



Module 4: Plant Growth, Management & Pest Control Instructor Guide

Module Overview

This module explores the relationship between plant biology and sustainable pest management practices through three integrated lessons. Students investigate how plants allocate resources for growth and defense, how Integrated Pest Management (IPM) supports sustainability, and how rapid diagnostics can prevent crop loss. The module builds systems thinking and equips students with applied agricultural skills through discussions, design activities, and critical evaluations.

Materials Provided

- Slide deck with speaker notes
- Optional Student-facing worksheets
- Student notes with vocabulary list
- Module mind map
- Optional lab activity instructions and reflection prompts

What Should Students Walk Away With

This module offers students an introduction to plant life and growth, as well as the necessary practice of the use of pest control. Diving into the concepts of plant growth through mechanisms of hormonal growth control, as well as natural and survival reactions to outside and internal forces.

By the end of the module, students should be able to:

- Explain how plants allocate energy between growth and defense under stress
- Differentiate key plant defense pathways (jasmonic vs. salicylic acid)
- Describe and apply the tiers of Integrated Pest Management (IPM)
- Compare diagnostic methods for plant pathogens in terms of speed, cost, and practicality
- Design a sustainable IPM plan incorporating early diagnostics and circular-economy principles
- Evaluate pest management strategies using environmental, economic, and social criteria

This curriculum is designed to equip students with a systems-level understanding of plant biology and pest management, while cultivating practical skills in sustainable agriculture, scientific reasoning, and real-world problem solving.

Key Question:

How can understanding plant biology and pest management systems lead to more sustainable agricultural practices?

Essential Questions:

- *How do plants balance the need to grow with the need to defend themselves against pests and pathogens?*
- *How can we maximize crop yield and quality AND minimize pesticide use?*
- *How can early detection of plant diseases improve sustainability and reduce crop losses in modern farming systems?*

Lesson A: How a Plant Grows & Fights

Summary: This lesson focuses on the internal trade-offs plants make between growth and defense. Students review photosynthesis as the foundation of plant energy production and learn how energy is allocated through source–sink dynamics. They explore how source tissues (leaves) and sink tissues (roots, fruits, flowers) interact to balance growth and defense demands. The role of plant defense hormones is highlighted, with an emphasis on the jasmonic acid pathway (insect chewing, necrotrophic fungi) and the salicylic acid pathway (viruses, biotrophic pathogens). Through case studies (e.g., Dr. Mauck’s research on virus-altered plant scent signals that attract or repel insects), students connect molecular signals to real ecological outcomes. The activity, a mini circular loop of plant metabolism, illustrates how limited resources must be recycled and

redirected under stress (e.g., drought, pruning, or heat). By the end of this lesson, students see plant metabolism not as a static process but as a dynamic balancing act between growth and defense, directly tied to crop productivity and resilience.

Focus: Understanding how plants manage the trade-off between growth and defense.

Slides: 3-21

Lecture Notes:

- Warm-Up Discussion: “How do plants balance the need to grow with the need to defend themselves against pests and pathogens?”
- Review the process of photosynthesis and the concept of source–sink dynamics (how sugars are allocated)
- Explain how stress—like drought, pruning, or pathogens—shifts plant priorities from growth to defense
- Introduce plant hormones: jasmonic acid (wounds/insects) vs. salicylic acid (viruses/fungi)
- Show Dr. Mauck’s research on how viruses manipulate plant scent signals
- Guide students through the concept of a “mini metabolic loop,” showing internal cycling under stress

Student Activities (Optional):

- Mini Circular Loop (Think-Pair-Share): Design a circular loop that shows how a plant makes energy, grows, responds to attack, and defends itself
- Metabolic Modeling (Think-Pair-Share): Use the metabolic modeling website to decide how to stop the pest

Key Vocabulary:

- Photosynthesis, source–sink dynamics, jasmonic acid, salicylic acid, plant hormones, stress response

Objectives:

- **Explain:** how photosynthesis supplies energy and how source–sink dynamics allocate sugars to growth or defense.
- **Differentiate:** between jasmonic acid and salicylic acid pathways and the types of pests/pathogens they target.
- **Create:** a “mini circular loop” of plant metabolism, showing how resources are cycled within the plant under stress.

