnecessary plants to encourage better air circulation and lower relative humidity in canopy (quarterly).**
Removal of unnecessary plants (e.g., unwanted “water suckers” and extra sword suckers) encourages better air circulation and lower relative humidity in the banana canopy. *Mycosphaerella fijiensis* (the fungus causing black leaf streak) requires high relative humidity and/or extended periods of leaf wetness to complete its life cycle, and by encouraging air circulation and lower relative humidity the farmer can promote rapid leaf drying and conditions which are less favorable for infection, symptom development, and fungal reproduction and dispersal. Pruning also increases spray penetration/coverage and reduces total amount of fungicide needed by removing unwanted plant foliage from the spraying area. Pruning also increases the penetration of sunlight into the canopy, creating stronger plants and more rapidly drying leaf surfaces. Nelson
- **Removal of plant debris to minimize disease inoculum**

Removal of plant debris (foliage) removes inoculum from the field; turning detached leaves facedown on ground reduces spore discharge into atmosphere.

Nelson

- **De-trashing of severely diseased leaves.**

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.

Nelson

- **Selection of large pseudostem keikis for higher BLS tolerance.**

Plants with larger pseudostem diameter will tolerate more black leaf streak disease than plants with smaller pseudostem diameter. There is a positive correlation between pseudostem diameter and total bunch weight. Keikis with larger stem diameters will produce larger bunches than keikis of similar age, but with smaller pseudostem diameters.

Nelson

- **Fungicide resistance management strategy i.e. rotation, etc.**

Incorporating fungicide resistance management strategies, i.e., mixtures of fungicides, rotation of fungicides, etc., reduces the probability that fungicide-resistant pathogen populations will evolve.

Nelson

Weed Management

Weeds cause a variety of problems in banana orchards, if left uncontrolled. They can compete with banana plants for water, nutrients, and sunlight. Younger orchards are generally more susceptible to weed competition than older orchards, as tree canopy increases and severely restricts weed growth. Weeds interfere with foot traffic, and increase harvesting costs.

All weeds in Hawaiian banana orchards can be grouped by life cycle. Annuals arise from seed; they germinate, grow, flower, and produce seeds within a few months, but may continue to grow for more than one year. Perennials can arise from seed or vegetative parts (rhizomes, stolons, tubers, and roots), and live for more than two years; many perennials do not require seed to propagate themselves. They are generally more difficult to control because of its extensive vegetative reproductive system.

Weeds can be controlled by non-chemical means such as mowing, cover crops, mulching, and cultivation, or chemically with preemergence and postemergence herbicides. A key element of integrated pest management is to reduce the amount of

herbicides used. This may include the effective use of a non-chemical control measure, but in some cases, the proper choice and timing of herbicides can greatly reduce the total amount of herbicide used.

Many of the weed problems associated with banana orchards can be addressed with proper preplant strategies. In general, most orchards are started with a mechanical knock down of existing vegetation. Heavy equipment is used to either scrape off the existing weed mass or plow it into the soil. Planting bananas soon after the removal of cover represent the worst way to start a new orchard. New plantings should begin with a knock down of existing foliage followed by close mowing. The mowed foliage should be allowed to regrow to a height of 6-8 inches to provide sufficient foliage for the adsorption of systemic herbicides. The weed regrowth should be treated with systemic herbicides containing glyphosate (Roundup Ultra, Rattler or Touchdown). Seldom will one application be enough to thoroughly kill all existing vegetation. One or two more spray applications should be applied to kill off as many perennial weeds as possible. When spraying has killed the existing vegetation, the orchard soil should be tilled to incorporate the required soil amendments. Following soil incorporation of amendments, weeds should be allowed to grow to allow for the kill of any emerged annual or perennial weeds. After a complete killed of new weeds, banana planting can begin.

These preplant weed control procedures are designed to eliminate as many of the weed propagules from the soil surface 1-2 inches as possible. It is important to remember that any soil brought to surface from 2-6 inches deep will have many weed seeds in it. Therefore, when holes for banana plants are prepared the backfill should be placed on a tarp or canvas so that all of it can be returned to the planting holes. Keeping the subsoil off of the soil surface will help to reduce subsequent weed pressure and improve the efficacy of chemical control measures. DeFrank

Weeds can harbor populations of the vector of the banana bunchy top virus, the banana bunchy top aphid. Fields should be kept virtually free of weed hosts for these aphids. By reducing aphid numbers, the rate of spread of banana bunchy top also is reduced. Nelson

- **Apply pre-emergence herbicides prior to canopy closure.**

Weeds are easiest to kill when moving from the cotyledon to the first true leaf stage. Pre herbicides like Diuron and Evik can be used to kill small-emerged weeds when proper surfactants are added to the spray solution. Spraying when weeds are small will help to reduce preemergence herbicide usage. DeFrank

- **Non-chemical weed management techniques (mowing, cover crops, cultivation, etc.).**

The areas around each banana plant should be kept free of weedy vegetation. To reduce herbicide, establish a low growing shade tolerant cover crop and mowed to a desirable height. A persistent cover crop in the between row space will

crowd out weeds and thus eliminate or reduce the need to treat these areas with herbicides. Examples of shade tolerant grassy cover crops include St. Augustine Grass (*Stenotaphrum secundatum*) and Carpet Grass (*Axonopus compressus*).

