Pesticide Formulations and Compatibility

Pacific Northwest Forest Vegetation Management Conference, December 6, 2022

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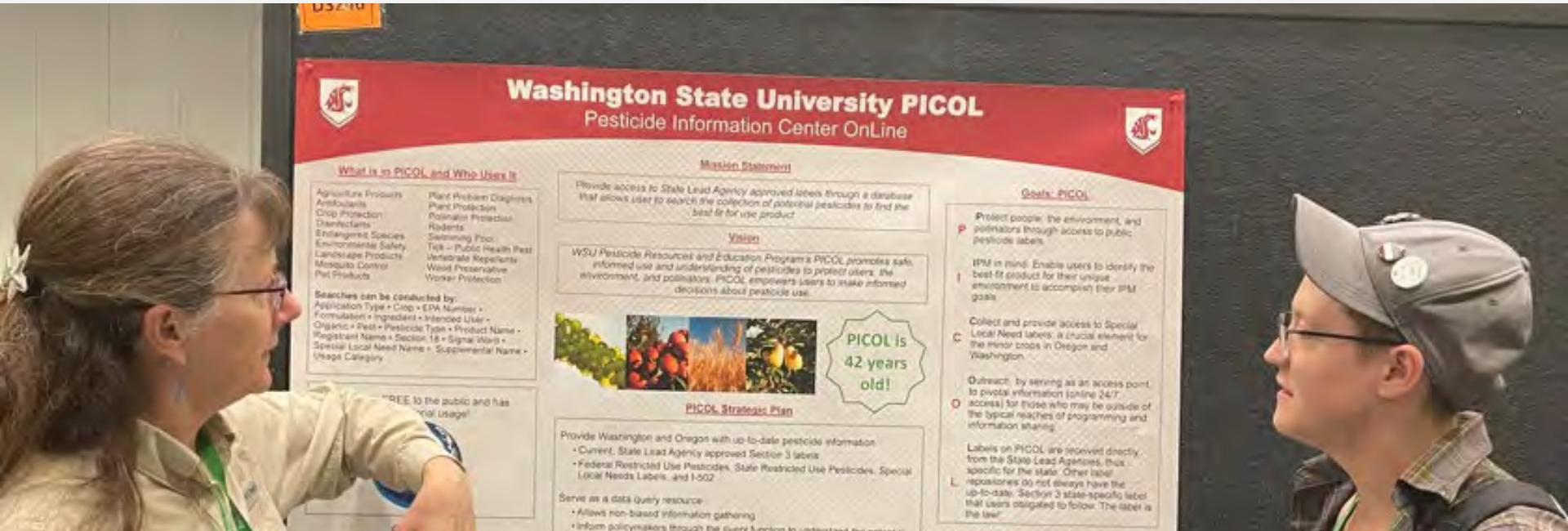
Wendy Sue Wheeler

Director of the Washington State University's

Pesticide Resources and Education Program

- Hands-on experience
  - Core of the Pesticide Safety Education for 14 years
  - 12 years of diving deep into pesticide registration and regulations



Adapted from:

PENN STATE CMEG Crop Management Extension Group

Pesticide Formulations Substitutes for Common Pesticide Formulations by Kevin Fry, Extension Educator PENN STATE Crop Management Extension Group And Pesticide Compatibility for the Applicator

UNIVERSITY of NEBRASKA–LINCOLN
Institute of Agriculture and Natural Resources
PESTICIDE SAFETY EDUCATION PROGRAM

Pesticide Compatibility for the Applicator Clyde Ogg and Erin Bauer University of Nebraska—Lincoln, Pesticide Education Office

VirginiaTech Invent the Future | Pesticide Programs

Hands on presentation - Pat Hipkins, Senior Research Associate and Assistant Coordinator of the Virginia Tech Pesticide Programs

PURDUE EXTENSION | Purdue Pesticide Programs

Avoid Tank Mixing Errors Fred Whitford, Director, Purdue Pesticide Programs

Objectives

- Formulations
  - Components of a formulation
  - Advantages and disadvantages
  - What to consider
- Compatibility
  - Mixing in proper order
  - Steps to test
  - Recognize when incompatible

Formulation

- Pesticide product as purchased
- Containing a mixture of one or more active ingredients
- Carriers (inert ingredients)

Formulation

- Other additives
  - Safety
  - Ease of application
  - Storage
  - Handling
  - Effectiveness

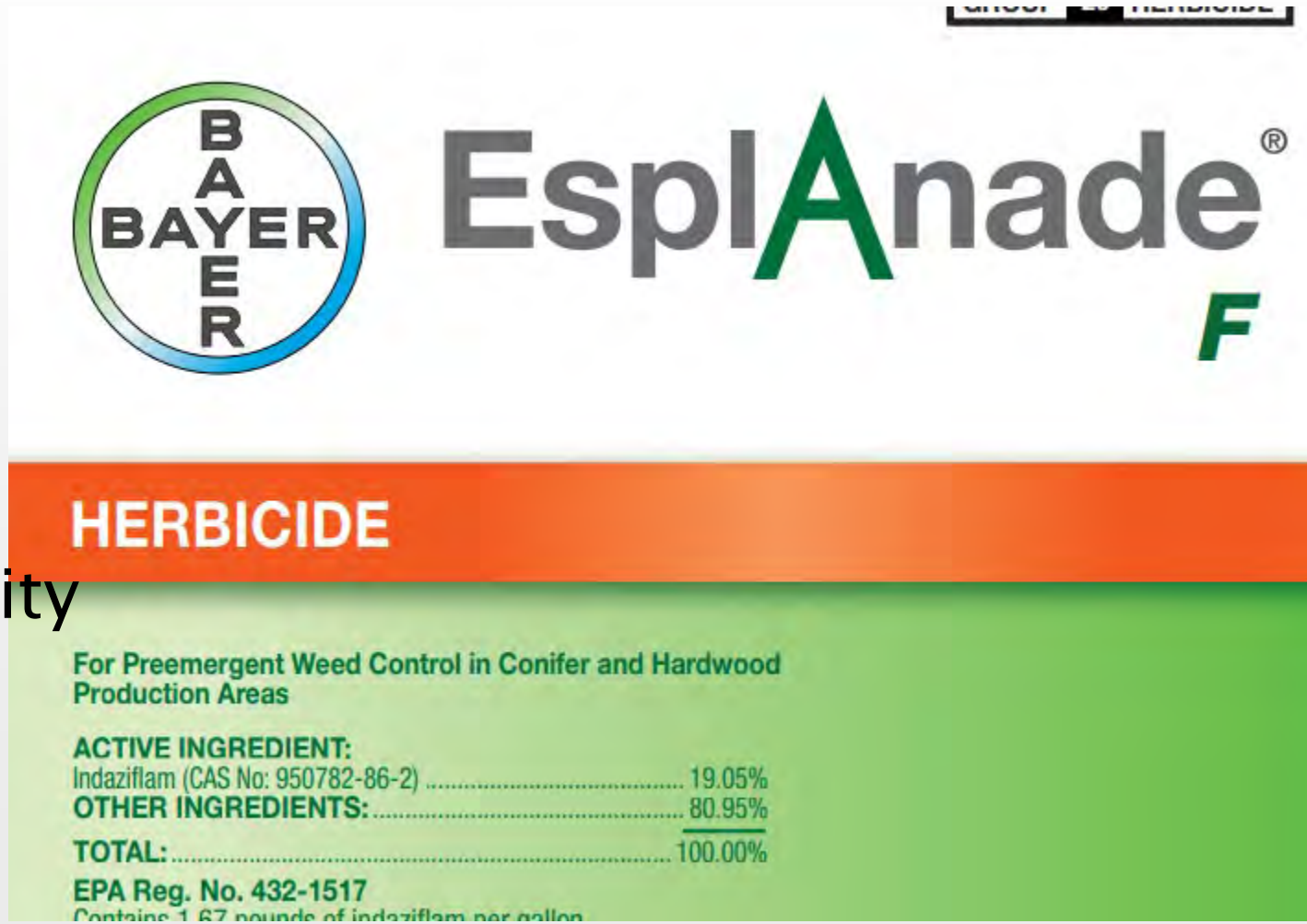
Formulation

- Letters that follow or part of brand name
  - Linex 4L ~ Liquid
  - Lorox DF ~ Dry

Formulation

Pesticide Product

- Active Ingredient
  - Physical compatibility problems
  - Inerts



Formulation

Suspensions

- Does not dissolve in water
- Needs constant agitation
- Dry particles in a liquid

Formulation

Solution

- Forms a true solution
- Dilutes out in carrier
- Over dose or under dose easily

Instructions

Household Items

Glass Cleaner

Ready-to-Use (RTU)

