

PESTICIDE 101



CDA
COLORADO
Department of Agriculture

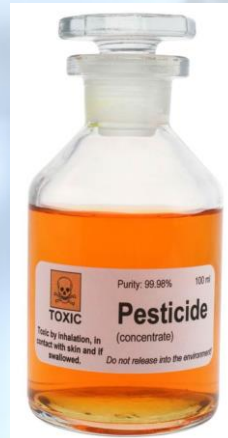
Topics

- Types of Pesticides
- Pesticide Formulations
- Pesticide Mechanisms of Action
- Discussion of products allowed for use on Cannabis

What is a pesticide?

As defined by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA),

“any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any insect, rodent, nematode, fungus, weed or any other forms of life declared to be pests; and any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.”



Types of Pesticides

Pest Name + "CIDE"



Disinfectants





Mixture of chemicals that effectively control a pest

PESTICIDE FORMULATIONS

Pesticide formulations

A pesticide contains:

**Active ingredients
(a.i.)**



**Inert or Other
ingredients**





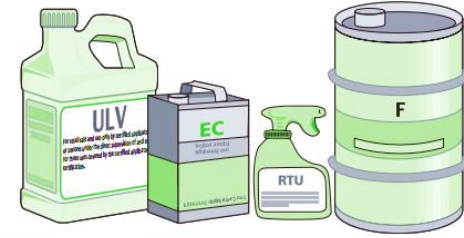
Pesticide Formulations

- Not all products are created equal even if same ACTIVE ingredient
- Check amount (% concentration) of active ingredient
- Think about price related to concentration
- Look at all ingredients
 - Some have many different components under ACTIVE

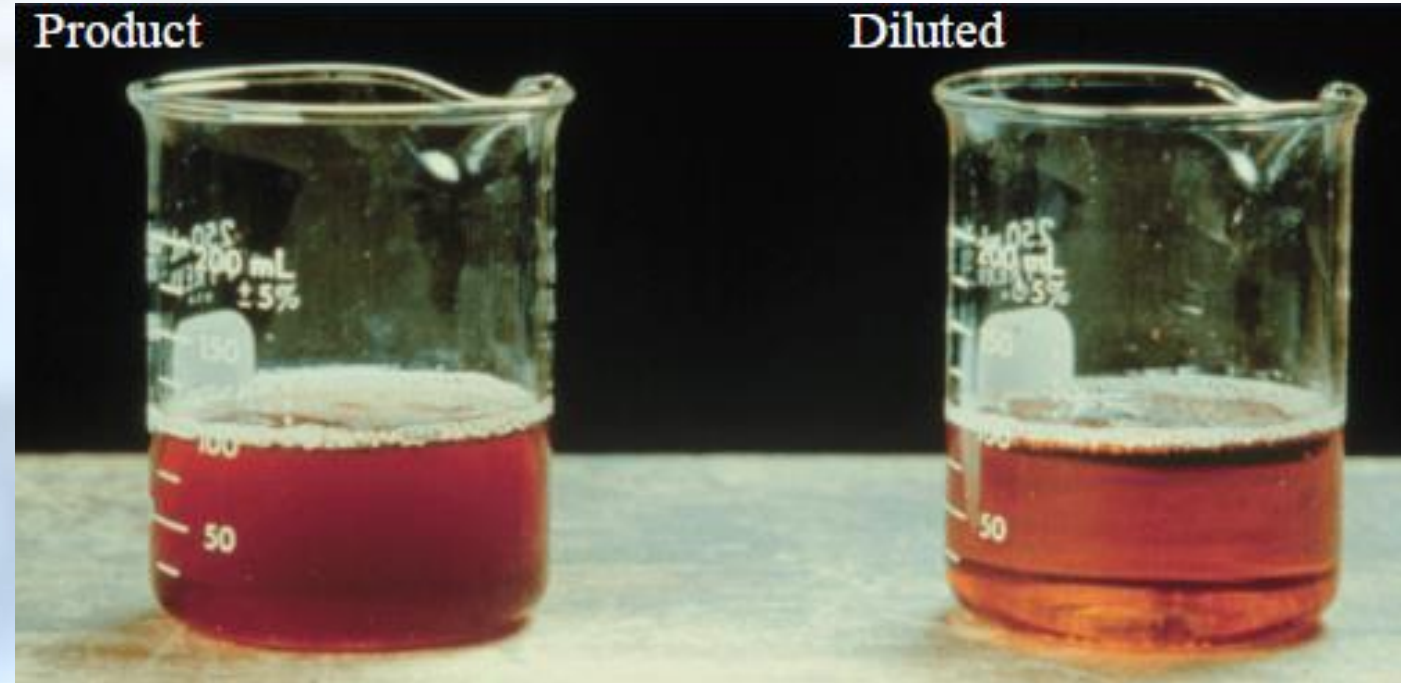


TYPES OF FORMULATIONS (LIQUID)

Liquid

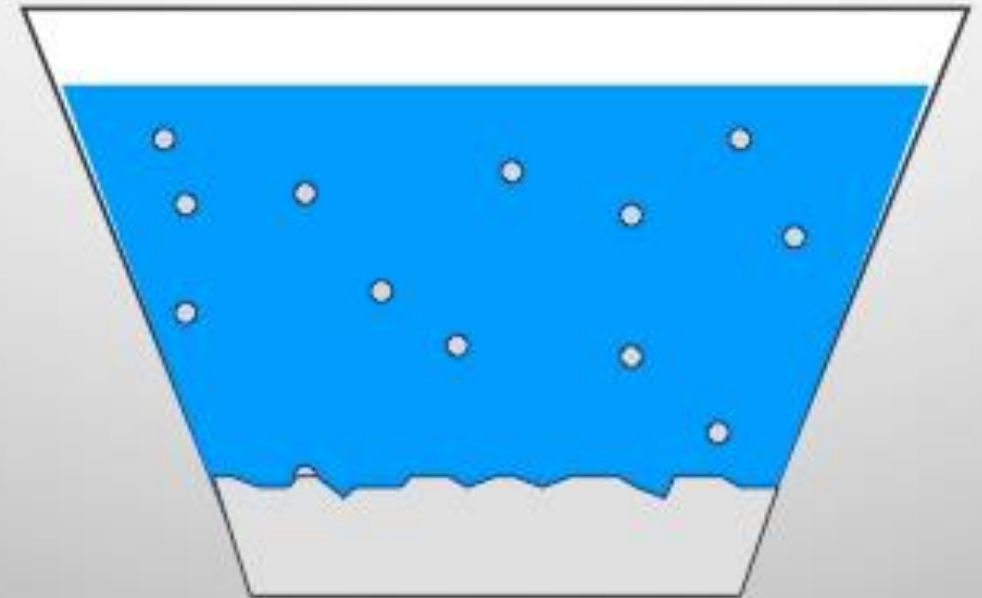
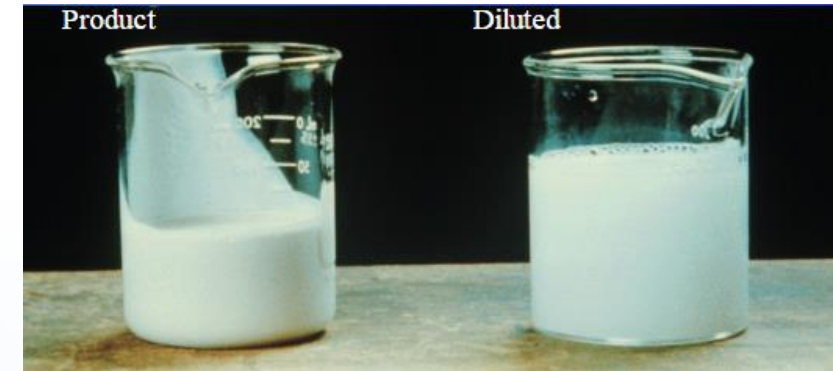


- Solutions—special additives allow formulation to become soluble in water
 - RTU= Ready to Use, no dilution needed
 - C= concentrate
 - LC= Liquid concentrate



Liquid

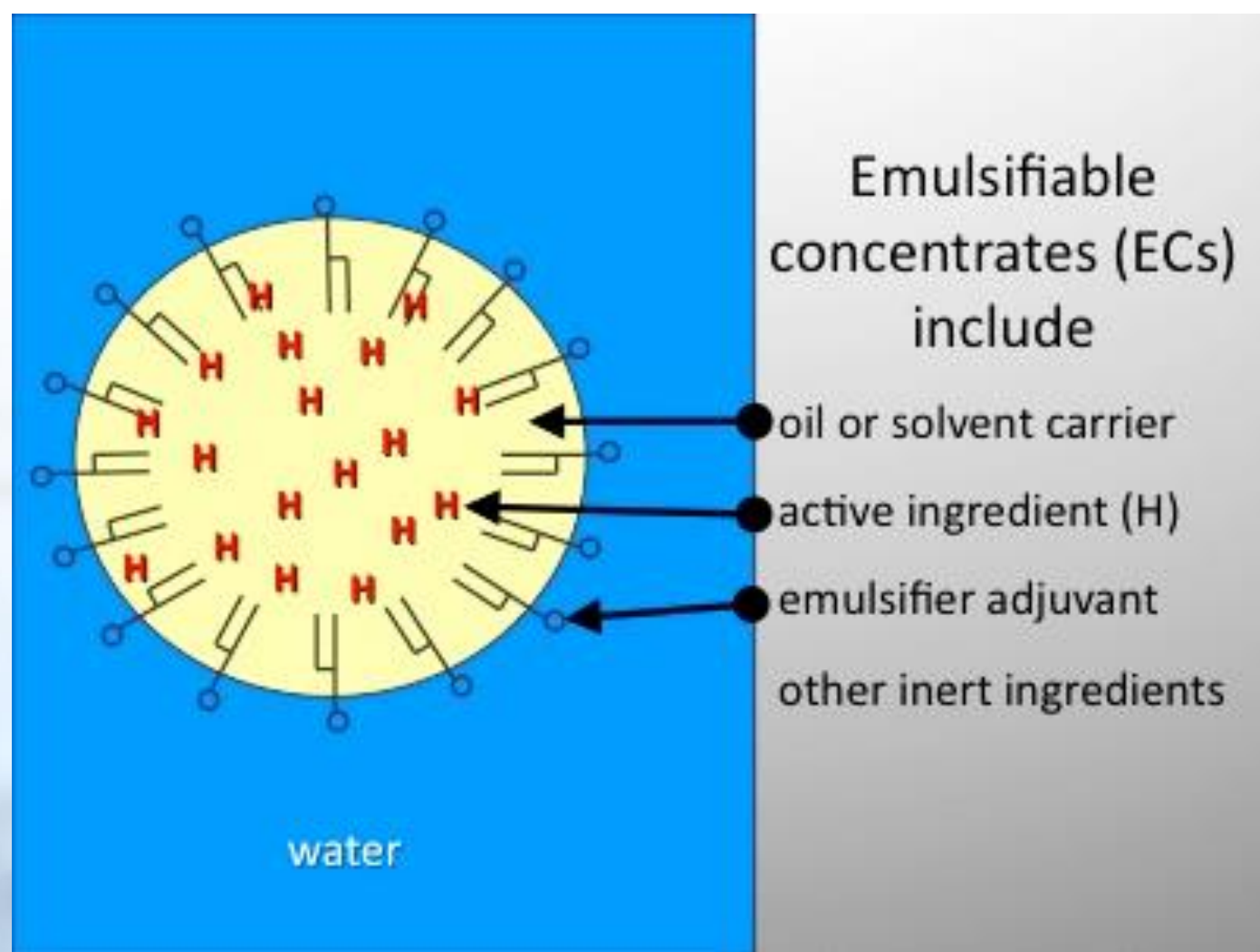
- Suspensions—very fine solid particulates are dispersed in liquid
 - Usually opaque, cloudy
 - Shake well before use
 - F=flowables



Particles in suspensions are larger than those found in solutions and can be evenly distributed by agitation in a spray tank. Without agitation the components may settle out.

Liquid

- **Emulsion**—a special active ingredient mixed with emulsifier + solvent
 - “milky” appearance when mixed with water
 - **EC**-Emulsifiable concentrate



