# Principles of Integrated Pest Management

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## 6 Steps of IPM

1) Proper pest ID - what is it?
2) Pest biology - life cycle, food sources, environmental issues
3) Monitor pest levels (and/or environmental conditions for certain diseases) – how many are there?
4) Determine action threshold – how many are too many?
5) Choose tactics – cultural, pesticides, environmental mgt, etc.
6) Evaluate how tactics worked

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## Integrated Pest Management

***Why Practice IPM?***

- Keep a Balanced Ecosystem
- Pesticides Can be Ineffective
- IPM Is Not Difficult
- You may save Money
- Promote a Healthy Environment
- Maintain a Good Public Image

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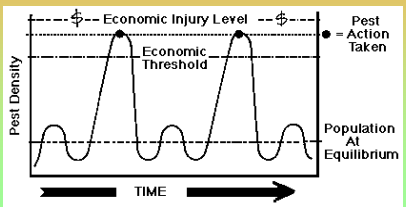
## Chapter XI Integrated Pest Management

***Economic thresholds***

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## When We Do Act

- **Choose:**
  - **The least toxic material that will do the job**
  - **A pesticide with as narrow a spectrum of activity as possible, especially against beneficials**
- **Apply:**
  - **At full labeled rate**
  - **To avoid drift onto non-target plants**

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## Non-Pesticide Tools that IPM May Employ

- **Proper soil management**
- **A composting operation**
- **Crop rotations**
- **Genetics**
- **Seed treatments**
- **Season extension**
- **Traps, pheromones, lures, fences, tree guards…**

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## Key Problems

- Access to appropriate technology
  - Traps/pheromones for small growers
  - Cultivators and other equipment for small farms
  - Biological control agents (registered, but access is difficult due to limited use)
- Access to land for crop rotations
  - Rotation for black vine weevil in strawberry should be several hundred feet – difficult on many farms

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## Production Practices that Reduce Pest Problems


## Soil Management

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## Putting the Focus on Soils

- Ideal soils is deep, well drained, fertile
  - 2-5 ft minimum depth
  - 2-5% organic matter min.
  - Sandy loam texture
  - pH 6.0 to 6.8 for most crops
- But most soils are not this ideal

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## Soil Management

- Optimize soil fertility and biotic life
- Select plant types and varieties adapted to our soils/environment
- Develop a plant system that maximizes soil health and productivity
- Manage soil moisture and temperature
- Manage weeds and other pests

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## Managing Soil Moisture

- Soils contain 3 key mineral components – sand, silt, and clay
- Water
- Free air space
- Organic matter

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Clay plays a key role in the fate of pesticides in the soil


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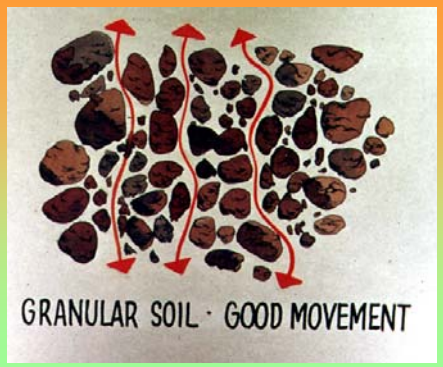


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- Soil Air
  - Atmospheric air moves into pores vacated as water is removed due to evaporation and plant use
    - Larger pores empty first
    - Smaller pores hold water more tightly, so soil air is less in soils with fewer large pores
  - If soil air is limiting, roots can be injured or die
    - This provides an ***entry port for many soil diseases***

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## Factors Affecting Pore Space

- Soil Texture
  - As low as 35% in sandy soils
  - Up to 60% or more in some clays (but individual pore size is much different)
- Handling of soil
  - Continuous sod, for example, has more pore space than a soil used for row crops
  - Reduction of pore space is associated with:
    - Decrease in organic matter content
    - Lowering of soil granulation



## Soil Organic Matter

- OM is the "granulator" of the mineral particles
  - Responsible for the loose, friable condition of productive soils
- Major source of 2 key plant nutrients – P & S
- Increases the amount of water a soil can hold and its availability
- Main source of energy for soil microorganisms
  - In an active state of decay due to action of soil micro-organisms



## The Influence of Organic Matter

- Binds smaller particles
- Lightens and expands soil
- Improves soil porosity greatly
- Has a marked effect on clay
  - Increased water holding may intensify freeze/thaw action