Lesson B – IPM as a System

Summary: This lesson introduces **Integrated Pest Management (IPM)** as a structured, layered, and sustainable approach to pest control. Students analyze the **IPM pyramid**, beginning with **cultural controls** (crop rotation, sanitation, resistant varieties), then moving to **mechanical/physical controls** (traps, barriers), **biological controls** (predators, parasitoids, beneficial microbes), and finally **chemical controls** (selective, minimal, last resort). Case studies such as lady beetles vs. aphids and the use of nematode-trapping fungi like *Dactylella* highlight biological interactions that reduce pesticide reliance. Students examine how monitoring thresholds and decision-making tools ensure that interventions are only applied when necessary, preventing waste and environmental harm. By designing their own IPM plan for a chosen crop, students apply these strategies holistically, balancing efficacy, cost, and sustainability. The emphasis on **system thinking** shows IPM as a circular process—feedback from monitoring informs interventions, and interventions are continuously adjusted to changing conditions.

Focus: Exploring Integrated Pest Management (IPM) as a holistic approach to sustainable agriculture.

Slides: 22-53

Lecture Notes:

- Warm-Up Discussion: “How can we maximize crop yield and quality AND minimize pesticide use?”
- Introduce the IPM pyramid and explain each tier: cultural, mechanical / physical, biological, and chemical
- Discuss the benefits of combining methods: economic, ecological, and health-related.
- Show examples from the Borneman Lab: fungi that kill nematodes, lady beetles vs. aphids, microbial vs. insect Biocontrol
- Discuss the economic threshold concept—when pest control becomes cost-effective

- Explore challenges: barriers to adoption, policy needs, and future research directions

Student Activities (Optional):

- Building an IPM Plan (Think-Pair-Share): Choose a crop from the list on the UC IPM website, and complete the IPM Pyramid Worksheet by filling in one tactic per IPM tier

Key Vocabulary:

- IPM, cultural control, mechanical control, biological control, chemical control, sustainability, economic threshold

Objectives:

- **Describe:** the four tiers of IPM (cultural, mechanical/physical, biological, chemical) and how each supports circular-economy principles.
- **Design:** an IPM plan for a chosen crop that incorporates at least one tactic per tier and a monitoring strategy.
- **Evaluate:** the sustainability of a chemical-only approach versus an IPM plan using environmental, economic, and social criteria.

Optional Extension Learning:

- Extended Learning: Metabolic modeling for root microbiomes
- Career Pathways: Plant Physiologist, Crop Scientist, IPM Specialist, Agricultural Extension Agent, Biological Control Researcher, Plant Pathologist, AgriTech Product Developer, Environmental Scientist, Sustainability Officer, Agri-Food Systems Educator.
- Modeling Microbial Cooperation Simulation (Activity Corner)

Lesson C – Fast Diagnostics

Summary: This lesson highlights how **rapid diagnostic tools** revolutionize pest and pathogen management. Students compare **traditional diagnostics** (e.g., agar plating, PCR) with **rapid field-ready methods** such as LAMP assays, paper-based microfluidic devices, and CRISPR-based detection. Each method is analyzed for speed, cost, accuracy, and field practicality, illustrating the economic and ecological cost of delayed diagnosis. For example, students work through a cost-of-delay scenario that models yield losses if a fungal blight is detected late versus early. Case studies—including Dr. Hill’s FAST device (automation of citrus budwood pathogen detection)—demonstrate cutting-edge applications. In the activity, students integrate rapid diagnostics into an IPM plan, showing how early, accurate information closes the loop: it enables targeted interventions, reduces chemical overuse, and prevents crop losses. Students leave with an appreciation of diagnostics as not just a laboratory tool, but as a **critical sustainability strategy** for 21st-century agriculture.

Focus: Exploring modern plant disease detection tools and their role in sustainable farming.

