UNIVERSITY OF ILLINOIS
EXTENSION

Understanding Insecticides and Selecting the Best Options

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How insecticides are used

- Soil-applied insecticides
  - For residual control
  - For systemic uptake
  - Soil fumigants
- Seed-treatment insecticides
  - For control of seed pests
  - For systemic uptake
- Foliar insecticides
  - For residual control
  - For systemic uptake/movement
  - For knockdown
- Parallels in other settings
  - Residual insecticides for residential pest control
  - Aerosol insecticides for residential pest control
  - Residual insecticides and fumigants in stored grains
  - Fumigants for grains and commodities
  - Residual and systemic insecticides for use on animals

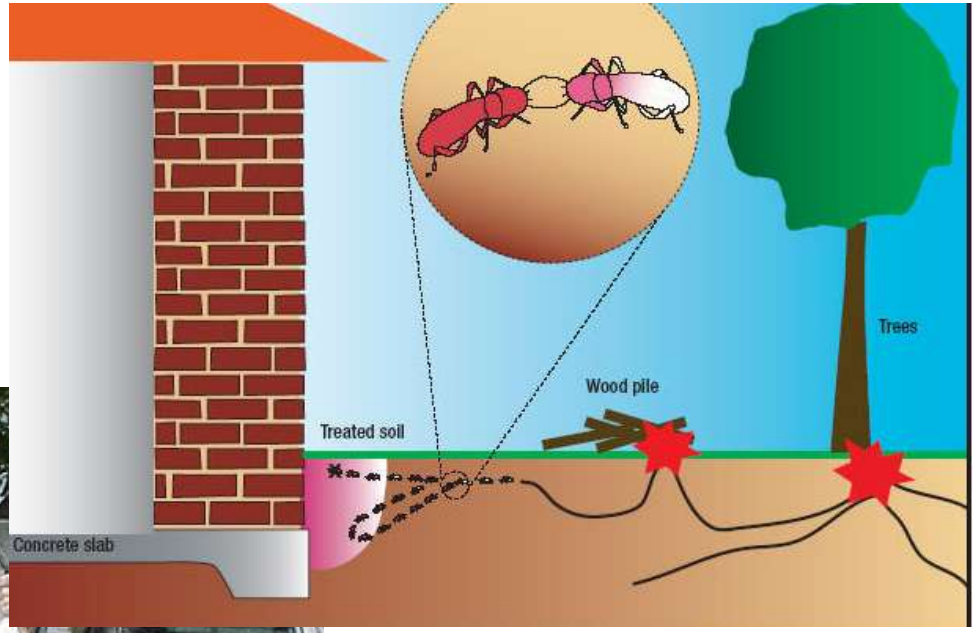
Soil-applied residual insecticides

- Soil-applied for extended control:
  - Applied to kill insects in treated soil at time of application and for a period up to several weeks later; incorporated (at least lightly) or injected to mix with soil
    - Applied at planting for control of rootworms, cutworms, wireworms, grubs, seed and root maggots, etc. in field crops, vegetables, small fruits, gardens
    - Applied as soil treatments for termite control around houses, other buildings
    - Examples:
      - Organophosphates: Lorsban, Counter, Diazinon
      - Pyrethroids: Force, Fortress
    - Band applications instead of broadcast applications are most common in crops

Soil-applied insecticides

- Soil-applied residual insecticides
  - Typically have half-lives of (very roughly) 30 to 90 days
  - Typically are low to very low in water solubility (so that they do not leach out of the treatment zone in spring rainfall)
  - Are not bound too tightly to soil particles as to be unavailable in contact with insects
  - Historic problems have included too-great persistence (aldrin, dieldrin, heptachlor, chlordane, and other organochlorines) and too-great solubility and too little persistence (enhanced degradation of carbofuran / Furadan)


TRIUMPH
MaxEmerge 2


Trees
Wood pile
Treated soil
Concrete slab

Seed-treatment insecticides

- Seed-applied residual insecticides
  - Insecticides applied to seed at seed company facility or as a planter-box mixture
  - Kill insects that feed directly on seeds and below-ground portions of seedlings
  - Common seed protectants have included diazinon, Lorsban, lindane, and permethrin
  - Targets: seedcorn maggot, other seed and root maggots, wireworms, white grubs, seedcorn beetles, and symphylans
  - IF effective, seed treatments are appealing because they use a lot less insecticide than band or broadcast applications


