

# Fungicides and Fertilizers Used for Disease Control: Chemistry and Use

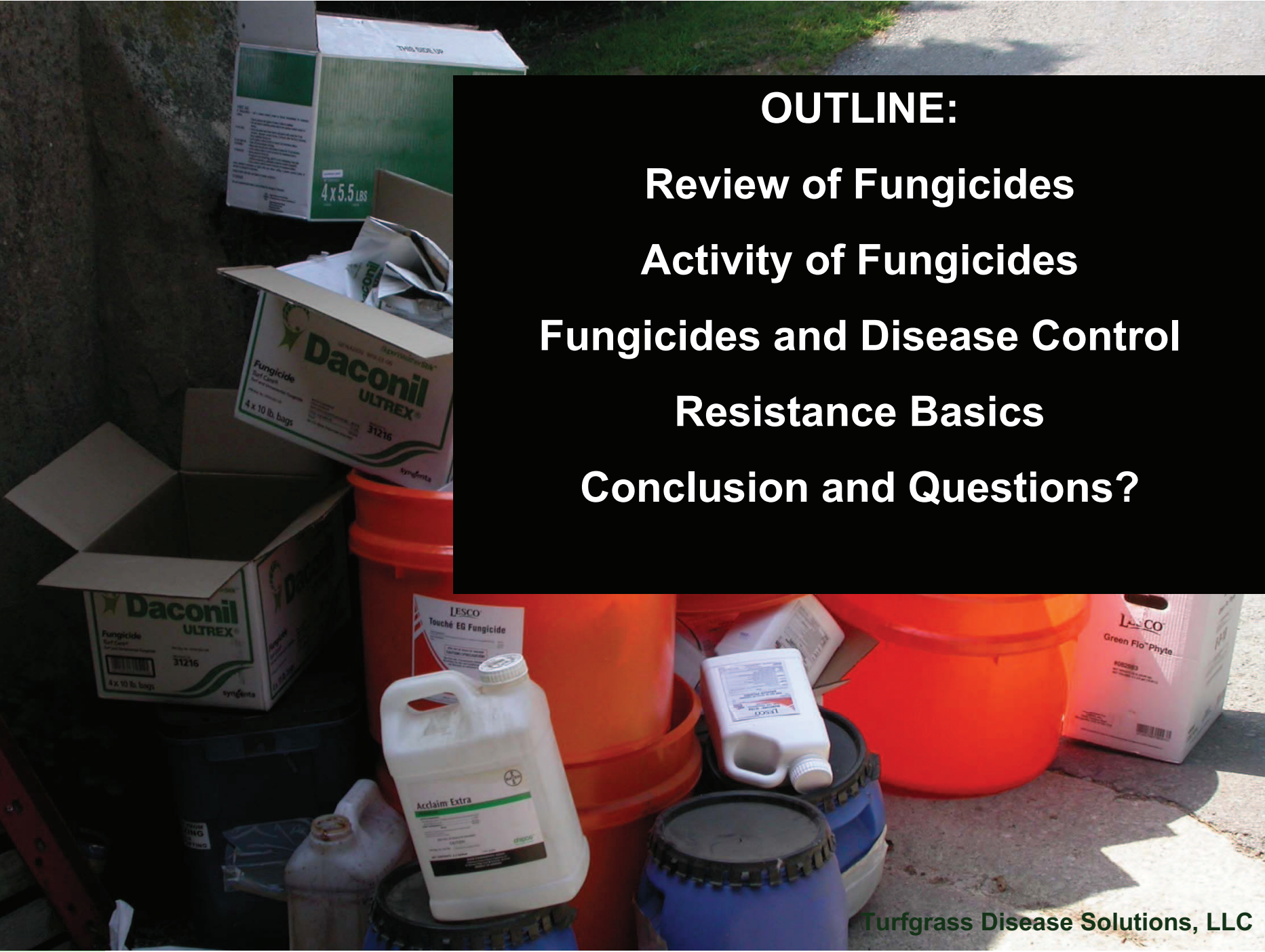
MAAGCS Educational Seminar

20 March 2008

Turfgrass Disease Solutions, LLC

Thanks





**OUTLINE:**

- Review of Fungicides**
- Activity of Fungicides**
- Fungicides and Disease Control**
- Resistance Basics**
- Conclusion and Questions?**

# Fungicides

- Important disease management tools for all cultivated crops
- In almost all cases, fungicides are fungistatic
  - Active ingredient suppress, inhibit, or limit fungal development and growth
  - Does not 'kill' fungi



Turfgrass Disease Solutions, LLC

# Types of Control

1. Preventive
2. Curative

- Preventive

- Insurance policy-may not even get disease

Prevents infection (successful penetration and establishment in the host)

Must be in place before process begin

# Types of Control cont.

- Curative

- Some refer to as eradivative or rescue
- Fungicide has activity after infection has already occurred
- Curative-fungicide stops or suppresses
- Eradivative- fungicide limits activity after the appearance
  
- What to know!

Preventive applications take place before outbreak or visible symptoms occur

Curative applications take place after outbreak occurs  
Sometimes rates on label are dictated by type of control!

# Fungicide Info

- Every fungicide has three names
  - Trade Name (most commonly used)
  - Chemical Name
  - Generic Name

# Examples of 3 Name System

Trade Name	Chemical Name	Generic Name
Daconil Ultrex 82.5WDG	tetrachloroisophthalonitrile	Chlorothalonil
Banner MAXX 1.3 MEC	1-((2-(2,4-Dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl)methyl)-1H-1,2,4-triazole	Propiconazole
Cleary's 3336 4F	Dimethyl 4, 4'-oxybis(3-thioallophanate)	Thiophanate methyl