Product

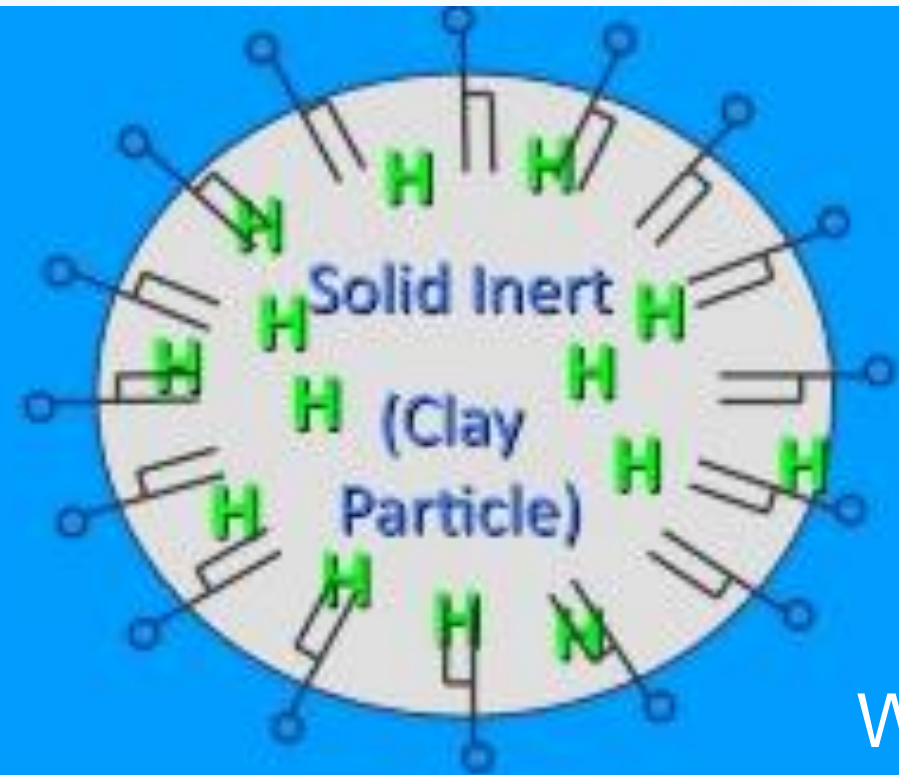
Diluted



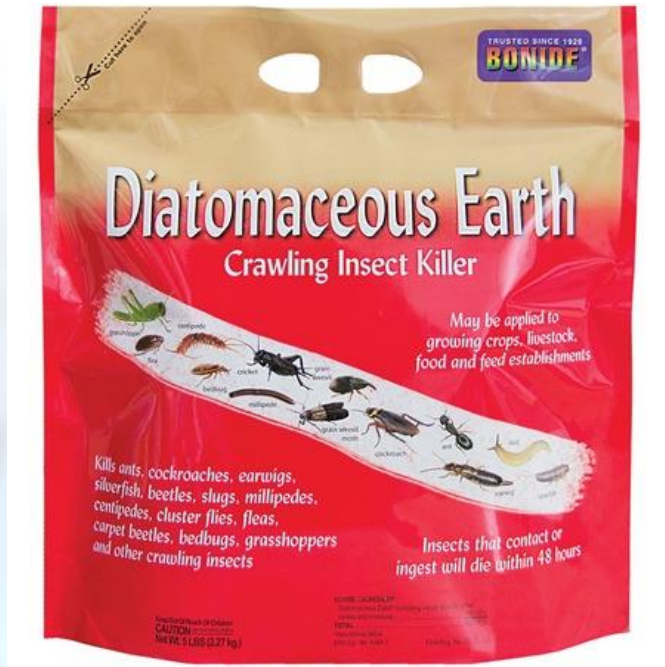
Liquid

Wettable Powders (WP)—
concentrated dusts mixed
with a wetting agent

- Carriers= talc/clay



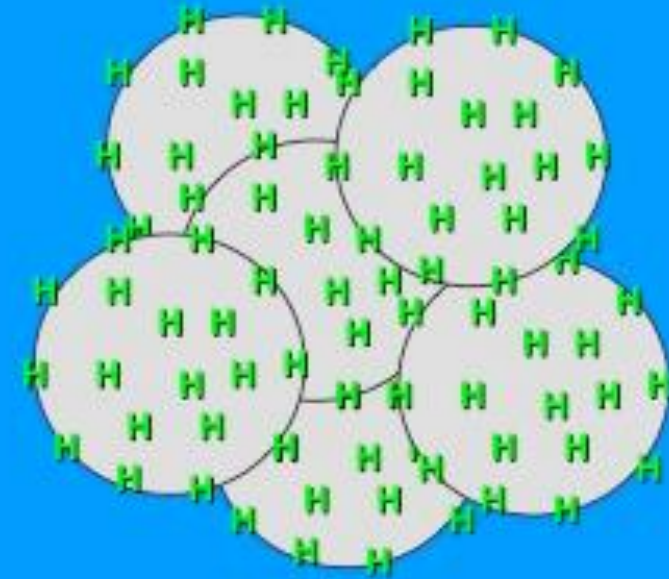
WATER



TYPES OF FORMULATIONS (DRY)

Dry spreadable

- **Dust**—chemicals are formulated as powders and applied directly, no mixing
- **Granules**—coarse particle formulation ($\leq 10\text{mm}^3$) applied to soil
- **Pellets**—coarse particle formulation ($\geq 10\text{mm}^3$, uniform size)
- **Baits**—active ingredient is mixed with materials to attract pest



Granules (G) and pellets (P) are made in a similar way to WPs, except the dry mixture of active ingredient and inert ingredient is pressed into large pellets or granules.

FORMULATION TYPES

A	= Aerosol	PS	= Pellets
AF	= Aqueous flowable	RTU	= Ready-to-use
B	= Bait	S	= Solution
C	= Concentrate	SP	= Soluble powder (or soluble packet; see WSP)
D	= Dust	ULV	= Ultra-low volume
DF	= Dry flowables (see WDG)	W	= Wettable powder
E	= Emulsifiable concentrate	WDG	= Water-dispersible granules (see DF)
EC	= Emulsifiable concentrate	WP	= Wettable powder
F	= Flowable	WS	= Water soluble
G	= Granules	WSB	= Water-soluble bag (see WSP : water-soluble packet)
GL	= Gel	WSC	= Water-soluble concentrate
L	= Liquid	WSL	= Water-soluble liquid
LC	= Liquid concentrate	WSP	= Water-soluble powder (or water- soluble packet; see WSB)
LV	= Low volatile		
M	= Microencapsulated		
P	= Pellets		

Label Examples



Ready to Use



Liquid concentrate
DoubleNickel™ LC

BIOFUNGICIDE

Aqueous Suspension Biofungicide/Bactericide

FOR ORGANIC PRODUCTION

ACTIVE INGREDIENT:	
<i>Bacillus amyloliquefaciens</i> strain D747*	98.85%
OTHER INGREDIENTS:	1.15%
TOTAL	100.00%

*Contains a minimum of $\times 10^7$ colony-forming units (cfu) per milliliter



Net Contents: 2.5 Gallons
EPA Reg. No. 70051-107
EPA Est. No. 70051-CA-001
Lot No:

Emulsifiable concentrate

Neemazad® 1% EC

INSECT GROWTH REGULATOR

Kills/repels a variety of insect pests including whiteflies, caterpillars, leafminers, aphids, and diamondback moths.

FOR ORGANIC PRODUCTION





Kill or prevent the growth of fungi and spores.

FUNGICIDES





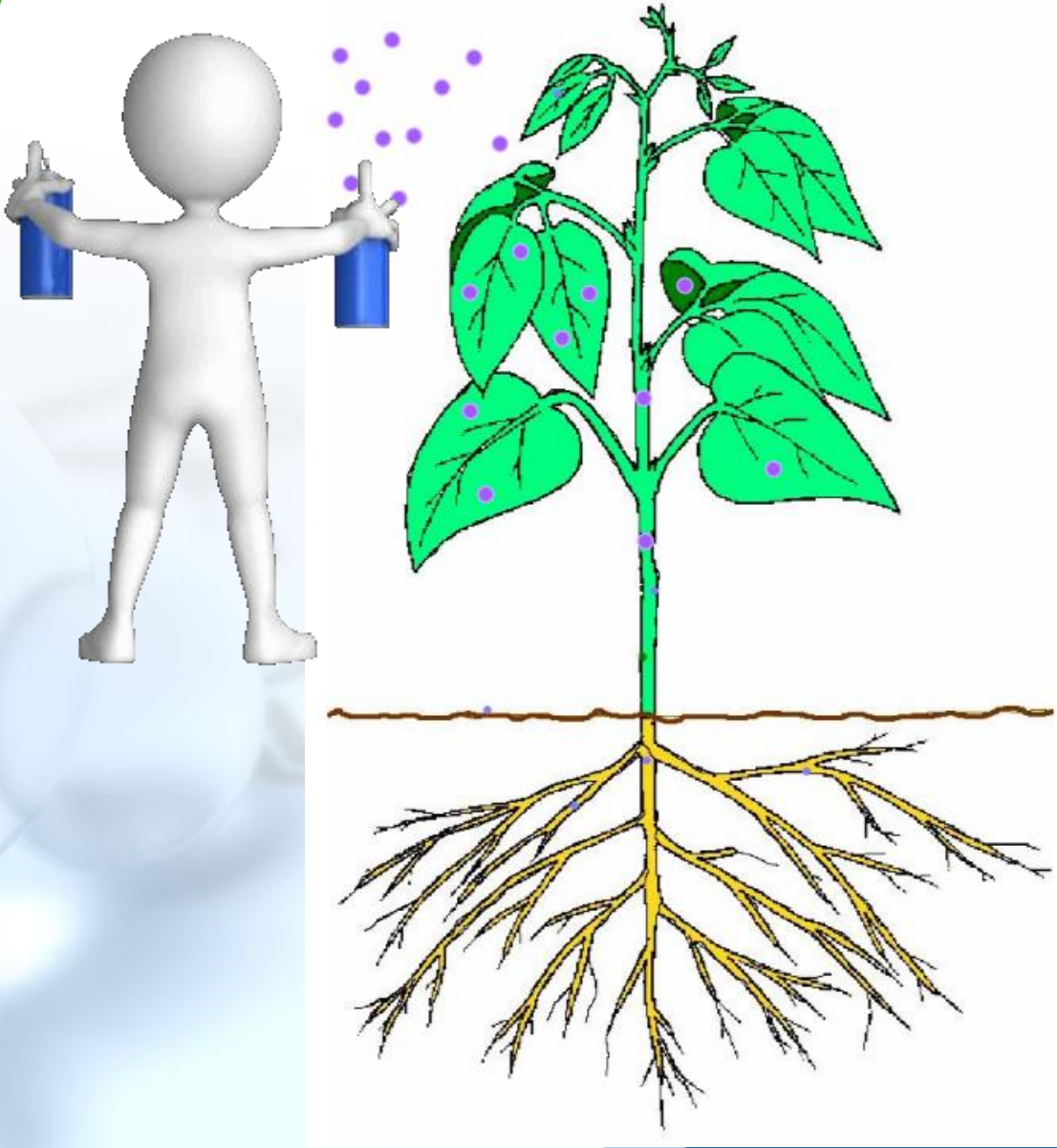
MOBILITY WITHIN THE PLANT

FUNGICIDE



Fungicide Mobility

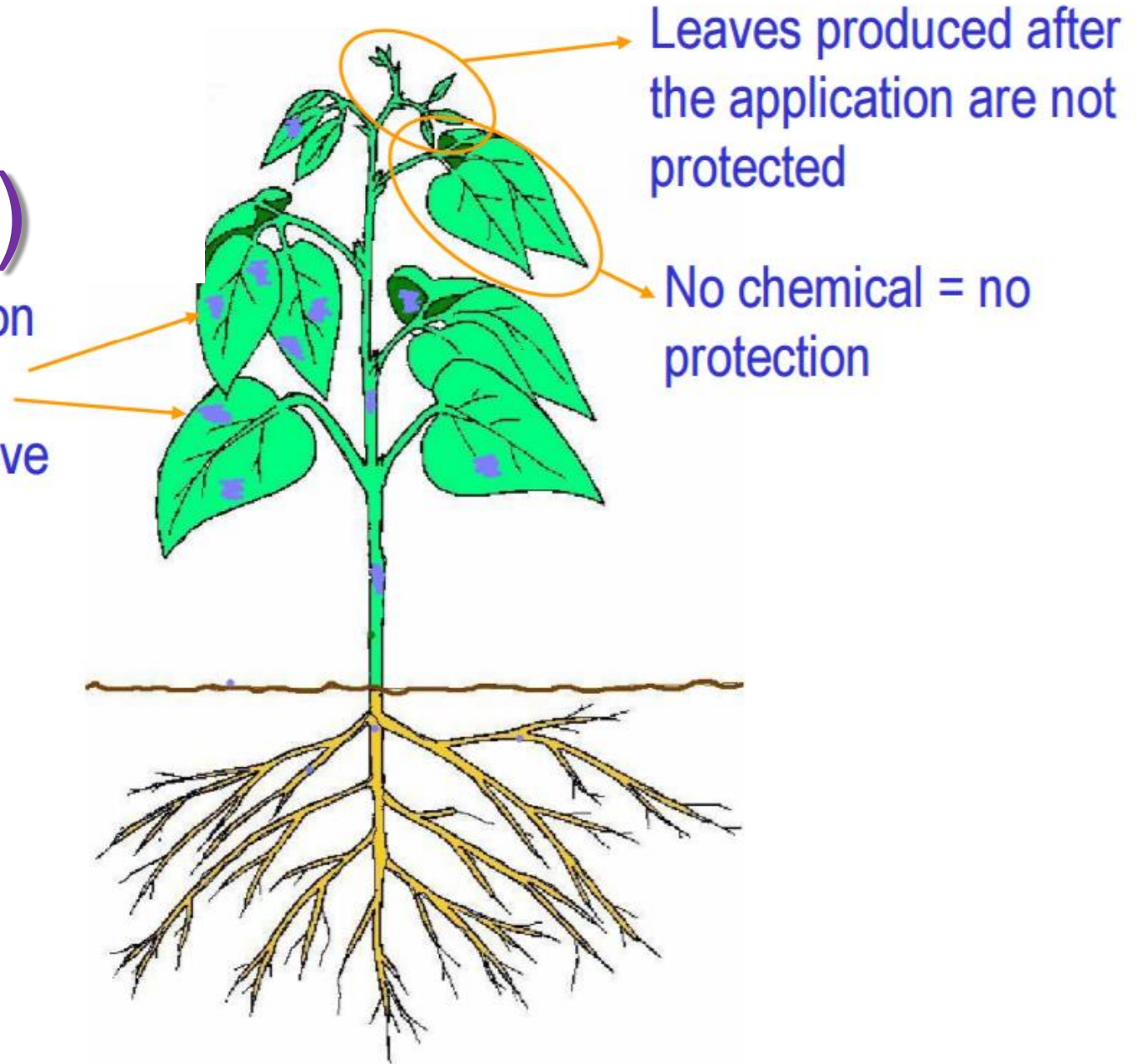
Fungicide applied



Fungicide Mobility

Contact (Protectant)

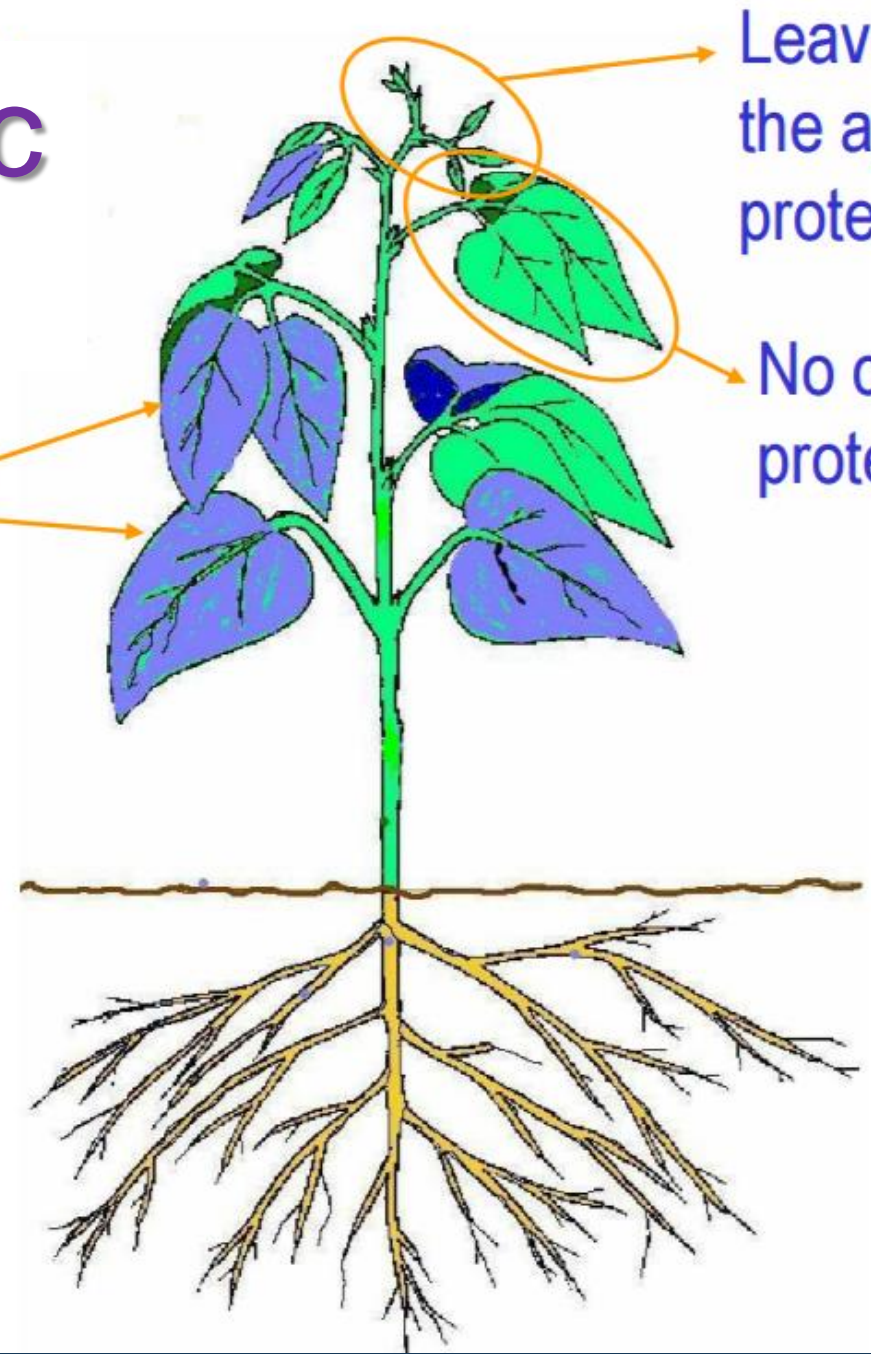
Droplets spread out on the surface where deposited; do not move inside



