



Light Brown Apple Moth (LBAM)
Epiphyas postvittana
Nursery Industry
Best Management Practices



Integrated Pest Management
Practices Manual



Authors' Acknowledgements and Credits

These voluntary recommended Best Management Practices (BMPs) provide practical culture and biosecurity guidelines intended to assist nursery crop producers in developing an effective monitoring and action plan to reduce the risks associated with LBAM for growers and/or interstate shippers of host and associated host plants of Light Brown Apple Moth (*Epiphyas postvittana*), or LBAM. The control of LBAM is based on minimizing the risk of introduction and preventing the establishment of the pest within nurseries.

The Cooperative LBAM Program of the U.S. Department of Agriculture/Animal Plant Health Inspection Service/Plant Protection and Quarantine (USDA/APHIS/PPQ) and the California Department of Food and Agriculture/Plant Health and Pest Prevention Services (CDFA/PHPPS) convened a state working group in January, 2009 to develop a basic menu of applicable systems approaches or BMPs for LBAM appropriate for nurseries, greenhouses, and cut flower growers. The working group was comprised of diverse representatives of LBAM Program staff, the nursery industry, the California Association of Nurseries and Garden Centers (CANGC), University of California Cooperative Extension, and the California Center for Urban Horticulture at University of California, Davis.

The working group would like to thank Helene Wright, Gary D. Carpenter, and Patrick McPherrin of USDA/APHIS, John D. Blasius and Bob Dowell of CDFA, and Robert Dolezal of CANGC for their vision, organizing the BMP Training Manual development project, and assembling the working group. Special thanks go to Leah D. Gayagas, Craig D. Noble, and Zachary J. Teachout of USDA/APHIS/PPQ; Steven Tjosvold and Neal Murray of U.C. Cooperative Extension; and Dave Fujino of the California Center

for Urban Horticulture, U.C. Davis, for their dedication and efforts. For the nursery industry, warm appreciation goes to Jon Beard, Dave Cavanaugh, David Cox, Richard Hartman, Steven Popp, John Service, Karen Suslow, and Jeff Rosendale, all of whom provided valuable experience by evaluating the content within the context of their working nurseries.

The Light Brown Apple Moth Best Management Practices Manual was edited by Robert Dolezal and prepared for publication by CANGC. Funding for reproduction and distribution of the manual was provided by USDA/APHIS/PPQ.

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The editors appreciate the cooperation of the following individuals and organizations that generously contributed photographs and illustrations to this manual (individual photo credits appear with each picture in the body of the manual; all photos are used by permission of their owners and/or copyright holders):

California Cut Flower Commission
California Department of Food and Agriculture
California State University System
Jack Kelly Clark, University of California
Cooperative Light Brown Apple Moth Program
of the U.S. Department of Agriculture and the
California Department of Food and Agriculture
Marc Epstein, CDFA
Todd Gilligan, Colorado State University
Hines Nurseries LLC
Neal Murray, University of California Cooperative Extension

New Zealand Institute for Plant and Food Research, Ltd.
South Australia Research and Development Institute
Entomology/Greg Baker
Steve Tjosvold, University of California Cooperative Extension
The Regents of the University of California
University of California/Agriculture and Natural Resources
College
University of California Cooperative Extension
U.S. Department of Agriculture/Animal Plant Health
Inspection Service
Village Nurseries, Inc.

BACKGROUND

Why Light Brown Apple Moth (LBAM) is Important

LBAM (*Epiphyas postvittana*) is a non-native, invasive, leaf-rolling (*tortricid*) moth from Australia with a history of significant crop damage across many plant families. USDA/APHIS has designated LBAM an Actionable pest, subject to a federal order of quarantine, eradication, and control. CDFA has established a state interior quarantine and put eradication protocols in place for all production and retail nurseries within areas infested by LBAM. These regulations also impact residential homeowners and other agricultural commodity producers within the quarantine boundaries. Presence of LBAM in a nursery imposes significant and ongoing cost impacts and responsibilities on the business establishment. Compliance with a robust Best Management Practices (BMP) Program will reduce these costs.

Regulatory Authority

Every production and retail nursery in an established LBAM-quarantine area must sign and comply with a legally binding compliance agreement issued by the LBAM Program, jointly managed in combination by USDA/APHIS and CDFA. Trade restrictions prohibit shipment of LBAM-infested plant material to many countries. Similar prohibitions prevent movement of LBAM-infested materials in interstate commerce within the United States. In intrastate commerce, movement of LBAM-infested plants is prohibited unless specific treatment protocols are followed.

Identification and Biology of the Insect

Learn about LBAM and its habits by referring to Appendix A: Biology and Appendix C: LBAM Staff Training. Become familiar with LBAM in all of its life stages and learn to recognize its host plant preferences and identify evidence and symptoms of its presence on plants. Consult the resources available through the LBAM Program staff, U.C. Cooperative Extension, U.C. County Farm Advisors, U.C. Master Gardener Program, county agricultural biologists, and online Internet resources offered by USDA/APHIS and CDFA. For suggestions of current online and bibliographic resources about LBAM, refer to the appendices of this BMP manual.

Authority and Responsibilities of BMP IPM Managers

Assign responsible senior nursery personnel authorized to manage the best management practices program for LBAM and integrated pest management procedures of the establishment. Create and apply written job descriptions tasking specific staff members with control of daily operations, training, inspections, and actions regarding LBAM.

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Native foliage surrounding nurseries is a key factor for LBAM risk

JUDGING NURSERY RISK FOR LBAM

UNDERSTANDING RISK FROM LBAM

Determine whether the nursery is at risk of becoming LBAM infested; whether the risk is high, medium, or low; and whether the degree of risk is increasing, staying constant, or declining.

Goal: Establish awareness of the business’s risk caused by LBAM and evaluate where those risks may be reduced or eliminated as foundations for a strong bmp program for LBAM.

Rationale: Nurseries may become infested with LBAM by three primary means: (a) migration into the nursery of egg-laying female moths from wild or cultivated host-plant foliage beyond the nursery perimeter or via landscape plantings of host plants on nursery grounds; (b) transport of life stages of LBAM into the nursery on incoming propagation materials or live plants; (c) reproduction and infestation due to survival of LBAM on improperly treated infested plants or pruned foliage.

Resources: Consult Appendix B: Risk Assessment Tools for evaluating risk to the nursery from LBAM.

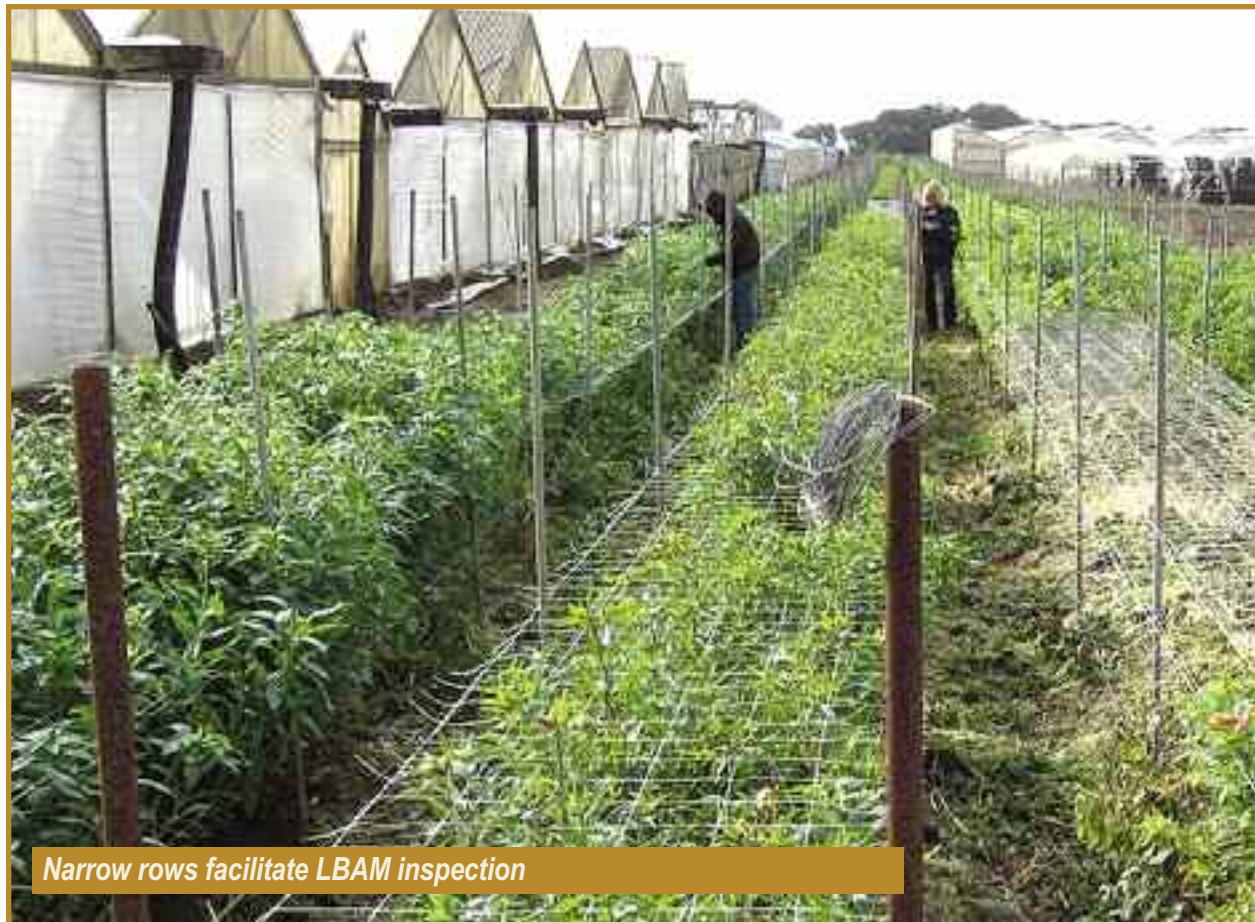
1 BMP

Understanding Risk from LBAM

Recommended Nursery Option

N/A

Other Notes:



Cooperative LBAM Program

Narrow rows facilitate LBAM inspection



Cooperative LBAM Program

Protect LBAM-preferred host plants with indoor structures

Section 1.A



Sharing LBAM experience with nursery personnel under actual nursery conditions

NURSERY PERSONNEL TRAINING

TRAINING AND EDUCATING NURSERY PERSONNEL

2 BMP

Training & Educating



Required

Regulatory Requirement:

Train all staff in:

- Biology of the pest
- Behavior of the pest
- Symptoms and damages it causes to plants during each of its life stages
- How to distinguish LBAM symptoms from look-alike insects and conditions.
- How to recognize preferred host plants, with special attention to incoming shipments and the nursery's surroundings.