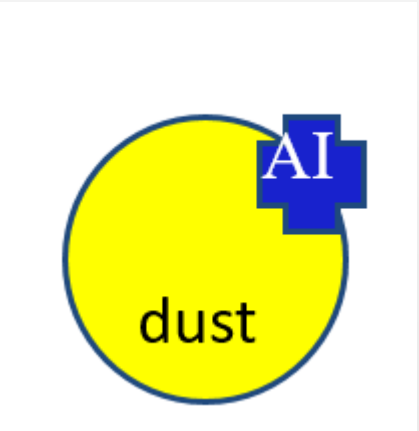
Solution or suspension diluted to use rate

Foot Powder


Compare to Dr. Scholl's® Original Foot Powder ingredients*
equate
foot powder
COOLS AND SOOTHES
ABSORBS WETNESS
7 OZ (198 g)

Dust (D)

- Fine solid particles
- Ready to use
- Not water-soluble



Dust (D)

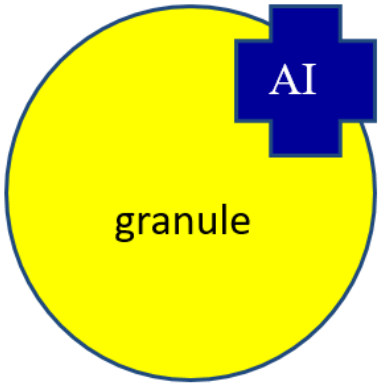
- Most are Ready to Use

Cat Litter & Grape-nuts

Granule (G)

Small particles

- Ready to use
- Not water-soluble



HERBICIDE
OPEN RANGE® G

Guinea Pig/Rabbit Food

Pellet (P or PS)

Formed small- to medium-sized particles

- Ready to use

Toothpaste & Granola Bar

Bait (B)

Attractant/feeding stimulant + food + pesticide

Applied without mixing

Example:
Abathor Granular Ant Bait
Lava-Lor Granular Bait

Bait (B)

Advantages:

- Ready to use with no further mixing or special application equipment

Bait (B)

Disadvantages:

- May be attractive to children and pets
- Domestic animals and wildlife may be affected
- Target pest may not be controlled because other available sources of food are more attractive

Hair Spray


UNSCENTED
AQUA NET
PROFESSIONAL HAIR SPRAY
ALL DAY
ALL OVER HOLD
3
EXTRA SUPER HOLD
NET WT. 14 OZ (397g)

Aerosol (A)

Fine airborne particles/droplets plus a propellant

- Wasp & Hornet Killer
- Bug repellent
  - DEET

Aerosol (A)

Advantage:

- Ready to use and easily stored

Aerosol (A)

Disadvantages:

- Relatively high cost
- Risk of inhalation injury
- Difficulty in confining the pesticide to the target site or pest
- Very hazardous if containers are punctured or used/stored near a heat source

Detergent Gelpacs & Liquacaps

Water Soluble Packaging

A semi-solid colloid (jelly) packaged in water-soluble film

Pine-Sol

Emulsifiable Concentrate (EC)

Emulsion; fine liquid particles suspended in another liquid

- Forms cloudy mixture when mixed with water

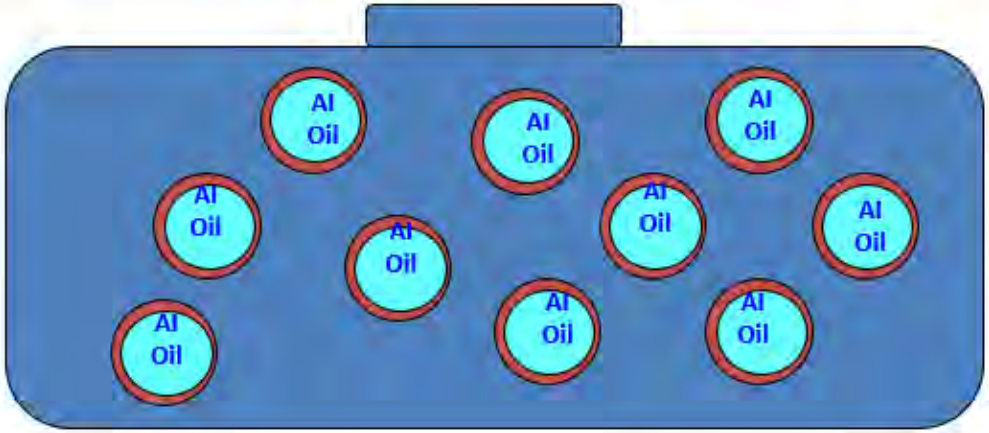
Homogenized milk

Emulsifiable Concentrate (EC)

Ai is dissolved in oil or petroleum solvent (oil/ai droplet) and mixed with an emulsifier

Creates an emulsion (white liquid)

One liquid dispersed in another liquid



Emulsifiable Concentrate (EC)

Product

Ai dissolved on oil + emulsifier

Oil mixture in water

Emulsifiable Concentrate (EC)

Advantages:

- Relatively easy to handle, transport and store
- Little agitation required
- Nonabrasive to equipment
- No plugging of screens and nozzles

Emulsifiable Concentrate (EC)

Disadvantages:

- High concentrations of active ingredient increases the hazard when mixing or applying
- May have high phytotoxicity hazard
- May be easily absorbed through the skin of humans and animals due to solvents

Emulsifiable Concentrate (EC)

Disadvantages:

- Solvents may cause equipment deterioration
- May be corrosive, causing pitting or discoloration on painted surfaces
- May be flammable due to petroleum solvents

White Grape Juice

Solution (S) / Concentrated Solution (C or LC)

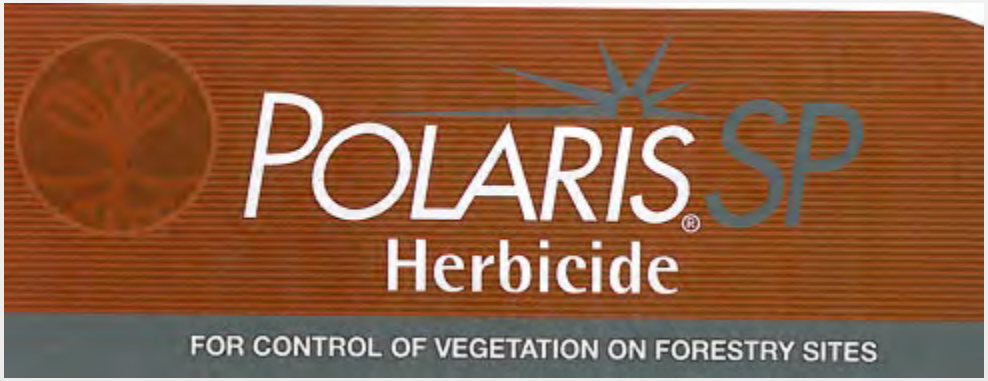
Liquid that will form a true aqueous solution

Drink Mix & Corn Starch

Soluble Powder (SP or WSP)

Fine- or medium-particle sized solid that will dissolve in water

- Form a true solution



Soluble Powder (SP or WSP)

Advantages:

- Reasonable cost
- Easy to store, transport, and handle
- Lower phytotoxicity that some liquid formulations (especially EC's)
- Many types of application equipment
  - Small portable
  - Aircraft

Soluble Powder (SP or WSP)

Advantages:

- Slower skin and eye absorption than EC's
- Sometimes available in premeasured soluble packets that dissolve in spray tanks, thus minimizing handling and inhalation exposure

Soluble Powder (SP or WSP)

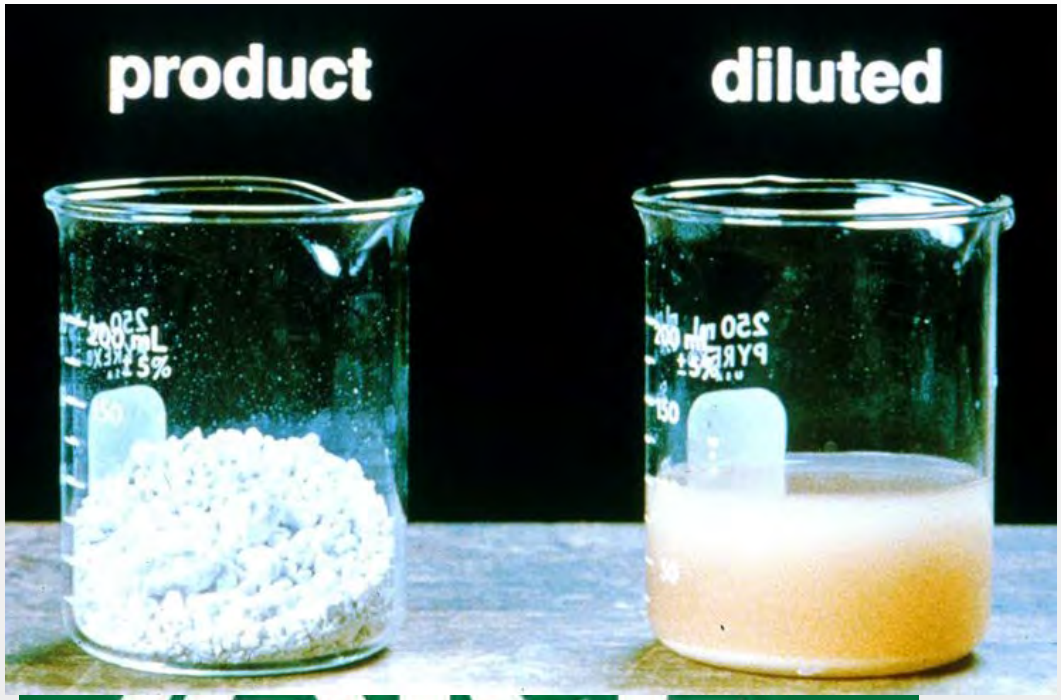
Disadvantages:

- Dust-like consistency
  - May be hazardous if the handler inhales product during mixing.
- Agitation or they settle out
- Abrasive

Cocoa & Flour


arn CASH for Your School!
Gold
MEDAL
ALL-
PURPOSE
Nestlé
TOLL
HOUSE
Cocoa

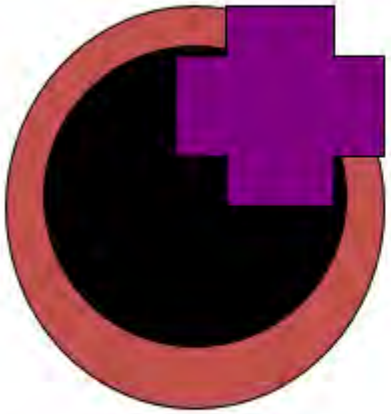
Wettable Powder (W or WP)



- Relatively insoluble fine-particle solid
- 25 – 85% a.i.
- Forms suspension
- Not a true solution

Example:
ProStar 70 WP Fungicide

Wettable Powder (W or WP)



Active Ingredient
impregnated onto Dry Carrier
and mixed with an
Emulsifier (slick, soapy)

Wettable Powder (W or WP)

Share all advantages / disadvantages of soluble powders.

Wettable Powder (W or WP)

Other Disadvantages:

- Require constant agitation
  - avoid settling of particles
- Nozzle / pump wear from abrasive spray mix
- Clogging sprayer screens and nozzles
- Difficult to mix in very hard or alkaline water

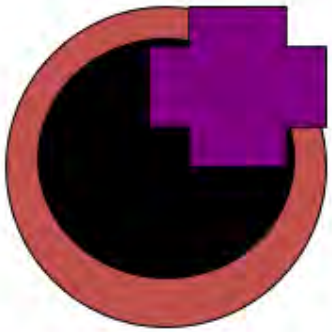
Grits & Dry Milk

Water-Dispersible Granules (WDG) / Dry Flowables (DF)

Small particles of a wettable powder

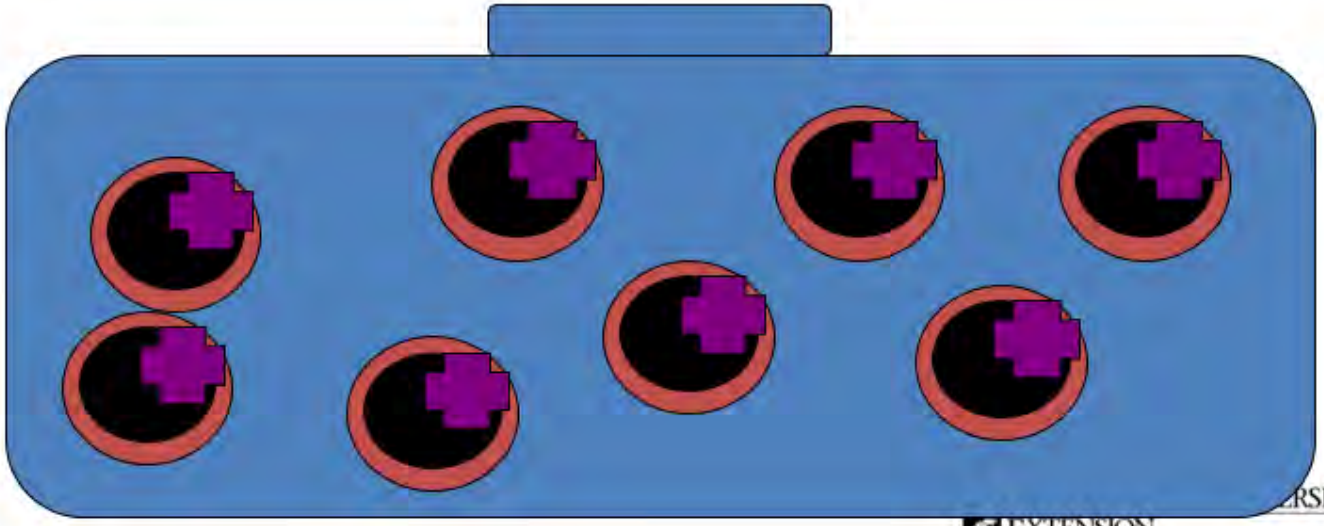
- Will form a suspension
- Not a true solution

Water-Dispersible Granules (WDG) / Dry Flowables (DF)

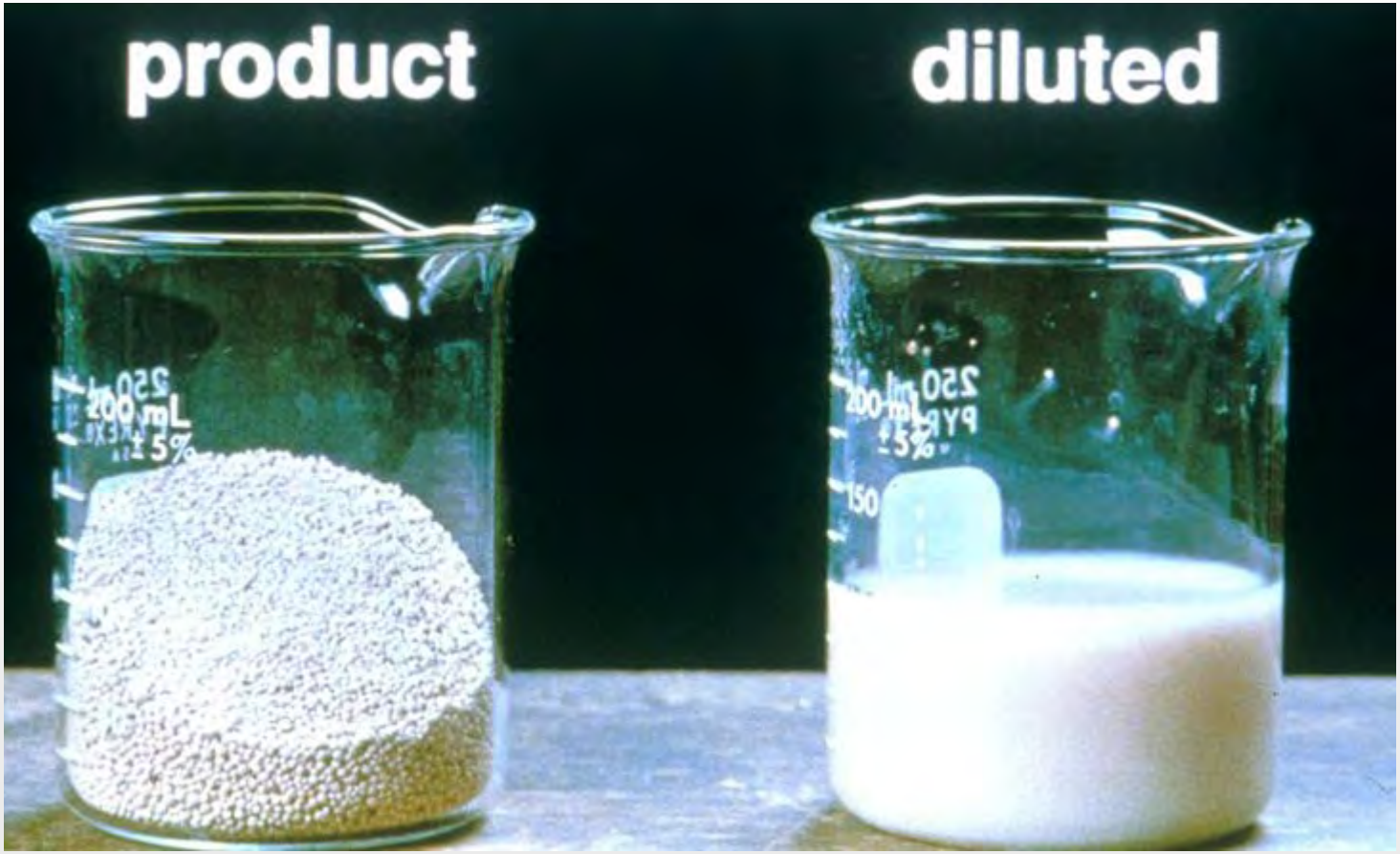


Active Ingredient (high %)
impregnated onto Dry Carrier
and mixed with an
Emulsifier (slick, soapy)

agitation required



Water-Dispersible Granules (WDG) / Dry Flowables (DF)