LP800
AgroMaxx

Soil-applied systemic insecticides

- Soil-applied for systemic uptake
  - Applied at planting or transplanting or as a side-dress
  - Historically in IL: Furadan and Thimet in corn, cucurbits, and/or potatoes for control of flea beetles, cucumber beetles, Colorado potato beetle, or aphids feeding on foliage
  - Elsewhere: Temik and Di-Syston in potatoes, (citrus), and wheat … problems with leaching into groundwater
  - Currently: Neonicotinoids such as Admire (imidacloprid) and Platinum (thiamethoxam) in similar crops against similar pests
  - Control usually begins a few days after application and persists 2 to 4 weeks; somewhat dependent on precipitation

Some soil-applied systemics can be applied in irrigation water

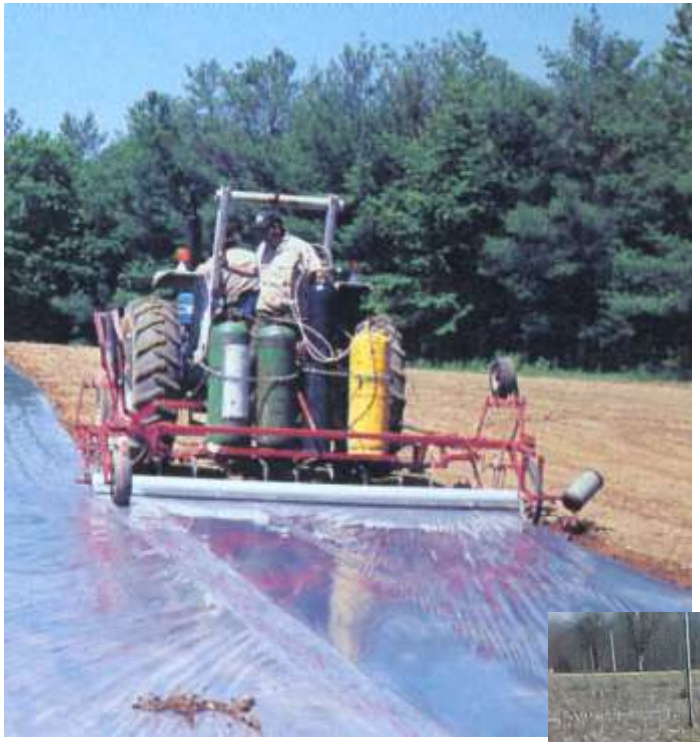
- Neonicotinoids
  - Admire, Platinum, Venom, Scorpion
    - Effective against Colorado potato beetle, leafhoppers, aphids, cucumber beetles/flea beetles
- Diamides
  - Coragen
    - Effective against Colorado potato beetle, Lepidopteran larvae
  - Synapse/Belt
- Combinations
  - Durivo
    - Range of target pests susceptible to either active ingredient

Seed-treatment systemic insecticides

- Seed-applied for systemic uptake
  - Old O-Ps and carbamates that are systemic were not used as seed treatments because they were phytotoxic (poisonous to the seeds)
  - Current systemic seed treatments are sold under the trade names Cruiser, Gaucho, and Poncho – all are neoniconitoids
    - On field crops, vegetables, and some ornamental plants
    - Targets include corn flea beetle, cucumber beetles, leafhoppers, and aphids for 1 – 3 weeks after seedling emergence

Soil fumigants

- Primary fumigant against insects, pathogens, and weeds in the soil is methyl bromide
  - Applications usually made to raised beds tarped with plastic (for specialty crops)
  - Fumigant gas kills organisms present at the time of fumigation; dissipates in a few days
  - Cost = several hundred dollars to $2,000 per acre
  - In IL, crops are "plasticulture" strawberries; some peppers and tomatoes
  - Soil fumigation is rare in IL, but in FL, TX, and CA (and a few other areas), fumigating before planting high-value fruits and vegetables is common.
  - Phase-out of methyl bromide because of its ozone-depleting effects presents a major challenge



Foliar-applied insecticides

- Foliar "knock-down" insecticides (with little or no residual control intended)
  - Very few insecticides are applied with the intent that they NOT last at least a few days, but insecticides that kill only the insects that are present at the time of application or persist for only a short time include: dormant oils, soaps, pyrethrins, and malathion.
  - Most insecticides that break down rapidly have short **preharvest intervals**; this can be especially important in fruits and vegetables where control may be necessary right up to the time the crop is picked.