Educate nursery supervisors and staff to recognize LBAM in all its life cycle stages. Know its preferred host plants, the preferred schedule and techniques for monitoring and scouting the nursery and stock inventory for the insect, and what actions to take when it is discovered.

Goal: Communicate the risks the nursery faces from LBAM. Understand and establish materials, processes, and procedures required to monitor the nursery for LBAM and deal with it if found. Make all nursery staff familiar with LBAM in each of its life stages, its preferred host plants, and the symptoms of its presence. Designate specific nursery staff responsible for inspection and train them on LBAM. Make nursery staff aware of all LBAM infestations adjacent to or surrounding the nursery facility. Establish actions to take upon discovery of LBAM in the nursery and train staff to apply them.



Visual aids and field training combine to educate nursery staff regarding LBAM

TRAINING AND EDUCATING NURSERY PERSONNEL...continued

Rationale: Reductions in the numbers of LBAM finds on nursery premises by LBAM Program inspectors during regulatory inspections and trapping typically follows effective nursery staff training. Nurseries are monitored individually to measure that risks from LBAM are reduced following staff training. Training and education programs are a necessary and important part of recognizing and detecting LBAM, as well as preventing infestations from becoming established. The nursery relies on their knowledge and experience to keep it free of LBAM, avoid regulatory inspection finds of LBAM, and prevent business disruption and consequential eradication expenses.

Resources: Consult Appendix C: LBAM Staff Training for training program practices useful for evaluating risk to the nursery from LBAM. Consult the bibliography and online resources in the back of this manual for training and learning materials. Training may use many teaching methods and aids, from personal demonstration and visual identification tools to videos, workbooks, and handouts. New materials to aid instruction on LBAM regularly appear; consult LBAM Program staff for new references and resources for training sessions.



Check incoming shipment of plants for invasive pests such as LBAM

PREVENTION AND EXCLUSION

3 BMP

Sourcing of Plants

Recommended Nursery Option

N/A

Other Notes:

SOURCING OF PLANTS AND PROPAGATION MATERIALS

Identify all sources of incoming plants and propagation materials, and accept only clean, disease- and pest-free plants.

Goal: If the nursery receives plant stock or materials produced by other growers or has returns of delivered merchandise from within an LBAM-quarantine area, establish procedures to perform receiving inspections to assure incoming stock is clean before releasing it into the nursery's general stock inventory. Establish procedures for rejecting shipments. Nurseries may establish separate holding areas for incoming shipments; separate received inventory from general stock inventory and establish holding periods.

Rationale: Receipt of incoming stock from infested sources, including but not limited to growers, trade, local sales, landscapers, etc., is a pathway for LBAM to enter the nursery. Procedures to limit this risk are warranted since BMP methodologies stress clean stock as a starting point for exclusion of pests.



A neat and clean nursery is less likely to have an infestation

CULTURAL PRACTICES AND SANITATION

Keep the nursery clean and weed-free, and dispose properly of all waste.

Goal: Establish a weed-abatement program and keep the nursery free from weeds. Promptly remove all leaf litter, pruning debris, dead plants, fruit, and foliage and dispose of same in accordance with LBAM Program guidelines for green waste removal or safe composting. Grow containerized plants on cleanable surfaces.

Rationale: Weeds and LBAM-host plants growing in the nursery increase exposure to LBAM infestation. LBAM finds in such plants subject the nursery to the same regulatory requirements as for stock inventory. Green waste and cut plant material can harbor LBAM larvae and pupae; it also moves the pest from area to area. Cleanable surfaces can be swept or hosed clean to avoid harboring pests.

4 BMP

Training & Educating



Required

Regulatory Requirement:
Nursery shall comply with California Department of Food and Agriculture Standards of Cleanliness, Food and Agriculture Code §3060.2(b).



Use tarps or screens to safeguard nursery stock from surrounding vegetation

5 BMP

Perimeters & Barriers

Recommended
Nursery Option

N/A

Other Notes:

NURSERY PERIMETERS AND BARRIERS

Plan, institute, and maintain active procedures and programs to keep LBAM from entering, infesting, or becoming established in the nursery.

Goal: Exclude LBAM from the nursery and monitor environmental pressure from nearby nursery surroundings.

Rationale: Landscape plantings and native surrounding foliage nearby the nursery may harbor active LBAM infestations. Monitoring over time the populations of LBAM, beneficials, related organisms, and related leaf-rolling moth species found on the perimeter and within the nursery helps determine when risk of infestation is highest. Closely inspect large plots of single-variety plantings of known LBAM-host plants. Fostering beneficial insects and predators in the nursery and trapping LBAM when they enter the nursery reduces risk of infestation of stock and finds. Reducing night lighting reduces moth attraction rates.



U.V. Light Traps help to protect perimeters

Cooperative LBAM Program

NURSERY PERIMETERS AND BARRIERS ...CONTINUED

Resources: Consult the resources section for information on active barriers and biological controls to determine the benefits of detection trapping (e.g. pheromone-baited and non-pheromone sticky traps), active barriers (e.g. UV-insect zappers), biological control measures (e.g. spiders, wasps, beetles), and operating practices (e.g. eliminating or turning off moth-attracting light fixtures in the nursery at night).



Preparing pheromone impregnated twist-ties for deployment

6 BMP

Mating Disruption & Prevention

Recommended Nursery Option

N/A

Other Notes:

MATING DISRUPTION AND PREVENTION

Establish and maintain an active program for LBAM pheromone mating disruption within the nursery for both field and greenhouse inventory stock.

Goal: Implement LBAM mating disruption measures to reduce the risk of LBAM being attracted to or depositing eggs on nursery stock and reduce likelihood of LBAM detections on nursery grounds.

Rationale: LBAM males find females to mate primarily by following pheromone scent trails. Baiting with pheromone at close intervals has been shown to reduce the likelihood of the male moths finding females and successfully mating, thus preventing the laying of viable eggs.

Resources: Consult U.C. Cooperative Extension farm advisors for advice and information on using pheromone-mating disruption agents in nurseries. Consult the bibliography and online resources in the back of this manual for sources of information on mating disruption agents.



Cooperative LBAM Program



Cooperative LBAM Program



California Department of Food and Agriculture

Carnivorous bluebird house, spiders, Trichogramma wasp parasitizing a moth egg

PREVENTION USING BENEFICIAL INSECTS AND BIOLOGICAL CONTROLS

Establish and maintain an active program for biological control of LBAM within the nursery.

Goal: Encourage predators and parasites of all stages and species of leaf-rolling moths and spot treat with parasitoid-benign agents.

Rationale: Maintaining natural predation and parasitic organisms is continuously effective and is generally preferable to chemical control of LBAM. Spot applications of chemicals preserve the biota of the nursery outside of the application area and aid in eliminating LBAM. Installation of birdhouses and bat boxes on nursery grounds attracts these insect-eating animals, reducing LBAM adult and larval populations. Monitoring of the habitat frequented by beneficial insects is necessary to avoid harboring an LBAM environmental reservoir.

Resources: Consult U.C. Cooperative Extension farm advisors, the bibliography, and online resources in the back of this manual for sources of information on natural predators and parasites of LBAM.

7 BMP

Prevention

Recommended Nursery Option

N/A

Other Notes:



Screens that can be closed at night will isolate plants and prevent infestation by LBAM

8 BMP

Isolation & Protection

Recommended Nursery Option

N/A

Other Notes:

ISOLATION AND PROTECTION OF PLANTS

Employ isolation and barrier-protective measures (e.g. hoop covers or greenhouses) to protect preferred host species of LBAM. Prevent LBAM from infesting plants by moving them indoors or safeguarding them.

Goal: Prevent LBAM from gaining access to nursery stock and structures through isolation and protection.

Rationale: Barriers prevent adult female moths from reaching host plants and laying eggs. Barriers may be temporary (ie. frost cloth) or permanent (ie. greenhouses).



Greenhouses provide the most secure isolation



Plants in exterior locations have greater risk of LBAM infestation

9 BMP

Responsibility for Inspection



Required

Regulatory Requirement: Nurseries subject to LBAM compliance agreements are required to designate a responsible manager to oversee their LBAM BMP program, train staff to recognize LBAM and its symptoms, and maintain a current knowledge of effective scouting techniques.

MONITORING AND SCOUTING

ASSIGN RESPONSIBILITIES FOR INSPECTION

Establish and maintain an LBAM scouting team appropriate to the nursery's scale. Designate and train LBAM-scouting team supervisors and members to regularly monitor and scout the nursery grounds and nursery stock. Maintain monitoring and scouting records.

Goal: Establish nursery procedures and protocols for conducting LBAM-specific inspections to detect at early stages any infestations or damage to plants resulting from LBAM. Train all LBAM scouting personnel until proficient on the insect's biology and behavior. Make the scouting team a resource that protects the nursery from LBAM.

Rationale: Making specific staff responsible for LBAM scouting and record keeping assures the nursery will comply with the BMP and deter LBAM finds. Assigning specific staff simplifies the BMP program's management.



Suspected LBAM finds require collection of life stages and plants even in indoor settings

CONDUCT IN-HOUSE INSPECTIONS FOR LBAM

Perform regularly scheduled, repeated inspections of nursery premises, landscape plants, and nursery stock to find and eradicate any LBAM infestations. Maintain records of inspections, finds, and actions.

Goal: Reduce or eliminate entirely, finds of LBAM in the nursery by LBAM Program inspectors during regulatory inspections. Compile records documenting in-house inspections and results.

Rationale: An effective scouting and monitoring program demonstrates through reducing the quantity, rate, and severity of LBAM finds during regulatory inspections, that the BMP is working and risk of the nursery spreading LBAM is minimized. Written records are suitable for evaluating efficacy and risks due to LBAM. In-house inspections complement compliance inspections.

Resources: Consult Appendix B: In-House Inspection Program Elements for effective monitoring and scouting practices.

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In-House LBAM Inspections



Required

Regulatory Requirement: Nurseries subject to LBAM compliance agreements are required to conduct regularly repeated scouting and monitoring inspections and demonstrate that their entire nursery premises are free of LBAM. They must retain written records of when inspections took place, what they found, and what actions were taken. In-house inspections do not replace regulatory inspections by LBAM Program inspectors.

