Discussion Topics

✓ Herbicide resistant weeds in Idaho
✓ Selecting for herbicide resistant weeds
✓ Herbicide classification
✓ Herbicide resistance
✓ Using these groups for resistance management
✓ Sustainable uses of glyphosate
How Widespread is Herbicide Resistance?

154 Species in the US
11 Species in Idaho
<table>
<thead>
<tr>
<th>Weed species</th>
<th>Group #</th>
<th>Herbicide examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prickly lettuce</td>
<td>2</td>
<td>Affinity BroadSpec, Ally, Pursuit, etc.</td>
</tr>
<tr>
<td>Kochia</td>
<td>2</td>
<td>Same as above</td>
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<tr>
<td>Russian thistle</td>
<td>2</td>
<td>Same as above</td>
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<tr>
<td>Mayweed chamomile</td>
<td>2</td>
<td>Same as above</td>
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<tr>
<td>Italian ryegrass</td>
<td>1</td>
<td>Discover, Axial, Assure II, Poast, etc.</td>
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<tr>
<td>Wild oats</td>
<td>1</td>
<td>Same as above</td>
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<tr>
<td>Wild oats</td>
<td>8, 26</td>
<td>Avadex MicroActive, Avenge</td>
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<tr>
<td>Kochia</td>
<td>4</td>
<td>Clarity, Banvel</td>
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<tr>
<td>Italian ryegrass</td>
<td>1, 2, 15</td>
<td>Discover, Axial, Amber, Axiom</td>
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<tr>
<td>Redroot pigweed</td>
<td>5</td>
<td>Metribuzin</td>
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<tr>
<td>Kochia</td>
<td>9</td>
<td>Glyphosate</td>
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</tbody>
</table>
How Does Herbicide Resistance Happen?

- Lack of alternative herbicides with different site of action.
- Limited labor and time available to use non-chemical practices.
- High percentage of leased land with lack of previous herbicide history to the renter.
- Preference for annual cropping systems reinforces heavy reliance on herbicides.
Estimated that within a population of 1 million plants of any species 1 biotype is resistant to any given herbicide
Selection for Herbicide Resistant Weeds

Repeated use of same herbicide mode of action
The more effective and the more a herbicide is used increases selection pressure
After repeated use, many weeds of that biotype are resistant.
Factors Affecting Speed of Selection

Length of time for selection of resistance varies by:

✓ Cultural practices
✓ Frequency of herbicide use
✓ Biology of weed species
✓ Frequency of resistant biotypes among weed species
✓ Herbicide mechanism of action
How Does Resistance Spread?

✓ Gene flow - spread of seed or pollen
  ✓ Known that SU resistant kochia pollen can spread at least 30 m (>98 ft)
  ✓ Whole-plant kochia, Russian thistle, tumble mustard and others move by wind
    ✓ Russian thistle moves up to 2.5 miles and disperses >50% of its seed.
      • Average seed/plant = 61,700
  ✓ Clean equipment before moving to another field
Herbicide Classification

✓ 1995 - Weed Science Society of America developed a herbicide classification system.
   ✓ Numbering system
✓ Currently, 27 classes/groups.
✓ The numbering system assigns each herbicide to a mechanism of action group.
✓ EPA recommends labels display the group number that identifies the mechanism of action for the active ingredient(s) in a formulated product.
Complete Directions for Use

EPA Reg. No. 524-537

AVOID CONTACT OF THIS HERBICIDE WITH FLOWERS, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS (EXCEPT AS SPECIFIED FOR INDIVIDUAL ROUNDUP READY® CROPS), DESIRABLE PLANTS AND TREES. AS SEVERE INJURY OR DESTRUCTION COULD RESULT.

Herbicide for Roundup Ready® Crops
Selective breed-spectrum weed control in Roundup Ready® crops
Non-selective, broad-spectrum weed control for many agricultural systems and farmsteads

THIS PRODUCT IS NOT REGISTERED IN ALL STATES.

