Integrated Pest Management

I. History.

Fruit growers became slightly dependent on chemicals in 1800's when Bordeaux mixture and lime sulfur came into widespread use.

In 1940's, synthetic organic pesticides became available, and evolved into a multi-billion dollar industry. Yields and quality improved greatly; growers became dependent on pesticides.

Today, chemicals de-emphasized, have shorter half-lives and non-target effects; BUT, still pose environmental and health hazards, kill beneficial organisms, and cause development of resistance in target organisms.

Chemicals are still the major means of pest control in fruit production.

II. Definition.

IPM A pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury.

* Definition *does not exclude* the use of chemicals.
* Objective: optimization of control in terms of the overall economic, environmental, and social needs of mankind.
* Requires higher level of management; better education, more supportive research.
* On average, reductions of .25% are realized with IPM vs. calendar or spray schedule approach, but in some years, pesticide applications in IPM programs are equal or may slightly exceed that dictated in spray schedules.

III. Control Tactics.

1. **Resistance** - Breeding or selection of crop species or cultivars that are genetically resistant to one or more pests.

A plant is truly resistant if the pest organism cannot complete its life cycle within the plant and manifest the signs or symptoms of the disease.

A plant is tolerant of a disease if the signs and symptoms are present but growth, production and survival are not affected at economic levels.

2. **Cultural Control** - Manipulating pest populations or those of predators or parasites by cultural practices other than spraying.

a. Sanitation.

- Removal of "mummified fruit" from trees which harbor fungal spores (brown rot of stone fruits)
- Removal of leaf litter, detritus, infected or dead branches in trees, to minimize level of inoculum
- Cleaning tools after use on disease-affected trees

van der Planck's law: $X = X_o e^{rt}$

X= amount of disease at any point in time
X_o= amount of initial inoculum
r= rate of disease spread (depends on environment, pathogen, host)
t= time over which disease increases

b. Alternate hosts. Remove plants from around the orchard which harbor disease organisms/pests.

Cedar-apple rust (remove cedars from orchard borders)
White pine blister rust (some currants and gooseberries are alternate hosts.
Wild plums - carry plum leaf scald and peach phony mycoplasmas; harbor plum curculio, fruit moths.

c. Pruning/training.

- better light (UV) penetration in canopy
- leaves to dry faster (light, air circulation)
- better spray penetration, chemical measures more effective.

* Over-pruning stimulates vigorous, succulent growth which may be more prone to attack by insects or fungi.

d. Fertilization.

- Excess N induces vigor, draws aphids often.
- Nutrient stress weakens plants, natural defenses less active.

e. Irrigation.

- Overhead irrigation keeps foliage wet longer, and may help disseminate organisms that are naturally disseminated by raindrop impact (citrus canker bacterium, fire blight).
- Intermittent irrigation may be helpful in arid areas by washing off dust which harbors mites (used on guard rows).
- Saturated soil around drip emitters - root or foot rot problems?

f. Orchard floor management.

- Mulch or high weeds next to trunk = mice, vole damage.
- Cultivation damages trunks, roots; may spread soil-borne diseases or nematodes
- Mowing when foliage feeding insects are present on sod cover can force insects up into trees to find food (Grasshoppers).
- broad-leaved weeds may attract insects to orchard; mowing beneficial.
- Certain species may be unattractive; may slow movement; e.g, 'Stella' wheat, Nimblewill in peach orchards for nematodes.
- Some natural weed species may provide **nectar and pollen for beneficial insects**.

3. **Biological control** - The regulation of pest populations by their natural enemies (predators, parasites, or pathogens).

a. Beneficial arthropods.

Creature	Feeds on
Ladybird beetles	aphids
Lacewings	aphids
Syrphid flies	aphids
Chalcid wasps	parasitize insect larvae
Trichogramma wasps	parasitize larvae and pupae of lepidoptera
predaceous thrips	mites and scale
predator mites	other mites
preying mantis	soft-bodied insects

Beneficial nematodes can actually be applied thru irrigation! 90-96% control of black vine weevil in cranberry, but at 10x the cost of chemical control ($300/acre) !!

Beneficials - take time to build-up; have special requirements, very sensitive to insecticide sprays.

Two important aspects = Food sources and alternate host insects.

1. Food sources

Parasitic wasps - **need pollen and nectar to live**. Obtain these from plants like (Umbelliferae) carrot, yarrow, dill, anise; mustards; some composites like Black-eyed Susan, daisies, goldenrod. Some gather nectar from foliar nectaries of peach and cherry.

Example: codling moth control.

71% larvae parasitism and 9.2% pupal parasitism in an **unsprayed, weedy** orchard.

Only 7.5% larvae and 0% pupae parasitism in nearby **sprayed, clean-cultivated** orchard.

In **sprayed but weedy** orchard, 17% larvae and 18% pupae parasitism.

2. Alternate hosts

Sometimes necessary for overwintering, completion of life cycle.

Examples:

Ragweed borers - can support parasites of oriental fruit moth; ragweed left in or around orchard may be beneficial.

Strawberry leafroller - hosts parasitic wasps that attack oriental fruit moth. Unsprayed strawberries nearby may help.