Water-Dispersible Granules (WDG) / Dry Flowables (DF)

Share all advantages / disadvantages of WP

Other Advantages:

- More easily measured and mixed than Wettable Powders
- Lower inhalation hazard to user during pouring due to reduced dust-like particles

Pepto-Bismol & V8

Flowable (F or L)

Fine solid particles dispersed (suspended) in a liquid

Examples:

- Malice® 2F Insecticide
- Quin-Way™ 1.5L Herbicide

Flowable (F or L)

- Advantages and disadvantages as WP

Other Advantages:

- Seldom clog nozzles
- Need only moderate agitation to stay in suspension
- Usually do not present an inhalation hazard when mixing

Vicks VapoRub & Air Freshener

ULV/Fog/Smoke

Fine particles/ droplets suspended in air

BIOMIST® 4+4 ULV

ULV/Fog/Smoke

Smoke and fog generators are used in structures for insect control

Contac Cold Medicine

Microencapsulated (ME)

Coated or encased units – time release

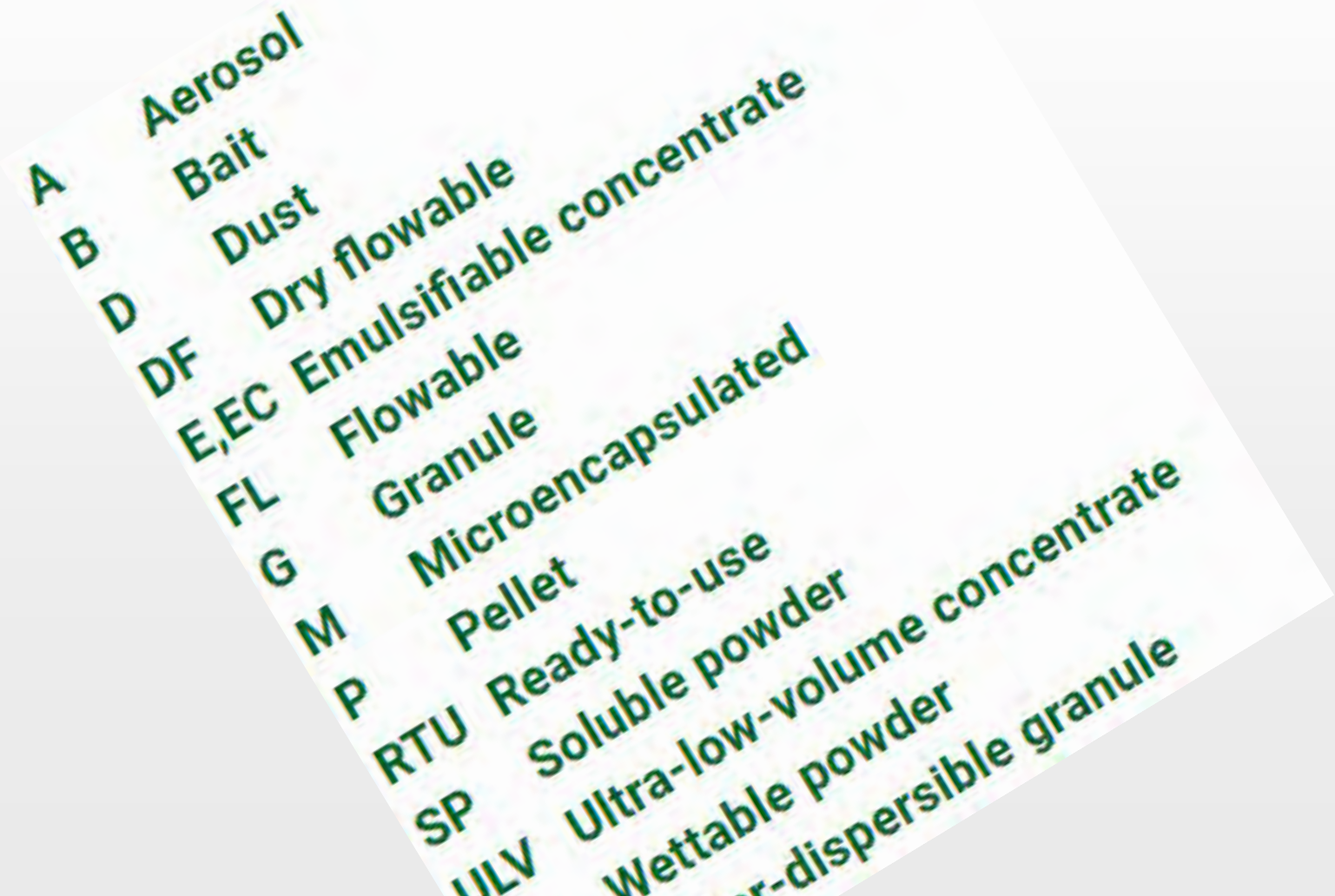
Chemical polymer wrapped around pesticide molecule

Microencapsulated (ME)

Disadvantage:

- Picked up with pollen
- Can contaminate hives
- Affect brood / other adults

Choosing a Formulation



Choosing a Formulation

Active ingredients are often sold in several kinds of formulations

- If more than one formulation is available for your pest control site and situation, choose the best one for the job

Choosing a Formulation

Base your decision on:

- Legal, labeled uses
- The signal word
- Applicator safety
- Environmental safety
- Pest biology

Choosing a Formulation

Base your decision on:

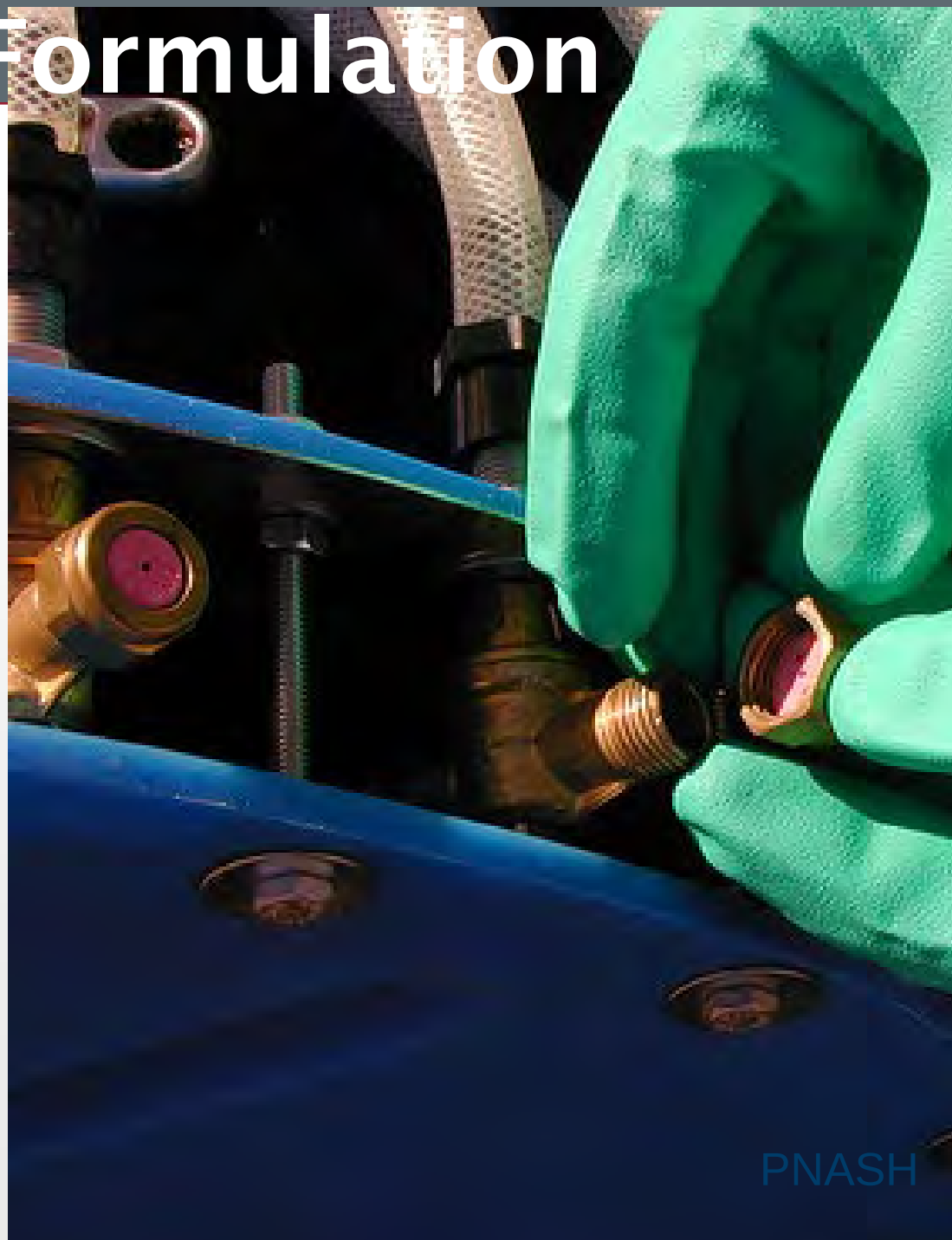
- Site characteristics
- Target (surface to be treated)
- Appropriate and available application equipment
- Will it harm contact surfaces?

