

**WEED MANAGEMENT WORKSHOP: 2006 IDAHO POTATO CONFERENCE**  
**Part 2**

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Topics covered during the second part of the workshop were herbicide mode of action and herbicide resistance management.

**Definitions**

- **Resistance** - *inherited* ability of a plant to survive and reproduce following exposure to a herbicide dose normally lethal to the wild type.
  - May be naturally occurring or induced by man.
- **Tolerance** - *inherent* ability of a species to survive and reproduce after herbicide treatment.
  - This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant.
- **Mode of action (MOA)** - the sequence of events in which a herbicide kills a weed.
- **Site of action/Target site** - the particular plant function that is affected by the herbicide - specific location(s) where the herbicide has activity within the plant.
- **Herbicide class/group/family** - herbicides with similar modes of action
- **Biotype** - a naturally occurring individual within a given species that has a slightly different, but distinct, genetic makeup from other individuals
- **Cross resistance** - resistance to two or more herbicides with the same mode of action, due to a single resistance mechanism.
  - Example: Wild oat resistant to Hoelon and Puma.
  - Examples: Kochia resistant to Express and Raptor.
- **Multiple resistance** - resistance to two or more herbicides with different modes of action, due to two or more distinct resistance mechanisms in the same plant.
  - Example: Kochia resistant to Express and Banvel.
  - Example: Wild oat resistant to Avenge and Fargo
- **Weed species shift** - changes in dominant weed species due to some selection pressure, example: herbicides or tillage.

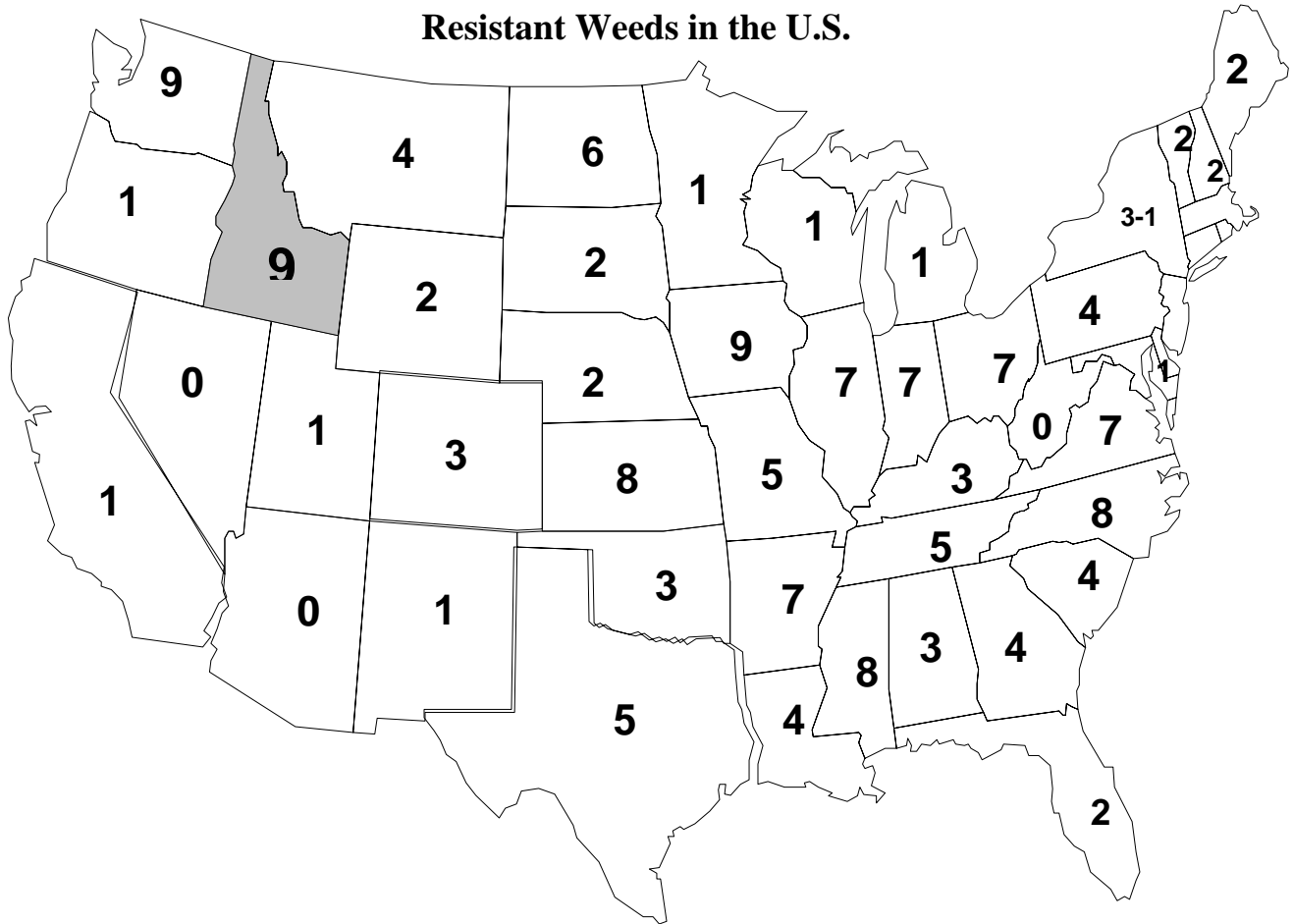
**Herbicide Resistance in the U.S. and Idaho**