Fungicide Mobility

Locally Systemic (translaminar)

Droplets spread out on and move inside leaf tissue = external and internal protection



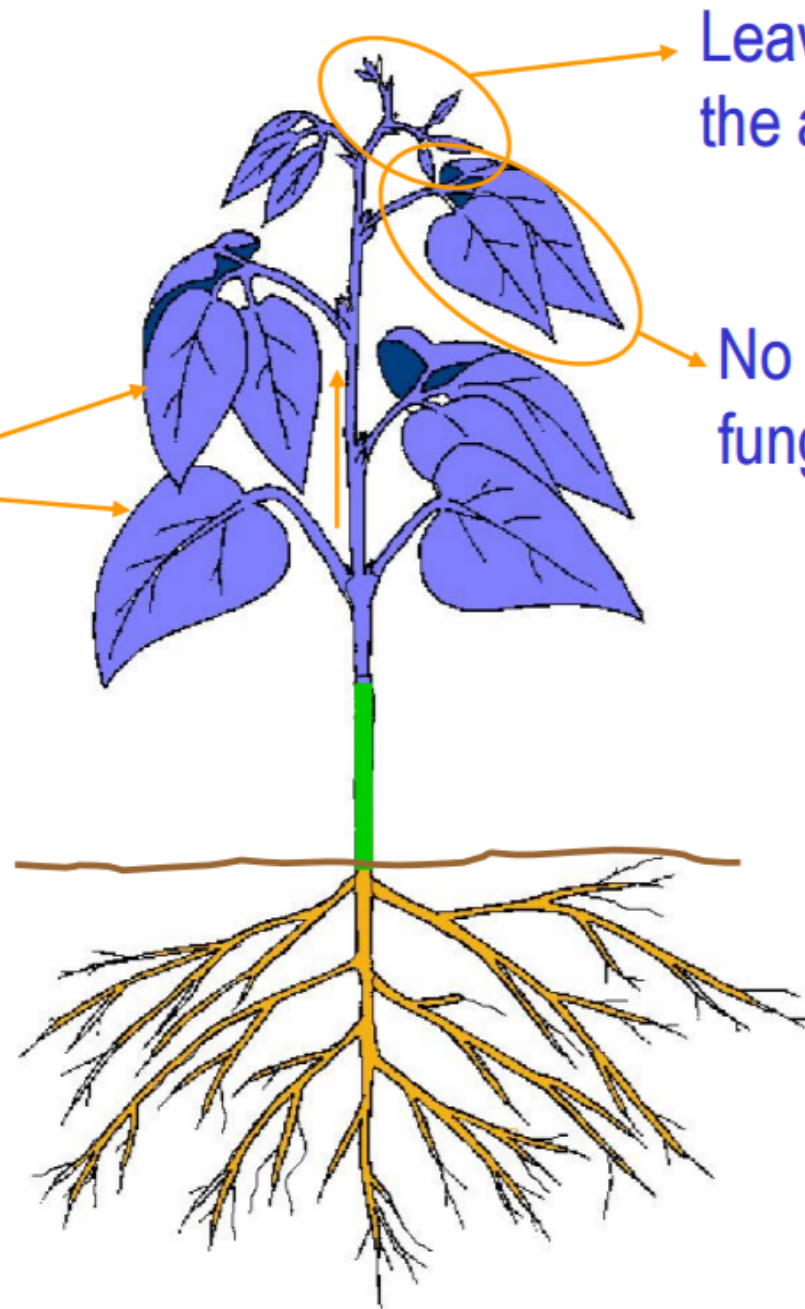
Leaves produced after the application are not protected

No chemical = no protection

Fungicide Mobility

Systemic (acropetal)

Droplets spread out on and move inside leaf tissue = external and internal protection;
Fungicide on the stem moves upwards in the xylem to new growth



Leaves produced after the application protected

No chemical = rely on fungicide via xylem

Fighting microbes with microbes

FUNGICIDE



Pathogen attacks, causes stomata to remain open

Causes plant to produce a compound that closes stomata, preventing further infection.

Bacillus
Produces iturins
colonizes roots

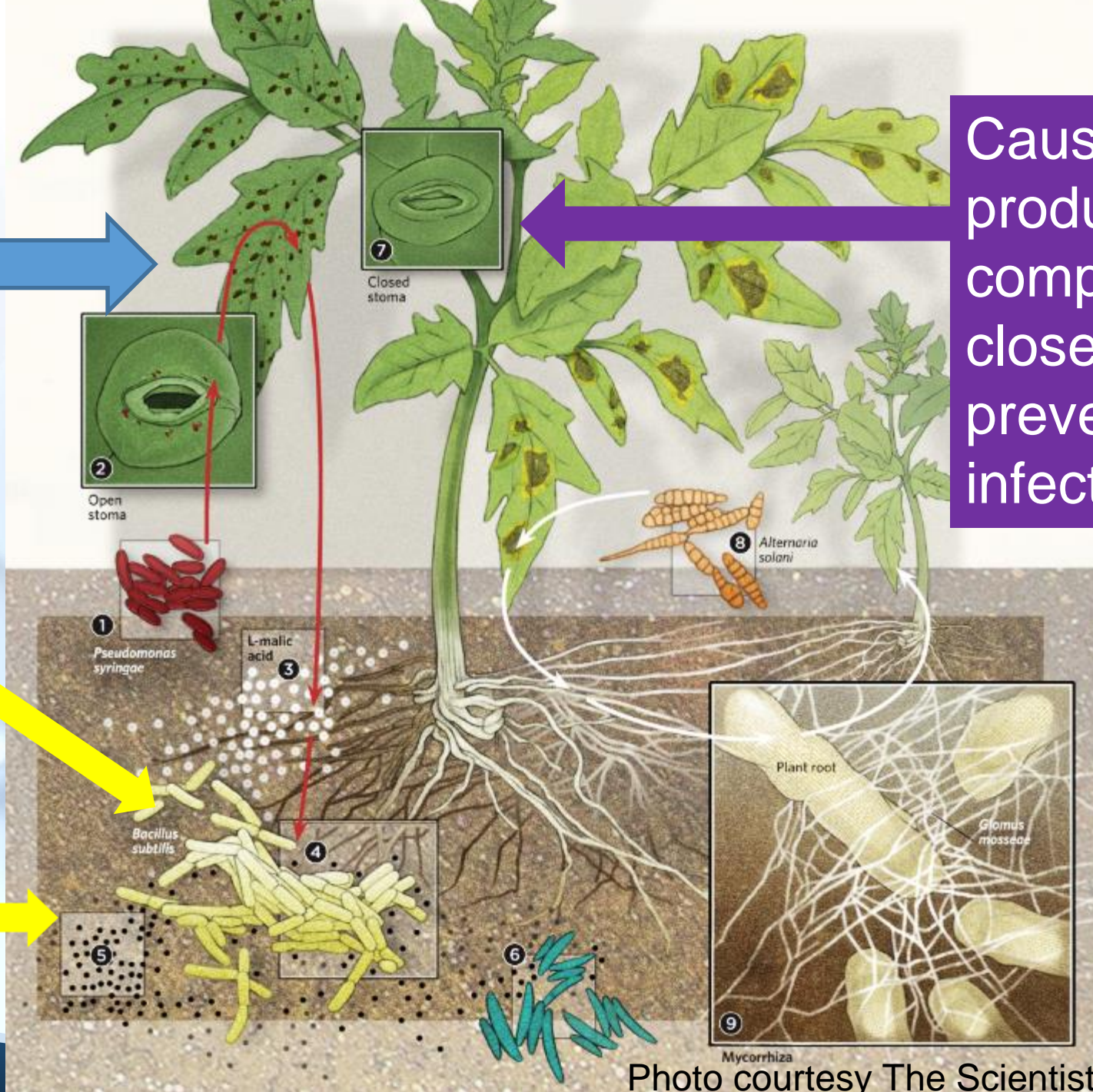
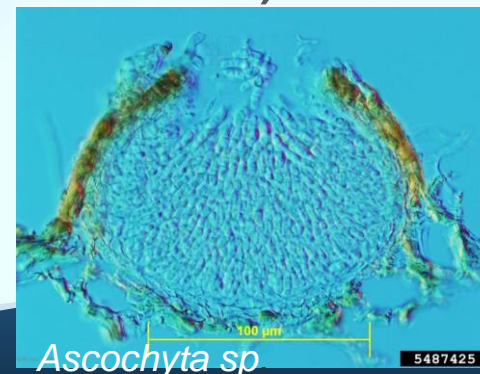
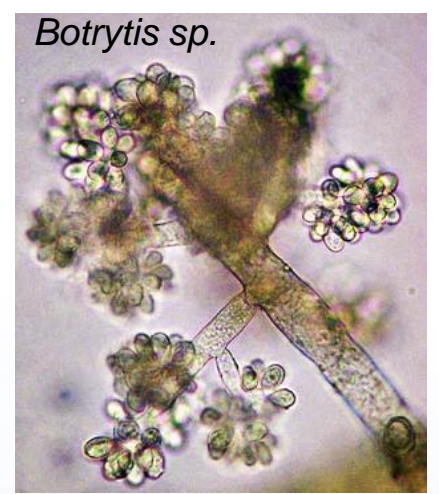


Photo courtesy The Scientist

Fungicides

- Try to ensure the fungi are identified properly. So the correct fungicide can be used.
- Air flow is important—wet leaves transfer fungus.
- Not all diseases caused by fungi can be adequately controlled by fungicides (think vascular diseases like *Fusarium wilt*.)





PESTICIDES

LISTED BY ACTIVE INGREDIENTS

ALLOWED FOR USE ON

CANNABIS

Copper Octanoate



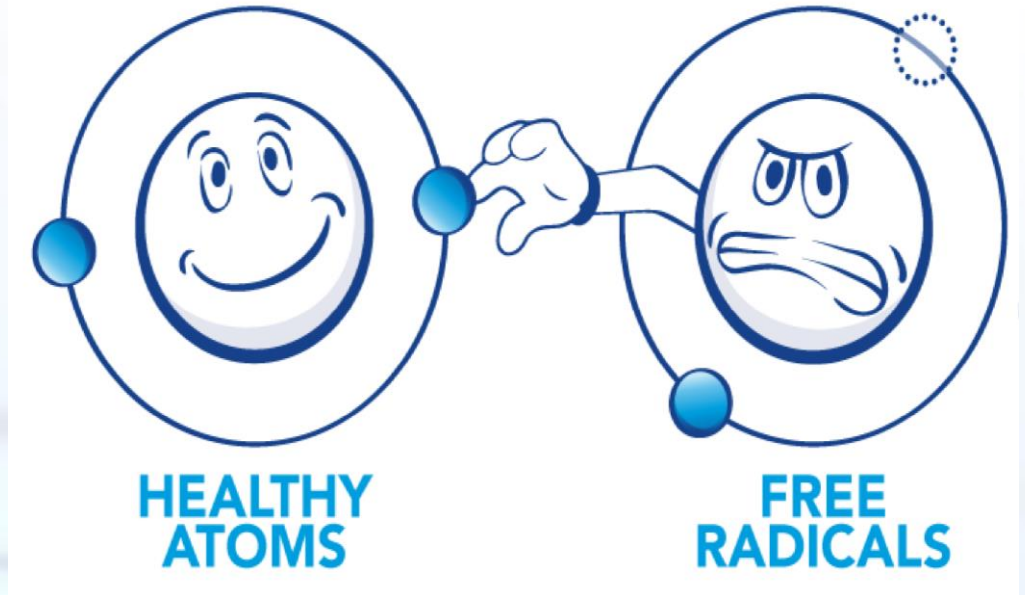
- General biocide; Non-selective (Plant, fungi, bacteria)
- *Efficacy* depends on **Metallic Copper** amount
- Protectant: Apply before infection

ACTIVE INGREDIENT	
Copper Octanoate (Copper Soap) . . .	0.08%
OTHER INGREDIENTS	99.92%
TOTAL	100.00%
Metallic Copper Equivalent	0.017%

- Brown blight, Anthracnose, Brown leaf spot, Gray mold, Powdery Mildew, Bacterial blight, Hemp canker, Yellow leaf spot