Choosing a Formulation

- Physical and biological characteristics of target

Choosing a Formulation

- Application equipment available and best suited for job
  - More abrasive – plastic tips
    - May choose stainless or ceramic
  - More corrosive – hoses



Choosing a Formulation

- Type of environment which the application must be made in
- Hazard of drift or runoff
- Possible plant injury

Choosing a Formulation

Ask yourself these questions:

- Can the formulation be applied appropriately under the conditions in the application area?
- Will the formulation reach the intended target and stay in place long enough to control the pest?

Choosing a Formulation

- Is the formulation likely to damage the surface?
- Could I choose a less hazardous formulation that would still be as effective?

So what!?

Why are formulations important?

- Storage – dry vs. liquid; concentrated?
- Handling – dry vs. liquid, do you have preference?

So what!?

Why are formulations important?

- Mixing and loading
  - No snot
  - No cottage cheese
- Transporting

Freelexx - Tank Mix

When tank mixing, read and follow the label of each tank mix product used for precautionary statements, directions for use, weeds controlled, and geographic and other restrictions. Use in accordance with the most restrictive of label limitations and precautions. Do not exceed any active ingredient's maximum use rates when tank mixing. Do not tank mix this product with any product containing a label prohibition against tank mixing with 2,4-D.

Why are formulations important?

Set of complex chemical structures

- Tank mix partner added

Mixing and Loading

Order

- Can be determined by the formulation
  - if not specified on label.

Formulation Tank Mixing Order

1. Fill tank ¼ to ½ full with water or carrier - begin agitation
2. Adjuvants used for anti-foaming, buffers, compatibility, etc.

Formulation Tank Mixing Order

1. Fill tank ¼ to ½ full with water or carrier and begin agitation
2. Adjuvants used for anti-foaming, buffers, compatibility, AMS, etc.
3. Dry products (WP, WDG, DF, WSP)
4. Liquid Flowables (F or L)

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5. Microencapsulated (ME)
6. Emulsifiable Concentrates (EC)

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7. Liquid solutions (S, C, LC) usually clear
8. Adjuvants used for efficacy enhancement (COC, NIS, MSO)

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7. Liquid solutions (S, C, LC) usually clear
8. Adjuvants used for herbicide efficacy enhancement (COC, NIS, MSO)
9. Add water/carrier to desired level

Remember acronym W.A.L.E.S*

- W – WP, WDG, DF, WSP
- A – Agitate
- L – Liquid Flowables
- E – Emulsifiable Concentrates
- S – Surfactants

*Read each product label for product-specific mixing instructions.

Notes on Sprayer Mixing

- Start with a clean tank
  - Leftovers may cause unforeseen problems
- Always use clean water
- Make a slurry of each dry formulation before adding to tank

Notes on Sprayer Mixing

- Agitate thoroughly before adding each product
- Spray solution and clean tank after each days use

PENN STATE

Notes on Sprayer Mixing

Note: If tank mixing with Accord®Concentrate or Rodeo® herbicides, mix the Milestone VM Plus with at least 75% of the total spray volume desired and ensure that the Milestone VM Plus is well mixed before adding the Accord Concentrate or Rodeo to avoid incompatibility.

Notes on Sprayer Mixing

Sprayer Clean-Out Instructions

Do not use spray equipment used to apply Milestone VM Plus for other applications to land planted to susceptible crops or desirable sensitive plants unless it has been determined that all residues of this herbicide has been removed by thorough cleaning of equipment.

Notes on Sprayer Mixing

- Certain insecticides and/or fungicides can be tank mixed with herbicides—check product label
- If you question the compatibility of a tank mixture, use the JAR TEST

Pesticide Compatibility

Pesticides and/or fertilizers may be mixed for application—saving time, labor, and cost

- Considerations before mixing products
  - Read label for each product
  - Perform compatibility jar test

Pesticide Compatibility

Tank Mix Compatibility Testing: Perform a jar test prior to mixing in a spray tank to ensure compatibility of Accord XRT II and other pesticides or carriers. Use a clear glass jar with lid and mix ingredients in the same order and proportions as will be used in the spray tank. The mixture is compatible if the materials mix readily when the jar is inverted several times. The mixture should remain stable after standing for 1/2 hour or, if separation occurs, should readily remix if agitated. An incompatible mixture is indicated by separation into distinct layers that do not readily remix when agitated and/or the presence of flakes, precipitates, gels, or heavy oily film in the jar. Use of an appropriate compatibility aid may resolve mix incompatibility. If the mixture is incompatible do not use that tank mix partner in tank mixtures.

Milestone® VM Plus

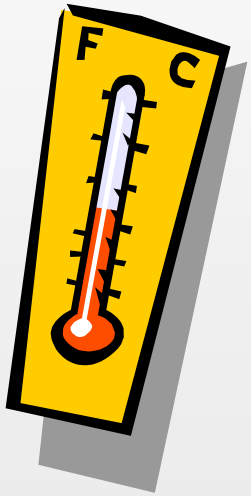
HERBICIDE

Pesticide Compatibility

Note: If tank mixing with a product containing triclopyr amine, such as Garlon® 3A herbicide or Capstone, ensure that the triclopyr amine product is well mixed with at least 75 percent of the total spray volume before adding this product to the spray tank to avoid incompatibility.