- International Survey of Herbicide-Resistant Weeds
  - The survey and more information about herbicide resistance can be found at [www.weedscience.com](http://www.weedscience.com)
  - As of 2005, 292 biotypes have been listed.
  - 174 different weed species
    - 104 dicots (broadleaf weeds)
    - 70 monocots (grasses and sedges)
  - Only 4 states do not list any herbicide resistant weeds, Alaska, Arizona, Nevada, and West Virginia.

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Presented at the Idaho Potato Conference, January 18-19, 2006.

## Resistant Weeds in the U.S.



### Herbicide Resistant Weeds in ID

Species	Year found	Mode of Action
Prickly lettuce	1987	ALS Inhibitors
Kochia	1989	ALS Inhibitors
Russian thistle	1990	ALS Inhibitors
Palmer amaranth	1992	PS II Inhibitors
Wild oats	1992	ACCase Inhibitors
Italian ryegrass	1992	ACCase Inhibitors
Wild oats	1993	Thiocarbamates & Difenzoquat
Mayweed chamomile	1997	ALS Inhibitors
Kochia	1997	Synthetic auxins

### **How Herbicide Resistant Weed Populations Develop**

- Resistance occurs through the selection of biotypes naturally tolerant/pre-adapted existing in a susceptible population in very small numbers. The herbicide provides the selection pressure.
- The biotype has survival and/or reproduction advantages in the herbicide environment.
- When and where depends on many factors such as the initial frequency and fitness of the resistant biotype, herbicide history, and cultural practices.

### **Herbicide Factors Contributing to Resistance**

- The more effective the herbicide is, the greater the selection pressure.
- Single site of action herbicides, e.g. ALS Inhibitors.
- Duration of effect (persistence or residual effect).

### **Weed Species Factors Contributing to Resistance**

- Ability to adapt and multiply in diverse environments.
- Frequency of mutations occurring within a plant population.
  - Weeds with diverse genetic background may have 1 resistant biotype for every 1 million or 1 billion seeds.
- Fecundity or ability to produce large numbers of seed.
- Ecological biotype fitness, i.e., ability to compete and survive in an environment.

### **Management Factors Contributing to Resistance**

- Repeat herbicide applications with the same site of action to the same or different crops.
- Herbicides used without other weed control options (e.g. cultivation) and are considered "stand alone" weed control programs.

### **Mechanisms of Resistance**

- Modified target site - changing the herbicide binding site that prevents the herbicide from binding or interacting.
- Enhanced detoxification (metabolism) - a weed's increased ability to metabolize/detoxify the herbicide - the rate is faster than in a susceptible biotype.
  - This mechanism is the most important of the ones mentioned in this presentation.
- Reduced absorption and/or translocation- the herbicide is not transported to the site of action in the plant.
- Sequestration or compartmentalization- sequestration of the herbicide away from the site of action or modification in the uptake and/or translocation of the herbicide to the target site.