Blackberries and prunes - support non-damaging leafhoppers which provide eggs for overwintering of grape leafhopper parasites. Plantings of grapes next to blackberries or prunes have lower infestations of leafhoppers.

Lady bugs - reproduce more slowly than aphids, outbreaks can occur despite presence.

Legume cover crops provide a substrate for pea aphids, which support lady bugs.

In USSR: Codling Moth control.

- One spray of broad-spectrum insecticide in early spring
- 3 releases of *Trichogramma* wasps
- 2 sprays of *Bacillus thuringiensis*

* This program gives adequate control - 3.5% infestation vs. 1.5% infestation for a strict chemical program; Unsprayed control = 54% infestation.

b. Pathogens, parasites.

1. *Bacillus thuringiensis* ("B.t.") - Rod-shaped, gram positive, crystalliferous, spore-forming bacterium. Useful **only against caterpillars**. e.g., Oriental fruit moth, codling moth

- Annual sales of B.t. = 35-45 million $, not quite 1% of 5 billion/yr insecticide market (1988 data).

* Biotech - gene for Bt endotoxin constructed, put into soybeans and other crops - "natural" pest control?

2. Baculoviruses - Most promising of viruses of insect pests.

- Controls 39 insect pests in forestry (16) and agriculture (23).

- Like B.t., these do not affect vertebrates or plants, only arthropods; so safe for environment and man.

- **Slow kill**; at best 4 days, worst = 2-3 weeks; feeding slows as death approaches. Too slow???

- Most effective on small larvae.

3. Fungi.

Hirsutella fungus kills citrus rust mite; greasy spot oil sprays in mid-summer reduce populations, allow rust mites to build.

4. **Autocidal Control** - Manipulation of pests so that they contribute to their own destruction.

Radiate males, causes sterility. Release sterile males into an area with normal males and females - most matings bear no eggs.

5. **Chemical Control** - The use of chemical agents to reduce pest populations; ideally, chemicals are selective for the target pest and do not harm beneficial organisms such as pollinators, or predators, parasites and pathogens of the pest species.

6. **Attractants, Repellents, and Hormones** - Nontoxic chemicals which alter the behavior or physiology of the pest and prevent completion of the life cycle. Also used to monitor pest populations.

a. Mating disruption: Pheromones are chemical "trails" which lead males to females. If area saturated with pheromone, males and females cannot find each other.

1. Codling moth: "Isomate-M" - pheromone impregnated into a twist-tie.

- one tie/tree, works for 90 days
- may require 1 "knock down" spray if populations are high.
* Doesn't work in **small or long and narrow orchards, or those with irregular borders.**

2. Grape berry moth: Ties also available soon.

- Primary insect pest of grapes; often only pest that requires sprays to control.
* Ties can double as ties to hold canes to wires.
- requires about 200 ties/acre.

b. Juvenile hormones: "Juvenoids" - hormones that interrupt dormancy process, disrupt life cycle.

Pear psylla - small, cicada-like insect that feeds on foliage, also a vector of pear decline.

Juvenoids interrupt diapause (dormancy process), exposing susceptible forms of the insect to winter weather. Eggs laid by sprayed individuals do not survive winter; spray in fall.

7. **Quarantine and Eradication** - The confinement of a pest to a given area (quarantine) or the elimination of the pest from a given area (eradication)

Citrus canker in Florida:

Eradicated in 1920's, back again. Eradicated by burning affected trees and neighboring trees.

8. **Mechanical** - Physically killing or removing pests.

e.g., **vacuuming leafhoppers from grapevines**. An air-blast sprayer run in reverse creates a vacuum, goes down the rows and sucks insects into bags. Can use dead bugs in bags as fertilizer!!

Claim is 50-90% control, but still unproven.
"If it flies, we can get it; if it crawls, forget it"

IV. Supportive Tactics.

A. Population sampling, monitoring - **"Scouting".** = regular inspection of the orchard to assess population levels of pests. *The basis for IPM.*

Growers currently avoid because: (New York survey data)

1. Cost of hiring additional personnel to scout.
2. Lack of trained personnel available for hire.
3. Complexity of sampling procedures.
4. Lack of effectiveness of sampling at an acceptable cost.

Cost of scouts ??? < $100/acre for large operations. At least this much can usually be recovered by avoiding unnecessary sprays.

Benefit ??? - as much as 3-fold reduction in pesticides, if environment is "cooperative".

* Former student of HORT 4020 made $22/hr alfalfa scouting !!

Example scouting procedure: Spotted tentiform leaf miner - apple pest.

- Sample at "pink" stage (prior to bloom).
- Sample 4 flower clusters from each quadrant of 5 trees (random).
- Count # eggs on undersides of 2nd, 3rd, and 4th leaves of each spur (leaf #1 = basal)
- If average >1 egg/leaf, or total >60 on all leaves, then spray at pink or petal fall stages. If below this threshold, wait until 2nd generation (July) to sample again.

B. Establishment of economic thresholds. Systematic research of pest population size vs. economic injury.

* Difficult, time consuming work; thresholds may vary with intended market, season, cultivar, etc.