Many Benefits of Tank Mixtures

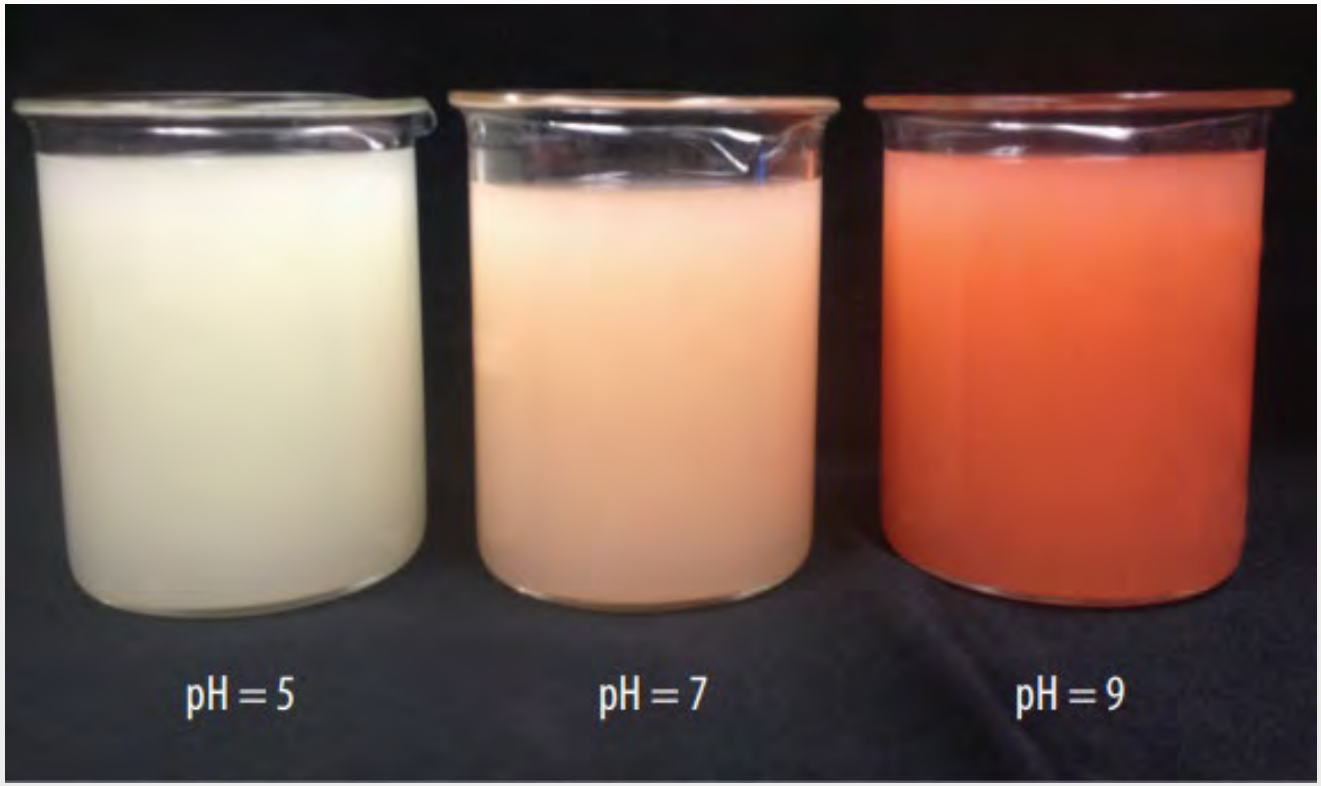
Physical and Chemical Compatibility



Can be affected by

- Temperature
- pH
- Chemical composition

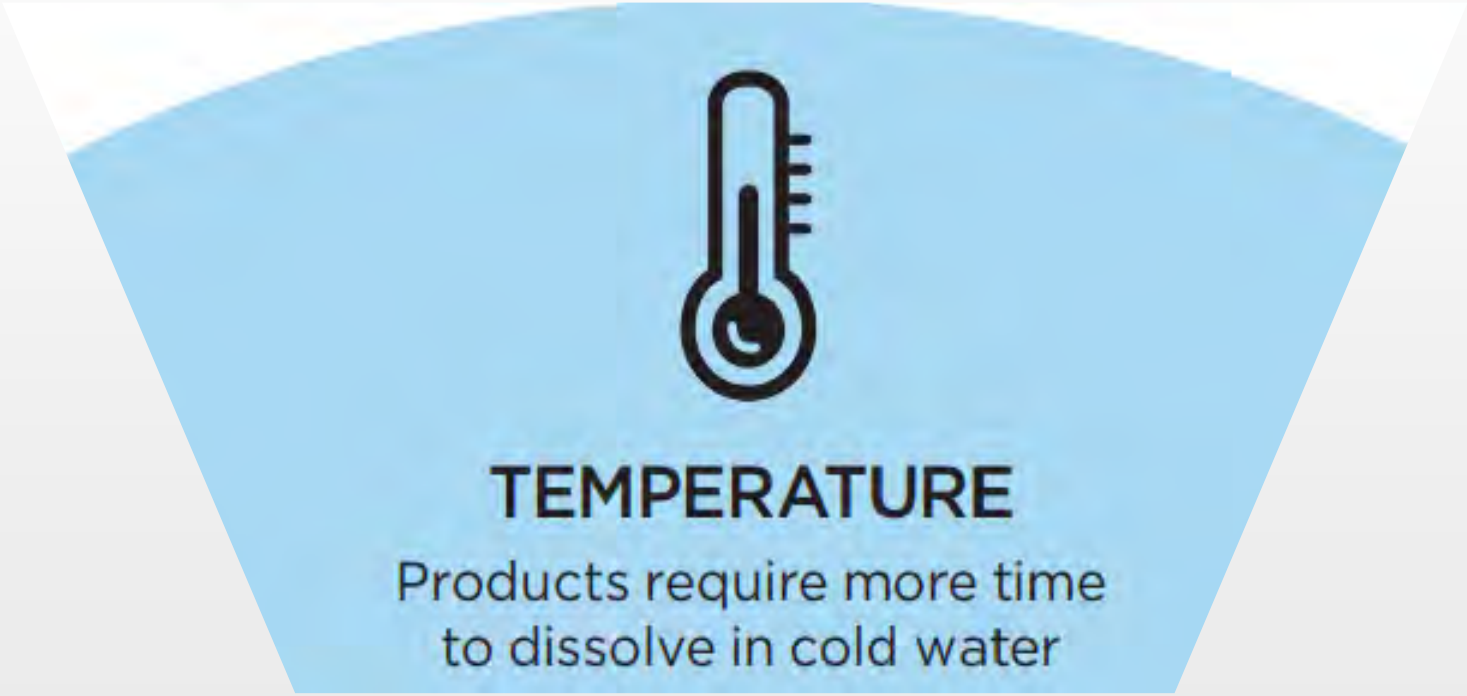
Physical and Chemical Compatibility



Same pesticide mixture

Chemical Incompatibility?

Physical and Chemical Compatibility



Jar Test

Better to have

- Gel
- Precipitate
- Sludge
- Concrete

In a jar rather than in your sprayer, hoses, pumps, and tips

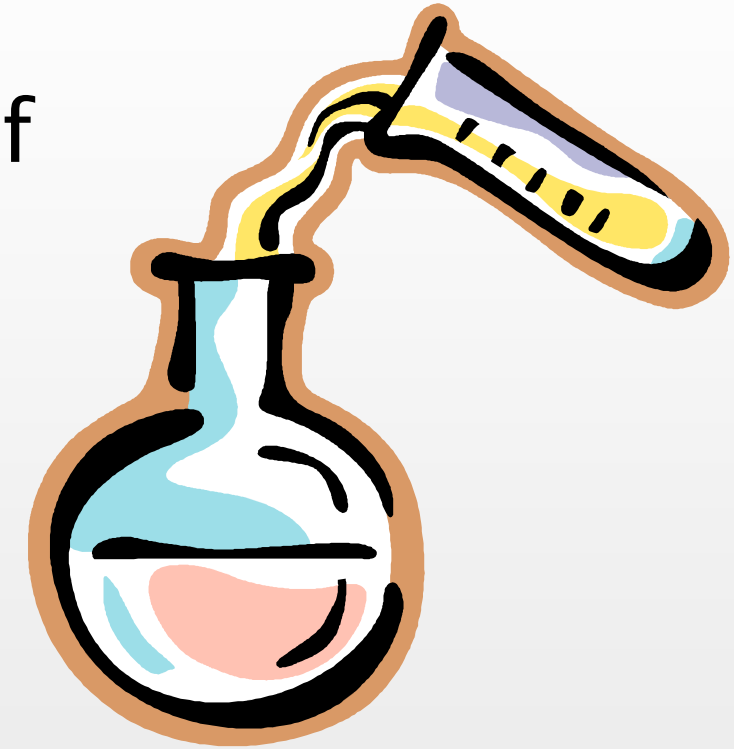
Photo by Purdue

Jar Test

Labeled combinations of

- Herbicides
- Fertilizers
- Insecticides
- Fungicides

~ are difficult to find



Jar Test Safety

- Always wear PPE
- Perform this test in a safe area
  - Away from food and sources of ignition
- After test, pesticide should be put into the spray tank
  - Applied to a labeled site
- Rinse all utensils and jars
  - Pour rinse water into spray tank

Compatibility Jar Test

Conduct before tank mixing

- Mix formulations in specific order—e.g.
  1. Wettable powders
  2. Dry flowables and flowables
  3. Emulsifiable concentrates

Jar Test

1. In 1-quart jar add 1 pint of carrier

Jar Test

1. In a 1-quart jar add 1 pint of carrier in each
2. Add the required amount of pesticide in proper order
3. When all ingredients have been added, shake jar for 15 seconds and allow to stand for at least 15 minutes. Then inspect for flakes, sludge, gels, etc., which may indicate incompatibility

Jar Test

1. In a 1-quart jar, add 1 pint of carrier in each.
2. To each jar, add the required amount (see below) of pesticide in proper order.
3. When all ingredients have been added, shake both jars for 15 seconds and allow to stand for at least 15 minutes. Then inspect for flakes, sludge, gels, etc., which may indicate incompatibility.
4. Decide if the mixture can be sprayed at all

Tank-Mix Compatibility Testing: Perform a jar test prior to mixing in a spray tank to ensure compatibility of Milestone VM Plus and other pesticides or carriers. Use a clear glass jar with lid and mix ingredients in the same order and proportions as will be used in the spray tank. The mixture is compatible if the materials mix readily when the jar is inverted several times. The mixture should remain stable after standing for 1/2 hour or, if separation occurs, should readily remix if agitated. An incompatible mixture is indicated by separation into distinct layers that do not readily remix when agitated and/or the presence of flakes, precipitates, gels, or heavy oily film in the jar. Use of an appropriate compatibility aid such as Unite or Complex may resolve mix incompatibility. If the mixture is incompatible do not use that tank mix partner in tank mixtures.

Pesticide Interactions

Additive effect: Combined effect of two pesticides neither hurt nor enhance each other when mixed

Antagonism: Mixture works less effectively than each pesticide alone

- Damage (i.e. increased phytotoxicity) may even occur in some cases

Pesticide Interactions

Synergism: Mixture works better than each ingredient alone

Enhancement: Mixture combines a pesticide and additive (i.e. adjuvant) to get a greater effect than the pesticide alone

Failed Tank Mix
Physical Incompatibility

Physical Incompatibility

Failed Tank Mix - Chemical Incompatibility

Solution may look fine in the tank

Product will have reduced biological activity

Solution may injure crop

PURDUE EXTENSION

Chemical Incompatibility

ADJUVANTS

The use of a surfactant is recommended to enhance the control of susceptible plants, except where noted. Apply at a minimum rate (concentration) of 1/4% volume/volume (1 quart per 100 gallons of spray solution), or at the manufacturer's recommended rate. Use only EPA approved surfactants containing at least 80% active ingredient. Certain types of surfactants, such as those incorporating acetic acid (i.e. LI-700), may not be compatible with Escort® XP Herbicide and may result in decreased performance. Certain surfactants may not be suitable for use on desirable plants, such as turf and conifers, listed on this label. Consult the surfactant manufacturer's label for appropriate uses.