### **Herbicide Classification History**

- Industry reps, weed scientists in Canada, Australia and the U.S. have been working on a herbicide classification system based on mode of action since 1989.
- PNW Bulletin 437 published in 1993 - revised 1999 and 2002.
- Herbicide class required on Australian labels – 1994.

- Weed Science Society of America commissioned drafting of a herbicide classification system –1995. Revised 2003.
- 27 classes/groups.
- *Knowing the mode of action/herbicide class is the key to planning a management strategy to reduce the potential for resistant weeds*

The Herbicide MOA Group is listed on most of the Canadian herbicide labels and some of the U.S. herbicide labels:

**U.S. rimsulfuron label**

**DUPONT**  
**DuPont™**  
**Matrix®**  
herbicide

**DRY FLOWABLE**  
**For Weed Control In Potatoes, Potatoes grown for seed and field grown Tomatoes**

Active Ingredients	By Weight
Rimsulfuron	
N-(4,6-dimethoxypyrimidin-2-yl)aminocarbonyl)-3-(ethylsulfonyl)-2-pyridinesulfonamide	25.0%
Inert Ingredients	75.0%
<b>TOTAL</b>	<b>100.0%</b>

EPA REG. NO. 352-556

**KEEP OUT OF REACH OF CHILDREN**  
**CAUTION**  
FIRST AID

**IF IN EYES:**

- Hold eye open and rinse slowly and gently with water for 15-20 minutes.
- Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
- Call a poison control center or doctor for treatment advice.

**IF ON SKIN OR CLOTHING:**

- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15-20

**PRECAUTIONARY STATEMENTS**  
**HAZARD TO HUMANS AND DOMESTIC ANIMALS**  
CAUTION! Causes moderate eye irritation. Harmful if absorbed through skin. Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist.

**PERSONAL PROTECTIVE EQUIPMENT**  
Some of the materials that are chemical-resistant to this product are listed below. If you want more options, follow the instructions for category A on an EPA chemical-resistant category selection chart.  
**Applicators and other handlers must wear:**  
Long-sleeve shirt and long pants.  
Chemical resistant gloves made of any water proof material such as polyethylene or polyvinylchloride.  
Shoes plus socks.  
Discard clothing and other absorbent material that have been drenched or heavily contaminated with this product. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

**ENGINEERING CONTROL STATEMENTS**  
When handlers use closed systems, enclosed cabs or aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR part 170 Section 170.240 (d)(4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

**Canadian rimsulfuron label**

23983-20050121-F1 E LABEL

GROUP 2 HERBICIDE

**PRISM® HERBICIDE**  
25% DRY FLOWABLE  
AGRICULTURAL

REGISTRATION NO. 23983 PEST CONTROL PRODUCTS ACT

FOR SALE FOR USE IN WEED CONTROL FOR POTATOES IN EASTERN CANADA, IRRIGATED POTATOES IN WESTERN CANADA, SEED POTATOES AND TRANSPLANTED PROCESSING TOMATOES AND FRESH MARKET FIELD TOMATOES ONLY

READ THE LABEL AND ATTACHED BOOKLET BEFORE USING

**GUARANTEE: Rimsulfuron 25.0%**

**WARNING - EYE IRRITANT**

**NET CONTENTS: 480 GRAMS**

E. I. DU PONT CANADA COMPANY  
AGRICULTURAL PRODUCTS  
P.O. BOX 2300, STREETSVILLE  
MISSISSAUGA, ONTARIO  
L5M 2J4  
1-800-667-3925