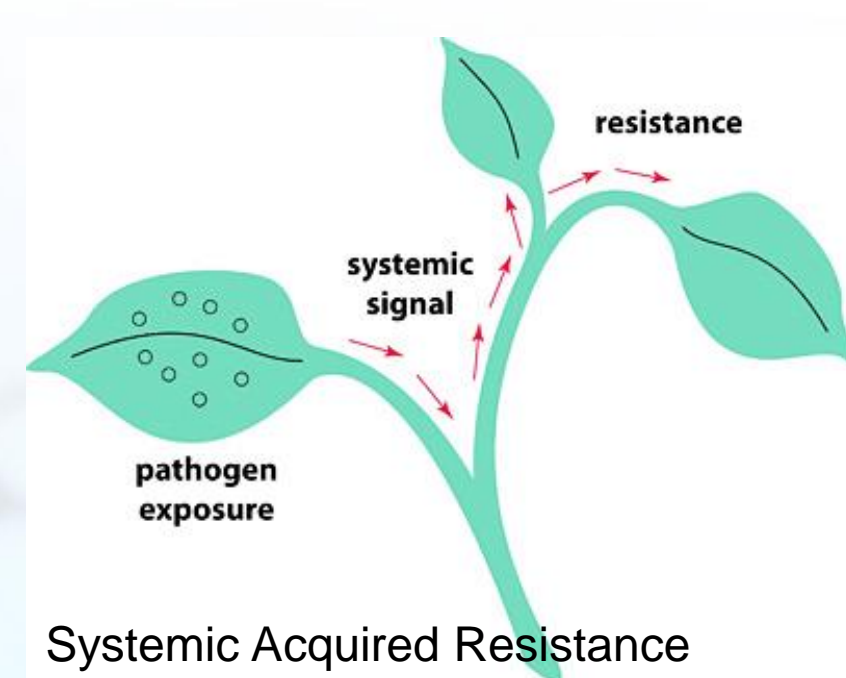
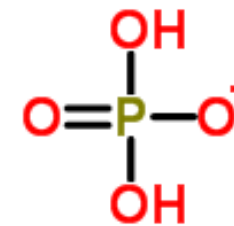
Hydrogen peroxide (Hydrogen dioxide)

- Broad spectrum fungicide
- Works by producing free radicals that attack, causing fungal cells to become brittle and leaky
- Also effective root treatment and in soils
- Fusarium wilt, Damping off, Phytophthora blight, Powdery Mildew

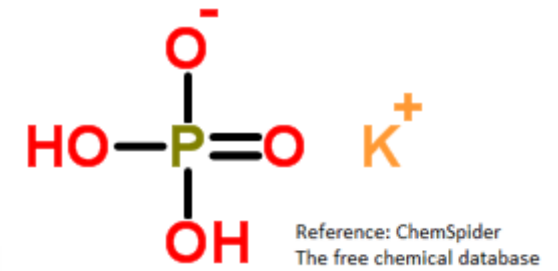


Monopotassium phosphate

- A mineral product that works on contact and helps plant fight pathogens, easily absorbed
- Systemic Acquired Resistance (SAR)
- Prevents fungi from making spores, destructs branches that hold spores
- Gray mold, Phytophthora blight, Powdery Mildew, Damping off, Verticillium wilt, Xanthomonas leaf spot

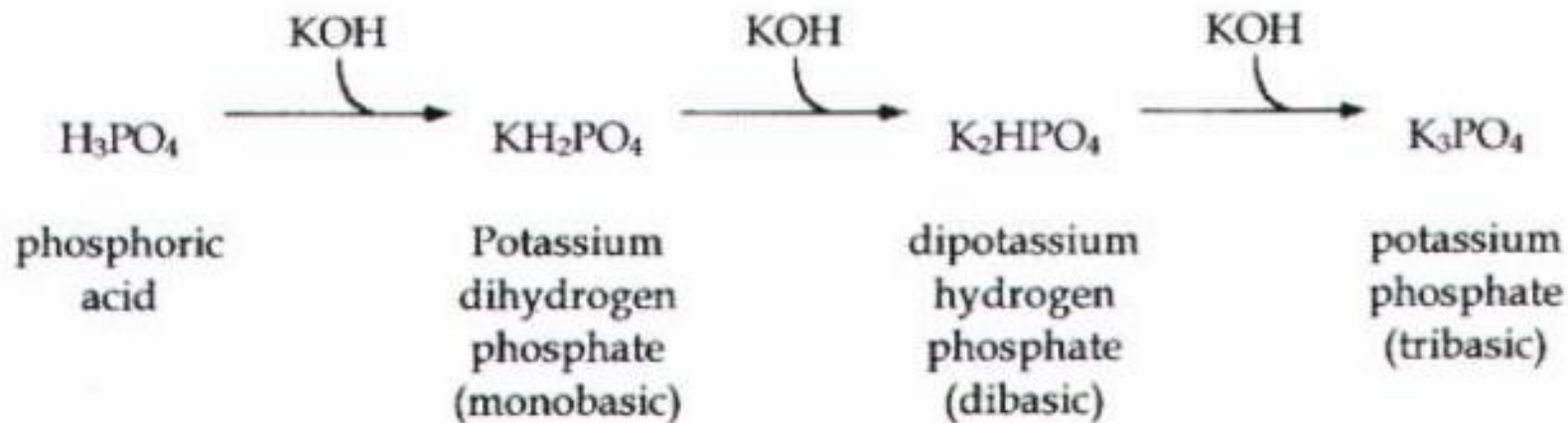


Mono- & di-potassium salts of phosphorous acid

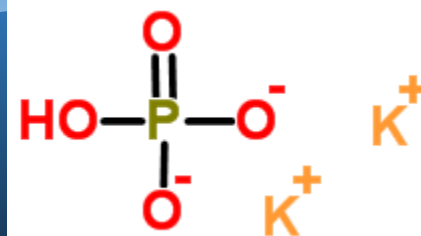


- Phosphoric acid (H_3PO_4) mixed with a base (KOH) results in these salts

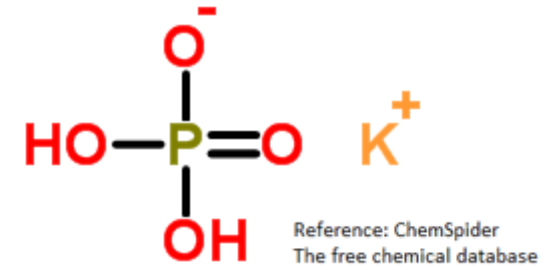
When phosphoric acid (H_3PO_4) is neutralized with a base, such as potassium hydroxide (KOH) or ammonium hydroxide (NH_4OH), a salt results. The salt of phosphoric acid is a phosphate. For example:



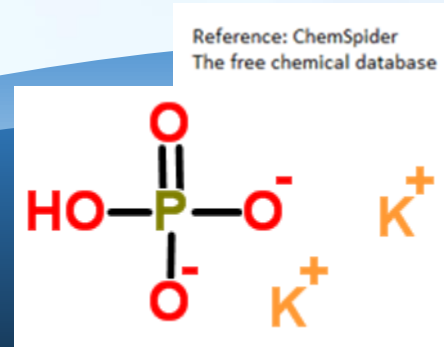
Reference: ChemSpider
The free chemical database



Mono- & di-potassium salts of phosphorous acid



- Works on **contact**
- Direct toxicity to the plant pathogen, aided by natural plant defenses (Systemic Acquired Resistance)
- Damping off, Phytophthora blight, Xanthomonas leaf spot



Neem oil

- Prevents the spread of fungus, not curative
- Degrades rapidly under UV light
- Powdery mildew, Gray mold, Root & crown rot



Sulfur

- Contact and protectant fungicide
- Careful with applications if using oils
- Do a phytotoxicity test

- Powdery Mildew





A fungicide that contains a living organism (usually bacteria or fungi) as the active ingredient

BIOFUNGICIDES ACTIVE INGREDIENTS

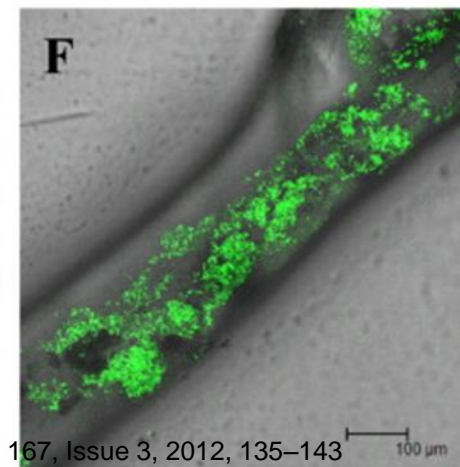
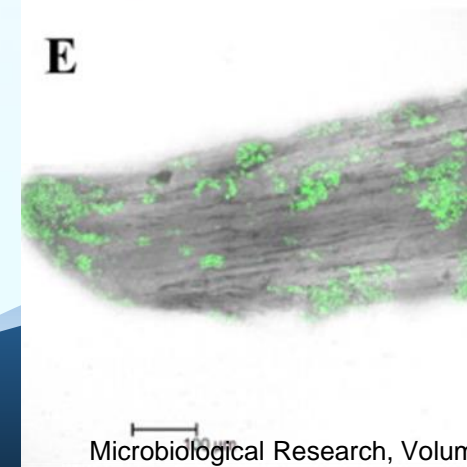
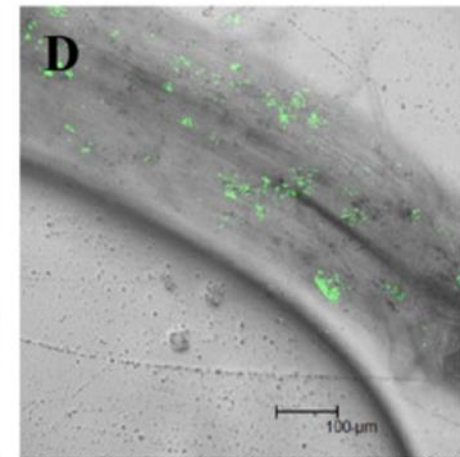
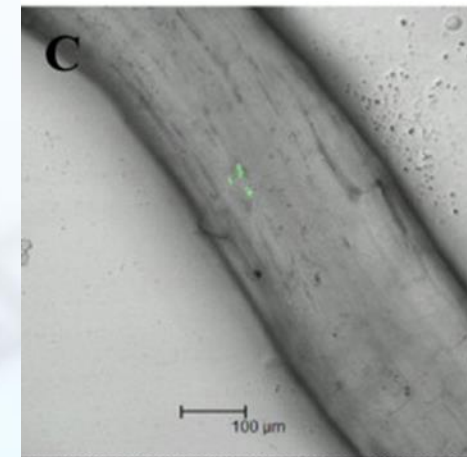
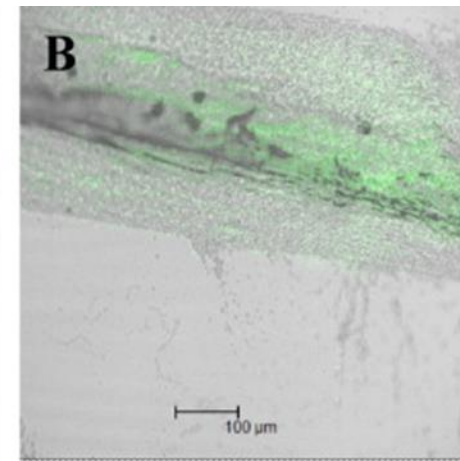
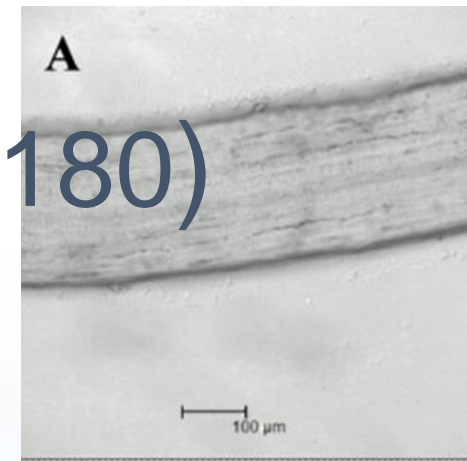
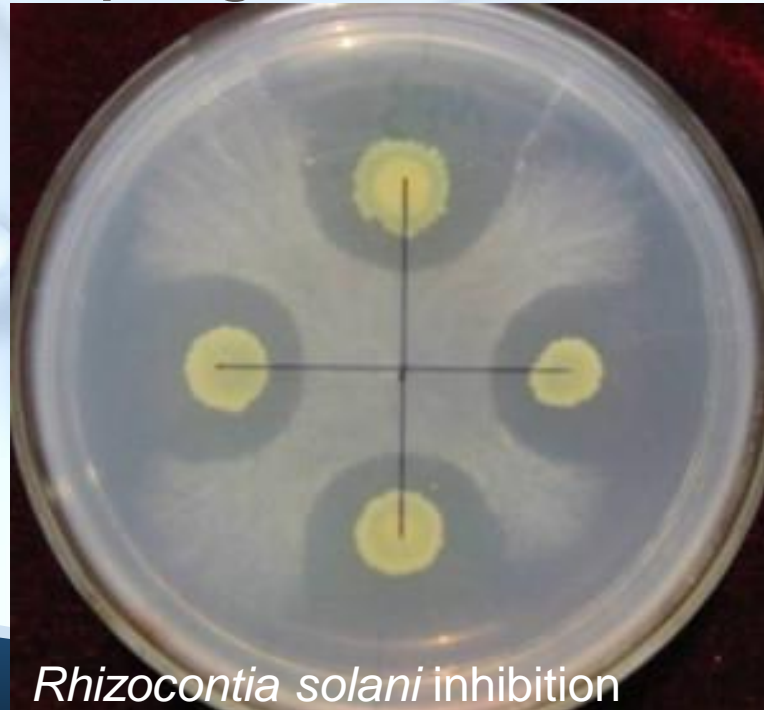
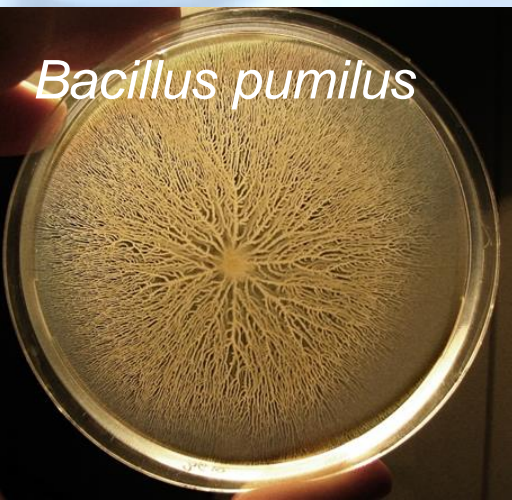
Bacillus amyloliquefaciens (strain D747)

- Kills pathogenic organisms on foliage and other plant parts by producing **antibiotic compounds** (iturins) which disrupt pathogen cell wall production
- Aids plants defense by competitive exclusion
- Aids plant in dealing with abiotic stress
- Fusarium: wilt, canker, foot & root rot, Damping off