# Classification of Fungicides

- **Three Systems to Classify**

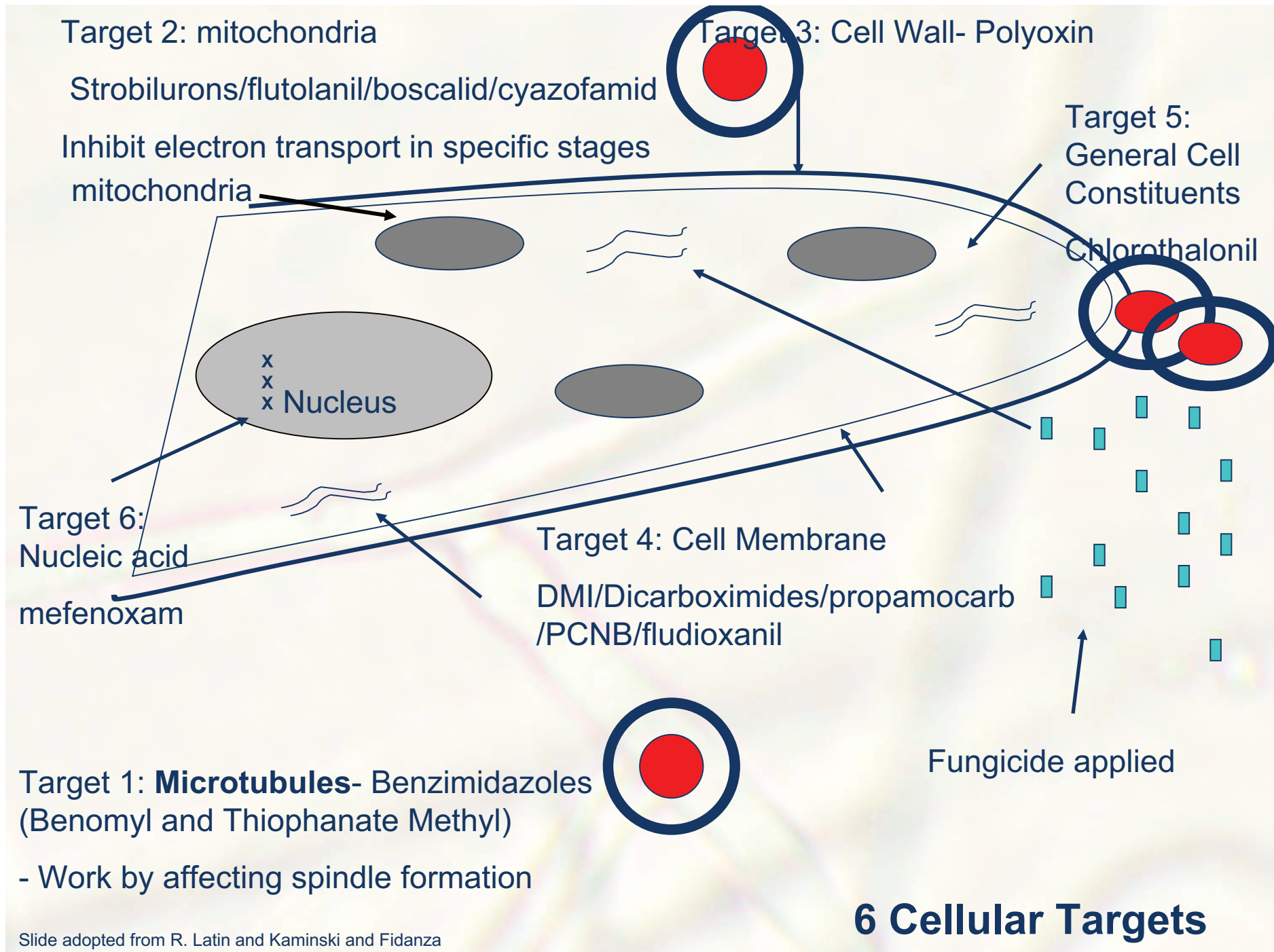
1. Chemical Class (Structure)

2. Chemical Mode of Action

- i.e. benzimidazoles
- Restrict fungal DNA synthesis
- etc,...

- 3. Activity on or in the plant**

**(contact, penetrant, and systemic)**



## 6 Cellular Targets





## Systemics: Phosphites and Fungicides

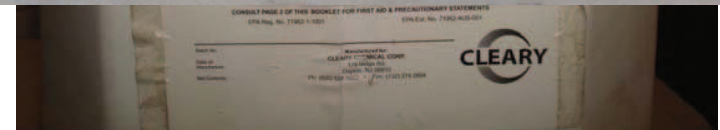
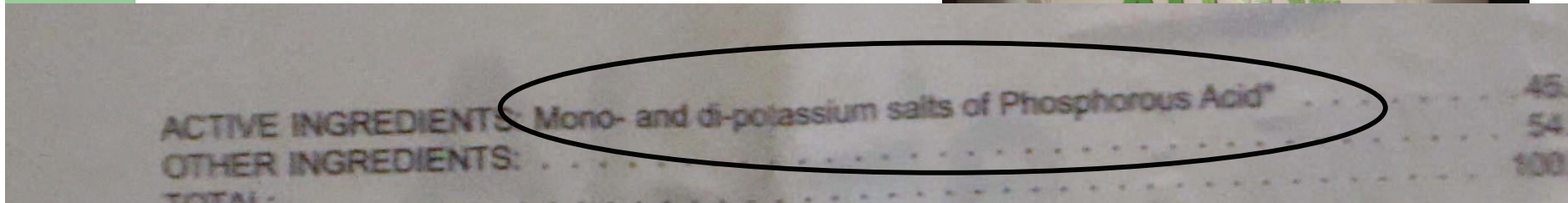
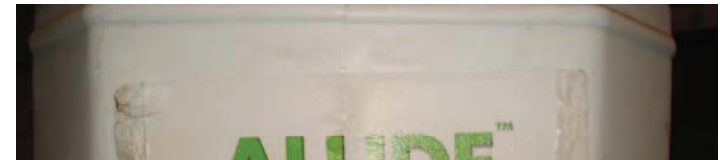
- Systemic- only one group of fungicides
- Systemic connotes translocation through entire plant
- Move in Xylem and Phloem
- Good Efficacy with Preventive Control
- Term Phosphonates (carbon to phosphorus bond (C-P))
  - Includes: Phosphonate Fungicides and Phosphite 'Fertilizer' or Supplemental Products

# Systemics: Phosphonate Products

- Phosphonates: Some are made up of salts and esters of phosphorous acid  $\text{HPO}(\text{OH})_2$
- Phosphorous acid + water = phosphonic acid
- Phosphonic acid if applied to a plant would be extremely phytotoxic-tip burn and death
- Hence, reduced with an alkali salt such as KOH to produce POTASSIUM PHOSPHITE

# Systemics: POTASSIUM PHOSPHITE

- Main ingredient in phosphonate fungicides such as:
  - Magellan
  - Alude



These products have EPA labels, hence, cost more and labels must be followed-labeled for specific diseases

# POTASSIUM PHOSPHITE

- Is the main ingredient in most phosphonate fertilizer products
  - (some call phosphite fertilizers)
- **Many** on the market (Some Examples)
  - K-Phite (0-29-26)
  - Plant Food Phosphite 29 (0-29-26)
  - Ele-Max Foliar Phosphite (0-28-26)
  - Nutri-Phite P+K (0-28-26)
  - PK Plus (3-7-18) 14% phosphite
  - Starphite (Two different analysis-2-40-16; 0-28-26)



# Green Flo™ Phyte

# 0-0-18

A Supplemental Fertilizer Solution for Stress Relief and Recovery

## GUARANTEED ANALYSIS

Soluble Potash ( $K_2O$ ) .....18%  
DERIVED FROM: potassium phosphite.