This product is not registered in all states. Read the entire label before using this product. Use only according to label instructions.

Read the “LIMIT OF LIABILITY AND LIABILITY” statement at the end of the label before buying or using. If terms are not acceptable, return all unopened.

THIS IS AN END-USE PRODUCT. MONGOLIAN COMPANY DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION. SEE INDIAN CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

1.0 INGREDIENTS

ACTIVE INGREDIENT
Glycine (monohydroxyaminomethylene), in the form of its potassium salt
48.1%
OTHER INGREDIENTS:
51.3%
300.0%

*Contains 660 grams of the active ingredient glyphosate, in the form of its potassium salt.

3.0 PRECAUTIONARY STATEMENTS

3.1 Hazards to Humans and Domestic Animals

Keep out of reach of children
CAUTION!

CAUSES MODERATE EYE IRRITATION
HARMFUL IF INHALED
Avoid contact with eyes, skin, or clothing
Avoid breathing vapor or spray mist

FIRST AID:
Call a poison control center or doctor for treatment advice.

IF IN EYES

- Wash eye open and rinse slowly and gently with water for 15 to 30 minutes.
- Remove contact lenses if present after the first 5 minutes then continue rinsing eye.

IF ON SKIN

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

IF INHALED

- Move person to fresh air.
- If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible.

- Have the product container or label with you when calling a poison control center or doctor, or going for treatment.
- You can also call (324) 694-4000, collect, day or night, for emergency medical treatment information.
- This product is identified as Roundup PowerMAX® II Herbicide, EPA Registration No. 524-537.

DOMESTIC ANIMALS: This product is considered to be relatively nontoxic to dogs and other domestic animals. However, ingestion of this product in large amounts of freshly sprayed vegetation may result in temporary gastrointestinal irritation (vomiting, diarrhea, colic, etc.). If such symptoms are observed, provide the animal with plenty of fluids to prevent dehydration. Call a veterinarian if symptoms persist for more than 24 hours.

Personal Protective Equipment (PPE):
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 resistance category selection chart.

Masks, Lubbers, Other Handlers and Applications, when handling this concentrated product or its application solutions of 30 percent concentration or greater, must wear: long-sleeved shirt and long pants, shoes, socks, and chemical-resistant gloves made of any waterproof material such as polyethylene or polyvinyl chloride.

Applicants, when handling only spray solutions where concentration is 30 percent of this product or less, must wear: long-sleeved shirt and long pants, shoes, and socks. Follow manufacturer’s instructions for cleaning/maintaining PPE (Personal Protective Equipment). If no such instructions for washables exist, wash detergent and hot water. Keep and wash PPE separately from other laundry.

Dissolve clothing and other absorbent materials that have been drenched or heavily
Herbicide
Nonselective Foliar Systemic Herbicide for Weed Control

Active Ingredient:
*Potassium salt of glyphosate: N-(phosphonomethyl) glycine . . . 44.9%
Other Ingredients: 55.1%
Total: 100.0%

*Contains 4.17 pounds per U.S. gallon of glyphosate acid.

KEEP OUT OF REACH OF CHILDREN.
AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION MAY RESULT.

ACTIVE INGREDIENT
*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt ................................. 41.0%
OTHER INGREDIENTS: .................................................................................................................. 59.0%
TOTAL 100.0%

*Contains 480 grams per liter or 4.0 pounds per U.S. gallon of the active ingredient, glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per liter or 3.0 pounds per U.S. gallon of the acid, glyphosate.

Licensed for Roundup Ready® cotton, corn, canola, Flex cotton, sugarbeets and soybeans.