**Some of the U.S. labels include a section on resistance management.**

**EXAMPLE: The Matrix label**

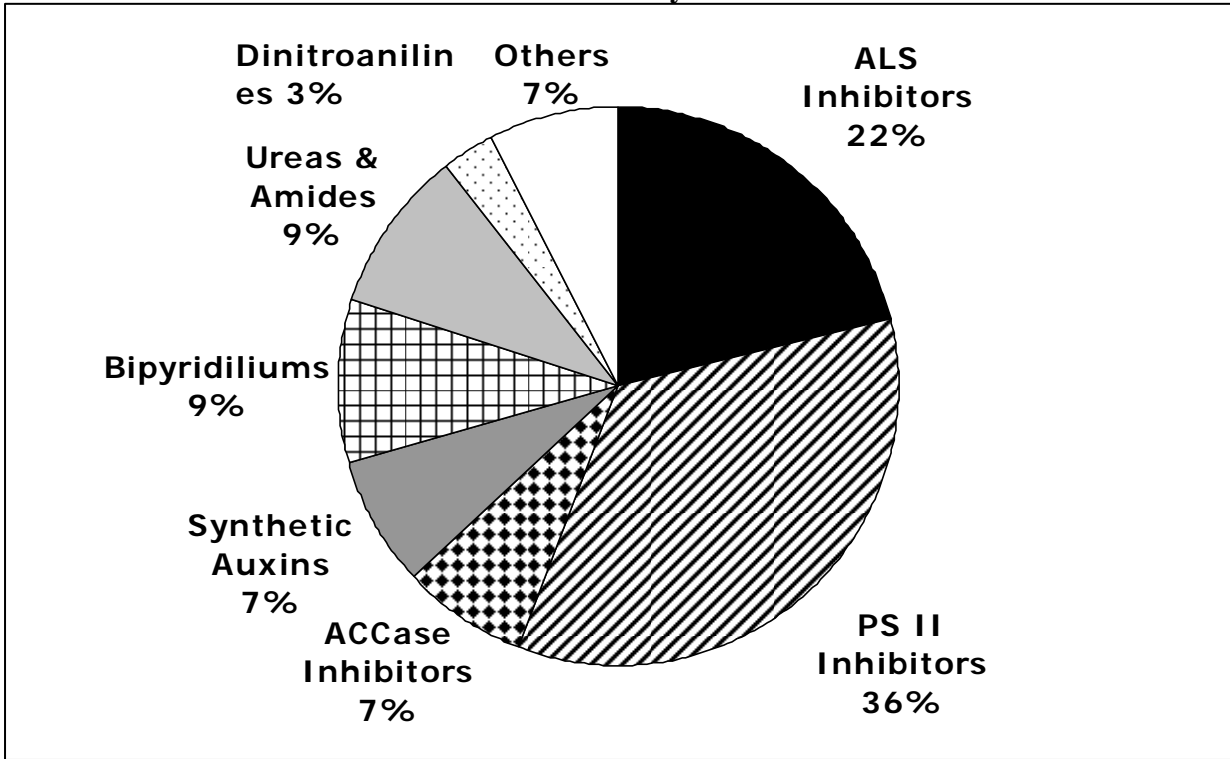
“*RESISTANCE*: When herbicides that affect the same biological site of action are used repeatedly over several years to control the same weed species in the same field, naturally-occurring resistant biotypes may survive a correctly applied herbicide treatment, propagate, and become dominant in the field. Adequate control to these resistant weed biotypes cannot be expected. If weed control is unsatisfactory, it may be necessary to retreat the problem area using a product affecting a different site of action. To better manage herbicide resistance through delaying the proliferation and possible dominance...”