## READ LABEL CAREFULLY

### PRECAUTIONARY STATEMENTS

Avoid prolonged or repeated contact with eyes, skin and clothing. Safety goggles or a full face shield should be worn. Wear appropriate protective equipment to protect skin, such as rubber or plastic aprons, rubber gloves and boots. Avoid breathing mist or vapor. Keep containers closed. Wash thoroughly after handling. May cause gastro-intestinal distress if swallowed.

### FIRST AID

In case of contact with eyes, immediately flush eyes with water for at least 15 minutes. Seek immediate medical attention if irritation occurs. In case of skin contact, flush skin with water. If irritation occurs, seek immediate medical attention. Remove and wash contaminated clothing before reuse. If swallowed, give large amounts of water and induce vomiting. Do not

**KEEP OUT OF REACH OF CHILDREN**  
**CAUTION - AVISO**

# starphite™

## 0-28\*-26

Potassium Phosphite Fertilizer

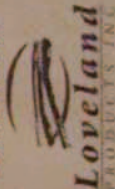
G U A R A N T E E D   A N A L Y S I S  
Soluble Potash ( $K_2O$ ) .....26.00%

Derived from: Potassium Phosphite

**KEEP OUT OF REACH OF CHILDREN  
CAUTION**

F1548

GUARANTEED BY:



PO BOX 1286  
GREELEY CO 80632-1286

NET WEIGHT 12.01 LBS./GALLON 5.44 kg

\*Not a source of Available Phosphite.

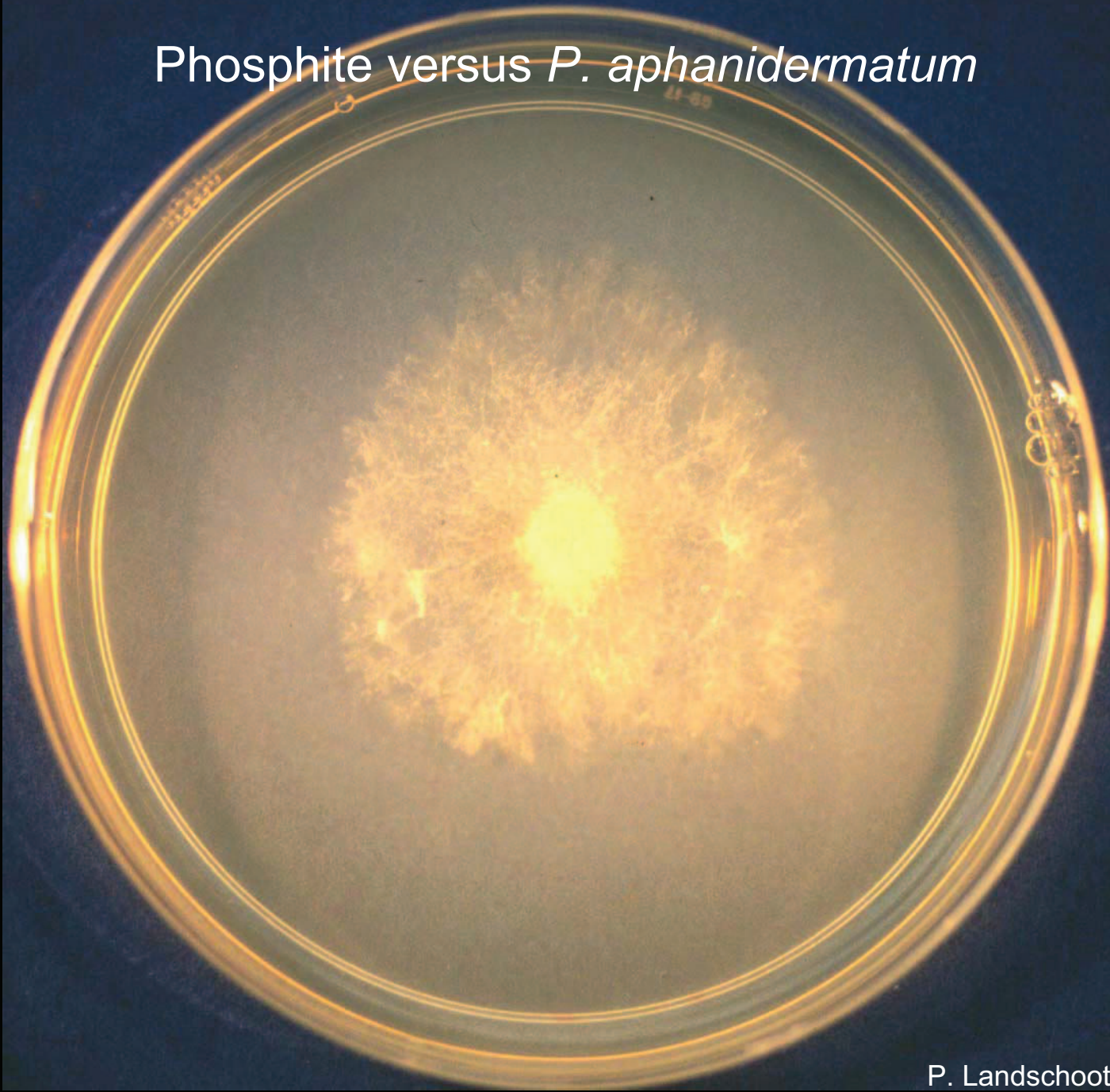
NET CONTENTS 2.5 US GALLONS (10 L)

# Phosphonate 'Fertilizer' Products

- Do not have a fungicide label
  - Your risk
- Do have fungicidal properties
  - Under most circumstances= good control
- Some will list the % P on the label
  - Example
    - 2-0-16 in northeast region
    - 2-40-16 in mid-Atlantic region