## Influence of Tillage

- Short term effects are generally favorable
  - Implements loosen soil
  - Organic matter is incorporated into soil
  - If moisture levels are favorable, breaks up soil clods
- Long term effects may be detrimental
  - Hastens oxidation of OM
  - Heavy equipment breaks down aggregates and compacts soil
    - Reduces macro-pore space



## Managing Soil Structure

- Sandy soils (coarse textured)
  - Tend to be droughty – too loose and open
  - Need granulation – add organic matter
    - Maintain in sod
      - Also protects soil from 'beating' effect of rains
    - Use farm manures and green manures



Clays and silts (fine textured soils)

| Crop | % Large Stable Aggregates (1 mm+) | % Small Stable Aggregates (<1 mm) |
|---|---|---|
| Corn, continuous | 8.8 | 91.2 |
| Corn in rotation | 23.3 | 76.7 |
| Meadow in rotation | 42.2 | 57.8 |
| Bluegrass, continuous | 57.0 | 43.0 |

## Soil Preparation

- Conventional system
  - Field is plowed in early spring (when soil moisture is appropriate)
    - Manure is generally applied *within a day or two before incorporation*
    - Fertilizers may be applied post plow if manure not availale– broadcast
  - Field is harrowed
  - Planting
    - Often includes placement of small amount of "starter fertilizer" near seed
    - May be followed by pre-emergence herbicide application





## Rototillers

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- **Soils are stratified (soil profile)**
  - **Layers are called horizons**
  - **We farm the "A" horizon – the topsoil**
- **Plowing and tilling can create a glazed pan layer**
  - **Drainage issue**

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## Conservation Tillage

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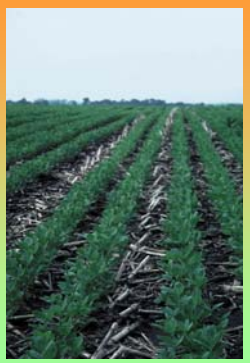
- **Minimum tillage systems**
  - **Protect soil structure (granularity)**
  - **Slow loss of organic matter**
  - **Reduce inputs, especially fuel and equipment use**
  - **Improve weed mgt**
  - **Reduce soil compaction**



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**No-till (corn follows corn)**

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## No-till

- **On the plus side**
  - **Impedes weed seed germination in spring**
  - **Protects soil from erosion over winter, in spring**
  - **Protects against soil compaction**
  - **Feeds micro and macro soil biota**
  - **Provides most P needs, partial K**
- **Liabilities**
  - **If manure is used, it cannot be incorporated (up to 50% of N lost)**
  - **Certain insect pest populations will be enhanced**

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## Soil Nutrient Management

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## The Soil Provides Essential Plant Nutrients

- Macro-nutrients
  - N, P, K
- Secondary nutrients
  - Ca, Mg, S
- Micro-nutrients
  - B, Cu, Zn, Mn, Fe
  - Cl, Mo

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## Soil pH

- Acid, Neutral, or Alkaline
- Dynamic
  - impact of fertilizers, herbicides
  - weathering and leaching
  - rainfall (& irrigation) vs evaporation

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## pH Affects Nutrient Availability

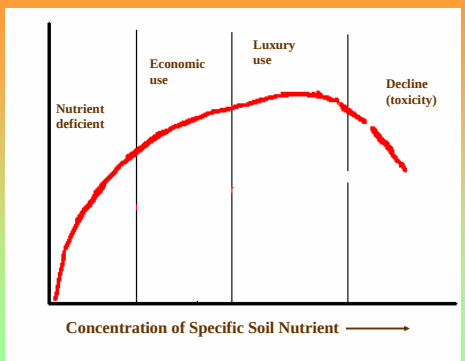
- Metallic elements are more soluble at lower pH's and less available as the pH nears 7.0
  - Zn, Fe, Mn, Cu, B
- N, K, Ca, S, Mg, and Mo become more available as pH rises from very acid to slightly acid levels
- P is in neither group - 6.2 to 6.8 is best
  - below 6.0, forms metallic precipitates
  - above 7.5, forms calcitic precipitates