DeFrank

- **Establish weed maps for use in determining herbicide types and rates.**
Weed maps will provide a detailed listing of problem weeds in each field. Herbicides can be selected to match the problem weeds and where possible use lower rates if more sensitive weeds are present.
DeFrank
- **Establish and maintain a weed free boarder.**
Prevent vine weeds from encroaching on the orchard. Vine-type weeds can enter a banana orchard from borders that contact weedy non-crop areas. A weed free border should be established around the perimeter of each banana planting to prevent invasion of vine type weeds.
DeFrank

Maintain Spray Records and Calibrate Sprayer Once a Year.

All spray equipment should be inspected for leaks and overall good operation at the beginning of each spray day (cleaning equipment at the end of each spray day is desirable as it could prevent equipment deterioration and cross-contamination). If applicable (e.g. broadcast applications), the sprayer should be calibrated before each spray day. Worn nozzles should be replaced and any other component of the equipment immediately repaired or replaced before spraying. Maintain spray records (e.g. amount of pesticides applied, method of application, area treated, etc.) Note: Although spot spraying generally doesn't involve calibration, equipment still should be inspected, and application records maintained.
Kawate

Optimum spraying efficiency means that pesticides are not wasted and are applied at the desired rate. Do not spray immediately before, during or after rainfall.

Nelson

Planting Decisions

- **Selection of tolerant or resistance commercial cultivars to Panama Wilt, nematode, and other pest.**
Banana cultivars differ in their susceptibility to nematodes. Cultivar selection can reduce the need for chemical pesticide applications.
Sipes
- **Use sterile planting material, clean of diseases, nematodes, banana root borer, and other insect pest. Examples: HWT, trim, tissue culture, etc.)**
Planting virus-free seed (tissue cultured or seed from virus-free field) eliminates the possibility of latent infection starting an epidemic in a clean field, by eliminating inadvertent introduction of initial inoculum into the field.
Nelson

Nematode-free planting material allows plants to establish vigorous growth before resident nematode populations increase to damaging levels. Nematodes can be found in the corm as well as the root tissue of bananas. Removal of the outer roots and corm tissue is not sufficient. Nematode-free planting can be obtained from tissue-cultured plants or hot water treated plants. A hot water treatment raising the corm tissue to 49⁰C for 10 minutes will kill infecting nematodes. Sipes

- **Use adequate plant spacing and density.**

Black Leaf Streak. Planting spacing and density can be managed to decrease relative humidity and duration of leaf wetness, and increase spray penetration and coverage. Do not exceed approximately 650-700 plant mats per acre. Plantings that are too dense will have restricted air movement, high relative humidity, prolonged periods of leaf wetness, and poor sunlight penetration.

Nelson

- **Use single row or double rows when planting to optimize spray penetration and coverage.**

Black Leaf Streak. Planting in single or double rows increase fungicide penetration and coverage, in relation to planting with three-row or four-rows between roads. Fungicide sprays can be blocked from penetrating inner rows of bananas by the rows of bananas adjacent to the sprayer. More exposed planting systems also increase the penetration of sunlight into the canopy, creating stronger plants and more rapidly drying leaf surfaces.

Nelson

- **Installation of wind breaks at planting.**

Banana Bunchy Top Virus. Windbreaks 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.

Nelson

Nutrient Management

- **Leaf tissue analysis conducted twice a year. Maintain records and fertilizer according to test results.**

Regular use of soil and plant tissue analysis is critical to maintaining adequate, but not excessive levels of soil fertility. Tissue analysis is a useful tool since the plant uptake is indicated and deficiencies or excesses of elements can be corrected in subsequent nutrient or amendment applications. Requirements for the application of nutrients can best be determined through graphing of long-term trends in plant tissue levels and through comparison with established critical and adequate nutrient levels. When used along with soil analyses, better nutrient management recommendations can be provided. [Note: several leaf tissue analyses per year may be useful in new plantings, to establish fertilizer requirements.]

Evensen

- **Annual soil analysis to determine pH regulation and pre-plant fertilizer requirements.**

Some amendments such as lime and phosphorus are best applied at planting since they should be mixed with the soil. In mature orchards, lime and P applied to the surface may not leach to deeper soil layers. Evensen

- **Calibrate and service fertilizer spreader annually.**

Regular servicing and calibration of spreaders is necessary to insure accurate and uniform application of nutrients to avoid excessive or insufficient applications to various areas on the farm. Evensen

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Banana IPM Multi-Disciplinary Committee

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