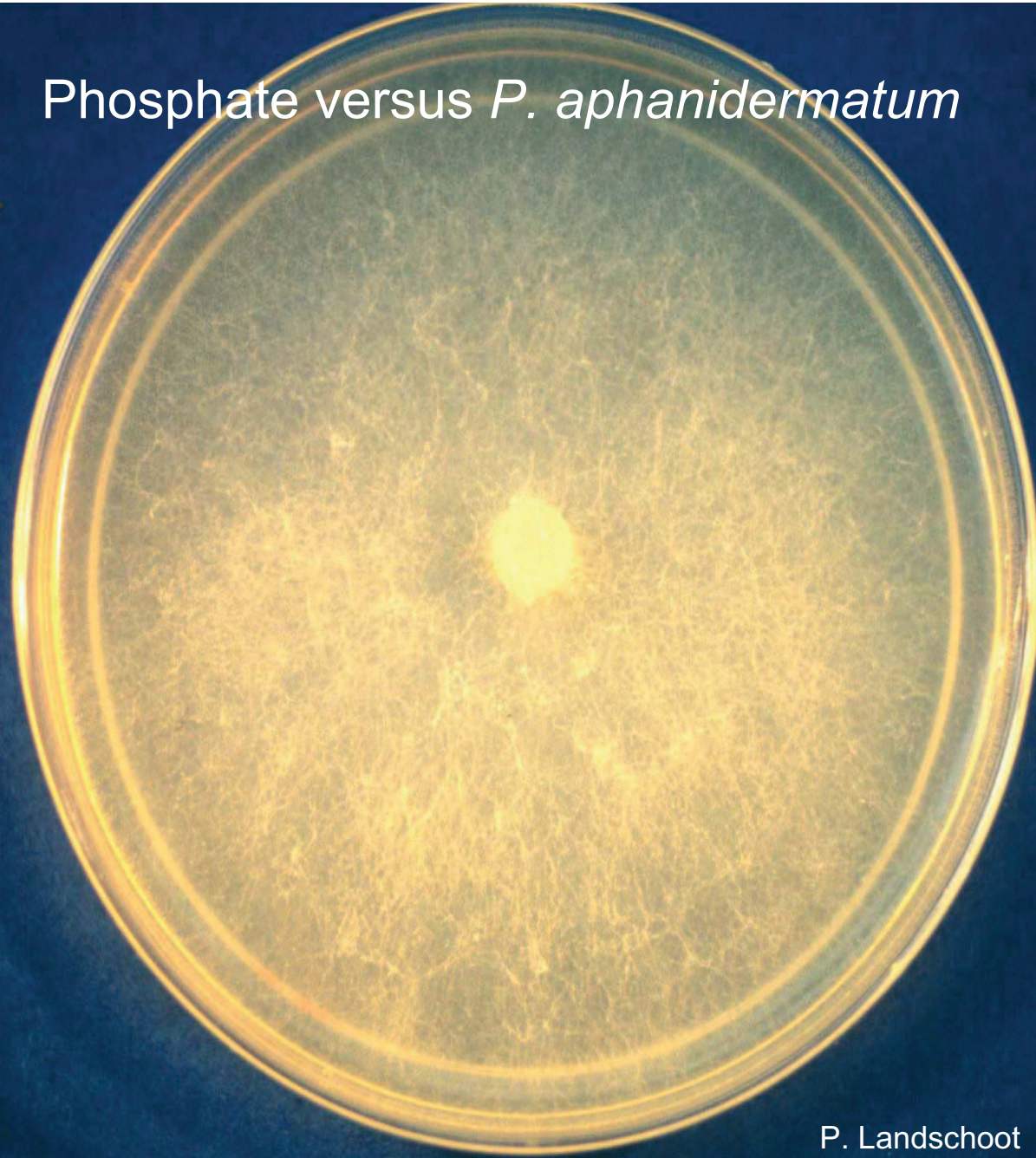
Most will state derived from potassium phosphite (

Phosphite versus *P. aphanidermatum*



P. Landschoot

Phosphate versus *P. aphanidermatum*



P. Landschoot

## Other Phosphonate Fungicides

- Instead of treating the phosphonic acid with a salt, it could be treated with an ethanol to form ethyl phosphonate
- Then treated with Aluminum ions to neutralize
- This forms Fosetyl-Aluminum
  - This is the active ingredient in Chipco (Alliette)  
Signature

# Summary: Two Phosphonates

1. Phosphonic acid

+ KOH = POTASSIUM PHOSPHITE

(often referred to as mono and di potassium salts of phosphorous acid or phosphoric acid)

2. Phosphonic acid

+ ethanol = ethyl phosphonate

+ Aluminum ions = Fosetyl-Aluminum

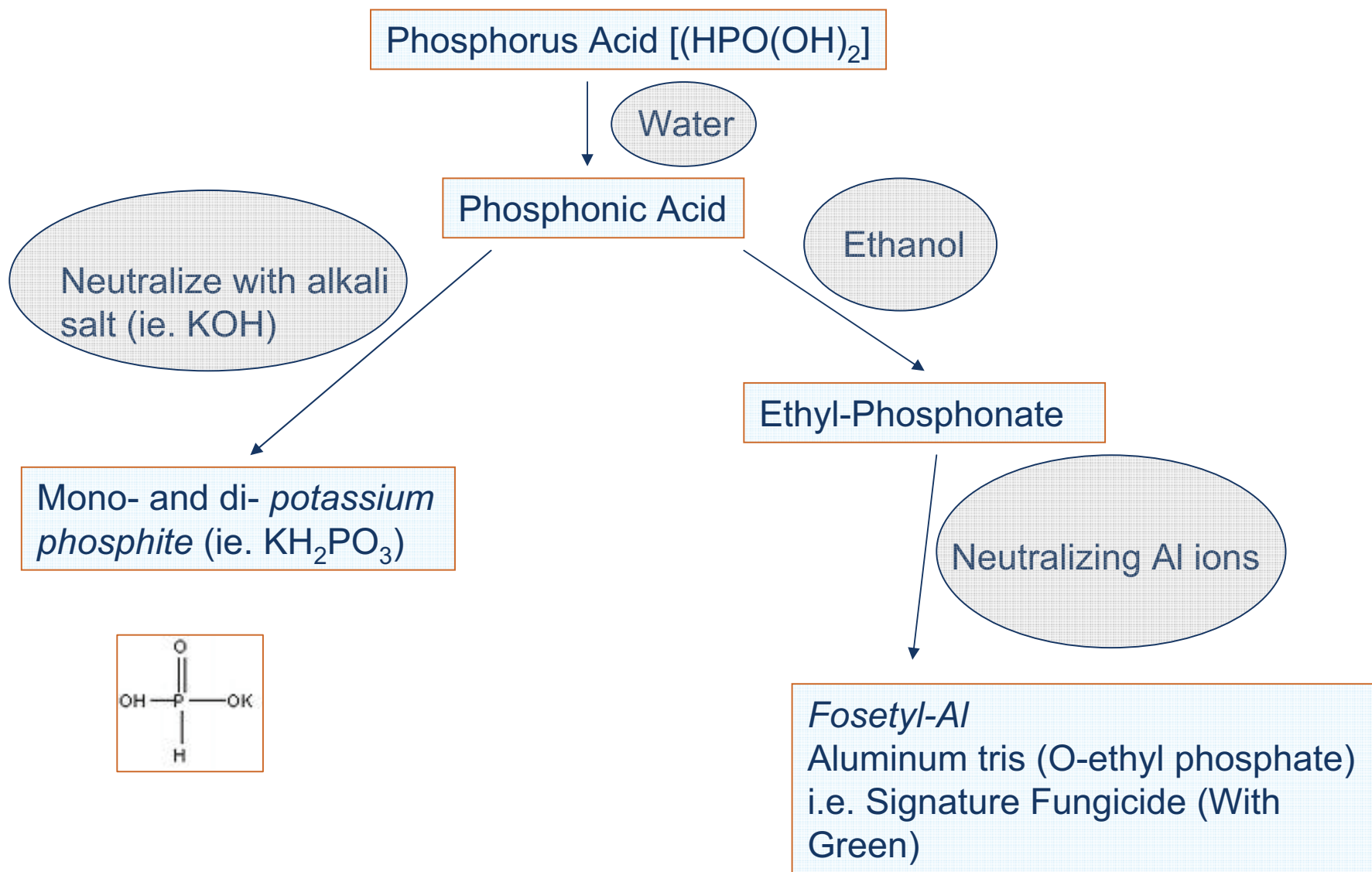
(Chipco Signature also has 'stress guard pigment')