Cooperative LBAM Program



Cooperative LBAM Program



Destruction by burial

ACTIONS AND TREATMENTS FOR LBAM INFESTATIONS

DESTRUCTION OF PLANT INVENTORIES

11 BMP

Destruction of Plant Inventories

Voluntary Nursery Option

N/A

Upon discovery of suspect LBAM life stages in a nursery, voluntary destruction under regulatory authority followed by reinspection is an option until the suspect is confirmed as LBAM.

Remove LBAM-infested plants from nursery stock and safely destroy them to eliminate LBAM infestations.

Goal: Eliminate LBAM infestation in nursery stock by removal from inventory or destruction of LBAM-infested plants, following LBAM Program approved guidelines for destruction and movement of such material.

Rationale: When a small number of plants are infested by LBAM or the nursery's risk of infestation is high, stock may be destroyed in compliance with LBAM-Program guidelines rather than treated to eliminate threat of new or repeat infestations from that source.

References: Consult LBAM-Program staff for advice and information on plant destruction and movement requirements. Consult the bibliography and online resources in the back of this manual for sources of information, approved methods of plant destruction, and green waste movement allowable under an LBAM compliance agreement.



Removing plant foliage denies LBAM places to lay eggs

DEFOLIATING PLANTS

Remove foliage to reduce the suitability of LBAM-host plants to attract and harbor LBAM eggs and larvae.

Goal: Reduce potential for infestation of plant inventories through defoliation to deny suitable conditions for LBAM females to lay eggs and for larvae to develop. Dispose of resulting green waste in accordance with LBAM-Program-approved methods.

Rationale: To initiate and complete its life cycle, LBAM requires young foliage growth to lay its eggs and shelter its larvae following hatch. Defoliation is a useful strategy for denying host material attractive to LBAM females and eliminating emerging infestations by killing young larvae present on the removed leaves.

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Defoliating Plants

Voluntary Nursery Option

N/A

Upon discovery of suspect LBAM life stages in a nursery, voluntary defoliation under regulatory authority followed by reinspection is an option until the suspect is confirmed as LBAM.



Hoop houses may be closed at night to protect LBAM-host plants

13 BMP

Isolating Plants

Voluntary Nursery Option

N/A

Other Notes:

ISOLATION OF INFESTED NURSERY STOCK

Deny LBAM access to plants and reduce its ability to spread from infested areas to LBAM-free plants through isolation techniques.

Goal: Safeguard LBAM host plants under cover, glass, screen, or by physical separation from adjacent blocks of nursery stock. Implement isolation after LBAM treatments to prevent reinfestation.

Rationale: LBAM must access host plants in order to complete its life cycle. Denying physical access through isolation techniques protects nursery stock from infestation. Using isolation techniques in combination with pesticide treatment is doubly effective and prevents reinfestation due to environmental exposure to LBAM. Isolation is appropriate primarily for small nursery operations.



Small-area treatments are appropriate for limited infestations by leafrollers

SPOT TREATMENT OF INFESTED NURSERY STOCK

Spot apply tortricid-labeled control agents to suspected LBAM-infested plants following Integrated Pest Management guidelines. **Re-inspect** after treatment.

Goal: Spot treat plants known or suspected to be infested with LBAM as soon as practical following any suspected or confirmed LBAM find in accordance with control agent label instructions. If feasible in the nursery, protect spot treated plants during the post-treatment period to prevent re-infestation. Re-inspect treated plants after label re-entry period expires to confirm they are free from LBAM.

Rationale: Spot treatments applied only to actively infested plants limit the negative impact on other organisms, including beneficial insects, parasites, and predators of LBAM. Spot treatments are most effective when applied immediately after infestation is discovered.

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Spot Treatment

Recommended Nursery Option

N/A

Upon discovery of suspect LBAM life stages in a nursery, voluntary spot treatment under regulatory authority followed by reinspection is an option until the suspect is confirmed as LBAM.



Wide-area application treatments

15 BMP

Expanded Treatments

Recommended Nursery Option

N/A

Upon discovery of suspect LBAM life stages in a nursery, voluntary expanded treatment under regulatory authority followed by reinspection is an option until the suspect is confirmed as LBAM.

EXPANDED TREATMENT OF NURSERY PREMISES

Apply tortricid-labeled control agents to pest management unit block(s) or nursery premises with suspected LBAM-infested plants following Integrated Pest Management guidelines. Re-inspect after treatment to confirm efficacy.

Goal: Following discovery of infestation, treat as soon as practical with control agents applied in accordance with their label instructions. Using a blanket application, spray all plants in pest management unit block(s) known or suspected to be infested with LBAM or, at the nursery's discretion, the nursery premises. Re-inspect treated plants after label re-entry period expires to confirm they are free from LBAM.

Rationale: When spot treatment fails, infestation is widespread, or recurrence of infestation is demonstrated, certainty of eradication of LBAM is assured by treating entire blocks of plants known or suspected to be infested. Treatments are most effective when applied immediately after infestation is discovered. Efficacy of treatment is best confirmed by careful re-inspection.



Hines Nurseries LLC

Boom sprayer application



Careful notation of suspected LBAM finds in the nursery is the first step in documentation

16 BMP

Record Management



Required

Regulatory Requirement:
Nursery shall maintain written records of all mandated activities performed and actions taken regarding the BMP.

RECORDS AND RETENTION

RESPONSIBILITY FOR RECORD MANAGEMENT

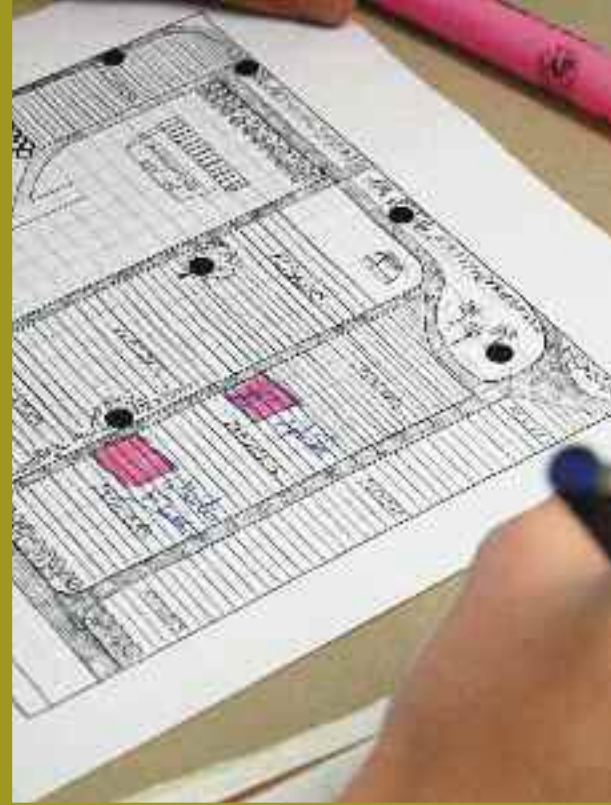
Establish clear lines of authority and responsibility necessary to maintain all records required by the BMP.

Goal: Authorize and give authority to one or more nursery personnel to receive and file reports, create records and summaries, and respond to requests for information by the LBAM-Program staff based on the written records of the BMP.

Rationale: Consistent and reliable documentation of the nursery's compliance with the BMP is necessary to meet the LBAM Program's audit requirements.



Cooperative LBAM Program



Cooperative LBAM Program

Suspected LBAM finds should be flagged (left) and mapped (right)

BMP-REQUIRED RECORDS

Define and create specific records required under the BMP. File and retain all reports and files as required by regulation.

Goal: Document all BMP processes and procedures, including changes following BMP program initiation and authorized approval of changes. Document all LBAM personnel training attendance records. Document all in-house inspections, schedules of inspection, and personnel assignments. Create and maintain files documenting all potential LBAM finds and actions taken to control the pest.

Rationale: Documenting the nursery's experience with LBAM provides valuable assets and resources for evaluating the efficacy of its LBAM BMP Program. This information is suitable for development and analysis by nursery management and by LBAM Program staff to evaluate and guide future LBAM preventive and control measures.

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Required Records



Required

Regulatory Requirement: Nursery shall maintain all records required under the BMP and compliance agreement. All such records must be retained as physical documents subject to audit for two (2) years from date of last confirmed occurrence of LBAM on the premises.



Appendix

Appendix A: Biology

Basic Biology for LBAM Management

LBAM Identification

Appendix B: Risk Assessment Tools

Environmental and Operating Risk Factors

Appendix C: LBAM Staff Training

LBAM Training Program Elements and Curricula

Appendix D: In-House Monitoring, Scouting, And Inspection

In-House Inspection Program

Monitoring Nursery Inspection to Detect LBAM

Appendix E: Actions And Treatments

Actions and Treatments

Appendix F: Cut Flower And Foliage Production Nurseries

Applying BMPs to Cut Flower Foliage and Production Nurseries

BIOLOGY

BASIC BIOLOGY FOR LBAM MANAGEMENT

The light brown apple moth (*Epiphyas postvittana*), or LBAM, was first detected in the continental United States in Berkeley, California in March 2007. It is classified as a high risk pest by regulatory agencies because of its potential to damage a wide range of plant species, its current limited distribution in the world, and its potential to harm agricultural commerce in California and the United States.

**Ten Most Common California Hosts of LBAM
C DFA Cumulative Detections, June, 2008**

Family	Genera or Species	Detections
Rosaceae	Prunus, Rosa	91
Myricaceae	Myrica californica	27
Rutaceae	Boronia, Citrus	23
Myrtaceae	Callistemon, Myrtus	22
Pittosporaceae	Pittosporum	22
Ericaceae	Vaccinium, Arctostaphylos	21
Proteaceae	Leucodendron, Protea	20
Scrophulariaceae	Penstemon	19
Asteraceae	Dahlia	18
Lamiaceae	Salvia	16

What plant species are attacked and where?

LBAM is native to Australia, and is established in Tasmania, New Zealand, New Caledonia, Great Britain, Ireland, and Hawaii. In those areas, it has a broad range of plant hosts, including many landscape trees, ornamental shrubs, fruit, and some vegetable crops. In California it has been detected on over 240 plant species and cultivars in over 77 plant families.