Slides: 54-70

Lecture Notes:

- Warm-Up Discussion: “How can early detection of plant diseases improve sustainability and reduce crop losses in modern farming systems?”
- Review traditional detection methods: agar plating and PCR
- Introduce rapid tools: paper microfluidics, LAMP, CRISPR
- Discuss Dr. Hill’s and Dr. Tsutsui’s work on field-ready diagnostic devices
- Explain how fast results help farmers act early and reduce waste
- Show a sample cost-of-delay analysis comparing early vs. late detection

Student Activities (optional):

- Rapid Diagnostic IPM Integration (Think-Pair-Share): Analyze a real-life scenario, choose a diagnostic tool and justify the test based on speed, cost, and accuracy

Key Vocabulary:

- LAMP, CRISPR, diagnostics, pathogen detection, paper microfluidics, cost-of-delay

Objectives:

- **Compare:** traditional (agar, PCR) and rapid (paper microfluidic, LAMP/CRISPR) diagnostic methods on speed, cost, and field practicality.
- **Calculate:** potential financial and resource savings gained by early detection with rapid testing tools.
- **Integrate:** a rapid diagnostic protocol into an IPM plan to show how timely information closes the loop and reduces waste.

Hands-On Labs (Optional, 45 min–90 min):

- In Progress

Assessment & Wrap-Up:

- Use the student worksheet (think-pair-share) to guide notetaking, exit tickets, and small-group review
- Use review questions at the end of each lesson for formative checks
- Assign a short reflection: “How do plant growth, defense, and pest management strategies work together as part of a larger system, and what trade-offs do farmers face when deciding how to protect crops while keeping agriculture sustainable?”

Teaching Tips:

- You do not need to cover all activities or notes—adapt to your students and your schedule
- Use the speaker notes to guide flow, but feel free to personalize delivery
- Vocabulary and mind map can be used as review tools or built upon throughout the module

Recommended Duration:

Approximately 3–5 class periods (45–55 minutes each). Lessons A, B, and C can be completed in one class period, with two-three additional periods suggested for hands-on lab activities or extension projects. The module’s timeline is flexible: educators may extend the design project or include the optional labs described below to deepen inquiry and real-world skill development.

Recommendations for Instruction:

- **Begin with relevance:** Frame the module around challenges students may already recognize, such as pest damage in gardens or food insecurity linked to crop losses. For example, open by asking: “Have you ever seen a plant in your yard or community look eaten up or sickly? What do you think caused it?” This grounds the science of plant defense and pest control in their lived experiences.
- **Reinforce systems thinking:** Continuously connect how plant metabolism (Lesson A), IPM strategies (Lesson B), and rapid diagnostics (Lesson C) are not isolated but interdependent. For instance, highlight how early detection (Lesson C) can make IPM (Lesson B) more sustainable, or how sugar allocation between growth and defense (Lesson A) determines crop vulnerability to pests. Encourage students to view plant health as a dynamic system where biology, ecology, and technology interact.
- **Use interactive tools:** Incorporate the mini circular loop activity (Lesson A), IPM plan design (Lesson B), and diagnostic integration exercise (Lesson C) as anchors of engagement. Provide visual aids such as the IPM pyramid, hormone pathway diagrams, and side-by-side comparisons of diagnostic methods to help students grasp abstract trade-offs. Encourage students to sketch feedback loops of plant and pest interactions to reinforce systems understanding.
- **Encourage local observation:** Prompt students to connect content to their environment. They might identify pests on nearby crops, gardens, or landscaping, then brainstorm which IPM strategies could apply. For Lesson C, have them reflect on how a rapid diagnostic test could help local farmers detect issues early, tying cutting-edge science to regional food security.
- **Differentiate as needed:** Lessons can be adjusted depending on time and student level. For example, shorten hormone pathway lectures for general audiences, but expand modeling activities for advanced learners. Each lesson includes at least one “hands-on” or “minds-on” activity, and teachers can extend these (e.g., expanding the microbial consortia activity into a mini-project) or condense them to fit time constraints.
- **Sustain positivity:** While discussing crop losses and pest threats, emphasize solution-oriented outcomes: beneficial microbes reducing pesticide use, farmers adopting IPM to cut costs and protect ecosystems, and new diagnostic tools empowering earlier, less wasteful interventions. Keep the tone forward-looking, showing how innovation and biology together can support a more sustainable food system.

Need Support?

Contact the curriculum team:

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