$H_2PO_4^-$  = used by plants for energy (ATP, DNA, many functions)

$H_2PO_3^-$  = not the same = direct fungistatic effects on pathogens

The difference in one oxygen molecule makes a huge difference!

# Phosphonate Compound – Salts and esters of phosphorus acid

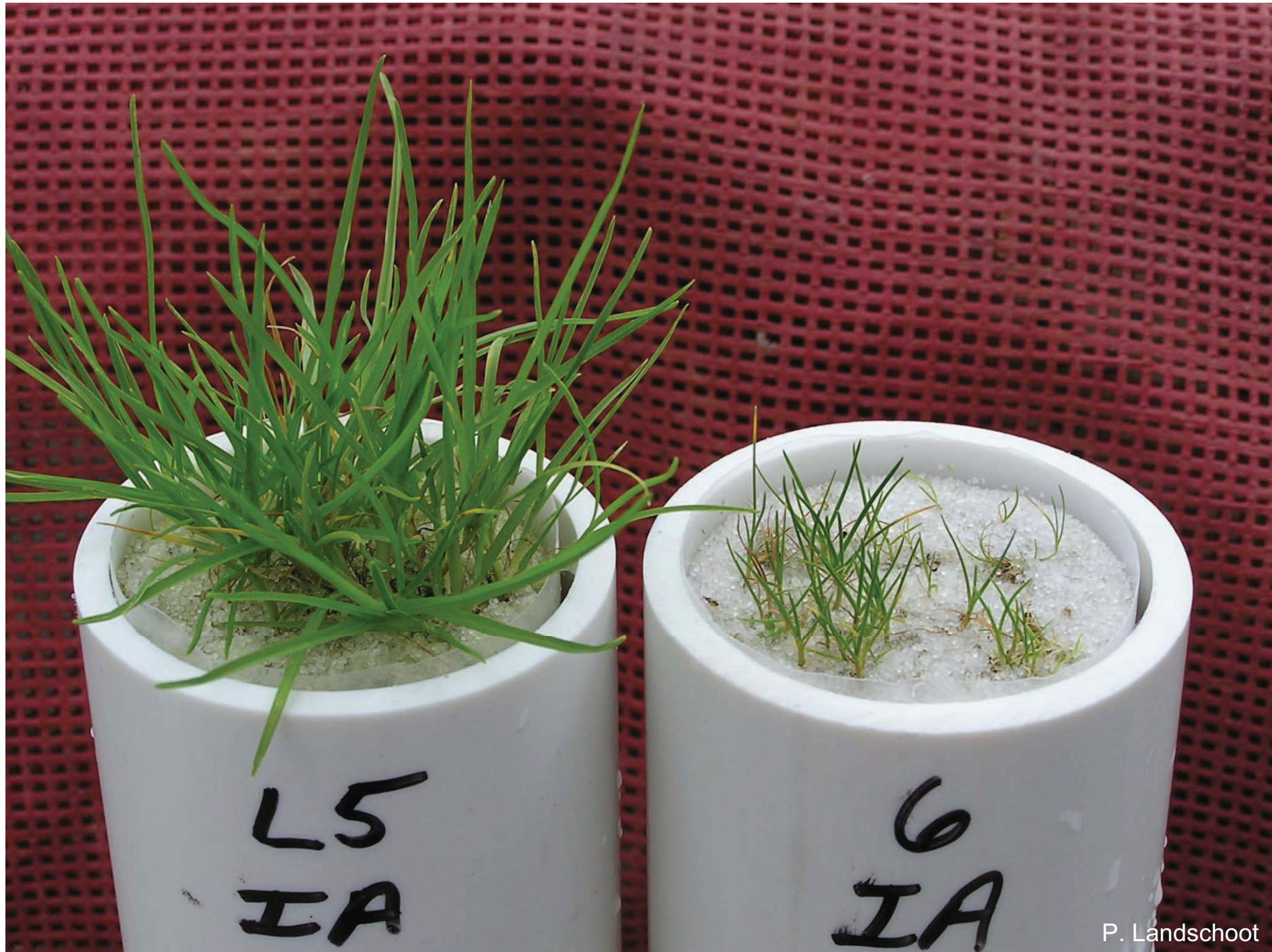






# Possible confusion

- Should not be confused with phosphate-derived fertilizers such as:
  - Ammonium phosphate
  - Triple super phosphate
- Chemically these phosphates are similar, however, differ in how they act on fungi and plants.
- These actually have a P fertilizer credit-used for ATP.



L5  
IA

6  
IA

# Classification of Phosphate Products

Compound	Cost	<i>Pythium</i> Control	Anthraco-nose Control	Turf Response
Potassium <b><u>phosphate</u></b> fertilizer	\$	None	None	Highest
Potassium <b><u>phosphite</u></b> supplemental 'fertilizer'	\$	Good	Marginal- to Good- Prev	Yes
Potassium phosphite fungicide (Alude, Magellan, Vital, etc)	\$\$	Good (Labeled)	Marginal- to Good- Prev	Yes
Fosetyl-Al Signature	\$\$\$	Good++ (Labeled)	Ok-Marginal	Yes

# Contact or Protectant Fungicides

- Only effective at site of contact or if deposit remains intact in high enough concentration
- Good coverage is essential (SV and Nozzle)
- Can be effective against germinating spores or active mycelium on surfaces they contact
- Do not penetrate plant or host tissues
  - Will not affect mycelium or fungal structures already established inside plant



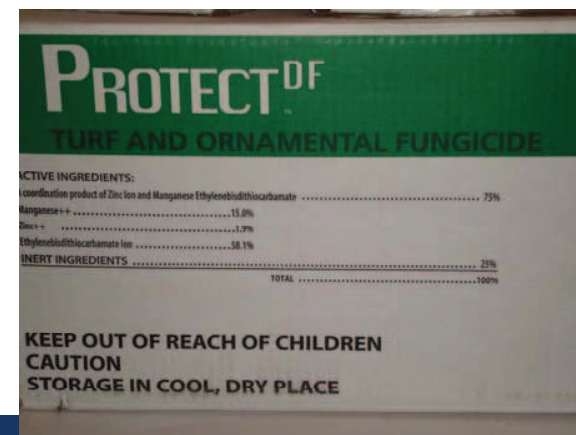
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## Contact Fungicides cont.