The pest has been detected in California produce commodity agriculture. A partial host list is found at: <http://www.cdфа.ca.gov/phpps/PDEP/lbam/factsheets.html>

The insect has been found over hundreds of square miles. As of November 2009 it infested 16 California counties. The prevalence of LBAM in nurseries in the Monterey Bay area is often related to the close proximity of these nurseries to uncontrolled LBAM populations in native vegetation or urban landscapes. As a result, these nurseries are subject to reinfestation from adult moths migrating into the nursery from these infested sites. Nursery stock and field-cut flower crops are particularly vulnerable to an establishment of an LBAM infestation apparently because of the diversity of potentially susceptible species and relatively minor use of insecticides in these crops. So far, cut flower and potted ornamental plants grown in greenhouses do not appear to be as vulnerable as other ornamental crops grown in the field, perhaps because of the generally more intensive insecticide programs already in place or that the greenhouse structure impedes migration of adult LBAM from infested areas into the greenhouses. The current LBAM distribution and levels in California is found at: http://www.aphis.usda.gov/plant_health/plant_pest_info/lba_moth/maps.shtml

BASIC FACTS ABOUT LBAM

LBAM is categorized in the insect order of Lepidoptera, the taxonomic group containing all butterflies and moths. They have complete metamorphosis, having four life stages—egg, larva, pupa, and adult. Larva and adults of the Lepidoptera, therefore, have very different roles and behaviors. Larvae (“worms” and “caterpillars”) have chewing mouthparts and are plant feeders, and the adults (“moths” and “butterflies”) have siphoning mouthparts and are nectar feeders. LBAM are further categorized in the insect family called Tortricidae, often called leafrollers because their larvae roll or connect leaves with silken webbing to form “houses” where they feed immediately within and around.

LBAM adults are capable of flying only short distances to find a suitable host. Most moths fly no further than 330 feet, but some may fly as far as 2,000 feet. They are less likely to leave areas with high-quality hosts. They stay sheltered in the foliage during the day, resting on the undersides of leaves. Moths fly 2 to 3 hours after sunset and before daybreak in calm conditions. Females begin to lay eggs 2 to 3 days after emerging, depositing eggs at night. The majority of the eggs are laid between 6 and 10 days after emergence, but females can continue to lay eggs for 21 days. Adult life span is 2 to 4 weeks, with longevity influenced by host plant and temperature. Usually an egg takes from 5 to more than 30 days to hatch with an average of 5 to 7 days. Eggs turn from green to orange to black, and then hatch into larvae. As LBAM larvae develop, they undergo a series of moltings, producing 5 or 6 consecutively larger stages (instars), until the transitional pupal stage is reached. Adult moths emerge after one to several weeks of pupation. Soon after emergence, female moths release a chemical attractant, called a pheromone, in the air to attract male moths. Eggs can be laid just two or three days after emergence.

LBAM is found throughout Australia but it does not survive well at high temperatures and is a more serious pest in cooler areas with mild summers. The insect does best under cool conditions (mean annual temperature of approximately 56°F) with moderate rainfall (approximately 29 inches) and moderate-high relative humidity (approximately 70%). Hot, dry conditions may significantly reduce populations. Two developmental models using these environmental parameters, predict that LBAM could establish very well along coastal California, and one model predicts significant development in much of the Central Valley. In the Monterey Bay some of the most established LBAM populations are in the cool and humid areas along the immediate coast.

TEMPERATURE INFLUENCES THE RATE OF DEVELOPMENT OF LBAM

Development of LBAM from one life stage to another (e.g. from egg to adult) requires a certain amount of heat. Since weather varies greatly from year to year, calendar dates are not a good basis for making predictions on development time. However, measuring the amount of heat accumulated over time is biologically more accurate and useful. Insects have a unique total heat requirement for each life stage and for many insects, including LBAM, the number of degree-days have been determined that are needed to complete the development of their life stages.

Two parameters are used when referring to the effect of temperature on insect growth and development. The lower developmental threshold for a species is the temperature below which development stops. The upper developmental threshold is less well defined, but is often stated as the temperature at which the rate of growth or development begins to decrease. Both lower and upper thresholds are determined through carefully controlled laboratory research and are unique for a specific organism. The lower developmental threshold temperature for LBAM has been determined to be approximately 45°F and the upper developmental maximum is approximately 88°F.

The amount of heat needed by an insect to develop is often expressed in units called degree-days (DD). For every degree over the organism's lower developmental threshold temperature in a 24 hour period, one degree-day is accumulated. Basically, any LBAM life stage (lower threshold of 45°F) subjected to a constant 46°F would accumulate one degree-day in a 24 hour period. No degree days would accumulate for temperatures above the maximum threshold of 88°F. Temperatures can be entered manually or entered from existing weather databases into a degree day calculator and the degree-days determined.

See: <http://www.ipm.ucdavis.edu/WEATHER/ddretrieve.html>

MANAGEMENT USING DEGREE DAYS

Degree-day monitoring does not indicate whether control action is warranted, however, it could be used to determine when a susceptible LBAM life stage is present. For example, young instar larvae are often targeted for treatment because they often can be controlled easiest with selective and low toxicity insecticides such as *Bacillus thuringiensis* (BT) or insect growth regulators (IGR). When susceptible larvae are predicted to be present, field scouting might be intensified to confirm LBAM presence and the predominant life stage before an appropriate chemical treatment is made.

Degree-day monitoring might help determine the follow-up treatment application in cases where there might also be non-susceptible life stages or individuals that were not contacted by the first treatment.

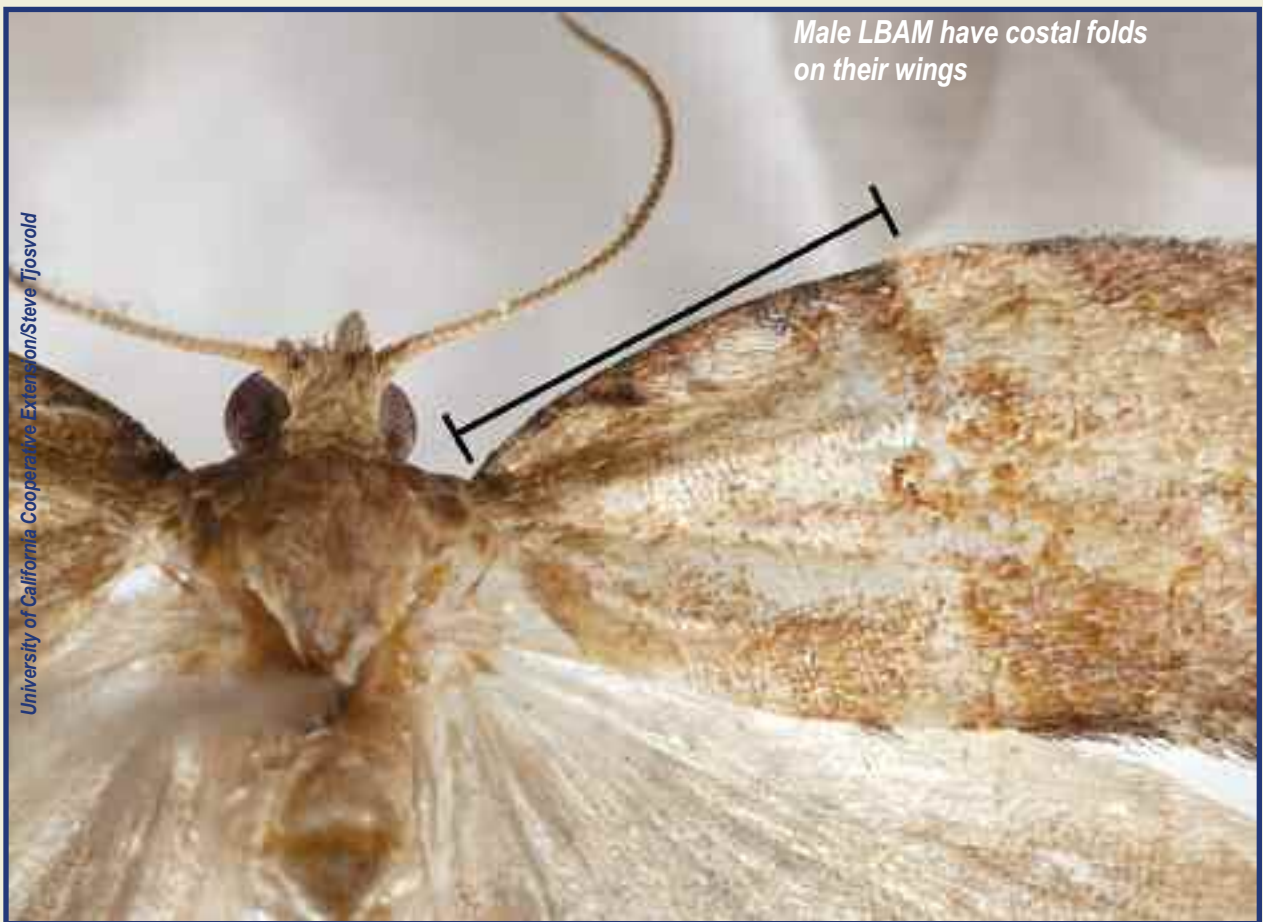
No formal strategy to use degree-day monitoring for LBAM has been evaluated at this time. This approach might be complicated if there are overlapping generations and several life stages present in a nursery at any one time. Thus it may be more difficult to pinpoint any predominant life stage or event to begin the accumulation of degree-days. This point is often referred to as a biofix. There may be factors, such as chemical treatments, extreme weather patterns, or natural biological control that focus life stages and events that could support the selection of a biofix.

Developmental stages of LBAM	
Life Stage	Degree-days (°F)
Egg	236
Larva	685
Pupa	238
Adult (preoviposition)	54
Adult (emergence to 50% egg-laying)	149
Egg to first egg	1,117
Egg to 50% egg-laying	1,212

LBAM IDENTIFICATION

ADULTS (MOTHS)

Typical LBAM males have a forewing length of 6–10 mm with a light brown area at the base, which is distinguishable from a much darker, red-brown area at the tip. The latter may be absent, with the moth appearing uniformly light brown, as in the females, who have only slightly darker oblique markings distinguishing the area at the tip of the wing. Males have an extension of the outer-edge of the forewing called the costal fold. Females have a forewing length of 7–13 mm. They usually have a dorsal spot, an indistinct to distinct brown spot on the forewing towards the head. LBAM adults are variable in color and may be confused with other similar leafrollers and other moth species.