Foliar-applied insecticides

- Foliar residual insecticides … Most applications of insecticides to plant foliage, by aerial or ground sprayers, are intended to last for a few to several days as residues on plant foliage
  - Most last from 3 to 10 days as effective residues
  - Treatments remain effective if sprays dry before rainfall of up to 1 inch
  - In general, most foliar residual sprays are effective as contact poisons … insects that crawl across treated surfaces are killed when insecticides are absorbed through the insect's cuticle

Animal insecticides

- Insecticides are applied directly to animals for control of lice, flies, grubs, ticks, mites, mosquitoes, etc.
  - Application methods for residual insecticides include:
    - Self-treatment devices such as back rubbers and dust bags
    - Controlled-release devices such as ear tags and flea collars
    - High-pressure sprays and mists
    - Pour-on on spot-on treatments that distribute in the coat
  - Application methods for systemic insecticides include:
    - Pour-ons and spot-ons
    - Feed additives
    - Injections


FRONTLINE®
Plus
for dogs
3
Applicators
Kills fleas, flea eggs & ticks
• Fast-acting
• Kills ticks including those that may transmit Lyme disease
• Waterproof
For Dogs
89-132 lbs.
ACTIVE INGREDIENTS
fipronil 9.8%
(S)- methoprene 8.8%
INERT INGREDIENTS 81.4%
TOTAL 100.0%
KEEP OUT OF REACH OF CHILDREN
CAUTION
Lift Here To Open
MERIAL

Surface residual sprays

- Surfaces may be barn walls, bin walls, baseboards, wall voids, carpets, and more
  - Sprays applied to barn walls, wooden fences, etc. for fly control
  - Empty-bin sprays applied to grain bin walls for control of weevils, "bran bugs," Indianmeal moth, etc.
  - Baseboard sprays and wall void treatments for cockroach control
  - Foundation and crawl-space sprays to control crickets, other "invaders"

Aerosol space sprays

- Examples include "bombs" for flea control, mists for fly control in livestock buildings, aerosols in food processing plants – often pyrethrins or pyrethroids with short residual and low toxicity
- These are not fumigants … the active ingredient is dispersed in very small droplets of liquid that float through the air and deposit on exposed surfaces (including insects' cuticles). They do not move as a gas into closed spaces such as cabinets, drawers, etc.

Space and Commodity Fumigants

- Examples: methyl bromide, phosphine, chloropicrin, sulfuryl fluoride, and even carbon dioxide.
- In agriculture, used to disinfest stored grains, flour, flour mills and other food processing plants, and ripe fruits and vegetables (Mediterranean fruit fly and similar pests).
- In general, fumigants are EXTREMELY toxic and require special training and equipment for safe handling
- The application of residual insecticides (Actellic, Storcide, Diacon) to stored grains (admixtures or surface sprays) is NOT fumigation

Fumigation chamber

So … choosing soil and foliar insecticides for vegetables

- Insecticides for vegetables
- What's effective against what?
- Available references

Insecticides for use on vegetables

- Organochlorines
  - endosulfan (Thiodan, Endosulfan, Thionex) (Group 2A)
    - Phase-out pending
- Organophosphates (Group 1B)
  - acephate (Orthene)
  - chlorpyrifos (Lorsban)
  - diazinon (Diazinon)
  - dimethoate (Cygon, Dimate, Dimethoate)
  - malathion
  - methyl parathion (Penncap-M)
- Carbamates (Group 1A)
  - carbaryl (Sevin)
  - carbofuran (Furadan)
  - methomyl (Lannate)
  - oxamyl (Vydate)
  - thiodicarb (Larvin)

Insecticides for use on vegetables

- Pyrethroids (Group 3)
  - bifenthrin (Capture, Brigade, Bifenthrin, Bifenture, Discipline, Fanfare, Sniper, Tundra)
  - cyfluthrin (Baythroid, Renounce, Tombstone)
  - cypermethrin (Ammo)
  - esfenvalerate (Asana, Adjourn)
  - fenpropathrin (Danitol)
  - lambda-cyhalothrin (Warrior, Silencer) (related, gamma cyhalothrin = Pro-axis)
  - permethrin (Ambush, Pounce, Arctic, Permethrin, Perm-UP, and more)
  - zeta-cypermethrin (Mustang Max)