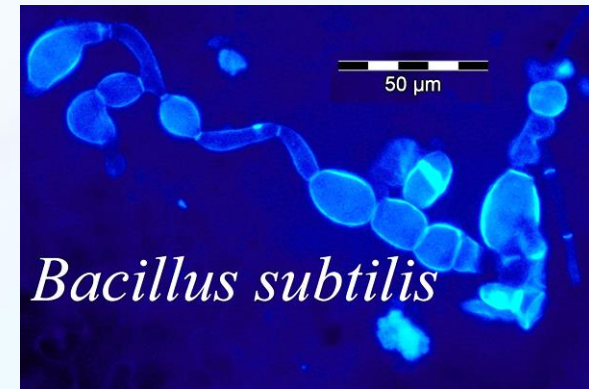
Bacillus pumilus (strain GHA 180)

- Produces iturins
- Colonizes roots
- Fusarium: wilt, canker, foot & root rot, Damping off



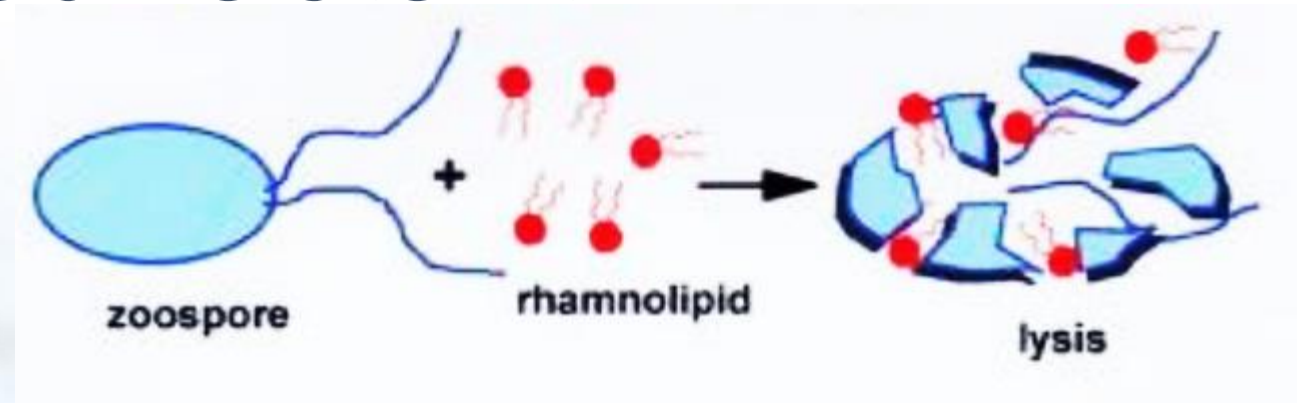
Bacillus subtilis (Strain QST713)

- Produces **antibiotic compounds** (iturins)
- Fungicidal activity on many pathogens; colonizes and attaches to fungal pathogens
- Symbiosis with plants, feeds on plant exudates, leaving none for the pathogens
- Brown blight, Anthracnose, Gray mold, Phytophthora blight, Powdery Mildew, Hemp canker, Yellow leaf spot, Xanthamonas leaf spot



Rhamnolipid Biosurfactant

- From a bacteria, *Pseudomonas spp.*
- Biosurfactants
- Works by contact and does not build resistance
- Causes cell lysis and growth inhibition of fungi and bacteria
- Aides absorption of fertilizers and nutrients through roots
- Cell lysis in: Phytophthora blight, Damping off



Trichoderma asperellum (strain ICC 012)

- “Fighting fungus”
- Competes with pathogens
- No toxic affects or resistance noted
- Controls many soil born pathogens:
Damping off, Phytophthora blight, Hemp
canker, Root rot, Verticillium wilt



25(b) minimum risk pesticides from the allowed pesticide list
on cannabis

FUNGICIDES

Cinnamon oil

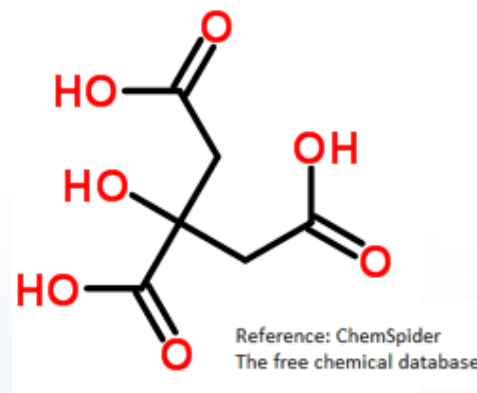
- Aids in controlling pathogen growth
- Contact pesticide
- Brown blight, Anthracnose, Gray mold, Powdery Mildew, Damping off



Citric Acid

- Contact pesticide
- Low toxicity
- Aids plant in defense

- Can decrease incidence of Powdery Mildew
- IF using as insecticide must be directly applied to pest



CAUTION: May cause mild skin and/or eye irritation, protective clothing and eyewear recommended.

Active Ingredients.....	By Weight
Citric Acid.....	0.05%
Inert Ingredients	
Potassium Sorbate.....	0.01%
Yeast(Enzymes).....	44.08%
Filtered Water.....	55.86%
Total.....	100.00%

DANGER

Avoid contact with skin and eyes. In case of contact, immediately flush eye or skin with water.

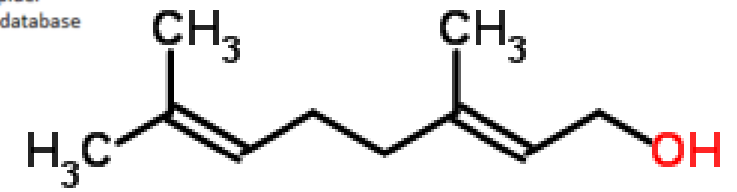
Active Ingredient: 99% Citric Acid

Inert ingredients: 1% dextrose

Clove Oil

- Effective on several strains of fungi, yeasts, bacteria, nematodes, thrips, aphids and mites.
- Fast acting contact
- Little or no residual activity
- May be phytotoxic to new growth
- Anthracnose, Damping off, Gray mold, Powdery Mildew, Yellow leaf spot





Geraniol

- Primary part of rose and citronella oil
Small quantities in geranium, lemon
- Slows spore and mycelium growth
- Brown blight, Brown leaf spot, Fusarium blight, Damping off

Horticultural Oils

- Corn
- Cottonseed
- Sesame
- Soybean

- Phytotoxic at high temperatures!
- Powdery Mildew



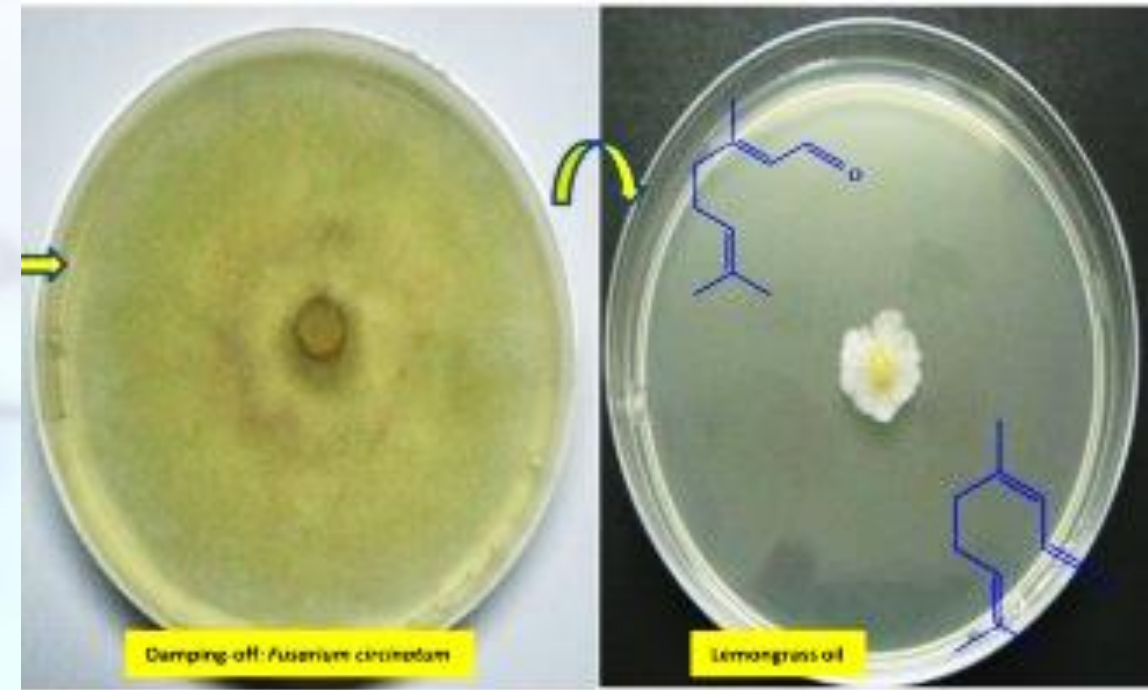
Sodium Laurel Sulfate

- Anionic surfactant—this ingredient has a negative charge
 - Negatively charged soap
- Moderate preventative
- Note: Could cause problems with sprayers (foaming)
- Effective on: Powdery mildew



Lemongrass oil

- Fungicidal properties (kills fungus)
- Effective on: Damping off, Gray Mold



Thyme oil

- Inhibits fungal growth
- Works on contact



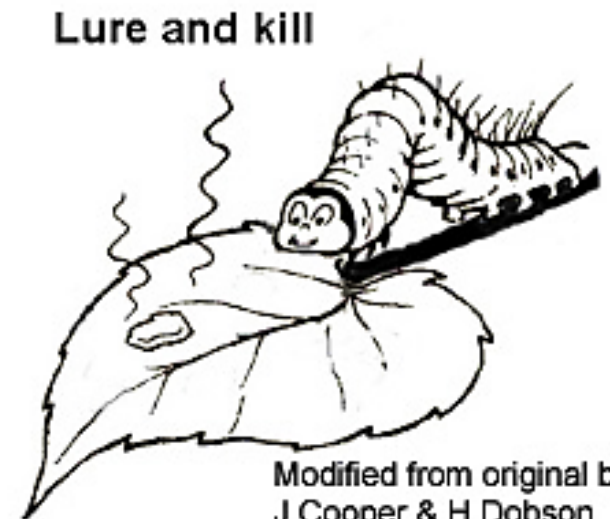
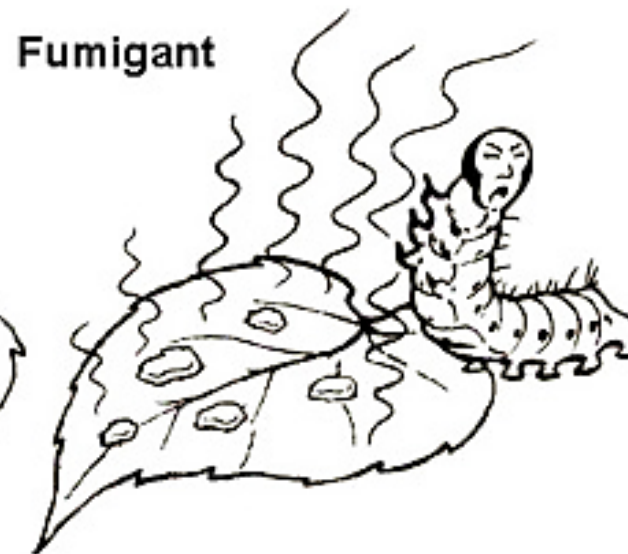
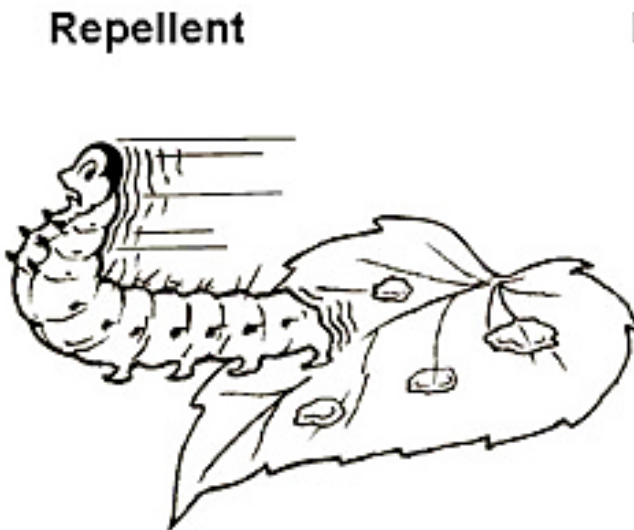
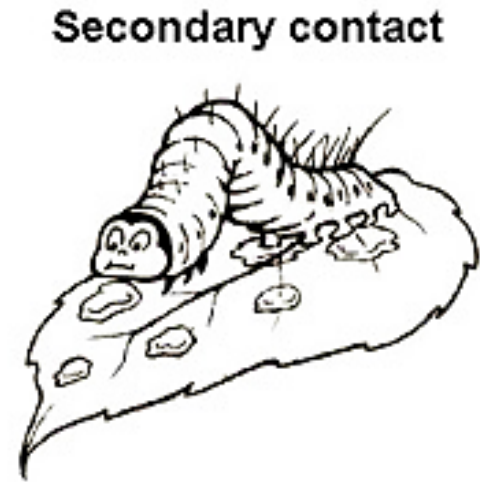
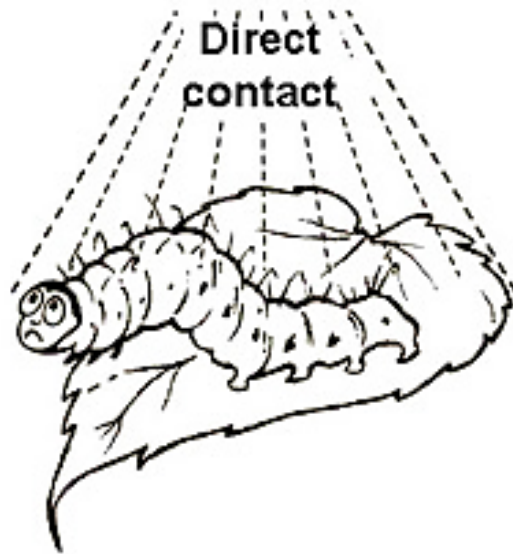
- Damping off, Gray Mold, Powdery Mildew, Yellow leaf spot, Hemp canker