Male LBAM (left)

Female LBAM (right)

LARVAE (CATERPILLARS, WORMS)

The first larval instar has a dark brown head; all other instars have a light brown head and prothoracic plate, just behind the head. Overwintering larvae are darker. First instar larvae are approximately 1.6 mm long, and final instar larvae range from 10–18 mm long. The body of a mature larva is medium green with a darker green central stripe and two side stripes. Larvae are not easily distinguished from the larvae of other tortricid leafrollers. Only DNA testing is a certain identification method.



LBAM larvae or instars molt six times, increasing in size at each life stage

LIGHT BROWN APPLE MOTHS

Male LBAM



Female LBAM



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U.C. Regents / Jack Kelly Clark



U.C. Regents / Jack Kelly Clark



Todd Gilligan & Marc Epstein (CSU / USDA / CDFA)



Male with light wings

Todd Gilligan & Marc Epstein (CSU / USDA / CDFA)



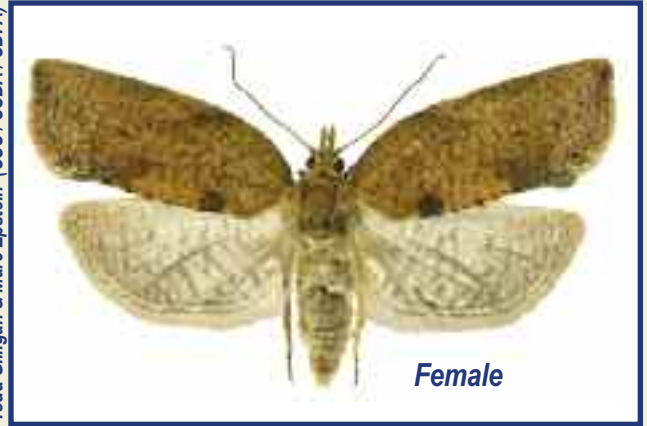
Male with normal wings

Todd Gilligan & Marc Epstein (CSU / USDA / CDFA)



Male with dark wings

Todd Gilligan & Marc Epstein (CSU / USDA / CDFA)



Female

THESE ARE **NOT** LIGHT BROWN APPLE MOTHS



U.C. Regents © 2000

Apple pandemis leafroller, Pandemis pyrusana



U.C. Regents © 2006

Garden tortrix, Pycholoma peritana



U.C. Regents © 2000

Obliquebanded leafroller, Choristoneura rosaceana



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Western avocado leafroller, Amorbia cuneana



U.C. Regents © 2004

Fruit tree leafroller, Archips argyrospila



U.C. Regents © 2008

Orange tortrix, Argyrotaenia citrana



U.C. Regents © 2000

Oriental fruit moth, Grapholitha molesta

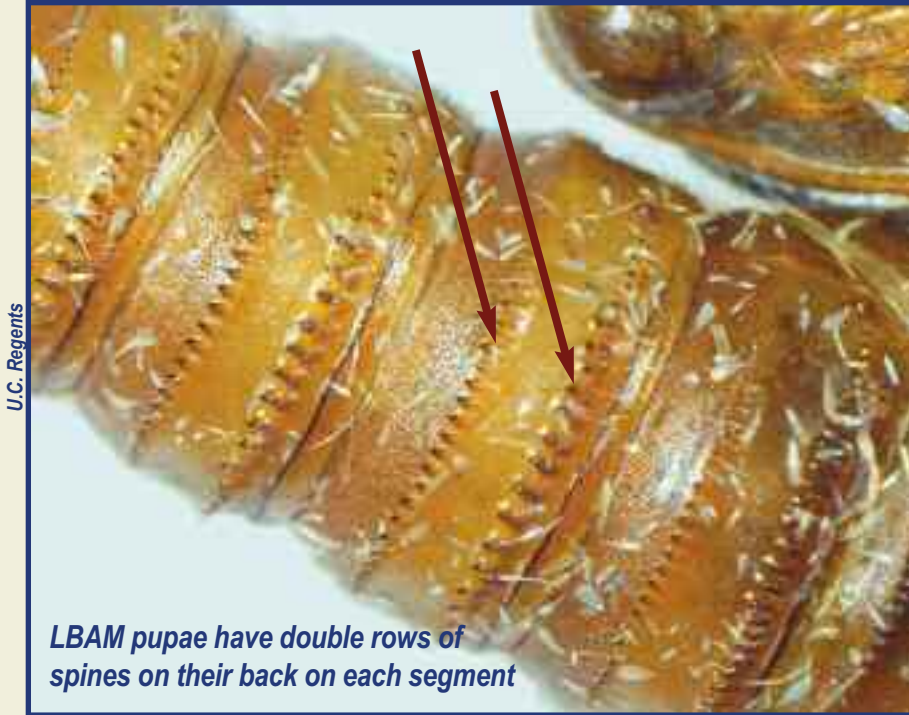


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Omnivorous leafroller, Platynoto sultana

PUPAE

Pupae are usually found in a silken cocoon between two leaves webbed together. They turn from green to reddish-brown as they mature and are between 10-15 mm long. Similar to other tortricid pupae, they have 2 rows of small spines on each abdominal segment.



EGGS

Eggs are usually found on the top of leaf surfaces in groups of 20-50. They are flat, scale like, white-yellow when first laid, later becoming red and then black. They are similar to other tortricid eggs.



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LBAM lay eggs on upper leaf surfaces. They change color as they mature, beginning as translucent, turning white, then brownish red, finally black just before they hatch. The eggs of other leafroller moths are closely similar in appearance.

RISK ASSESSMENT MANAGEMENT PRACTICES

ENVIRONMENTAL AND OPERATING RISK FACTORS

Determine the LBAM hazard due to the nursery's environment, design, and daily activities.

Goal: Rate the nursery in each situation that follows as high, medium, or low risk to determine its level of inherent risk.

Rationale: Some nurseries are low risk, while others have a higher potential for LBAM contamination. The surrounding environment and the supply and abundance of preferred host plants present in the nursery are key among the factors to consider when you evaluate the risk of your property.

Cooperative LBAM Program



Judge The Nursery On Each Element:

I. Environmental Risk

A. How likely is the nursery to be prone to infestation?

1. Is the nursery facility in an LBAM-infested county or quarantine?
 - Has nursery been contacted by LBAM Program staff regarding compliance or inspection?
 - Have other nurseries in the area been inspected for LBAM?
 - Has county agriculture staff expressed concerns regarding LBAM in the vicinity?
2. What flora is in the immediate area and surroundings?
 - Are LBAM preferred host plants prevalent in or around the nursery's perimeter?
 - Which ways do prevailing winds blow?
 - Could adjacent native plants, landscape, or surrounding vegetation become a conduit for infestation?
 - Do plants in the area show evidence of leaf-roller moth damage?

B. Prior Evidence of Infestation

1. Is pest detection trapping information available for the surrounding area?
 - Ask LBAM Program staff and county agriculture commissioners to provide results of detection trapping in areas adjacent to the nursery, including trends over time.
 - Do they feel that the nursery is at risk of infestation? If so, how great a risk?





II. Operating Risk

A. Greenhouse versus outdoor plants

1. Greenhouse-reared plants are protected from exposure to LBAM provided that stock is clean upon entry and the premises are tight and secure.
2. If LBAM preferred host plants are present, risk increases.
3. Plants grown outside of houses are more prone to infestation to LBAM. Again, risk increases if LBAM preferred host plants are present in stock.

B. Susceptible host plants

1. LBAM is a polyphagous pest (infests many plant families). Familiarize yourself and your staff with the preferred host plants of LBAM. U.C. Cooperative Extension farm advisors can provide information on the most common plants infested in your area.
2. Resources are also available listing LBAM preferred host plants. Match this list against your nursery stock and inventory.

C. Public Access

1. Does the nursery sell to the wholesale market (trade), both wholesale and to retailers, or solely to retail customers?
2. Do customers with plants from offsite locations enter the nursery property to make purchases?
3. Can customers enter the growing area?
4. Could customers experience hazard due to treatments or potentially disrupt inventory control of infested plants?



D. General condition of the nursery

1. Is the nursery generally clean, tidy, weed and refuse free?
2. Are structures in good operating condition?
3. Is stock in good condition?

E. Specific deficiencies and corrective actions

1. Note major and minor deficiencies and the actions necessary to remedy them.
2. Assign responsibilities to staff for all items that may increase likelihood of infestation by LBAM.

III. Plant and Propagation Materials Sourcing Risk

A. Know all sources of incoming plants and accept only clean and pest-free stock.

1. Does a separate receiving and holding area exist to keep incoming stock from being mixed with other nursery stock?
2. Do suppliers of plant material operate under an LBAM compliance agreement?
3. Are incoming shipments routinely and thoroughly inspected upon arrival for presence of LBAM, condition, or other pests and diseases?
4. What happens to incoming plants when pests or diseases are found in incoming stock?
5. Is returned merchandise inspected if it was off-loaded to a site within the quarantine boundary?

LBAM STAFF TRAINING

LBAM TRAINING PROGRAM ELEMENTS AND CURRICULA

Train nursery personnel that LBAM is a serious nursery and agricultural pest, systematic inspection provides a means of early detection, finding suspect LBAM in the nursery has significant economic and regulatory consequences, and control upon find of suspect LBAM means prompt action and documentation must be taken.

Goal: Acquaint all nursery personnel with a working knowledge of LBAM biology, behavior, preferred host plants, symptoms, identification, control actions, and all treatment options.

Rationale: Every nursery worker may encounter suspected LBAM symptoms or leafroller egg masses, larvae, pupae, or adults in the course of daily work. The nursery is best protected by actively training all personnel regarding LBAM.

Cooperative LBAM Program



TYPICAL LBAM TRAINING PROGRAM SUBJECTS

Include the following topics in the nursery's LBAM Training Program:

- Brief History of LBAM in California
- Biology of LBAM and Related Tortrix Moths
- Life stages
- Behaviors
- Host Plants
- Recognition of LBAM
- Symptoms of Infestation
- Look-alike Insects and Symptoms
- Control Treatment Agents and Application Methods

I. Light Brown Apple Moth Identification Training

Educate all nursery personnel on all stages of the LBAM life cycle, when the BMP program is started and thereafter as part of the hiring training of new staff. Conduct continuing education of all staff at periodic intervals to refresh their understanding of LBAM's biology and appearance.

