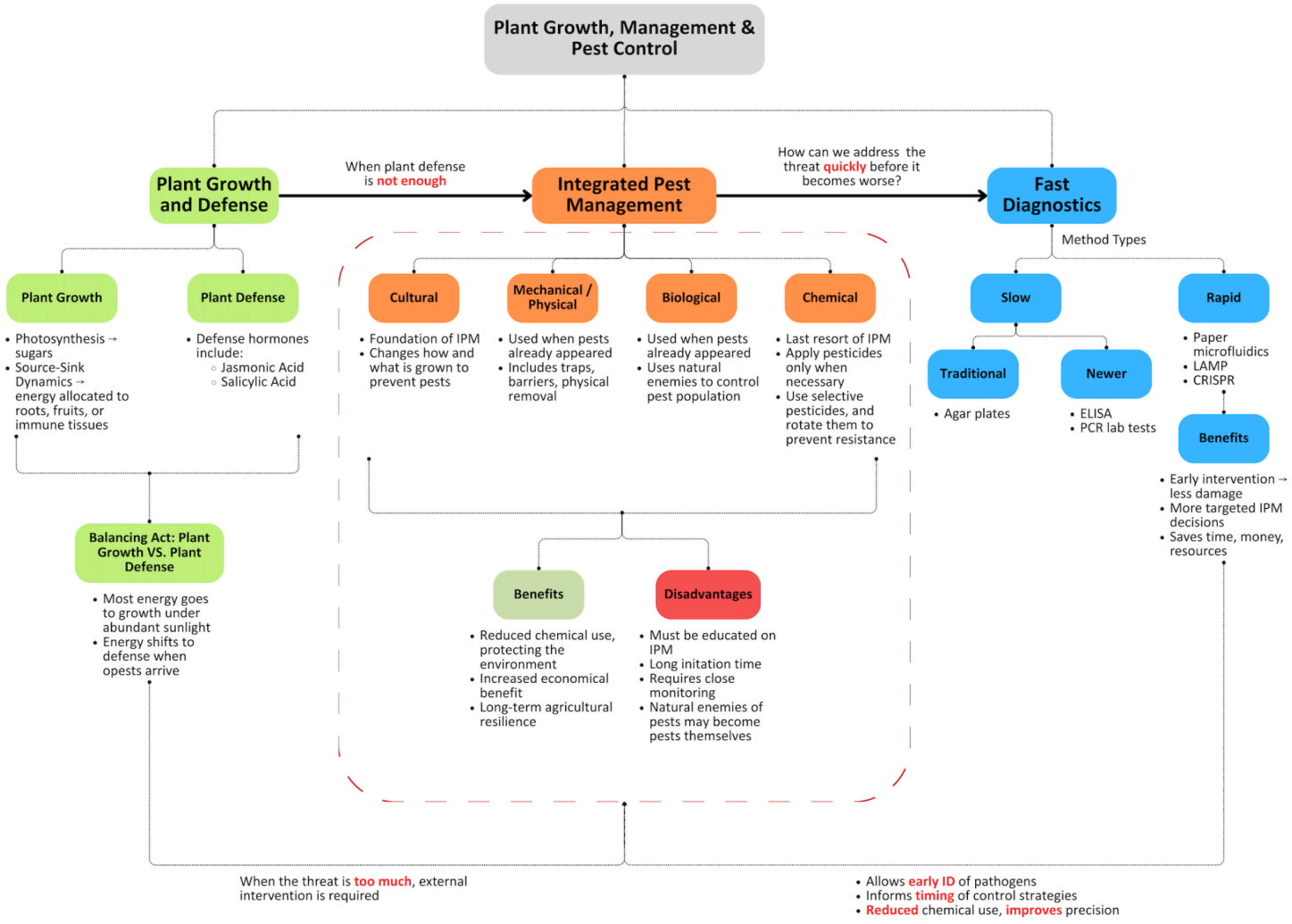
Module 4: Plant Growth, Management & Pest Control

What You'll Learn

Comprehensive Mindmap



This module explores how plants grow, defend themselves, and interact with their environment, and how farmers can manage pests using smarter, more sustainable strategies. You'll examine real-world examples of Integrated Pest Management (IPM), biological control, and microbial design to reduce chemical use, protect crops, and build resilient farming systems.