**Herbicide Mode of Action (MOA) Classes Herbicides Commonly Used in Idaho**

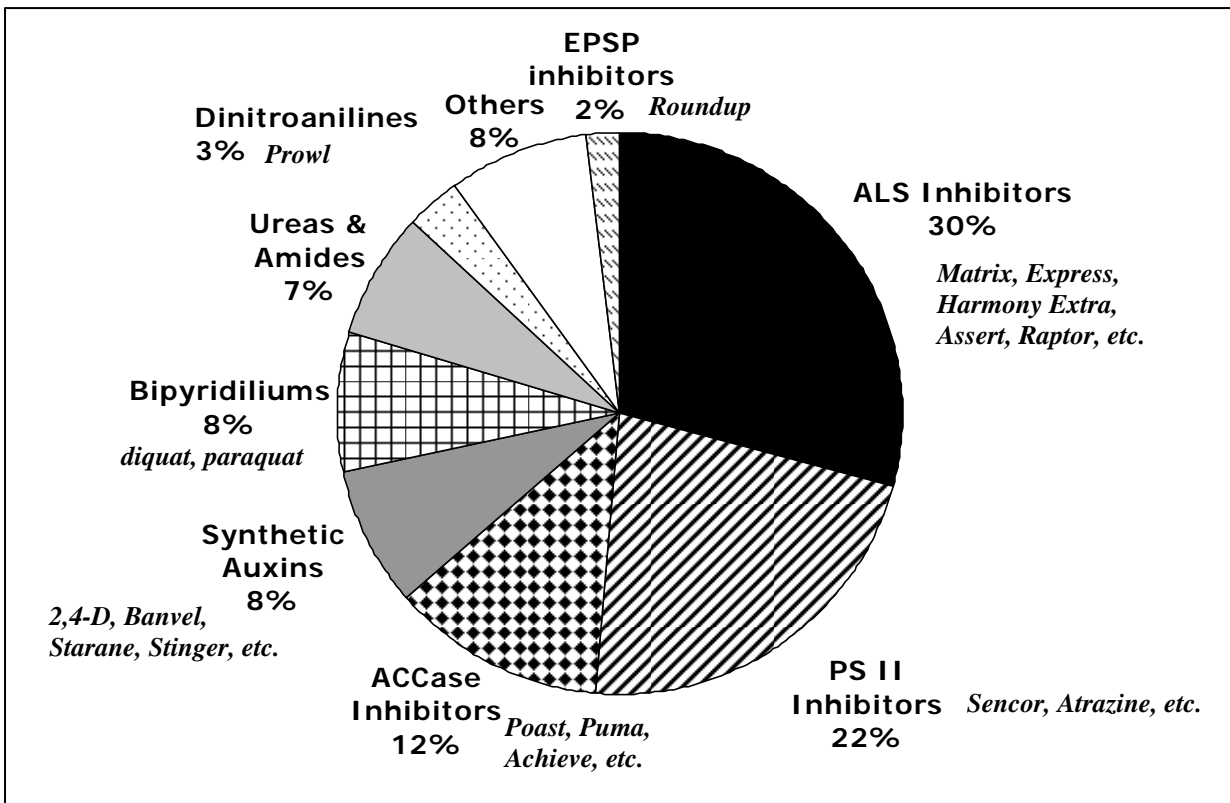
- **Group 1:** Acetyl CoA carboxylase (*ACCCase*) inhibitors
  - Achieve, Assure II, Axial, Discover Select, Poast, Puma,
- **Group 2:** Acetolactate synthase (ALS) inhibitors
  - Imi's- Assert, Raptor, Arsenal
  - S.U.'s- Matrix, Express, Harmony Ex., UpBeet, Maverick, Oust
- **Group 3:** Microtubule assembly inhibitors – Dinitroanilines (DNA's)
  - Prowl, Sonalan, Treflan, Balan
- **Group 4:** Synthetic Auxins
  - Phenoxy - 2,4-D, 2,4-DB, MCPA
  - Benzoic acid - Banvel, Clarity
  - Carboxylic acid - Curtail, Starane, Stinger, Tordon
  - Quinaline carboxylic acid - Paramount
- **Group 5:** Photosystem II inhibitors at Site A
  - Triazines - Atrazine, Velpar
  - Triazinone – metribuzin (Sencor and others)
  - Uracils - Hyvar, Sinbar
  - Phenyl carbamate - Betamix,
  - Pyradazinone – Pyramin
- **Group 6:** Photosystem II inhibitors at Site B
  - Benzothiadiazoles/nitriles- Basagran, Buctril
- **Group 7:** Photosystem II inhibitors at Site A with a different binding behavior than Group 5 herbicides
  - Ureas - Karmex, Lorox
- **Group 8:** Lipid synthesis inhibitors (not *ACCCase*)
  - Thiocarbamates - Eptam, RoNeet, Far-Go
  - Avenge
- **Group 9:** EPSP synthase inhibitors
  - Glyphosate (Roundup and others)
- **Group 10:** Glutamine synthetase inhibition
  - Liberty
- **Group 14:** Protoporphyrinogen Oxidase (Protox) Inhibitors
  - Spartan, Chateau, Aim
- **Group 15:** Inhibitors of synthesis of very long-chain fatty acide (VLCFA)
  - Chloroacetamides – Outlook, Frontier, Lasso, Dual Magnum, Stalwart