Goal: Familiarize entire nursery staff to recognize LBAM, its preferred host plants, and symptoms of plants when it is present. Refresh and renew awareness of the insect periodically. Demonstrate the biology of LBAM and how to identify its distinctive features.

Rationale: As a non-native pest, LBAM is unfamiliar to most nurseries and even well trained nursery staff may confuse LBAM with similar native leaf-rolling moths. Understanding the appearance and life cycle of LBAM is essential to recognize and detect the insect in the nursery.

Resources: Consult the bibliography and online resources in the back of this manual for training and learning materials on the biology of LBAM. Training may use many teaching methods and aids, from personal demonstration and visual identification tools to videos, workbooks, and handouts. New materials to aid instruction on LBAM regularly appear; consult LBAM Program staff for new biology references and resources for training staff.

II. Effective Scouting and Monitoring Training

Educate all nursery personnel in how to monitor, scout, and detect LBAM in and around the nursery, in its inventory stock, and in landscape plantings. Communicate the schedule and frequency of inspections with the nursery staff.

Goal: Teach staff techniques and procedures for inspecting the nursery and its stock for LBAM symptoms on plants and the presence of LBAM life stages, with special attention to examining preferred host plants. Show how to examine plants to find leaf-rolling moths such LBAM.

Rationale: Hands-on demonstration of effective scouting and inspection techniques accompanied by field identification resources are the best methods for qualifying staff as effective LBAM inspectors and assessing their skills.

Resources: Consult the bibliography and online resources in the back of this manual for training and learning materials on effective scouting.

Cooperative LBAM Program



III. Training on Actions Required for LBAM Finds

Educate all nursery personnel in the specific actions and procedures they must follow upon finding suspicious symptoms that may be due to LBAM or any suspected LBAM life stages in the nursery.

Goal: Make all nursery staff aware of their specific responsibilities and duties when they or other employees find LBAM life stages or suspect symptoms while performing their regular duties or scouting. Explain the mandatory compliance actions that follow when LBAM Program inspectors discover probable, or confirmed LBAM on the premises.

Rationale: Understanding the impact and consequences of LBAM finds in the nursery and instilling personal responsibility in each staff member for reporting and other actions is necessary is essential to keeping the nursery free of LBAM.

Resources: Consult the bibliography and online resources in the back of this manual for training and learning materials.



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IN-HOUSE MONITORING, SCOUTING, AND INSPECTION

IN-HOUSE INSPECTION PROGRAM

Implement an in-house nursery early-warning program for LBAM detection and response and assign qualified nursery staff to an LBAM inspection team. Members of the team should have strong core understandings of LBAM and follow set protocols for monitoring, scouting, and inspection.

Goal: Create a custom protocol for the nursery, assign responsibility to staff, and train them on scouting technique, LBAM identification and infestation marking, reporting, and treatment actions.

Rationale: The most effective scouting programs are based on a core group of nursery staff with clear understanding of the impact of LBAM. Each scouting team member embodies the nursery's collective knowledge of LBAM risk and helps to continually improve the process of inspection, detection, and response. Regular scouting is the most important element in keeping the nursery free of LBAM.

Cooperative LBAM Program



LBAM larva in webbing



Scouting using a 10x hand lens

TYPICAL LBAM SCOUTING PROGRAM SUBJECTS

Include the following topics in the nursery's LBAM Scouting Program:

- Define scope of inspections and methods used
- Assign staff to scouting teams
- Establish Inspection intervals
- Instruct in strategies of inspection for nurseries
- Perform detailed inspection of plants
- Make finds and collecting suspect insects
- Report suspicious insect life forms and plant symptoms
- Mark LBAM find location
- Document LBAM finds
 - Date of find
 - Nursery location block
 - Collector/inspector
 - Life stage of suspected insect
 - Host plant
 - Deposition of find
 - Response action
- Choose treatment actions
- Mark infested plant blocks as pest management units for treatment
- Conduct post-treatment inspections
 - Determine intensity of post-treatment inspections

MONITORING: NURSERY INSPECTION TO DETECT LBAM

WHAT IS MONITORING



A female LBAM adult

Monitoring, also called scouting, is the regular, systematic inspection of nursery stock and non-cropped areas to detect pests, diseases, and weeds. Monitoring is the foundation that supports a strong IPM program. It helps find, identify, and quantify disease, pest, and weed populations so a grower can make intelligent pest management decisions. Usually a few pests can be tolerated on most crops for short periods; they can be left for natural biological control or environmental control mechanisms or the minor damage they cause can be tolerated. With monitoring, the manager can decide when populations are heading toward levels that are not tolerable and control strategies can be implemented. Predators and parasites can be introduced into nursery stock early enough to be effective or more specific and less toxic insecticides

could be applied when most appropriate and effective. With a quarantined pest such as LBAM, however, there is no such tolerance for the pest. In this case, monitoring is used for finding any LBAM life-stages, and then they must be immediately destroyed.

MONITORING FOR LBAM

Monitoring for LBAM can be initiated as part of an existing robust IPM program or it can be the sole purpose for beginning a monitoring program. There are multiple benefits of having a monitoring program that includes all pertinent pests, diseases, and weeds in the nursery. Monitoring has been proven to reduce the amount of crop damage, minimize the cost of control, and facilitate the use of management practices that are safer to workers and reduce potential negative impact on the environment. For the purpose of this training module, the monitoring plan will be tailored for that of detecting LBAM, but there are other references that can help in implementing a more complete monitoring program beyond LBAM control.

LBAM PEST MANAGEMENT TEAM

A responsible senior nursery individual should be assigned to lead the implementation of the LBAM best management practices (BMP). As part of those practices, a monitoring program targeting LBAM is at the core of a successful program to detect and eliminate LBAM in a nursery. Currently, regulatory officials require a monitoring program through nursery compliance agreements. The team leader is responsible for forming a pest management team of other work staff and tasking them with the responsibilities needed to implement the monitoring program. The team leader would stress to the pest management team and other staff the economic and environmental impact to agriculture and the community, and the serious consequences that occur for the nursery if the pest is found there by regulatory officials.

One or more trained individuals in the team, the scouts, have the dedicated responsibility for regular and systematic inspection of nursery stock. The scout walks the nursery and perimeter areas with the goal of finding the targeted pest. The scout communicates results and observations back to the team leader who ensures the proper identification of all detected pests and makes decisions on how each pest will be controlled. In many large -scale agricultural crops in California, outside professional scouts are hired to provide monitoring information to the pest management team leader. So far, this service is not well developed for ornamental crops in California, nor are there specific professionals that scout for LBAM. In smaller nurseries, the team leader might also perform the job duties of the primary scout.

The team leader should utilize all appropriate staff at the nursery to help monitor for LBAM as they perform their normal duties. Many workers already spend most of their time working closely in the nursery stock and walking around the nursery. If trained properly, workers who are irrigating, shipping, and weeding can be very effective in detecting LBAM. These workers should be trained to recognize the likely symptoms on plants and life-stages of LBAM. Pictures showing symptoms of infested plants and life stages of LBAM are very useful in training the pest management team and staff to recognize actual LBAM infestations, as are demonstrations at actual infestation sites. Scouts and other nursery staff should immediately mark all potential infestations with flagging tape, flags, or other indicators, and report them to the team leader.

START WITH A NURSERY MAP SHOWING CURRENT STOCK

Nursery maps that include the current inventory of nursery stock help scouts determine the most effective strategy for walking and inspecting the nursery. Identify areas or crops on the maps that may require closer monitoring and targeted inspection by the scout. These include:

- Nursery perimeters near infested ornamental landscapes or wild vegetation.
- Nursery perimeters or areas where prevailing winds facilitate movement of LBAM moths into the nursery.
- Nursery areas where crops have been previously infested with LBAM.
- Nursery crops that are known or common LBAM hosts (genera or species).
- Nursery crops that are at a vigorous growing stage or exhibit habit that is particularly prone to LBAM infestation.
- Nursery areas where LBAM and other tortricid moths have been caught in pheromone-baited or ultraviolet-light traps.
- Nursery crops that will be sold or shipped within 2 weeks.

Maps can be used to quickly communicate information visually to others that must manage or treat an infestation. They can be used as a record that provides a memory upon which to base future actions. For many nurseries that are relatively large and diverse, it may be best to have several maps that are broken down into manageable units (sometimes referred to as Pest Management Units, or PMUs).

In its most simple form, the monitoring map might be used both to help the scout determine the most effective strategy of monitoring and as a data sheet to record the location of detections of LBAM or other leafrollers. All the data might not be efficiently marked or recorded on maps in larger nurseries, or when the scout includes other pertinent pests and diseases. In such cases, separate worksheets are needed to record monitoring data. Maps and worksheets should be dated and kept in a ring binder or other file in chronological order for easy updating and assessing. These records will become written documentation of the location of nursery hotspots, the occurrence dates of LBAM and other leafrollers, key infested hosts in the nursery, and other useful information. In addition, records are evidence for regulatory officials that an active monitoring program is in place.

	0	0	15		16	0	0	
		1WF	1LM		14	0	0	
	0		2LM		12	1LM	0	
		0	1LM		10	1LM	0	
	1LM	Card	5LM		8	1LM	Card	0
	0	0			6	0	0	
CARD *					4	1LM	0	
28 WF		1WF	3LM		2	0	0	
14 LM		0	0	#6				
	7LM	Dino	0	15	16	2WF	S. Pacific ^m	
		Dino	1LM	4LM	14		Orca	1WF
	0	Grizzly	3LM	11	12	3LM	Dragon	0
CARD *		Grizzly	0	9	10	1LM	Imbala	1LM
48 WF	1LM	Card			8	1LM	Card	0
36 LM		Lamborghini	1LM	7	6	5LM	Furore	2LM
		Lamborghini	0	5	4	0	Furore	1LM
	2LM	Maya	0	3	2	0	Alice	1LM
		Maya	3LM	1LM	1			
				#5				
	0	Jewel	4LM	15	16	1LM	Anastasia	0
		Tofo	3LM	1LM	14	0	Diane	2LM
	2LM	Jewel	5LM	11	12	3LM	Mammut	0
		Vamp	0	1LM	10	1LM	Serena	1LM
CARD *	0	Card	1LM	7	8	0	Card	0
12 WF		Bidiane	0	5	6	1LM	Giulina	0
4 LM			0	1LM	4	0	Italia	0
		King Alex	0	3	2	0	Chariso	0
		Venus	0	1				
				#4				

CARD *
29 WF
20 LM

CARD *
14 WF
32 LM

CARD *
5 WF
2 LM

* Cards were left up for 2 weeks.