## Plants Require N, P, & K in Large Amounts

- Nitrogen is the key nutrient affecting plant growth and crop yield
  - Low levels can lead to plant vigor and health issues
  - Excess levels can be worse
    - Too much N can set plants up for diseases, mites, etc
    - Too much K can reduce Ca and Mg uptake





## Sources of Soil Nitrogen

- Atmosphere
  - Soil microbes convert $N_2$ into useable forms via "nitrogen fixation" – both symbiotic and non-symbiotic
- Organic
  - N is released into soil as organic matter decomposes
- Fertilizer inputs

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## Symbiotic Nitrogen Fixation

- Nitrogen gas ($N_2$ from atmosphere) is converted to ammonia ($NH_3$)
  - Legumes are the plants that fix N
    - Alfalfa, clovers, soybean, lupines, beans, peas, vetch, cowpeas…
  - *Rhizobium* bacteria mediated
    - Specific species for each legume species
- Legumes are key plants used in agriculture to supply nitrogen to rotation crops

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## Soil Phosphorous

- Phosphorous is generally considered 2nd in importance as a plant nutrient
- In fertilizers, expressed as % phosphate ($P_2O_5$)

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## Phosphorous in Soil

- Very low solubility
  - Very low availability to plants
- Original source is rock phosphate
- Plants absorb P as $H_2PO_4^-$ and $HPO_4^{2+}$
  - Readily precipitated and adsorbed to soil particles (phosphorous fixation)
  - At low pH, Al and Fe precipitate P
  - At high pH, Ca does the deed
  - More soluble under anaerobic conditions
- Keys to availability are correct pH and OM

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## Other Nutrients

- K (potassium) often supplied based on crop removal
- Mg, Ca levels addressed via pH
- B, Fe, Mn, Cu, Zn, etc

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## Soil Fertility & Plant Health

- Soil Fertility requires a balance of critical plant nutrients
- Deficiency or excess can adversely affect
  - Plant growth
  - Susceptibility to pests
    - Fireblight, mites, etc
  - Post-harvest quality





## Use of Manures

- Amount of bedding will affect nutrient content
- Collection and storage prior to use will affect nutrient content
  - Composting
  - Stacking
  - Liquid systems
  - Phosphorous addition
    - P risk
- To conserve nutrients at application
  - Apply to growing crop such as growing cover crop
  - For annual crops, plow down immediately after application
  - Never apply to frozen, bare, or highly erodible soil
  - Calibrate the spreader

## Composted Manures

- Converts manure, bedding, and other raw products into humus
  - Relatively stable
  - Nutrient rich
  - Chemically active
- Almost eliminates free $NH_3$ or soluble $NO_3^-$
- Safe
  - Low soluble salts (no burn)
  - Can be applied directly to growing vegetable crops



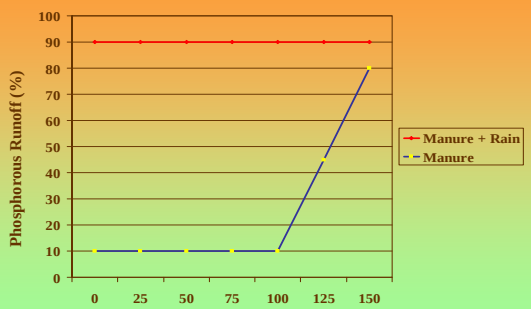
## Impacts on Soil Fertility

- Manure use can lead to nutrient imbalances
  - Rich in P and K
    - Repeated applications can build excessive levels in soil
    - Excess P ties up Cu and Zn
    - Excess K competes with Mg (Ca) for uptake
  - Gradually acidifies the soil
  - Excessive application to growing crops is no different than excessive application of commercial fertilizers
    - It can burn roots
    - It can reduce immunity to pests
    - It can shorten produce shelf life post harvest



## Incorporate Manure

- To prevent N loss to volatilization, incorporate within 4 hours of spreading
- P in manure is very soluble – 90%
  - Rain after application can be a disaster
  - P in bio-solids is less soluble
  - P in compost is somewhere in the middle
- Focus is on reducing P in manure
  - P in diet (grain) increases P in manure and it is soluble

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- **Composting will not eliminate heavy metals**
  - **Cu in poultry diets accumulates in compost**
    - **Essential plant nutrient, but too much is toxic**
    - **If Cu fungicides are used, risk is increased**
- **Composting *may* kill weed seeds**

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## Site Preparation

- **Eradicate perennial weeds**
- **Correct drainage issues**
- **Pick stones**
- **Seed to cover crop for winter**

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## What Are Cover Crops?