- **Group 16:** Unknown MOA/site of action
  - Benzofuran - Nortron
- **Group 22:** Photosystem I electron diverters
  - Bipyridyliums - Reglone, paraquat
- **Group 26:** Unknown MOA/site of action
  - Avenge
- **Group 27:** Inhibitors of the enzyme 4-HPPD
  - Pyrazole - Callisto

Herbicide Resistance by MOA- 1984



Herbicide Resistance by MOA- 2006



## **Herbicide Resistance Management**

- *You can prevent or delay the development of resistant weeds in your cropping system if you follow a good strategy.*
- Herbicide rotation: Plan your herbicide rotations and tank mixtures carefully and make herbicide resistance management a key part of those plans – as important as your choices for weed control, crop safety, follow crop concerns, economics
  - Use herbicides with different MOA's
  - Tank-mix with a different mode of action
  - Overlapping weed spectrum
  - Economics can be considered if different MOA herbicides or tank mixtures cost about the same as the original herbicide used
- Crop rotation
  - Possibilities of different herbicide MOA's, cultural practices, and planting times for break-up of weed life cycle
- Use Integrated Weed Management practices
- Maintain herbicide/weed control histories.
- Use certified seed for all your crops.
- A competitive crop with a good stand aids in weed suppression/control
- Scout - before and after application
- Use appropriate herbicide(s), as necessary.
- Do something about escapes/shifts
- Make accurate herbicide applications
- Use sanitation to prevent spread
  - Clean equipment before moving
  - Screen irrigation water

## **Determine if There's a Cause of Poor Weed Control First**

Rule out all other possibilities for poor herbicide performance before considering the possibility of resistance.

- Misapplication occurred such as use of the wrong rate or timing
- Environmental conditions contributing to poor weed control
- Heavy weed pressure
- Sprayer skips

*The more diversity in weed control tools used - the less risk of selecting resistant weeds.*

## **Resistance Management Planning Tools**

- PNW 437: Herbicide-Resistant Weeds and Their Management – available at: [info.ag.uidaho.edu](http://info.ag.uidaho.edu)
- Herbicide classification charts
- Management worksheet
- Examples of customized worksheets – planning tools were given during the workshop and can be obtained from the authors

### **Growers Should Ask These “IF” Questions**

- If the same herbicide or class of herbicides has been used in the field for sequential/ several years.
- If the suspected resistant weed species has been controlled effectively in the past.
- If weed control is good on all the other labeled weed species.

### **What to do If you suspect herbicide resistance**

- Do not respray the field with the same herbicide or herbicide class - control the weed with another means - do not allow seed to mature.
- Report your suspicion to crop advisor/ extension educator/ extension specialist/researcher.
- Collect plants or seed that can be used to confirm resistance has developed.

### **Last Words**

- *The most comprehensive resistant weed management programs are set up before herbicide-resistant weeds become a problem.*

# ***Herbicide Resistance Management Worksheet***

		<b>Herbicides/Herbicide Classes</b>					<b># of Modes of Action/ Herbicide Classes on Key Weeds</b>
<b>1st year crop</b>							
<b>2nd year</b>							
<b>3rd year</b>							
<b>Key Weeds</b>	<b>mark activity with an X</b>						

Fill in crop rotation, key weeds and planned herbicide program. Mark weed spectrum activity with an X. Use a different column for each herbicide class. Total the # of herbicide classes used on each weed. Plan to rotate herbicide classes, do not to use herbicides from the same class 2 years in a row, use herbicides with overlapping weed spectrum activities in the same year.