- Low solubility and should not be drenched into soils-rarely effective against root and crown diseases.
- Oftentimes broad spectrum in their control because of multi-site activity.
- Very low risk for resistance development
- Subjected to: weathering, mowing
- Relatively short application interval needed

# Contact Fungicides

## Dithiocarbamates



- Broad Spectrum and Contact Activity;  
Interferes With in Amino Acids
- Thiram Fungicides ; Spotrete® and Thiram®
- Mancozeb Fungicides; Fore®, Dithane M-45®,  
and Manzate®, Protect
- Maneb Fungicides; Dithane M-22®



## Dithiocarbamtes

- Generally, provide good control of Dollar spot, Brown Patch and Foliar Diseases
- Short re-application interval needed
- ‘Fore Example’

# Contact Fungicides Cont.

- Phenylpyrrole Chemistry
- An Antifungal Compound Derived From a Bacterium *Pseudomonas pyrocinia*
- Interferes With Fungal Membrane Transport
- Fludioxonil : Medallion



# Medallion<sup>®</sup>

## Fungicide

Active Ingredient:

Fludioxonil (CAS No. 131341-86-1) . . . . . 50.0%

Other Ingredients:

50.0%

Total:

100.0%

Medallion is a wettable powder.

Water-soluble Packaging.

Not for homeowner use.

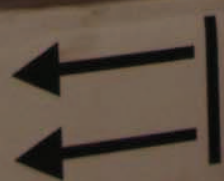
Reformulation is prohibited.

EPA Reg. No. 100-769

PRODUCT ID.  
**30427**

**syngenta**

**2 x 16 x 5 oz. bags**



RAIN SHIELD

1 U.S. GAL

Antino-Lok

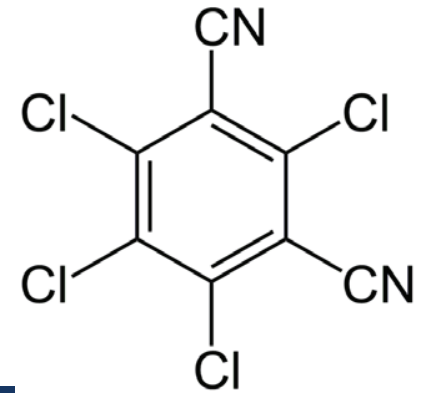
# Fludioxonil : Medallion

- Broad Spectrum Control
  - Does not have activity on dollar spot
  - Good to Excellent: brown patch, anthracnose, dead spot, snow molds, gray leaf spot material
  - May improve performance of other fungicides
  - Low use rates 0.15-0.5 oz/1000ft<sup>2</sup>

# Contact Fungicides

- Benzonitriles or Nitriles
- Chlorothalonil ; Daconil®, Echo®, and Manicure®
- Broad Spectrum and Contact Activity; Affects many general fungal cell constituents
- Eye Irritation- big EPA issue

# Chlorothalonil



- Number one used fungicide in turf
- Rates and Application intervals restricted by the EPA
- Wide range of effective diseases
  - Excellent brown patch, anthracnose, dollar spot, dead spot, snow molds, gray leaf spot material



**Daconil**  
**ULTREX**  
Fungicide  
For Corn  
31215  
4.5 lb. bags  
syngenta

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syngenta



19/83

18/52

674894

LESCO  
MANURE, UREA  
15-15-15  
NET WT. 25 LBS  
GROSS WT. 28 LBS



# Contact Fungicide Continued

## Aromatic Hydrocarbons

- Three Products in Turf
  - Chloroneb (Terramec)
  - Ethazol (Koban), or Etridiazole (Terrazole)
  - Quintozenone (PCNB)
- Interferes With DNA Synthesis and Enzyme and Membrane (chitin) Production Needed for Growth and Reproduction

## Chloroneb (Terramec)

- Contact fungicide used for control of *Pythium* blight and some snow molds
- Examples include :  
Fungicide V 6G (3 to 5.9 lb/1000ft<sup>2</sup>),  
Teremec SP 65W (4.0 oz/1000ft<sup>2</sup>)  
others.....

# Ethazol (Koban) or Etridiazole (Terrazole)

- Used for Pythium control
- Best used for curative control (good knockdown), than apply a systemic or penetrant that will last longer
- Provides only short duration of control

# CONTACT FUNGICIDES

## Quintozene (PCNB)

- Effective against gray snow mold, pink snow mold, melting out diseases, brown patch, and dollar spot
- Frequently used in areas where long snow cover is typical
- Can cause some discoloration (phyto) when used in warmer areas (above 65°F)
- Relatively cheaper when compared to other snow mold materials...

# Localized Penetrant

- Have some characteristics similar to contact fungicides (can affect germinating spores and suppress active mycelia on plant surfaces)
- Must contact surfaces
- Limited capacity to be absorbed into underlying tissues in concentrations effective for disease control

# Localized Penetrant

- Translaminar in movement- move very short distances from the site of application, such as across a leaf blade from one surface to the other (Diffusion)
- More soluble than contact fungicides, however, few are effective against root pathogens
- Relatively Broad Spectrum

# Localized Penetrant

- Considered 'Site-specific'
- Many 'at risk' for resistance development

# Localized Penetrant Fungicides

## Dicarboximides

- **Became Available in 1974 -75**
- **Mode of Action : Activity at the Cell Membrane- Interferes with Cell Division and DNA And RNA Synthesis**



# Localized Penetrant

- **Examples:**

- **Iprodione : Chipco 26019® , 18 Plus, 26GT® , Iprodione Pro among others**
- **Vinclozolin : Curalan® , and Touche®**

# Localized Penetrants

- Polyoxins Class
  - Endorse (Polyoxin-D)
  - Good to Excellent Fairy Ring, Brown Patch, Anthracnose material
  - No known resistance, yet!