- Crops planted to help revitalize the soil between production crops
  - Not harvested for sale
  - Used to:
    - Add nitrogen to the soil OR
    - Soak up nutrients that might otherwise leach
    - Increase soil OM
    - Help with weed management

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## Cover Crop Choices

- Winter Rye
  - Planted in late summer/early autumn
  - Growth in spring in particular can be spectacular
    - Effective nutrient sponge (*trap* crop)
  - Often used as a winter cover to prevent erosion and frost penetration into soil
  - Can serve as tarnished plant bug sink if allowed to flower

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## Other Small Grains

- Barley, wheat, and oats are options
  - Grain sales or grain for use as animal feed on farm
  - Straw sales
- Spring oats
  - Seeded in late summer, make great fall growth
  - Die during winter, providing great seedbed in spring
    - Soil protection
    - Nutrient absorption
    - Weed suppression

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Photo: W.Lord

- Spring oats seeded in autumn
- They die by early December most years
- Corn is seeded directly into dead oat debris in spring
- Oat debris reduces weed seed germination

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## Other Grasses

- Japanese millet
  - Fast growing, summer annual
  - Establishes well in cool soils
  - Very competitive with weeds
  - 4 feet high in 7-8 weeks
- Sudan grass
  - May suppress soil nematode populations
  - Needs heat to grow well – generally seeded in late May/June
  - 6 feet or more – difficult to incorporate

**Neither is allowed to go to seed**

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- Sudan grass is an excellent cover crop!
  - Dense shade for weed smother
  - May reduce parasitic nematode populations
  - High production of organic matter

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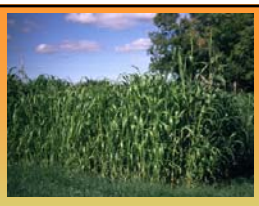

**Flail mow before seed formation**

- Can be soil incorporated in late summer, followed by winter cover of spring oats
- Can be left as debris cover for winter
  - Will re-grow and die when freezing temps occur in fall

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## Buckwheat

- Broadleaf offers good weed smother
- Flowers important nectar source for bees
- Great scavenger plant
  - Will do well in low pH soils
  - Little if any N is needed

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## Legumes

- Alfalfa
  - Deep rooted, likes well-drained friable soils
  - Produces up to 4 or more tons of dry hay per acre in NH
  - Plant in spring or in late summer
    - Seed should be inoculated with nitrogen fixing bacteria
- Clovers
  - Red
    - Will tolerate pH down to 5.5 and broader range of soils than alfalfa
    - Rapid establishment and seed is cheap

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- **Alsike, Ladino, and White clovers**
  - Spring or fall seedings – good stand in 10 weeks
  - Alsike will tolerate low pH soils
- **Alfalfa**
  - Perennial legume – likes high pH soil
  - Spring or early August seeding
  - Produces heavy amounts of N and OM
  - Deep rooted
- **Hairy Vetch**
  - Fast growing winter annual - seed in August or very early September
  - Can supply 100 lb or more of N for next crop

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## Incorporating Cover and Green Manure Crops

- **Options**
  - **Mow aggressive crops when 20-24 inches, plow down**
  - **Flail mow, then plow down**
  - **Flail mow winter killed crops in late summer (ie Sudan grass), allow to re-grow till frost kills**
  - **Roll, then plow in**

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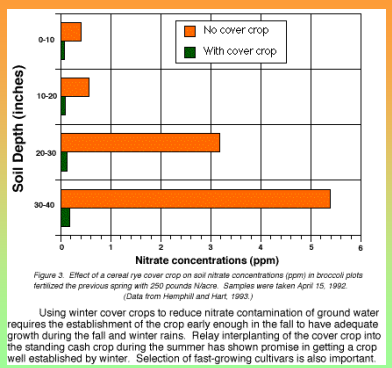


*Figure 3. Effect of a cereal rye cover crop on soil nitrate concentrations (ppm) in broccoli plots fertilized the previous spring with 250 pounds N/acre. Samples were taken April 15, 1992. (Data from Hemphill and Hart, 1993.)*

Using winter cover crops to reduce nitrate contamination of ground water requires the establishment of the crop early enough in the fall to have adequate growth during the fall and winter rains. Relay interplanting of the cover crop into the standing cash crop during the summer has shown promise in getting a crop well established by winter. Selection of fast-growing cultivars is also important.