MONITORING STRATEGIES

There are no specific recommendations on how much to monitor. There is a compromise between cost and benefits derived. Conceivably, every plant in a nursery could be inspected very closely on a weekly or more frequent basis, but the cost could easily be prohibitive. Yet, the seriousness of any regulatory action that might result from missing an LBAM infestation should be considered in determining how much time and effort to expend on monitoring. As a possible guideline, a 14-acre nursery surrounded by LBAM infested vegetation has spent as much as 160 man-hours per month for LBAM monitoring. In this case, the lack of regulatory finds can be directly attributed to the implementation of its monitoring efforts.

It is suggested that a scout visually inspect all field crops once a week in the growing season and less frequently in the winter when crops and LBAM are developing more slowly. More frequent or intensive visual inspections may be necessary in some areas or crops, such as the special situations previously described in the bulleted list.





Scouts must visually cover the inspected area efficiently. Begin at an entrance of a greenhouse or the end of a nursery bed. Walks down an aisle, scanning back and forth for visual symptoms of an infestation. Scouts must be close enough to the plants and have sufficiently sharp sight to detect symptoms. The scout may walk every walkway at first, but improved knowledge and efficiency may lead over time to more efficient monitoring. Perhaps alternate rows could be walked and inspected by scanning across one or more beds. Alternatively, a scout might use a worker crew to systematically walk through a nursery, block by block. In this way, the scout can train the crew to look for symptoms during the systematic phase of monitoring as well as when the workers are performing their normal duties.



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All plants with characteristic symptoms of an LBAM infestation need to be examined closely. Look for distorted leaves in terminal shoots or those bound together in an unusual manner. Leaves that are just emerging from terminal buds in the spring are likely targets. Upon closer inspection, a single LBAM larva or other leafroller larva may be seen within a leaf shelter drawn in by silken threads it produces. Leaves may be chewed within and outside the leaf shelter. If the larva is disturbed it may wiggle quickly and drop on a silken thread. (Caution is needed here because the larva must be captured for examination and identification). A 10X hand lens will help the scout examine larva for characteristic features of LBAM. Spiders are often present in unsprayed crops and can bind terminal shoots in similar ways.

If one LBAM or another leafroller larva is found, then there is a greater probability that more will be found on the same plant or adjacent plants in the same crop. If larvae are present, the scout should carefully scan each plant until the entire crop of that species has been inspected and closely inspect all suspicious symptoms. The tops of plants can be gently wiped with the hand or a yard stick, bamboo stake, or other implement to disturb adult moths that could be hiding on the plants. Adult moths can be trapped with insect nets, jars, or cupped hands. A solitary pupa would be found closely wrapped in a silken case between leaves pulled together by silken threads. Eggs masses are found on the upper surfaces of leaves and occasionally on fruit or young stems. However, eggs have rarely been detected by scouts. Nearby nursery stock should be scrutinized closely, too. Priority should be given to all species likely to be infested.



Adult Female LBAM

U. S. Department of Agriculture



LBAM Egg Mass

New Zealand Institute for Plant & Food Research



LBAM Larva

U. C. Regents ©2008



LBAM Pupa

U. C. Cooperative Extension / Steve Tjosvold

Appendix D-2

As nursery policy dictates, the larva or other life stages can be destroyed immediately if they can be identified in the field, otherwise other suspicious insects should be carefully collected in a jar, securely sealed, and taken to the nursery office where they can be safely scrutinized and a reasonable identification can be made with identification guides.

EXAMPLES OF LBAM SYMPTOMS



Leaves bound together with silk-like webs or threads

U. S. Department of Agriculture



Closeup of silk-like web binding leaves together

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Leaves damaged and chewed with holes

U. C. Cooperative Extension / Steve Tjosvold



Distortion of new growth

U. C. Cooperative Extension / Steve Tjosvold



Pupa hid in distorted leaves

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Closeup of pupa in leaves

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Leaf surfaces mined

U. S. Department of Agriculture



Rasping damage from feeding LBAM larvae

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Foliage tip damage

U. S. Department of Agriculture

LOOK-ALIKE SYMPTOMS **NOT** CAUSED BY LBAM



Spiders

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Spider and web

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Powdery mildew

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Aphids

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LBAM PHEROMONE AND ULTRAVIOLET-LIGHT TRAPS TO DETECT MOTH MIGRATION

Commercial sticky traps are commercially available that contain the chemical scent (pheromone) of a female LBAM moth. They can be used to attract and trap male moths. Place these traps on the perimeter boundary and within the nursery to detect moth migration.

Another detection option is the use of ultraviolet-light traps. These have the drawback of trapping many types of moths and other insects. Some such traps use electricity to kill the attracted insect, but unfortunately they destroy the insect beyond recognition. It is possible to combine kill strips or sticky tapes impregnated with dichlorophos with ultraviolet-light traps to capture the insect for identification. Detection of male LBAM with these traps is a likely indicator that female and male LBAM are migrating and could justify increased frequency or intensity of monitoring efforts in key crops.

NURSERY ACTIONS FOR SUSPECTED LBAM DISCOVERIES

The exact location of a life stage of LBAM should be marked with flagging tape or flags. The date of the find, location, scout's name, life stage (egg, larva, pupa, or adult), and the host plant upon which it was found should be recorded on the scouting map or scouting worksheet. All adjacent areas that were scouted more thoroughly as a result of the find should also be distinctively marked. The LBAM nursery team with the leader or team manager must determine the extent and boundaries of areas that require treatment or other actions to take. Mark on the scouting map the area considered for treatment or action. This marked map can be used by the scout at the next regular scouting to gauge the efficacy of response. The scouting map and field markings also can be used to communicate the exact treatment area to the pesticide applicator or other treatment personnel. They are also useful in communicating to other nursery staff the treated areas subject to pesticide re-entry prohibitions.

Monitoring frequency may require increases to at least twice a week until the infestation has been proven to be destroyed and all plants in the marked area are free from LBAM.

CHECK LIST FOR MONITORING

- Identify the LBAM management team: the team leader, scout(s), and other pertinent staff.
- Produce maps and/or forms that will be used for monitoring and recording information.
- Identify areas within the nursery at high risk for an LBAM infestation.
- Develop a monitoring strategy: determine how often and the details for the inspection process.
- Develop a training program for the LBAM management team and other pertinent staff.
- Place LBAM-pheromone or ultraviolet-light traps in the nursery to detect LBAM migration.
- Develop an action plan to be followed if LBAM is discovered.

TREATMENTS

ACTIONS AND TREATMENTS

Upon discovery of suspect LBAM life stages in a nursery, voluntary spot or expanded treatment performed under regulatory authority and followed by reinspection are options until the suspect is confirmed to be LBAM.

Goal: Eliminated infestations of leafrolling moths in the nursery by prompt action upon find of suspected symptoms or collection of life stages.

Rationale: Frequent and intensive inspections followed by the destruction of larvae with any treatment can be effective in eliminating leafrollers. Early detection means actions and treatments prevent the population from damaging nursery stock, reproducing, and being transported outside of the nursery.

PROGRESSIVE TREATMENT OPTIONS:

Upon discovery of leafroller life stages, the targeted areas should receive one or more of the following treatments.

- Destruction of the infested plant or plant block.
- Pruning out of infested vegetative or flowering shoots.
- Defoliation of the infested plant or plant block.
- Spot treatment with registered insecticides appropriate for life stages present
- Covering the crop with a “frost-prevention cloth” or similar material following application of insecticide treatment to reduce the chance of re-infestation.

AN EXAMPLE OF AN INTEGRATED APPROACH TO THE MANAGEMENT OF LEAFROLLERS

A possible management strategy would use a combination of monitoring for moths, field monitoring, degree-day concepts, and known approximate residual activity of the insecticide treatments. With detection of probable or identified leafroller's life stages in a nursery, leafrollers must be eradicated. Repeated applications are recommended because rarely are insecticides completely effective and applied to provide perfect coverage and contact with the insect. This strategy is provided only an example, and has not been proven in the field.

Winter to early spring

- Monitor for moths with LBAM-specific pheromone traps weekly.
- When a moth is first trapped or otherwise detected, begin or intensify field monitoring to every week to two weeks.
- If larvae are detected in the field, apply an insecticide active on larvae in and around the area of detection to cover the most likely area where other larvae might be present.
- Repeat application at 236 Degree Days (typically 1–4 weeks allow all eggs to hatch) with short residual pesticides (e.g., *Bt* and spinosad), or repeat application at the end of the residual activity period of the longer-lasting insecticides (e.g., some IGRs).

Late spring to fall

- Continue to monitor adults with pheromone traps weekly.
- Scout the fields at least every two weeks.
- If moths found in pheromone traps rise suddenly or peak, scout fields every week.
- If larvae detected, spot spray as above.
- Wait 236 Degree Days (1–2 weeks) and repeat application.

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE LIGHT BROWN APPLE MOTH APPROVED TREATMENTS FOR NURSERIES AND HOST CROPS¹

Listed in the chart at right are examples of approved products for control or prevention of Light Brown Apple Moth (LBAM) at nurseries and/or crop production areas. Establishments where a LBAM infestation has been detected must follow procedures outlined in the *LBAM Regulatory Procedures Manual* at:

<http://phpps.cdfa.ca.gov/PE/InteriorExclusion/CPTM/pdf/LBAMtoc.pdf>

It is incumbent upon the user to read completely and follow exactly all label restrictions. Products not on the list below may be approved if they can be applied at the equivalent active ingredient (AI) rate specified for the example product. Search products based on multiple categories (site and chemical code) at:

<http://www.cdpr.ca.gov/docs/label/m4.htm>.

Label rates lower than approved quarantine rates may not be used for quarantine purposes.

¹A current list of approved quarantine treatments are available online at:
<http://phpps.cdfa.ca.gov/Pe/lbam/LBAMApprovedTreatments.pdf>

CDFA APPROVED¹ TREATMENTS FOR OFFICIAL QUARANTINE ERADICATION OF LBAM IN ORNAMENTALS

¹CDFA approved list of chemical treatments for official quarantine eradication available on CDFA website.