Mechanisms of Action

INSECTICIDE



Insecticide—mode of dose transfer



Modified from original by
J Cooper & H Dobson

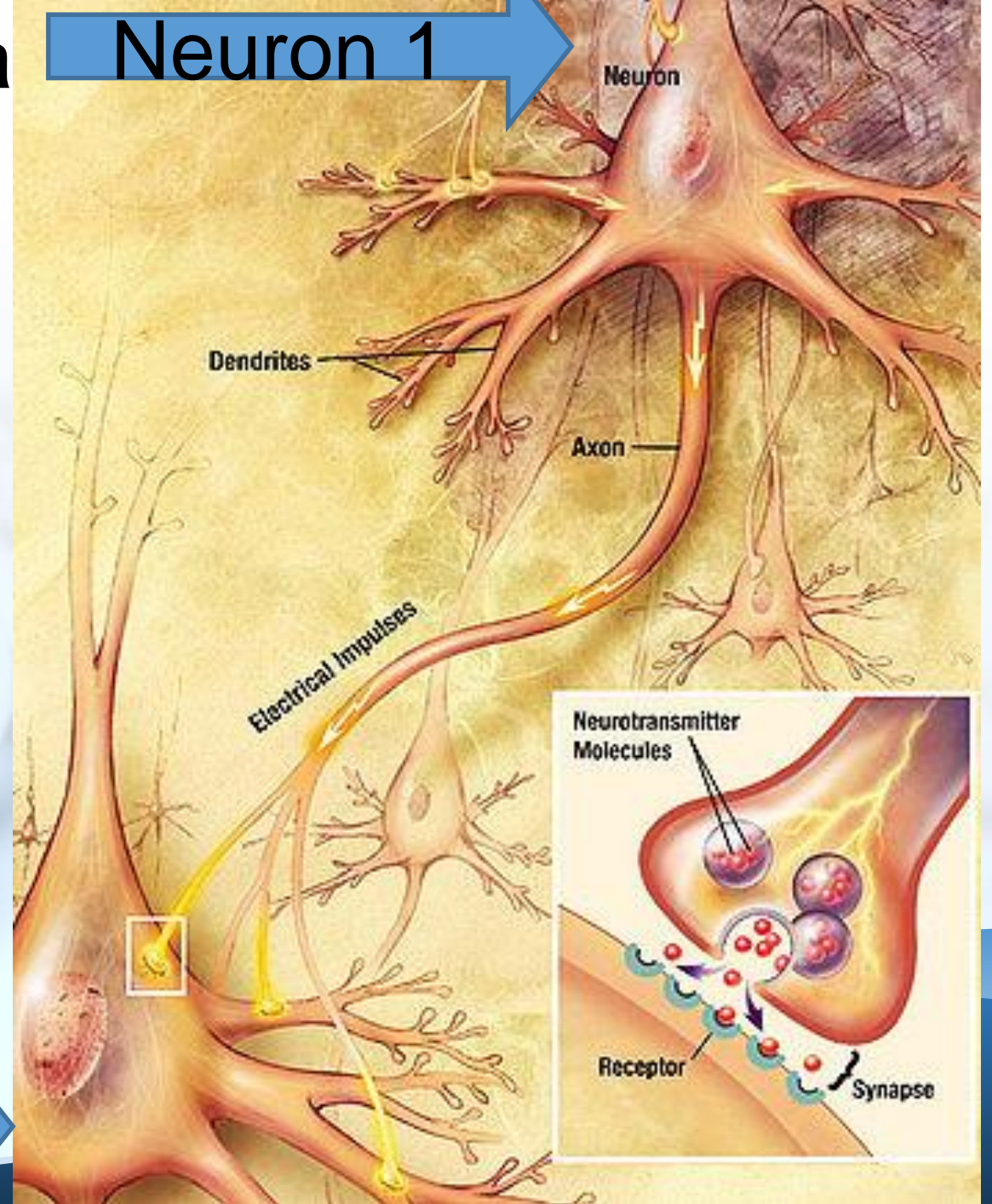
Nerve impulse background information

INSECTICIDE MODE OF ACTION

Neurotransmission within a pest

- Electrical impulse travels from neuron 1 to another neuron
- When it reaches the synapse, jumps the gap
- Binds to receptors on neuron 2 continues impulse or completes action

Neuron 1



Neuron 2

Insecticide Mode of Action (MoA)

Insecticide Resistance Action Committee (IRAC): 28 MoA classification

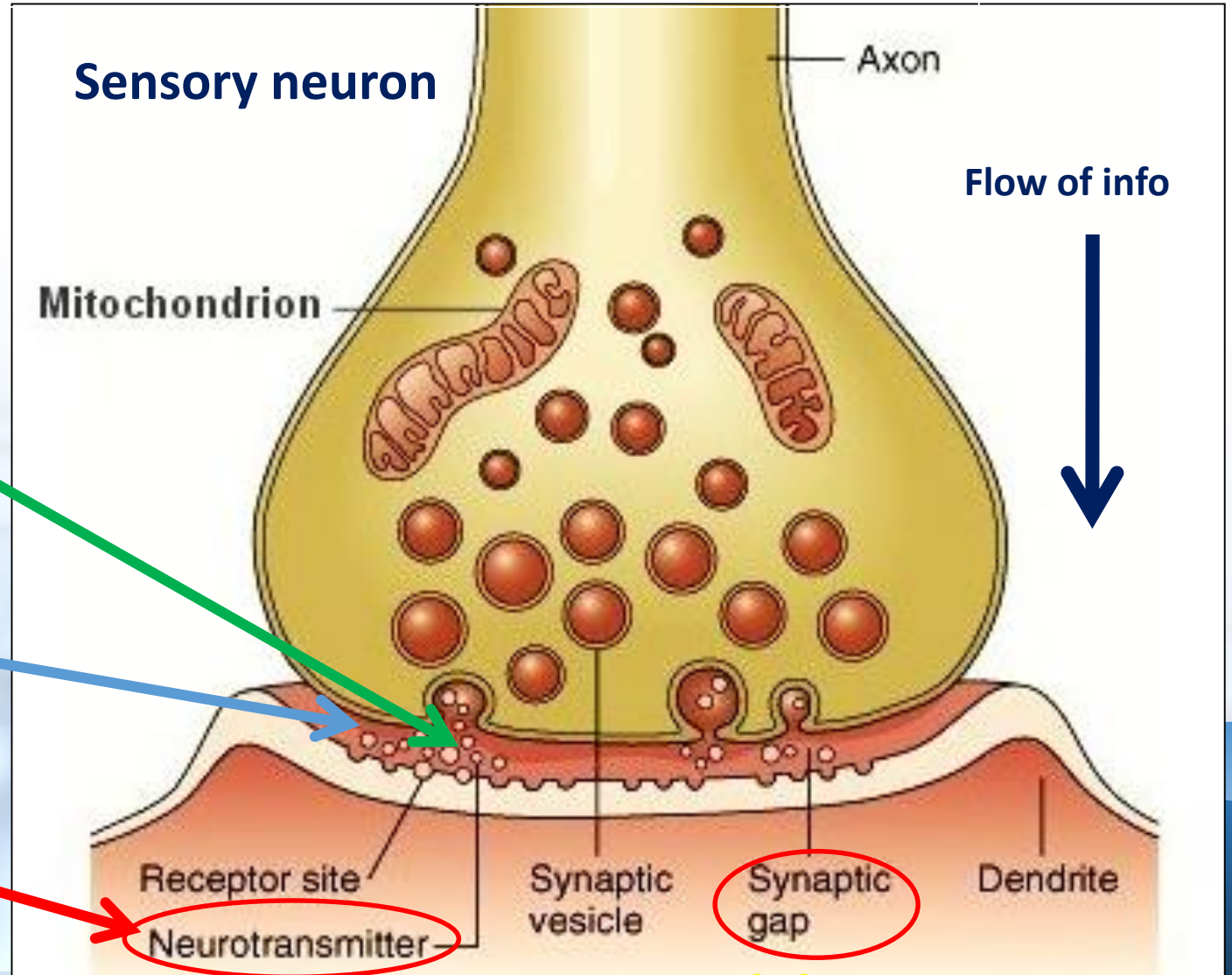
Inhibit enzyme that breaks down neurotransmitter

MoA 1 Acetylcholinesterase:
Carbamates, OP (act in the synaptic gap)

MoA 2 GABA blocker:
Cyclodienes (block GABA channel)

MoA 3 Sodium Channel:
Pyrethrins (act on receiving neuron)

Nicotinic acetylcholine receptor
MoA 4 :Neonicotinoids,
MoA 5:Spinosyn
(mimic neurotransmitter)



Receiving neuron

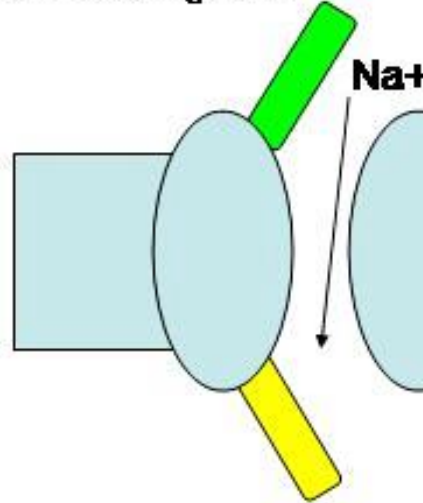
MoA 3

Sodium Channel:

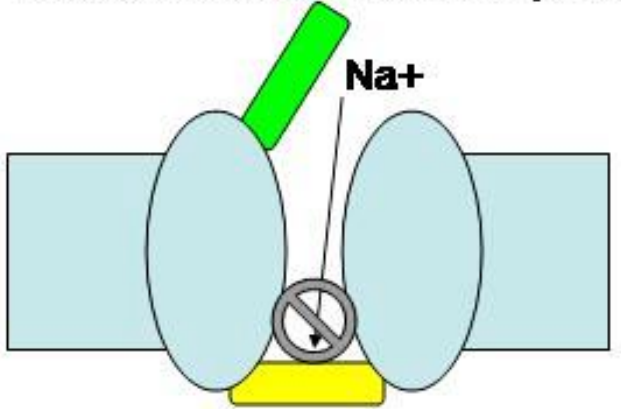
Pyrethrins

NORMAL

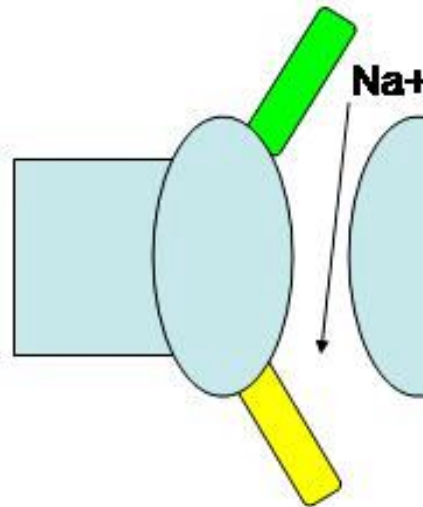
Increase in membrane potential with Na^+ entering nerve



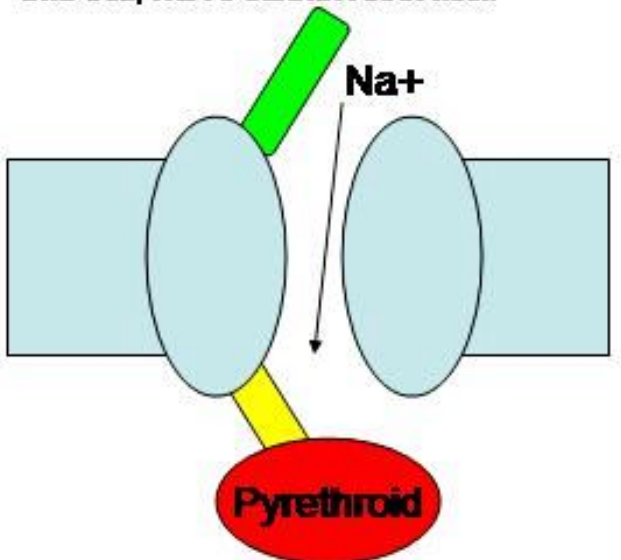
Gate shuts down Na^+ travel inside to allow cell to reset for next neural impulse