Insecticides for use on vegetables

- Neonicotinoids (Group 4A)
  - acetamiprid (Assail)
  - imidacloprid (Admire, Provado, Couraze, Imida, Macho, Malice, Montana, Nuprid, Torrent, Widow)
  - dinotefuran (Venom)
  - flonicamid (Beleaf) (Group 9C)
  - thiamethoxam (Actara, Platinum)

Insecticides for use on vegetables

- Spinosyns (Group 5)
  - spinosad (SpinTor, Entrust)
  - spinetoram (Radiant)
- Avermectins and similar compounds (Group 6)
  - abamectin (Agri-Mek, Abba, Epi-Mek, Zoro)
  - emamectin benzoate (Proclaim)
- Juvenile hormone analogs (Group 7)
  - pyriproxyfen (Esteem)
- Benzoylureas (Group 15)
  - Novaluron (Rimon)

Insecticides for use on vegetables

- Diacyl hydrazines (Group 18)
  - methoxyfenozide (Intrepid)
  - tebufenozide (Confirm)
  - azadirachtin (neem)
- Indoxacarb (Group 22)
  - Indoxacarb (Avaunt)
- Tetronic acid derivatives (Group 23)
  - Spirotetramat (Movento)
- Anthranilic diamides (Group 28)
  - chlorantraniliprole (Coragen)
  - flubendiamide (Belt/Synapse)

Miticides for use on vegetables

- Organochlorines
  - dicofol (Kelthane, Dicofol) (Group un)
- Avermectins (Group 6)
  - abamectin (Agri-Mek, Abba, Epi-Mek, Zoro)
- Tetronic acid derivatives (Group 23)
  - spiromesifen (Oberon)
- Neuronal inhibitors
  - bifenazate (Acramite) (Group 25)

Various microbials, botanicals, and/or OMRI products for use on vegetables

- *Bacillus thuringiensis* ssp. *kurstaki* and *aizawai* (Group 11B1 and 11B2)
  - Dipel, Agree, Biobit, Crymax, Deliver, Javelin, Lepinox, Xentari
- azadirachtin (Group 18B)
  - Neem, Neemix, Aza-Direct
- rotenone (Group 21)
- pyrethrins (Group 3)
  - Pyganic, Pyrenone
- suffocating oils
- abrasives, surface films
  - diatomaceous earth
  - kaolin clay (Surround)
- soaps
  - (M-Pede)

Insecticide Modes of Action

- IRAC Mode of Action Classification
  - Insecticide Resistance Action Committee
  - 28+ modes of action and insecticide groups
  - On-line listing of classifications

http://www.irac-online.org/documents/IRAC%20MoA%20Classification%20v5_3.pdf

So why are chemical structures and modes of action important?

- Insecticides work if (1) they remain intact within an insect to reach a "target site" and (2) the target site is susceptible to their attachment and interference.
- Differences among species in "natural susceptibility" to an insecticide and evolution of resistance in populations of a given species result primarily from (1) increased metabolism or breakdown of insecticide molecules – related to their structure – and from (2) receptor sites that are not susceptible to insecticide attachment and interference.
- Repeated use of insecticides within the same structural family or mode of action group result in more rapid development of resistance
- Rotating among structural families and modes of action – assuming there are alternatives that are effective – is recommended to maximize long-term effectiveness of insecticides and miticides.

So what is the range of target pests for the different groups?

- Group 1A, carbamates, acetylcholinesterase inhibitors
  - Furadan: few remaining labeled uses.
  - Orthene: effective against aphids and certain Leps (corn borer in peppers and snap beans).
  - Sevin: effective against many beetles; not great against most Leps; kills natural enemies of aphids and mites and triggers their outbreaks.
  - Larvin and Lannate … some Lep activity (generally not as effective as pyrethroids), some aphid activity. Lannate's residual activity is very short.

- Group 1B, organophosphates, acetylcholinesterase inhibitors

  - Lorsban: Soil and seed treatment uses against root and seed maggots, ~corn rootworm larvae, wireworms, and white grubs
  - Diazinon: Soil and seed treatment uses against rot and seed maggots, wireworms, white grubs
  - Dimethoate: Moderately effective against aphids and leafhoppers.
  - Malathion: Remains labeled on several vegetable crops but is rarely recommended, usually for aphids
  - Penncap-M: Few uses remain labeled; may be used against European corn borer in dry beans and sweet corn.