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## Nematodes

| Cover crop and nematicide treatment | Aug. 10 *M. chitwoodi* No./250g soil | Percent culled tubers |
|---|---|---|
| Wheat stubble (check) | 3,246 | 82 |
| Wheat stubble + Mocap | 2,158 | 81 |
| Sudangrass (cv. Trudan 8) | 145 | 76 |
| Sudangrass (cv. Trudan 8) + Mocap | 8 | 28 |
| Rapeseed (cv. Humus) | 6 | 13 |
| Rapeseed (cv. Humus) + Mocap | 6 | 2 |

Data from R. Ingham, 1993.



## Crop Rotations Help with Pest Management in Strawberry

**(Weeds, Black Vine Weevil, Nematodes)**

Photo: Kopsell

- **5 year rotation**
  - **1 grow year, 3 harvests**
  - **1.5 cover crop years**
- **Cash cover crops**
  - **Sweet corn, pumpkins**
- **Annual grasses**
  - **Sudan grass and sudan/sorgham hybids; millet, spring oats**



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## Living Mulches

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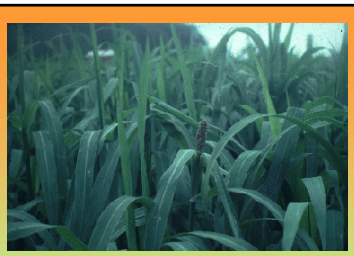

- Work by M. Pritts at Cornell showed that Sudan Grass could be used as a living mulch for strawberry
  - Mow to keep from competing with berry plants
  - Dies when first good frost hits in autumn
  - Plant debris on soil surface in spring reduced weed seed germination
  - As effective as herbicides; yields comparable

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## Summary

- Prepare soil properly
  - pH adjustment; P & K based on soil test
  - Organic matter (cover crop program)
  - Drainage
- Once established, N based on growth, P & K based on soil test
  - Apply N early to reduce risk of winter injury
- Micro-nutrients based on tissue analysis only
  - Make applications on a trial basis only

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## Weed Control Options

- Mechanical cultivation is the most used weed control option
  - Rototillers are effective but pull up weed seeds and pound soil
  - Stirring the top inch of soil is the preference

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## Other Options

- Finger weeders
- Weed flamers
  - Propane is the fuel source
  - These are effective, but slow and expensive from an energy perspective
- Herbicides
  - Pre-emergence (apply to weed free soil at planting to control most annual grasses and broadleaf weeds)
  - Post-emergence (apply to actively growing weeds)

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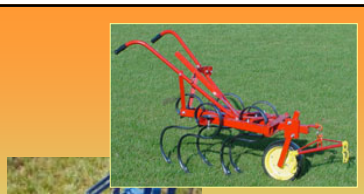


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## It Is Hard To Beat A Hoe

- Shallow cultivation is key
- Hoe should be sharpened regularly
- Hoe in the direction of strawberry crowns to pull soil up

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## A Solid Set, Overhead Irrigation System

Use it to activate your pre-emergence herbicides

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## In Summary

**An IPM approach means that farmers:**

- **Use multiple tactics to prevent pest buildups**
- **Assess the damage**
- **Monitor pest populations**
- **Make informed management decisions**
  - **Keeping in mind that pesticides should be used judiciously**



## Pesticide Resistance Management



## Resistance Issues

- **Overuse of a pesticide can result in a pest developing a tolerance or resistance to the chemical**
  - **Apple scab fungicides (dodine, SI's, etc)**
  - **Insecticides for control of a host of critters**
    - **Pear psylla**
    - **Roaches, bedbugs, etc**
    - **Mites**
- **You get the point**

## Reduce the Risk

- Rotate chemistries
- Use complimentary chemistries in tank mix applications
  - Example: a protectant fungicide with an SI
- Use pesticides at labeled rates and frequency
- Follow label directives on resistance management
  - You loose all claims about product efficacy if you do not
- Integrate non-pesticidal control methods into your pest management plan
  - Soil & nutrient management
  - Resistant varieties
  - Etc…

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