Lesson A: How a Plant Grows & Fights

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

Lesson B: IPM as a System

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

Lesson C: Fast Diagnostics

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

Important Vocabulary/Terms

Term	Definition	Example
Photosynthesis	The process by which plants convert light energy into chemical energy (glucose) using CO_2 and water.	A leaf capturing sunlight to produce sugar for plant growth.
Jasmonic acid	A plant hormone involved in defense responses, particularly against chewing insects.	When a caterpillar eats a leaf, the plant produces jasmonic acid to trigger protective proteins.
Salicylic acid	A plant hormone that helps defend against pathogens like viruses and bacteria.	A plant infected by a virus activates salicylic acid signaling to slow infection.
Plant hormones	Chemical signals produced in plants that regulate growth, development, and stress responses.	Auxins promote stem elongation, while ethylene triggers fruit ripening.
Stress response	The way a plant reacts to environmental challenges such as drought, pests, or pathogens.	A plant closing its stomata during drought to reduce water loss.
Integrated Pest Management (IPM)	A way of managing pests using multiple strategies—like changing planting habits, using traps, and introducing good	Using ladybugs and sticky traps before spraying pesticides on tomatoes.

	bugs—instead of relying only on chemicals.	
IPM Pyramid	A framework with four tiers: cultural, mechanical/physical, biological, and chemical controls.	Start with crop rotation (cultural) and use chemicals only as a last resort.
Cultural Control	Changing how plants are grown to avoid pest problems.	Rotating crops or choosing pest-resistant seeds.
Mechanical / Physical Control	Tools or barriers that physically stop or trap pests.	Yellow sticky traps to catch whiteflies.
Biological Control	Using natural enemies—like predators or microbes—to fight pests.	Lady beetles eat aphids; fungi kill root nematodes.
Chemical Control	Applying pesticides carefully and only when necessary.	Spraying insecticidal soap after monitoring shows a pest outbreak.
Sustainability	Meeting current needs without compromising the ability of future generations to meet theirs; balancing environmental, social, and economic factors.	Using crop rotation and reducing pesticide use to maintain healthy soil for future harvests.
Economic Threshold	The pest level where the damage would cost more than the treatment—this helps decide when to act.	If pest damage costs $120 but spraying costs $40, it makes sense to spray.
Biocontrol [Agent]	A living organism used to control pests or pathogens.	Dactylella oviparasitica fungus kills nematode eggs in soil.
Dactylella oviparasitica	A beneficial soil fungus that traps and kills root-knot nematodes—used as biological control.	Found by UCR's Borneman Lab; protects tomato roots from nematode damage.
KBase	A software platform scientists use to model microbial communities.	Used in metabolic modeling to predict microbial cooperation.
Metabolic Modeling	Using computer simulations to predict how microbes interact, compete, or support each other.	Simulating how root microbes share nutrients or fight off a new pathogen.
Pathogen	A harmful organism that causes disease in plants.	Nematodes, fungi, or bacteria that attack plant roots.
Source-Sink [Dynamics]	How sugars made in leaves (source) move to where they're needed for growth or defense (sink).	Sugars travel from leaves to roots during root development.
Threshold	The point where pest damage gets too	Spraying only when 25% of leaves

	high and action is needed.	show pest signs
Consortium	A team of different microbes that work together in the root zone.	Designing a group of microbes that help plants grow and block disease.
LAMP	Loop-mediated isothermal amplification, a rapid method to amplify DNA at a constant temperature.	Detecting plant pathogens in the field within an hour using LAMP.
CRISPR	A genome-editing tool that can precisely modify DNA sequences; also used for diagnostic purposes.	Using CRISPR-based tests to identify specific bacterial strains in crops.
Diagnostics	Methods or tests used to identify diseases or pathogens.	Rapid diagnostic kits that detect a virus in infected plants before symptoms appear.
Pathogen detection	The process of identifying the presence of disease-causing organisms.	Testing soil or leaves to confirm the presence of a fungal pathogen affecting lettuce.
Paper microfluidics	Miniaturized diagnostic devices made on paper that allow fluid manipulation for testing.	A paper strip that changes color to indicate infection in plant sap.
Cost-of-delay	The potential loss or negative impact caused by delaying an action or intervention.	Waiting too long to treat infected crops increases loss of yield and treatment costs.