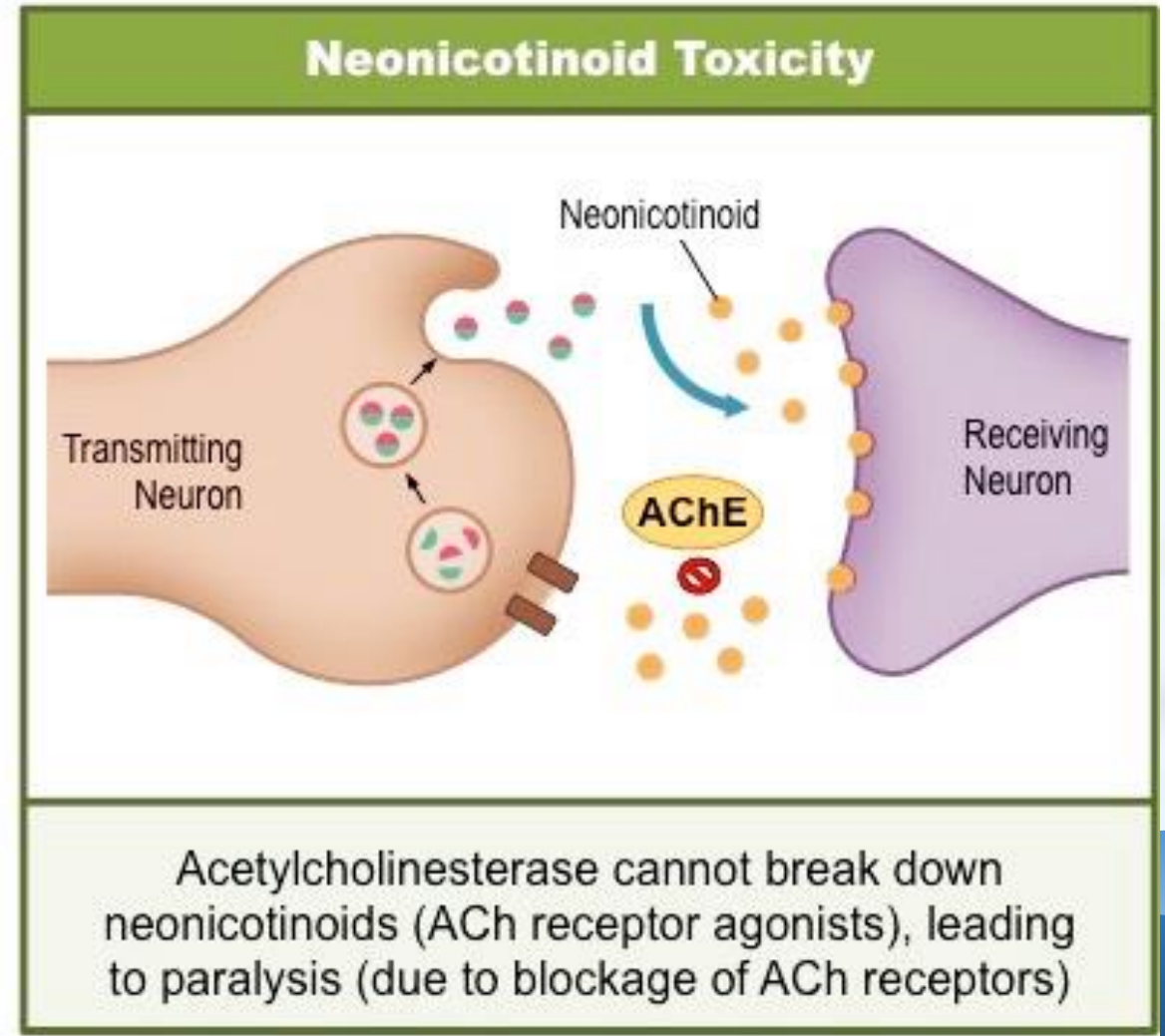
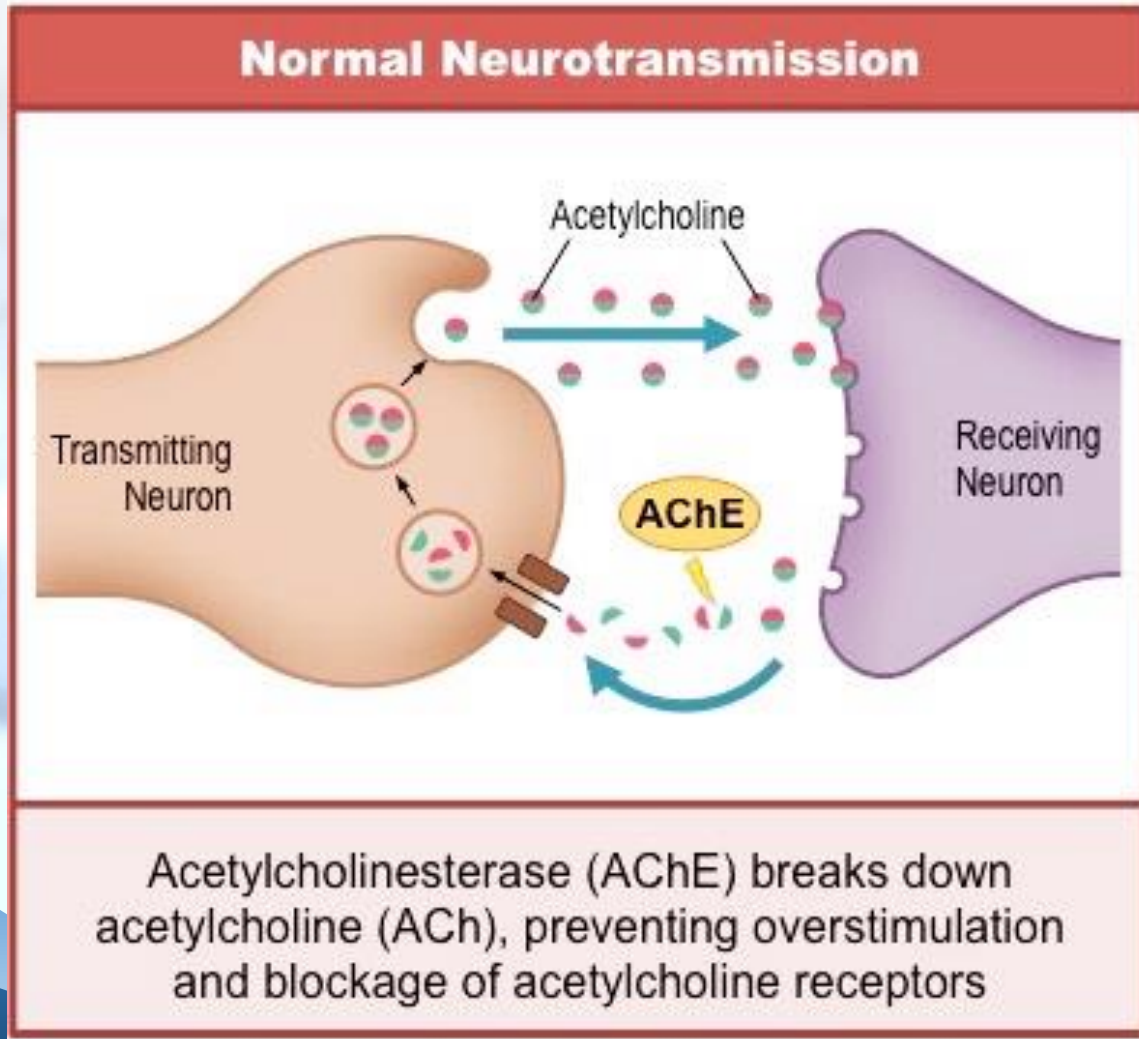
Insecticide



Gate cannot shut, Na^+ continues to travel into cell, nerve cannot reset itself

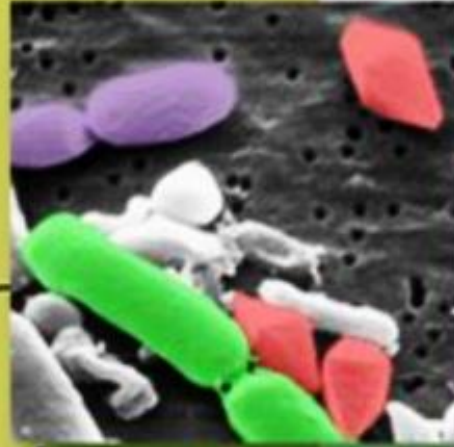


Neonicotinoids Mode of Action (MoA 4)

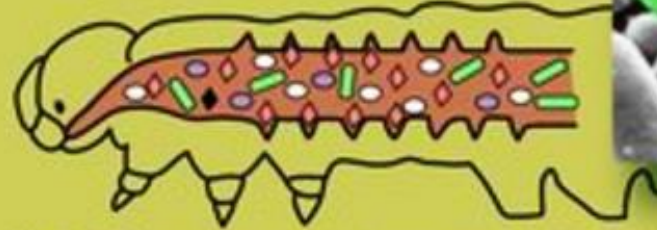


MoA 11: Microbial disruptors of insect midgut membranes *Bacillus thuringiensis*

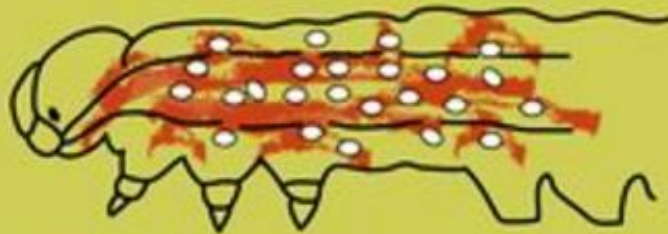
- Bt endospores
- ◇ Bt crystalline toxin
- ▬ Bt whole bacteria
- Normal gut bacteria



Scanning electron microscope image of Bt showing whole bacteria (green), endospores (violet), and crystal protein toxins (red).



Within minutes, the toxin binds to specific receptors in the gut wall, and the caterpillar stops feeding.



Within hours, the gut wall breaks down allowing spores and normal gut bacteria to enter body cavity.



24 to 48
hours
later.

Dead cabbage looper. Those killed by BT may turn black and/or become shrivelled.



Are pesticides that are created to kill, harm, repel or mitigate one or more species of insect.

INSECTICIDES

Insecticides

Before use identify the pest correctly.

Read the label to ensure the insecticide you want to use controls the pest in question.





PESTICIDES

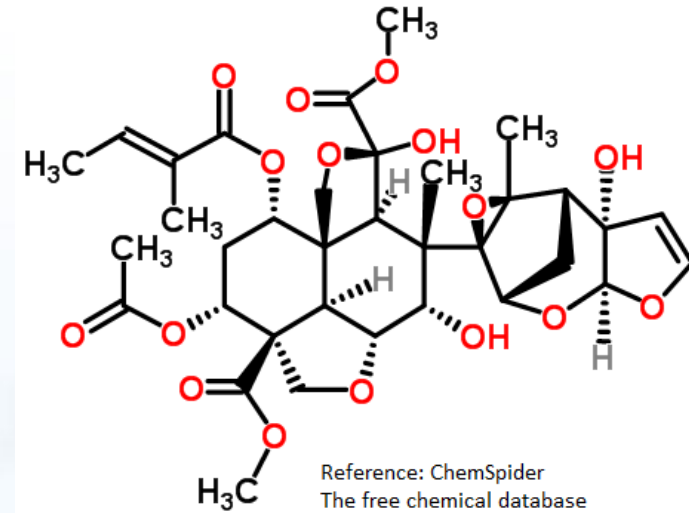
LISTED BY ACTIVE INGREDIENTS

ALLOWED FOR USE ON

CANNABIS

Azadirachtin—neem seeds extracts

- Contact action
- Slows growth, feeding, reproduction and repels insects.
- No resistance has been reported
- Aphids, Caterpillar, Fungus gnats, Leaf miners, Mealy bugs, Thrips, White fly (also controls immature insect forms)



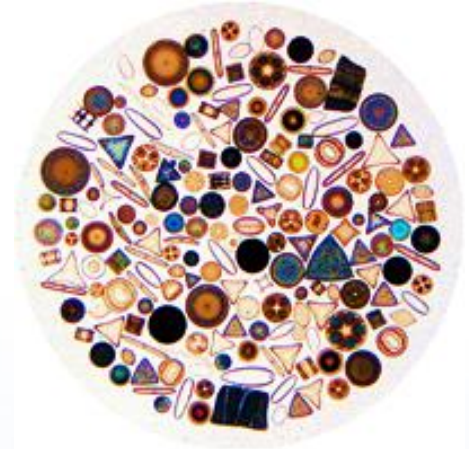
Capsicum Oleoresin Extract



- Active ingredient from chili peppers
- Primarily used as a repellent and irritant; weakens cuticles(exoskeleton) of immature stages of insect and mite pests.
- Mites, Thrips, Leafhoppers, Whiteflies

Diatomaceous Earth

- Comes from fossilized remains of tiny, aquatic organisms (diatoms)
- Usually a dust but may be a wettable powder
 - Especially careful with PPE
- Death by cutting exoskeleton and drying out
- No known resistance and minimal toxicity
- Crawling insects



Kaolin

- Natural desiccant, feeding deterrent
- Sticky coat on leaves
- As soon as washed off not effective

- Aphids, Thrips



Neem Oil

- Dries out & suffocates pests
- Contact activity ONLY
- Degrades rapidly under UV light
- Aphids, Caterpillar, Fungus gnats, Spider mites, Thrips



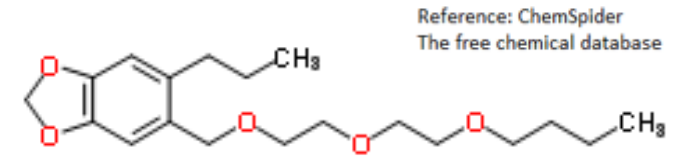
Mineral Oil

- Smothers insects
- Minimal harm to plants, actually increases respiration
- Check label for UR or Unsulfonated Residue
 - Higher the rating lower the amount of sulfur, could cause phytotoxicity
- Aphids, mites and soft bodied insects
- Powdery Mildew

Active Ingredient:	
Mineral Oil*	80.0%
Other Ingredients	20.0%
Total	<u>100.0%</u>
*Contains petroleum distillates.	
Unsulfonated Residue of Mineral Oil...	92.0% min.

Piperonyl butoxide

- Synergist with Pyrethrins
- Prevents insect from being able to remove(digest) toxin=pesticide
- Derived from sassafras oil
- Some toxicity: moderately to fish and highly toxic to aquatic organisms
- Aphids, Caterpillar, Fungus gnats, Thrips, White flies



Potassium laurate

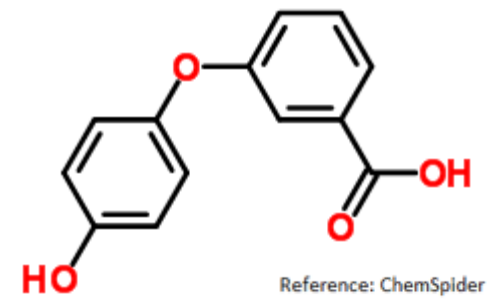


Reference: ChemSpider
The free chemical database

- Penetrates insects body and disrupts cell membranes; causing insect to dehydrate and die
- No resistance.
- Product must be wet to be active
- May harm some beneficial insects.
- Selective for soft bodies insects: Whiteflies, Aphids, Thrips, Caterpillars, Spider mites

Pyrethrins

- Chrysanthemum
- Works on contact, stomach poison.
- Break down rapidly in light
- Aphids, Caterpillar, Fungus gnats, Mites, White flies

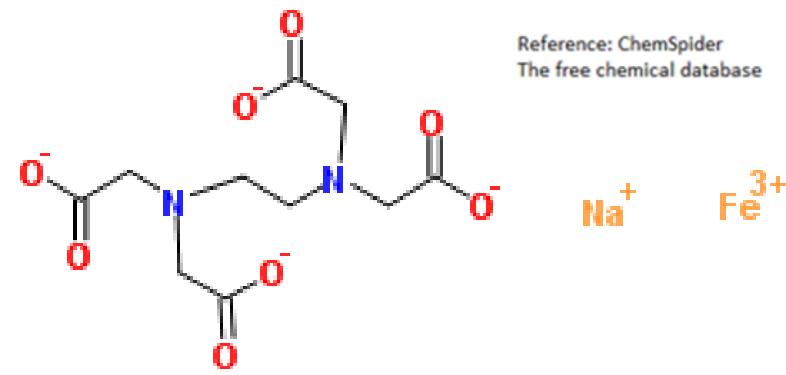


Reference: ChemSpider
The free chemical database



Sodium Ferric EDTA

- Interacts with oxygen transport in blood and eventually causes death
- Contact and digestive poison
- EDTA causes iron to be released in digestive system
- Snails and Slugs



25(b) Active Ingredients

INSECTICIDE



Essential Oils

- Cedar, Cinnamon, Citronella, Clove, Garlic, Geranium, Lemongrass, Peppermint, Rosemary, Thyme
- Most work by disrupting the insect's neurotransmitter
- Repellent
- Reapplication necessary