Category	Active ingredient	Product examples ²	Comments ³
Biological	<i>Bacillus thuringiensis</i> ssp. <i>Kurstaki</i>	<i>Crymax</i> <i>Dipel Pro</i>	Best on small larvae. Larvae must ingest to be effective. Residual: up to 7 days
Carbamate	carbaryl	Sevin	Active on all larval stages. Residual: up to 14 days
Organophosphate	chlorpyrifos dimethoate imidan	Dursban DuraGuard Chlorpyrifos-Pro Dimethoate 400 Phosmet	Active on all stages. Residual: up to 14 days
Insect Growth Regulator	tebufenozide methoxyfenozide	Confirm Intrepid	Best on small larvae. Residual: 7 to 21 days
Mineral	superior oil	Bonide All Seasons Purespray Green	Eggs smothered and desiccated
Spinosyns	spinosad	Conserve Entrust	Residual: up to 7 days Organic label
Pyrethroids	lambda-cyhalothrin deltamethrin	Scimitar Suspend	Residual: 7-21 days

Footnotes:

1. CDFA combines horticultural oils with other chemical treatments for egg activity.
2. The products listed are only examples and should not be considered endorsements. Product labels need to be read for the most current and specific application information.
3. The effective residual activity on leafrollers is based on the recommended interval of spray application on chemical labels and other experimental results.
4. There are other insecticidal products that could be useful in controlling LBAM larvae and other leafrollers but are not officially approved by CDFA to eradicate infestations. Consult a farm advisor or PCA to obtain other options.

CUT FLOWER AND FOLIAGE PRODUCTION NURSERIES

APPLYING BMPs TO CUT FLOWER AND FOLIAGE PRODUCTION NURSERIES

The BMP suggestions included in this manual can be generally applied to the needs of the cut flower and foliage production nurseries. What makes them different from other nursery crops is that they are harvested as cut stems and sold as a group of stems (bunches). Most cut flower or foliage crops such as roses, gerbera, stephanotis, fern and ivy are harvested, or cut away, many times from long-lived or perennial crops. Some crops such as lilies, tulips, and daffodils will be harvested once and the remaining plant may be discarded or prepared for the next planting cycle. For the long-lived production plants that remain behind, these plants are often dense and therefore difficult to inspect or effectively cover with chemical sprays. Make sure that harvesting personnel are trained to detect an LBAM infestation. If trained, they can be very effective scouts as they usually harvest crops on a frequent, regular basis. Harvest personnel should make particular note of the vulnerable young shoots that arise near previous cut points.

The harvested cut flowers and foliage are usually brought to a central area and either stored temporarily dry or in buckets of water before the stems are graded and packed for shipment. In these grading and packing areas, many operations also have refrigerated areas where the crop is stored temporarily to keep them fresh before they are graded and after they are packaged and await shipment. The temperatures (33°F to 42°F) in these coolers are not likely to kill LBAM life stages but arrest development and make the larvae or moths temporarily lethargic. The personnel that are grading and packing are usually very capable and trained to judge flower quality and detect blemishes or imperfections.

They should also be trained to inspect for a LBAM infestation. Inspection for LBAM will insure that LBAM life stages do not hitchhike along with the shipments. Conduct training and place LBAM identification information such as pictorial posters in these grading and shipping areas to keep personnel alert to a potential LBAM infestation.



© California Cut Flower Commission



© California Cut Flower Commission

Many cut flower and foliage crops are grown in greenhouses to support the proper development or desirable timing of the crop. Be especially aware of production cycles where shoots are forced into growth for crop-timing purposes by pinching or heating because vigorous young growth can be particularly supportive of LBAM development. Over-fertilization can also create similar vulnerable soft and pliable foliage and stems. These vulnerable crop flushes may need to be inspected for LBAM at least once a week.

Greenhouses and other protective structures or covers may limit the migration of LBAM into the crop from dusk to dawn when the moths migrate. Closing greenhouse vents and doors in the evening will further restrict entry into the greenhouse. In crops and conditions that must be vented at night, for example, when trying to control certain diseases by reducing humidity, insect screening on the vents may further restrict the entry of migrating LBAM into the greenhouse. Insect screens with about ¼-inch mesh should limit moth entry without appreciably reducing air flow.

Greenhouses most frequently become infested because infested propagative plant material, transplants, or other plants are brought into the greenhouse. Be sure to carefully inspect incoming shipments before bringing them into the greenhouse. Ideally, isolate them in another area of the nursery and inspect them for several weeks before introducing into the production greenhouse.

BMP DEFINITIONS

A-Rated Pest: An organism of known economic importance subject to state (or county agricultural commissioner when acting as a state agent) enforced action involving: eradication, quarantine, containment, rejection, or other holding action.

Action: In LBAM, a treatment or control measure to manage or eliminate light brown apple moth life stages from plants or a nursery.

Adjacent Landscape: Planted or wild species of plants, including weeds, whether under or not under cultivation, near cultivated nursery stock.

APHIS: U.S. Department of Agriculture/Animal and Plant Health Inspection Service.

Agricultural Commissioner: County-appointed official responsible for agriculture within California.

Baiting: Applying a lure or bait to attract a target organism; in LBAM, a pheromone laced medium applied to traps or deployed in a nursery.

Beneficials: In general, organisms that feed on, infest, prey, or are parasites of an unwanted organism.

Biological Control: A method of controlling pests (including insects, mites, weeds and plant diseases) that relies on predation, parasitism, herbivory, or other natural mechanisms.

Biota: An ecosystem of organisms; a population.

Blanket Treatment: Spraying with pesticides of an entire area or areas of plants with or without regard to the presence or absence of a target pest.

BMP: Best Management Practices

CDFA: California Department of Food and Agriculture

Defoliation: Removal of foliage and/or fruit.

Detection Trapping: An ongoing cooperative effort of the state and county to monitor levels of native and pest organisms with pheromone-baited traps placed according to a precise geographic grid.

Egg Mass: In LBAM, a grouping of eggs, usually found on host-plant foliage.

Infested: A nursery or plants with life stages of LBAM present.

Inspections: In LBAM, a system for evaluating and finding presence of light brown apple moth life stages in a nursery, usually involving visual monitoring of nursery plants.

IPM: Integrated Pest Management

Laboratory Identification: In LBAM, confirmation of identity to species level of a collected sample insect by a trained entomologist or by DNA analysis performed at an authorized laboratory.

Larva, Larvae: In LBAM, the caterpillar life stage of light brown apple moth.

LBAM: (see Light Brown Apple Moth)

LBAM Compliance Agreement: A legally binding contract between a private individual and a government agency requiring performance with respect to light brown apple moth quarantine and eradication orders.

LBAM Find: Discovery of a confirmed life stage of light brown apple moth.

LBAM-Preferred Host Plant: A plant species or family on which one or more life stages of light brown apple moth either lives or uses as a food source during one or more of its life stages. A wide range of plant materials are potential hosts of LBAM.

LBAM Program: A cooperative quarantine and eradication program of U.S. Department of Agriculture/APHIS, California Department of Food and Agriculture and County Agriculture Commissioners.

Life Stages: The various phases of an organism's development.

Light Brown Apple Moth (LBAM): *Epiphyas postvittana*, a diurnal (typically night flying), non-native, invasive, polyphagous moth of the Family Tortricidae, order Lepidoptera, commonly known as tortrix or leaf-rolling moths.

Master Gardener Program: A certificate program of adult education on gardening and horticulture sponsored by the University of California Cooperative Extension.

Mating Disruption: Any action taken or means applied to prevent successful consumption of a fertile male with a fertile female resulting in conception and viable offspring, usually involving the use of sex pheromones or sterile release.

Monitoring: In LBAM, a system or methodology for evaluating and finding light brown apple moth life stages in nursery premises or in the environment.

Non-Native: Originating outside of California and/or the United States; *syn.* exotic, invasive.

Plant Stock Inventory: Plants reared by nurseries for sale to customers.

Pheromone: An olfactory signal-carrying chemical (semiochemical) relied on by an organism to announce its presence to others of its species or to attract a mate. Both natural and synthesized pheromones exist.

Polyphagous: An organism that eats many types of plants.

Preferred Host Plants: The most frequent or common plants associated with an organism.

Propagative Materials: Buds, budwood, scions, grafts, genetic clones, tissue cultures, and other source materials used for growing cultivars in a nursery.

Q-Rated Pest: As defined in Section 403 of the California Food and Agriculture Code, an organism or disorder requiring temporary “A” action pending determination of a permanent rating.

Quarantine: A geographically bounded area in which movement of certain plants and plant materials are restricted or subject to requirements for treatment and inspection prior to movement.

Regulatory Agreement: A legally binding contract between a private individual and a government agency requiring performance with respect to a pest or disease.

Regulatory Inspection or Re-inspection: In LBAM, a mandatory action to determine the presence or absence of light brown apple moth life stages in a nursery’s or commodity’s business premises.

Regulatory LBAM Find: In LBAM, discovery by LBAM Program inspection teams of a suspected life stage of light brown apple moth.

Regulatory Treatment: In LBAM, a mandatory application under a compliance agreement of an approved pesticide or combination of pesticides to eliminate light brown apple moth life stages from plants or a nursery.

Section 8

Re-Entry Period: A pesticide label-regulated interval between the application of a pesticide and when the treated plants are environmentally safe to handle.

Re-inspection: In LBAM, the act of performing a second inspection, typically following a treatment action, to confirm the absence of LBAM from the treated plants.

Scouting: In LBAM, a system or methodology for evaluating and finding light brown apple moth life stages in nursery premises or in the environment.

Scouting Team: Inspectors working together systematically to find target organisms that may or may not be present.

Spot Treatment: A limited application of pesticide or other control agent to the immediate site of an infestation.

Sticky Trap: A delta-shaped or other trap containing surfaces coated with adhesive that sticks insects to the trap, collecting them for later identification.

Symptoms: In LBAM, evidence of plant damage due to feeding or leaf-rolling behavior typical of light brown apple moth.

Tortrix, Tortricid: Moths of the family Tortricidae, or leaf-rolling moths.

Treatment: In LBAM, an application of pesticides or other control measure to manage or eliminate light brown apple moth life stages from plants or a nursery.

Treatment Block: In LBAM, a contiguous block of plants of the same or different species. A physical division of at least 8 feet must separate treatment blocks.

U.C.: University of California

U.C.C.E: University of California Cooperative Extension

U.S.D.A.: United States Department of Agriculture

Visual Identification: In LBAM, identification of light brown apple moth based on its overall notable characteristics.

Weed Abatement Program: A systematic effort to eliminate weeds and discourage new weeds from growing.