- Group 2A, organochlorines, cyclodienes
  - Endosulfan: still useful against aphids, plant bugs, stink bugs, and leafhoppers. Some control of beetles and Leps. (Not systemic)
  - Phase-out is underway

- Group 3, pyrethroids and natural pyrethrins, sodium channel modulators

  - Pyrethroid products include Permethrin, Asana, Capture/Brigade, Baythroid/Renounce, Danitol, Warrior, Mustang Max. Natural pyrethrins include Pyganic, Pyrenone, etc.
  - In general, all pyrethroids are good against a range Leps and beetles, as well as grasshoppers, stink bugs, plant bugs, and some thrips.
  - Most compounds in this group are ineffective against aphids and mites and trigger more severe infestations of these pests by killing their natural enemies.
  - Natural pyrethrins are effective against several beetles but break down very rapidly. Using synergists (not OMRI-approved) and spraying at night increases effectiveness.

- Group 4A, neonicotinoids, nicotinic acetylcholine receptor promoters and antagonists
  - Products that are active primarily against aphids, leafhoppers, etc. (plus systemically against Colorado potato beetle, corn flea beetle, and cucumber beetle) include
    - Admire/Provado (and Gaucho seed treatments)
    - Actara/Platinum (thiamethoxam seed treatments)
  - Assail: Effective against aphids and leafhoppers, also some Leps (though not corn borer or corn earworm; not recommended against key cabbage Leps in cole crops)
- Group 5, spinosyns, nicotinic acetylcholine receptor promoters that differ from group 4A
  - SpinTor, Entrust, and Radiant … effective primarily against Lep larvae – earworm, corn borer, Leps in cole crops, etc. – and some thrips and leafminers

Effective primarily against Lepidopteran larvae…

- Group 6: Chloride channel activators
  - emamectin benzoate (Proclaim)
- Group 11: Microbial disruptors of insect midgut membranes:
  - *Bacillus thuringiensis* (with multiple subspecies) (and multiple trade names)
- Group 15: Chitin inhibitors
  - Novaluron (Rimon) (also effective against Colorado potato beetle)
- Group 18: Ecdysone (molting hormone) promoters / mimics & molting disruptors
  - 18A: tebufenozide (Confirm), methoxyfenozide (Intrepid)
- Group 22: Voltage-dependent sodium channel blockers
  - indoxacarb (Avaunt)
- Group 28: Ryanodine receptor modulators
  - chlorantraniliprole (Coragen)
  - flubendiamide (Belt/Synapse)

Effective primarily against aphid, whitefly, and similar sucking insects …

- Group 7: Juvenile hormone mimics
  - pyriproxyfen (Esteem)
- Group 9: Selective feeding blockers (unknown MOA)
  - pymetrozine (Fulfill)
  - flonicamid (Beleaf)
- Group 23: Lipid synthesis inhibitors
  - spiromesifen (Oberon) … also a miticide
  - Spirotetramat (Movento)

Specific miticides …

- Group 6: Chloride channel activators
  - abamectin (Agri-Mek)
- Group 23: Lipid synthesis inhibitors
  - spiromesifen (Oberon) (also effective against whiteflies)
- Group 25: Neuronal inhibitors (unknown mode of action)
  - bifenazate (Acramite)
- Group un: Unknown mode of action
  - dicofol (Kelthane)

Pyrethroids that have some miticidal action include Capture and Danitol, but these are not usually the best choices for mite control.

Resistance Management

- Simple rules:
  - Do not use insecticides in the same MOA group repeatedly in the same crop/field/season
  - Rotate among MOAs at least across generations
  - Where an insect pest is not controlled by application(s) of an insecticide in a given MOA group, do NOT switch to another insecticide within the same MOA group
  - If the target pest migrates into the region from an area with known resistance to a particular MOA, do not rely on an insecticide from that MOA group for control at your site

Useful References

- 2011 Midwest Vegetable Production Guide
  - http://btny.purdue.edu/Pubs/ID/ID-56/
- IRAC Mode of Action Classifications
  - http://www.irac-online.org/documents/IRAC%20MoA%20Classification%20v5_3.pdf
- Illinois Fruit and Vegetable News
  - 20 issues per year
  - $20.00 by mail
  - Free via the web … subscribe for email notifications
  - http://www.ipm.uiuc.edu/ifvn/index.html
  - Email weinzier@uiuc.edu to request notifications
- Similar newsletters from other states