## Localized Penetrant

### Strobilurins

- **Currently, four strobiluron fungicides in turf and ornamental market**
- **Two are localized penetrants and two are acropetal penetrants**
- **Strobilurins (QoI) interfere with respiration by disrupting electron transport at the Quinol-oxidizing site of cytochrom bc in the mitochondria-resulting in impaired ATP**

# Strobilurins

- **Considered to be low-risk pesticides due to the fact that humans don't have that pathway and that they are derived from a natural fungi**
- **This Class of Fungicides Mimic an Anti-Fungal Compound Found in Wood Decaying Fungi ; Allelopathic Effect**
- **Single site activity**

# Localized Penetrant Strobilurins

- **Compass®: trifloxystrobin**
- **Introduced in 1999**
- **A mesostemic broad spectrum**
- **Optimum control occurs in a preventative program**
- **Application rates vary from .1 to .25 oz/M**
- **Brown patch, summer patch, red thread, gray leaf spot**

## Localized Penetrant Strobilurins

- **Insignia®: pyraclostrobin**
- **2002 season**
- **A broad spectrum**
- **Optimum control occurs in a preventative program**
- **Application rates vary from .5 to .9 oz/M**
- **Brown patch, summer patch, red thread, gray leaf spot, Pythium, Dollar spot suppression, leaf spots-melting out**

# Unique Activity of Localized Penetrant Strobilurins

- Some also refer to these two localized penetrant strobilurins activity as mesostemic
- Trifloxystrobin- moves through vapor through leaves- can be redistributed (as AI metabolized other particles move into the leaf).
- Pyraclostrobin- translaminar movement moving across leaf tissue through diffusion-higher concentrations to lower. No vapor like Trifloxystrobin

Neither move significantly in the xylem!

# Localized Penetrant

## Cyazofamid

- Segway
  - Cyazofamid
  - Released in late 2006-early 2007
  - Labeled for Pythium (foliar and root dysfunction) and damping off
  - QIL-Quinone inside binding site-acts closely to QoI fungicides-too date no cross resistance with QoI fungicides (such as Heritage, Insignia, Disarm, and Compass) has been documented.



# Acropetal Fungicides

- Most effective against pathogens in plant
- Formulated to penetrate plant tissues rapidly so have little activity on surface
- Almost all of them move upward from the point of absorption

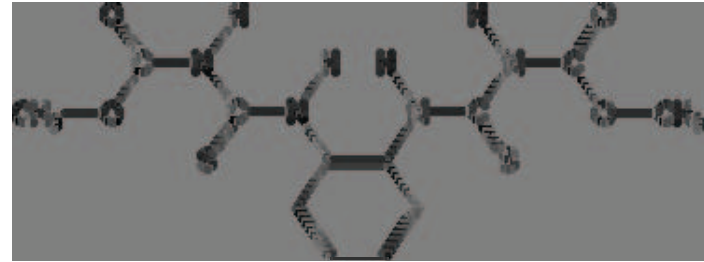
Acropetal movement= translocated only in the xylem

# Acropetal Fungicides

- Once inside the plant, restrict fungal growth, and limit colonization by the pathogen and/or reduce its ability to reproduce.
- Move upward in vascular tissues-not downward
- Fairly soluble and most are effective against root, crown, foliar and rhizome diseases
- Site specific and 'at risk' for resistance

# Acropetal Penetrants

## Benzimidazoles



- **First Acropetal Penetrant Fungicide**
- **Effective at Relatively Low Rates**
- **Inhibits Cell Division ; Affects Microtubule (Spindel) Formation**
- **Tersan 1991 : benomyl**
- **Fungo, Cleary 3336, TM, others : Methyl Thiophanate**

# Acropetal Penetrant Benzimidazoles T-Methyl and benomyl

- Generally, used to control:
  - Pink snow mold
  - Dollar spot
  - Brown patch
  - Gray leaf spot
  - Red thread
  - Summer patch
  - Anthracnose

# Sterol Inhibitors or DMI's

- **Consist of Five Different Chemical Families, Two Have Labeling in Turf and Ornamentals**
- **Interfere With Ergosterol Synthesis**
- **Largest group of fungicides (n=currently 7, maybe more shortly)!**
- **Began to Come Into the Market During 1980's**
- **Growth Regulating Effects**

## Sterol Inhibitors

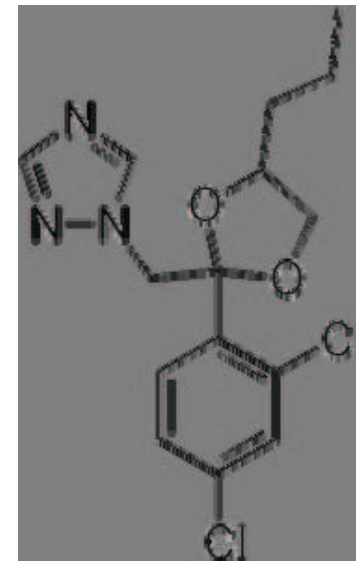
- **Triazole Class:**

- **Banner® - Propiconazole**
- **Bayleton® - Triadimefon**
- **Sentinel® - Cyproconazole-off of the turf market**
- **Eagle® - Myclobutanil**
- **Lynx® - Tebuconazole\*-?**
- **Tourney®- Metaconazole**
- **Trinity®-Triticonazole**
- **Trition®- Triticonazole\***

\*EPA registration Pending

- **Pyrimidinols Class:**

- **Rubigan® - Fenarimol**



# Sterol Inhibitors

- Extremely broad spectrum
  - Summer patch
  - Anthracnose
  - Dollar Spot
  - Brown Patch
  - Take-all Patch
  - Leaf spots
  - Some snow molds
  - Some do well on fairy ring



## Localized Penetrant Pythium Fungicides

- **Banol®:**
  - Carbamate : Propamocarb ; Membrane Biosynthesis
- **Subdue® MAXX:**
  - Phenylamide : Metalaxyl ; Interfere With Nucleic Acid Synthesis
- **Steller ® (State Reg. Pending, EPA Complete)**
  - Combines new chemistry (fluopicolide) with another acropetal penetrant (propamocarb-banol)
  - Fluopicolide belongs to the acylpicolides and is an acropetal penetrant which is distributed in xylem tissue – anti-sporulant activity



# FUNGICIDE CLASSES

## Benzamides

- Introduced into Turf Market in Early 1990's
- Prostar® : Flutolanil
- Interferes With Cell Respiration in Mitochondria

## Prostar® : Flutolanil

- Originally developed for the control of *Rhizoctonia* diseases (brown patch) on rice.
- Control of many basidiomycete fungi
  - Fairy ring, brown patch, red thread

# Acropetal Penetrant Dollar Spot Only Fungicide

- Emerald (Boscalid)
  - Effective for two turf diseases
    - Bentgrass Dead Spot
    - Dollar spot
  - Effective at very low rates (0.13-0.18 oz/1000M)

# Acropetal Penetrant Strobilurins

- Two materials
- Move upward in the xylem from



# Acropetal Penetrant Strobilurins

- **Heritage® : Azoxystrobin**
- **Introduced in 1997**
- **Works Better in Preventative Control ; Low Use Rates**
- **Broad Spectrum of Control ; 14 to 28 Day Residual Based on Rate**

# Acropetal Penetrant Strobilurins

- **Disarm® : Fluoxastrobin**
- **Introduced in 2006**
- **Works Better in Preventative Control ; Low Use Rates**
- **Broad Spectrum of Control ; 14 to 28 Day Residual Based on Rate**

# Heritage and Disarm

- Good to excellent
  - Brown patch
  - Take-all patch
  - Red thread
  - Summer Patch
  - Some short term Pythium control
  - Dollar spot?