EO by pest

Spider Mites

Cinnamon,
Citronella,
Garlic,
Peppermint



Fungus gnats

Cinnamon, Clove,
Geranium,
Peppermint,
Rosemary



Aphids

Cinnamon, Clove,
Garlic, Peppermint,
Rosemary, Thyme



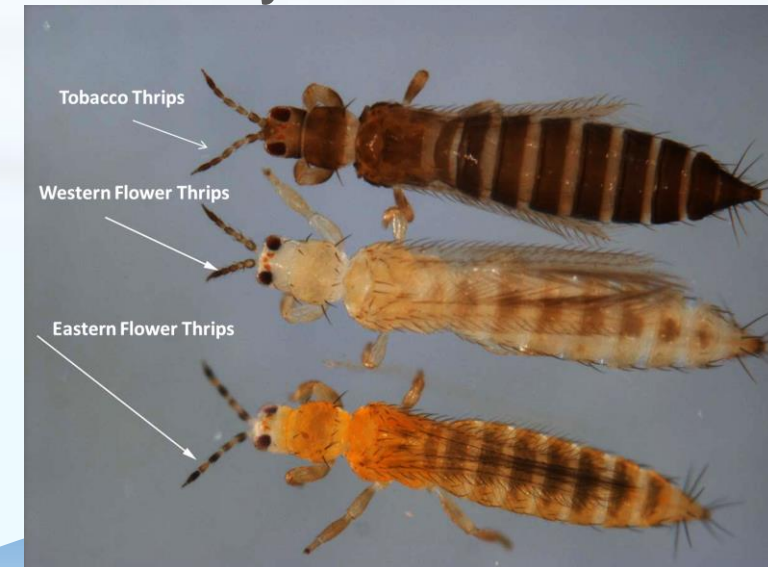
White fly

Peppermint,
Rosemary,
Thyme



Thrips

Cinnamon, Clove,
Garlic, Peppermint,
Rosemary





Biological Active Ingredients
INSECTICIDE



Beauveria bassiana strain GHA

- Contact action
 - Slow acting but effective
 - Aggressive fungal parasite
 - Immature & adult
-
- Whiteflies (nymphs & adults), thrips, aphids

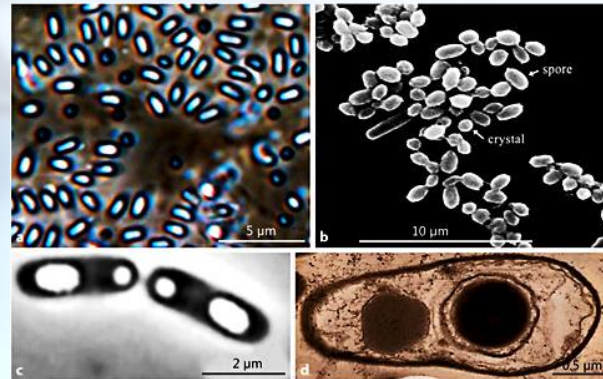


Beauveria bassiana fully emerges from dead Bagrada bugs and produces more spores. These spores will continue the infection process in bug population.
Surendra Dara, UCCE

Bacillus thuringiensis spp. *Aizawai*

Bacillus thuringiensis spp. *Kurstaki*

- Must be ingested
- Works best at curative stage
- Caterpillars and many vegetable pests



Chromobacterium Sub Strain PRAA4-1 Cells

- Contains fermentation solids.
- Isolated from soil under an eastern hemlock
- Works as a stomach poison upon ingestion.
- No systemic activity.
- Toxic to bees exposed to direct treatment or residues
- Thrips, Mealy bugs, Spider mites, Caterpillar



Myrothecium verrucaria

- Inactive (killed) fungus and mixture in which it was grown
- a cellulose decomposer
- Biological nematicide
 - Active on plant pathogenic nematodes
 - Kills by paralyzing muscles for feeding and movement.
 - Causes disorientation
 - Prevents egg hatching & development



GROWTH REGULATORS

Insect Growth Regulator

- Azadiractin—insects unable to molt, or go next stage of life cycle.
- Slows growth in general.
- Works on all instar stages of insects

Plant Growth Regulator

- Cytokinin—promote cell division in roots & shoots
- Harpin Alpha Beta—activates immune system (growth & defense genes)
- IBA (Indole-3-Butyric Acid)— (auxin)vigorous root formation, development & increases cell elongation
- Gibberellins—helps cell division, elongation in stems & leaves

Plant Growth Regulator--Promoters

Cytokinin 
Induce growth of shoot

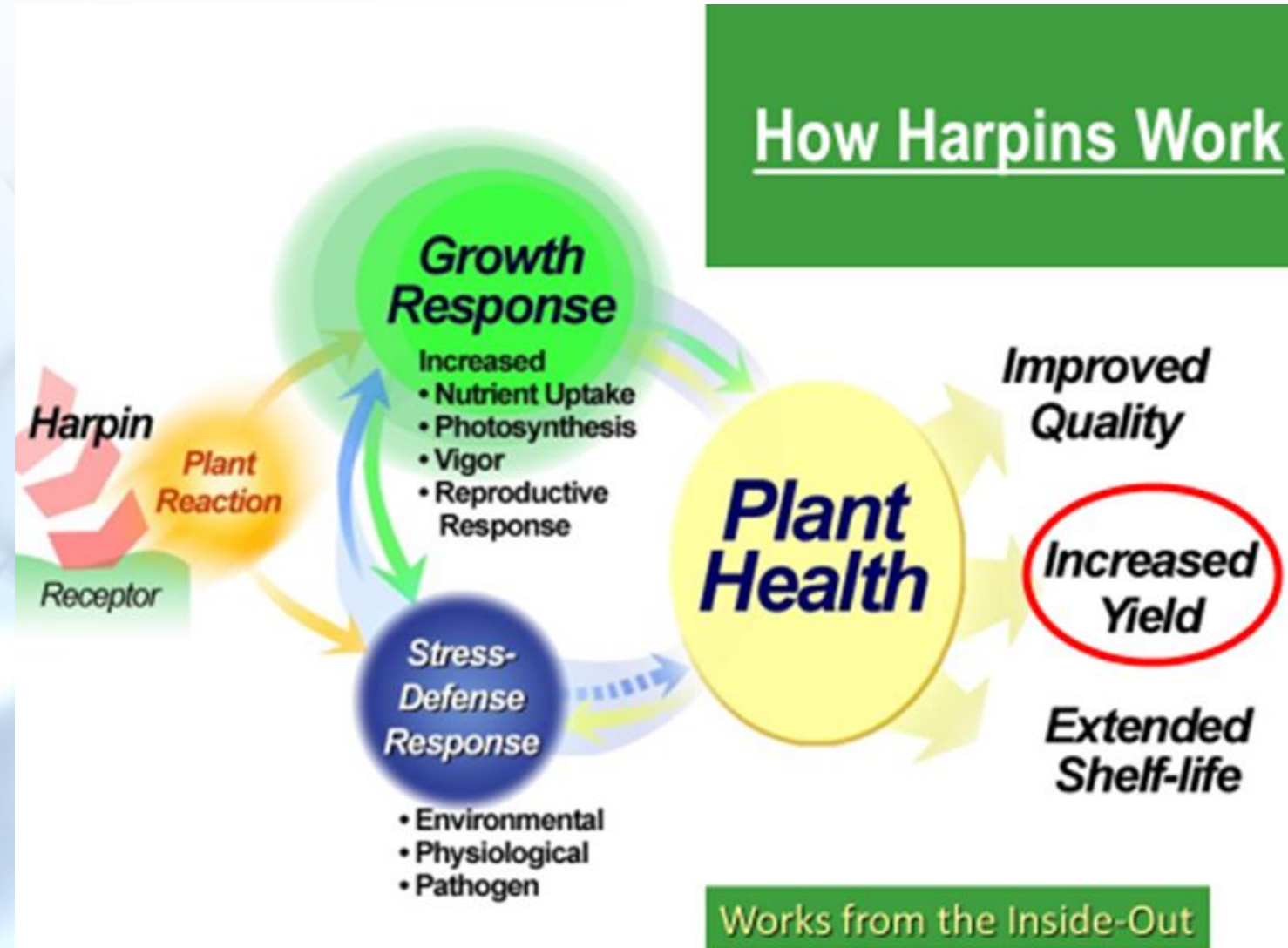
Auxin 
Promote root initiation

Gibberellin 
Stimulate cell elongation

(IBA (Indole-3-Butyric Acid))

Plant Growth Regulator

- Harpin Alpha Beta—activates immune system (growth & defense genes)
- Apply before pathogens, takes a few days to induce response



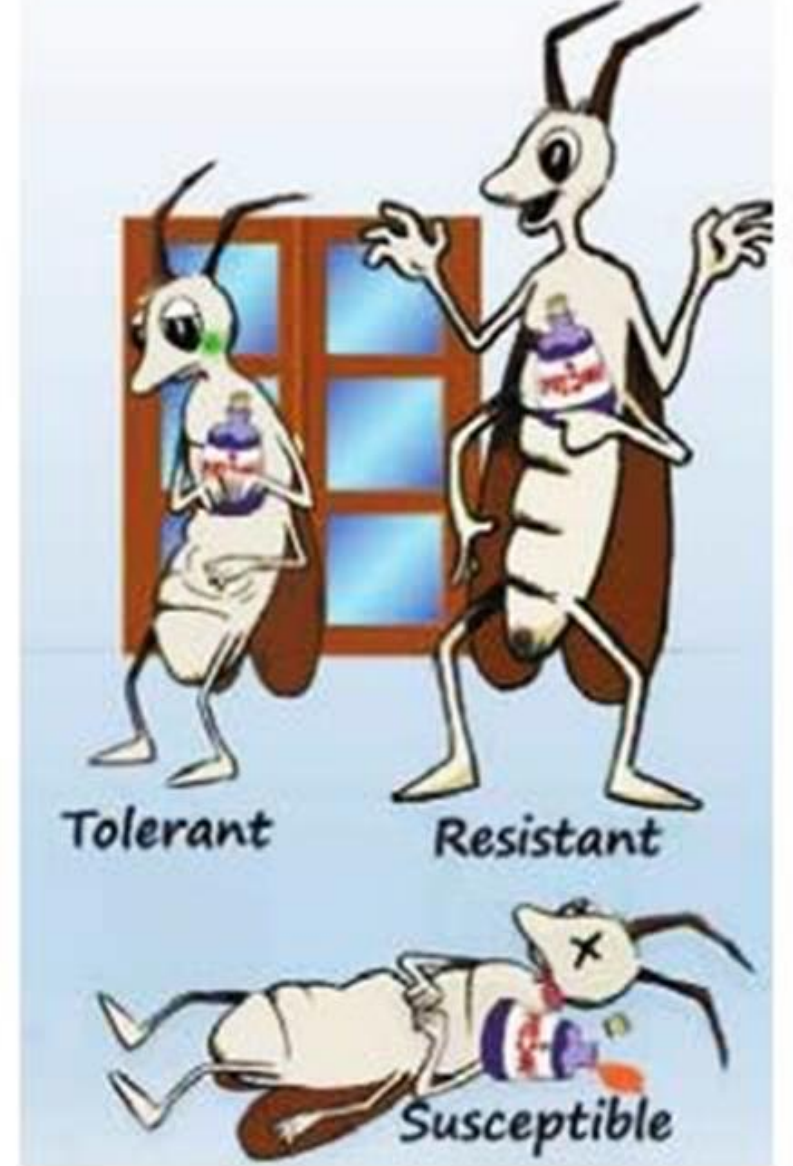


PESTICIDE RESISTANCE



Pesticide Resistance

- Genetically acquired ability of an organism to survive a pesticide application at doses that once killed most individuals of the same species



A single pest species can react dramatically differently to the same dose of an insecticide, depending on the strain.

Pesticide Resistance



First Spray



Second Spray

Legend



Natural Enemy



Metabolic Resistant Insect



Behavioral Resistant Insect



Pest



Third Spray



Fourth Spray

Remember to follow the RULES

- **R** = Rotate pesticides (use different groups)
- **U** = Use labeled rates
- **L** = Limit total number of applications
- **E** = Educate yourself about pesticide groups and management tactics.
- **S** = Select pesticides that have multiple modes of action, tank mixes

Fungicides Mode of Action List



- 13 DIFFERENT MoA CATEGORIES
 - 76 codes—combination of letters & numbers that identify the cross resistance behavior
 - Look for group number on label

Quadris®

Flowable Fungicide

Broad spectrum fungicide for control of plant diseases

GROUP 11 FUNGICIDES

Active Ingredient:

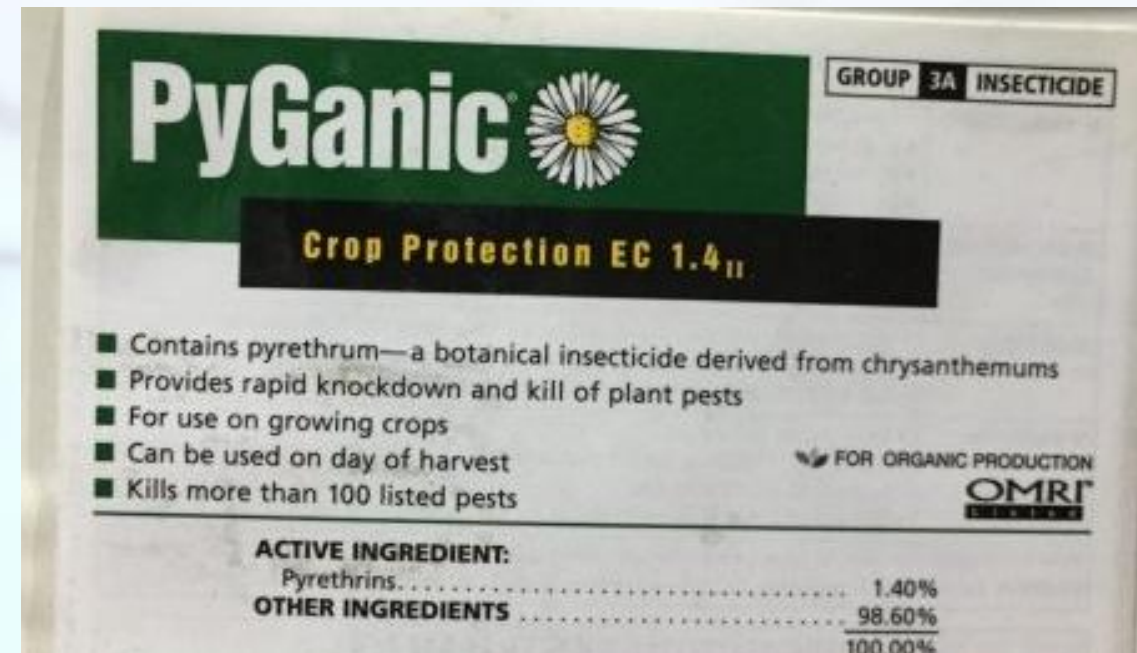
Azoxystrobin: methyl (E)-2-{{2-[6-(2-cyanophenoxy)pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate*	22.9%
Other Ingredients:	77.1%

Total:	100.0%
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FRAC Code on the Quadris label

Insecticide Mode of Actions (28 MoA)

- Categorizes insecticides based on MoA & likelihood of resistance becoming a problem
- Look for group number on front of the label
 - e.g. GROUP 3A INSECTICIDE



Take-Aways

- Know the pesticide you are using.
 - Why to use? When to use? How to use?
- Think about *concentration* of active ingredient
- Follow the **RULES**





Questions?
More Information?

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303.869.9053