Escort® XP

Compatibility Demonstrations

Simulated compatibility jar tests

- Show physical/chemical incompatibilities
  - Can occur when mixing pesticides

Compatibility Demonstrations

Insoluble Liquid/ Separation Line

Insoluble Liquid/ Separation Line

A definite separation line forms

Elimination of Separation Line

Add a compatibility agent. When agitated, mixture can be applied through sprayer

Note: In real life, compatibility agent should be added FIRST to tank.

Color Change

Quart jar filled with about 1 ½ cups water to 1/8 teaspoon cornstarch

Color Change cont.

5-10 drops Betadine added

Mixture turns purple

Color Change cont.

Purple precipitate settles to the bottom after sitting for awhile

Precipitate Formation

Gas Production

Gas Production cont.

Bubbling and fizzing results, as well as slight heat reaction

Gas Production cont.

Remember…

Compatibility agents may be helpful

- Test first

Complete Compatibility®

Eliminates tank-mixing problems and reduces water ph.

Aids Blending In Tank-Mix Solution

Complete Compatibility® eliminates problems that occur in liquid fertilizer and pesticide tank mixes due to differing physical and chemical properties. Free ammonia in liquid fertilizer may cause incompatibility problems in tank-mix solutions that lead to unsprayable mixtures, less compatible tank mixes, product losses, and cleanup and disposal costs. Complete Compatibility® helps bring the product back into suspension; improves wetting, emulsion and stability; and prevents lumping problems. It also acts as an acidifying agent to lower spray solution pH, which slows pesticide decomposition and improves efficacy.

Remember…

Mix products in correct order

- Incompatibility can still occur
  - If compatible products not mixed properly

Remember…

Incompatibility Example:

- Dry flowable (DF) mixed with liquid fertilizer **directly** creates "cottage cheese" like product
- Mix DF with **water** prior to adding to fertilizer to get compatible result. Follow label instructions!

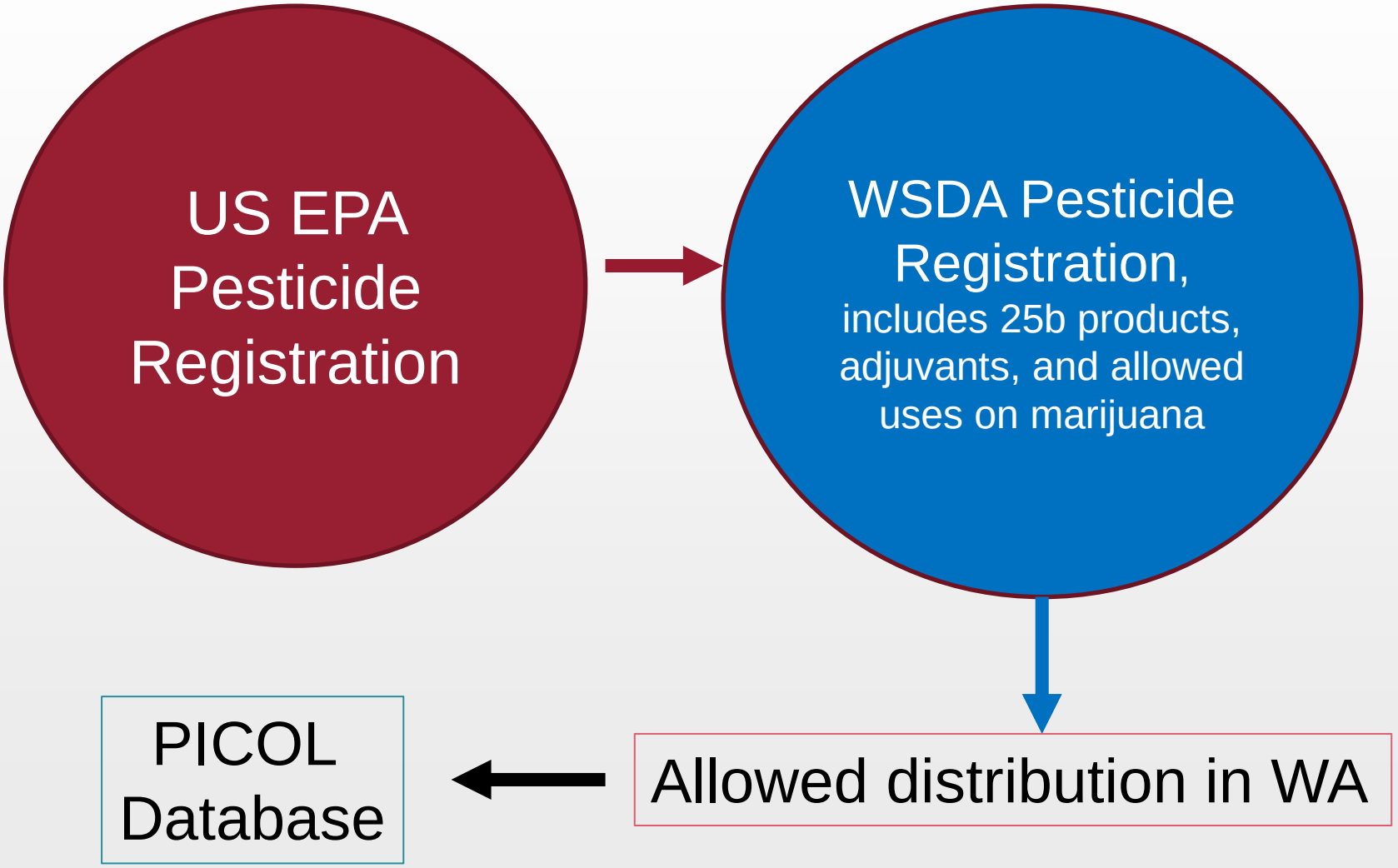
Eight factors that will help you avoid tank-mix incompatibilities.

- Check Containers First
- Follow Label Instructions
- **Mix** in the Proper Order
- Use the Right Water Volume
- Be Patient When Adding Products
- Agitate Properly
- Adjust for the Carrier
- Account for Product and Water Temperatures

Pesticide Product

- Active Ingredient
  - Physical compatibility problems
  - Inerts


SOME ACTIVE INGREDIENTS
become less effective when tank mixed with other products.


US EPA Pesticide Registration
WSDA Pesticide Registration,
includes 25b products, adjuvants, and allowed uses on marijuana
Allowed distribution in WA
PICOL Database

WSU Pesticide Information Center OnLine (PICOL)

WASHINGTON STATE UNIVERSITY

- Home
- Searches
- Lookup
- Account
- API Documentation
- Help
- Privacy Policy
- Open Source

CWR Home ↗

CAHNRS Home ↗

Pesticide Information Center OnLine (PICOL) Database

Note to Users: Not all PICOL features may be compatible with your browser. We recommend using Chrome, Firefox, or Edge for the best experience. Known issues: PICOL Advanced Search features are not compatible with the Mac version of the Safari browser.

Welcome to the Washington State Pest Management Resource Service's (WSPRS) pesticide label database. This free, searchable database is operated by Washington State University through funding provided from the Washington State Department of Agriculture, the Oregon Department of Agriculture, Oregon State University, and WSU.