# Review of Fungicide Classes

- Four Types
  - Contact
  - Localized Penetrant (LP)
  - Acropetal Penetrant (AP)
  - Systemic

Contacts-outside plant

LP- May move in outside leaf tissues

AP- Move upward from point of application

LOCK AND KEY-Fungicide binds to certain target of fungi



# Managing Fungicide Resistance

- Documented Cases To date:

Dollar spot= DMI- thiophanate methyl-dicarboximides

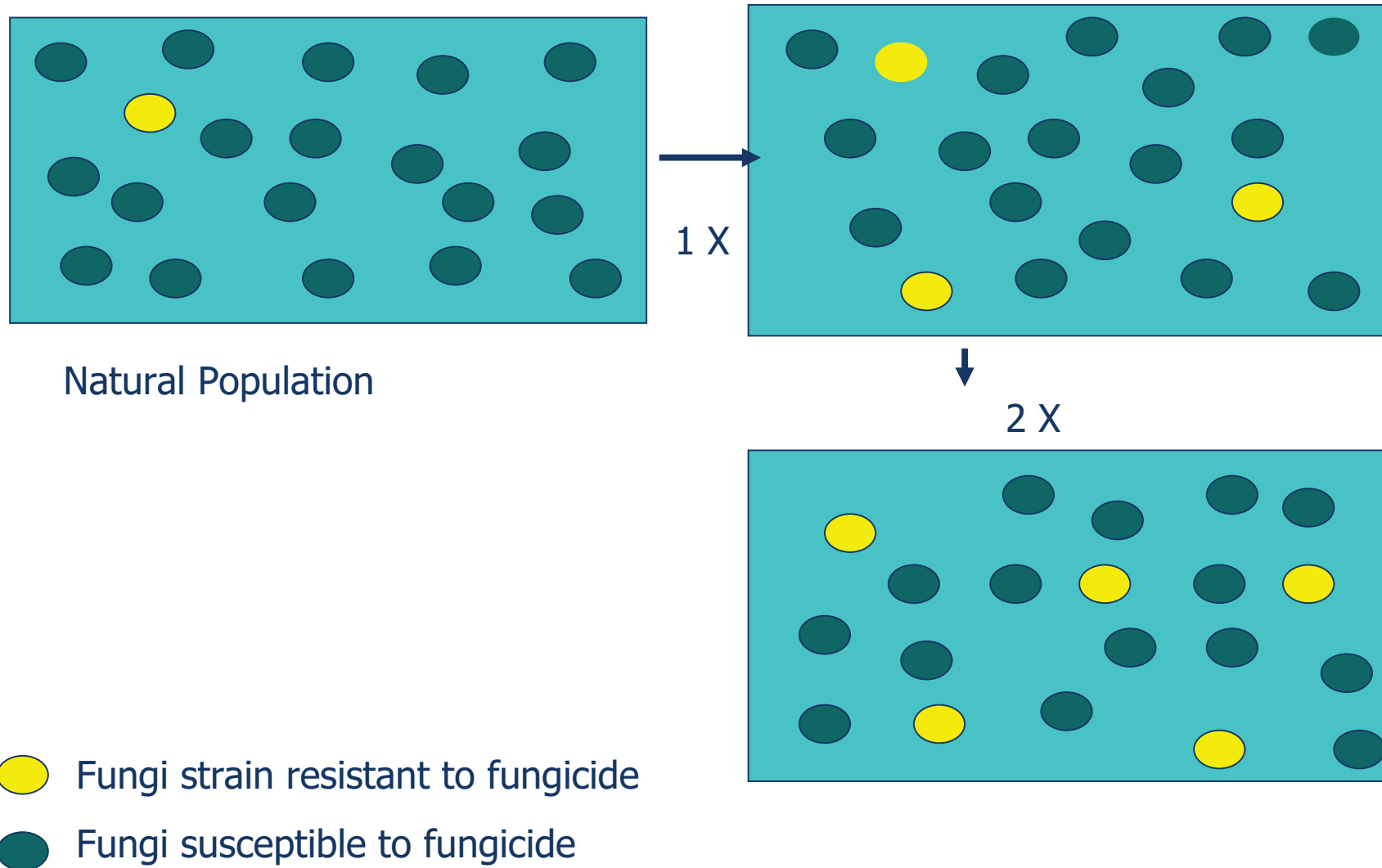
Anthraco-nose=strobiluron- thiophanate methyl-DMI

Pink Snow Mold- dicarboximides

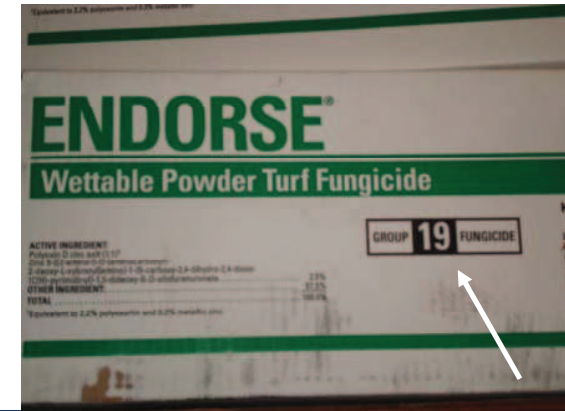
Gray Leaf Spot= strobiluron and maybe others?

Pythium Blight= strobiluron and mefenoxam

# How Resistance May Happen



# FRAC



- Fungicide Resistance Action Committee Classification Scheme of Fungicides
- Uses numbers and letters to
- Helps to determine
  - 1.) risk or potential resistance issues
  - 2.) Help end users determine good tank mixes

Examples= FRAC Code M; FRAC Code 4- Subdue  
MAXX

# Tank mixing, Pre mixes and Rotations

- Besides Cultural Practices and Preventive Applications-Remain the Best Method



 **TARTAN**

Many 'pre-mixed' fungicides are currently on market

**Armada**

Any Questions?