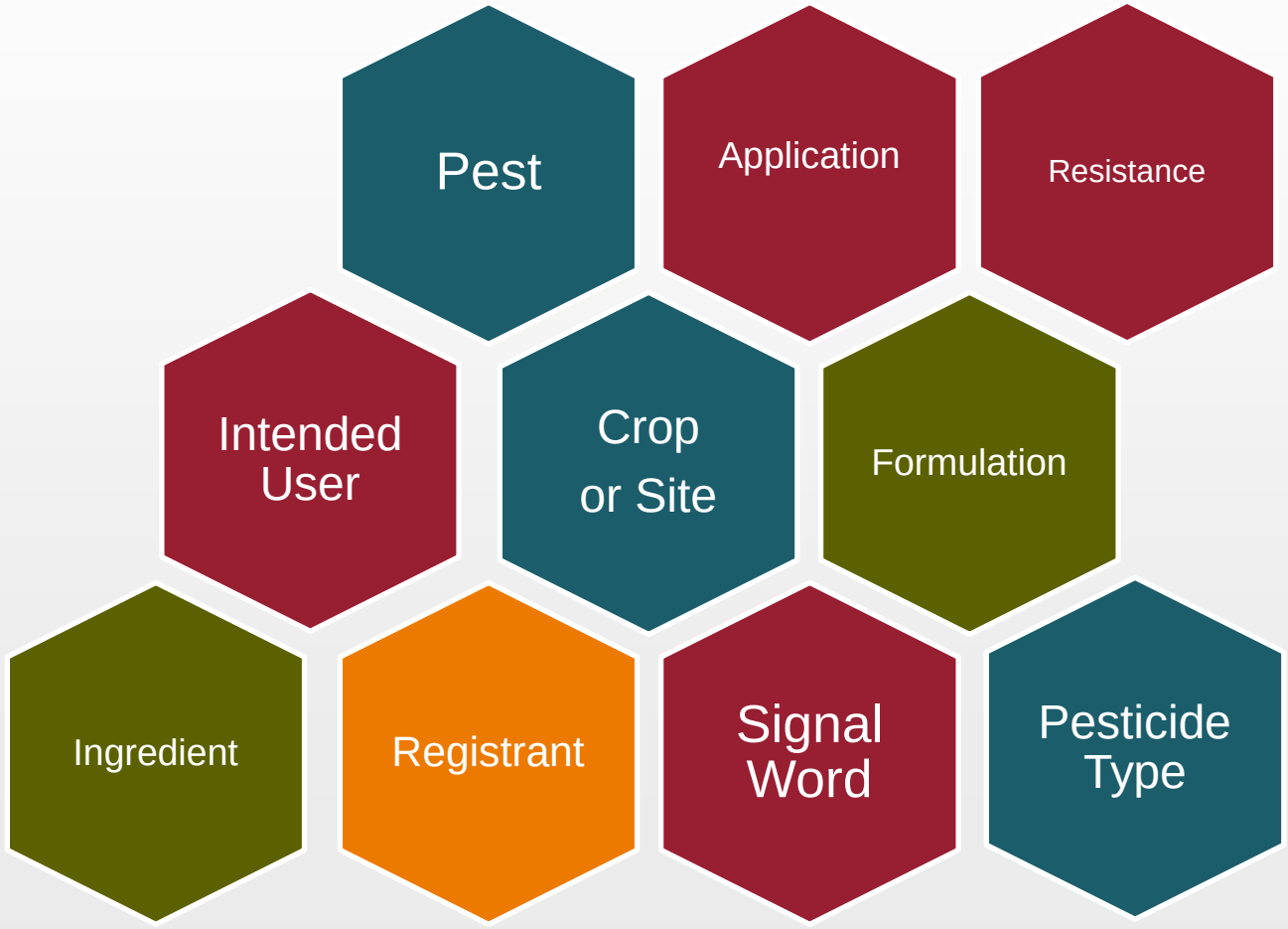
PICOL contains selected information from pesticide products registered in either Oregon, Washington, or in both states. Washington data includes Section 3, Section 25b, Section 24c, Section 18, adjuvants, and federal supplemental labels. It does not include EUPs. Oregon data includes Section 3, Section 25b, Section 24c, and federal supplemental labels. It does not include EUPs or Section 18 labels.

PICOL provides electronic copies (i.e., PDFs) of most Washington and many Oregon registered labels. PDFs are only accepted directly from WSDA and ODA. NOTE: WEB LABELS ARE FOR INFORMATIONAL PURPOSES ONLY. THIS DATABASE IS NOT A SUBSTITUTE FOR OBTAINING, READING, AND FOLLOWING PESTICIDE LABEL DIRECTIONS. PICOL INFORMATION HAS NO LEGAL STATUS, WHEREAS THE CONTAINER LABEL IS A LEGAL DOCUMENT.

PICOL

- A tool to help you identify products for different use sites/crops and different pests
- Resistance management groups
- Can manipulate findings to a smaller group of labels
- Review labels to find out which product can be used under your specific situation

General Overview – PICOL Lookup



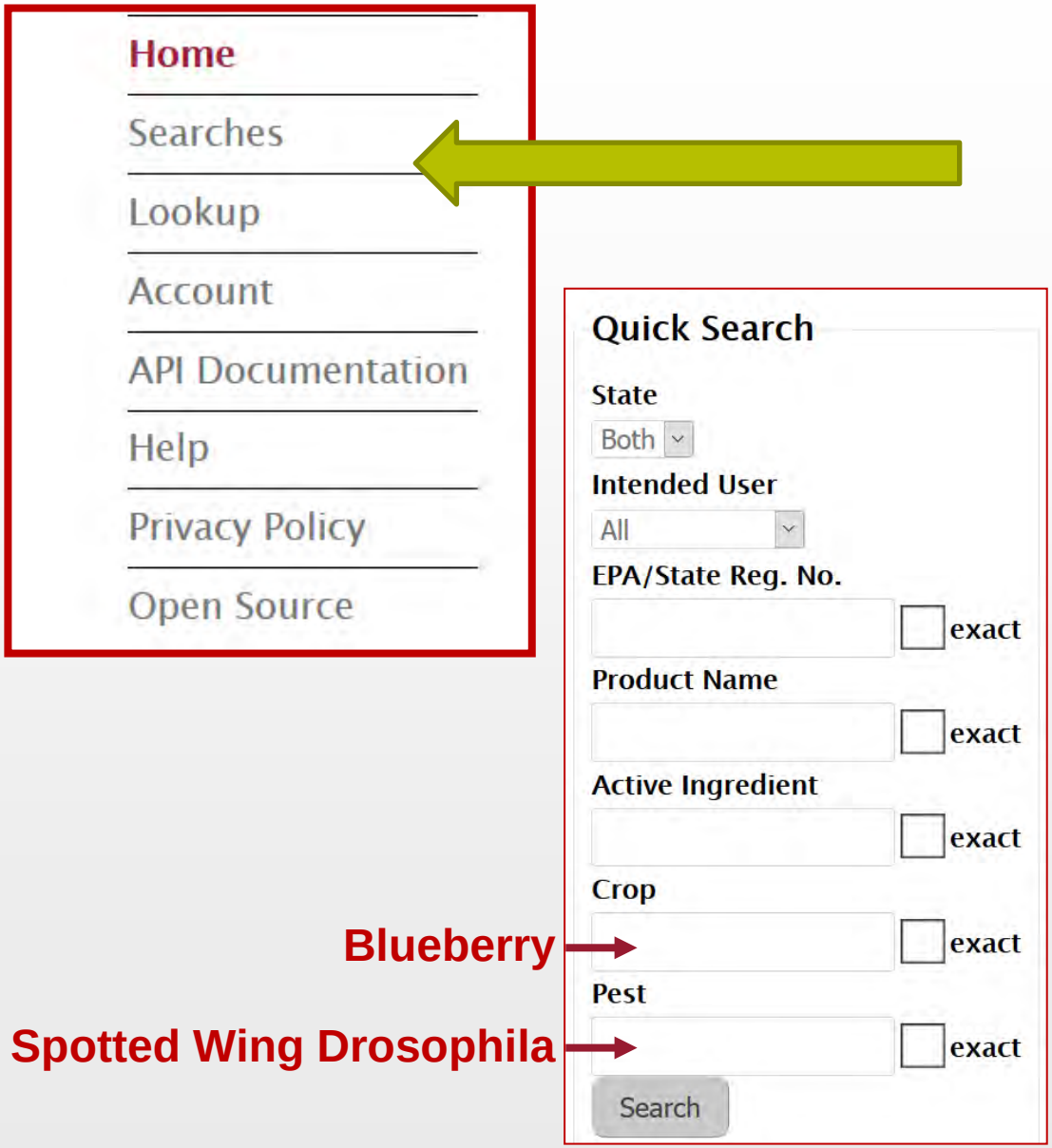
Label (pdf) Access

- Click on **Labels** results: **WA or Online**
- Click **Actions - Details** and download label

Current Reg	Labels	Actions
OR	OR	Details
OR	OR	Details
OR	OR	Details
OR		Details
WA, OR	WA | OR	Details
OR		Details

Quick Searches

- Simple options for basic searches
- Limited set of search terms
- Current-year only
- State default can be set by user!
- Exact vs. Contains



Great Resource

- https://ppp.purdue.edu//wp-content/uploads/files/PPP-122.pdf

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This presentation was developed by Kevin Fry, Penn State Extension Educator in Armstrong County.

Use of this presentation or parts of this presentation is encouraged as long as this credit slide is included.

This presentation was adapted from a hands-on presentation and handouts given by Pat Hipkins, Senior Research Associate and Assistant Coordinator of the Virginia Tech Pesticide Programs, at the Northeastern Region Pesticide Safety Education Center Workshop in September 2005.

All product photographs in this presentation were taken by Kevin Fry, Penn State Extension Educator in Armstrong County.

The mixing and loading photographs in this presentation were taken from pesticidepics.com, the National Pesticide Media Database on the Virginia Tech Pesticide Programs web site.

Where trade names appear, no discrimination is intended, and no endorsement by the Penn State College of Agricultural Sciences is implied.

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Institute of Agriculture and Natural Resources
PESTICIDE SAFETY EDUCATION PROGRAM

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