KEEP OUT OF REACH OF CHILDREN
CAUTION
Fusilade DX Herbicide

Postemergence Herbicide for Control of Perennial and Annual Grass Weeds

Active Ingredient:
Fluazifop-P-butyl
Butyl (R)-2-[4-[[5-(trifluoromethyl)]-2-pyridinyl]oxy]phenoxy]propanoate*..................24.5%

Other Ingredients:..................75.5%
Total:..................100.0%

*Fusilade DX Herbicide contains 2 pounds (+) isomer (fluazifop-P-butyl) per gallon.
Contains petroleum distillates.

KEEP OUT OF REACH OF CHILDREN.
Sequence® Herbicide

Foliar systemic herbicide with residual weed control for corn, cotton, legume vegetables (succulent or dried), peanuts, potatoes, sorghum, soybeans, sugar beet (glyphosate-tolerant), sunflowers, and tomatoes.

Active Ingredient:
* Glyphosate: N-(phosphonomethyl) glycine ........................................... 21.8%
** S-metolachlor (CAS No. 87392-12-9) ................................................. 29.0%
Other Ingredients: ............................................................................. 49.2%

syngenta®
Herbicide Groups- PNW 437

Herbicide-Resistant Weeds and Their Management

Download for free at uidaho.edu/extension
Click on ‘Search Publications’
Guide for Herbicide Rotation in the Pacific Northwest

To avoid selecting an herbicide resistant weed, do not use herbicides from the same select group more than once within three years. Rather, rotate to a different group every year or part of this production system.

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Download at: uidaho.edu/extension ‘Search Publications’
New Herbicide Development

✓ No herbicides with new mechanisms of action are in advanced development trials.
✓ The last new mechanism of action was introduced over 20 years ago;
✓ Will have to rely on currently available herbicides for the foreseeable future.
✓ ‘Stacked’ resistance developed for corn and soybean.
✓ Sugar beets next?
Herbicide Resistance Management
Management Strategies

Proactive management - implementing tactics before herbicide-resistant weeds are apparent.

**PROACTIVE:** before confirmation

Reactive management - implementing tactics after herbicide resistance has been confirmed in the field.

**REACTIVE:** after confirmation
Proactive Management Tactics

Strategies to **proactively** delay herbicide resistance can include one or more of the following tactics:

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mechanical</th>
<th>Cultural</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multiple herbicides</td>
<td>• Tillage</td>
<td>• Crop rotation</td>
</tr>
<tr>
<td>with different mechanisms of</td>
<td>– Pre-plant</td>
<td>• Fall vs spring crops</td>
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<tr>
<td>action</td>
<td>– In crop cultivation</td>
<td>• Plant population</td>
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<tr>
<td>– Mixes</td>
<td>– Post harvest</td>
<td>• Planting date</td>
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<tr>
<td>– Sequence</td>
<td>• Mowing</td>
<td>• Fertilizer placement</td>
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<tr>
<td>– Across seasons</td>
<td></td>
<td>• Cover crops</td>
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</tbody>
</table>

Photo credits from left to right: Flickr jwinfred; Deere Photo Library; Allianz
The Proactive Fallacy

✓ Can be cost and time prohibitive, e.g. tank mixing herbicides, increase integrated weed management practices
✓ Managing resistance often similar to preventive practices
✓ Increasing integrated practices considered prohibitive
✓ Less effective if neighbors are not using preventive practices
Herbicide Rotation and Mixtures

- Lack of suitable herbicide options associated with a crop rotation can impede herbicide rotation.
  - Herbicides with same efficacy level
- Herbicide mixtures are considered better for delaying resistance longer than rotating herbicides.
  - Mixtures add to production cost
- Using a combination of rotation and mixtures might be more suitable.
## Rotating Herbicide MOA

<table>
<thead>
<tr>
<th></th>
<th>Herbicides/Herbicide Classes</th>
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<tbody>
<tr>
<td><strong>Corn</strong></td>
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<tr>
<td></td>
<td>Glyphosate 9</td>
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<td></td>
<td>Glyphosate 9</td>
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<tr>
<td><strong>Sugar beets</strong></td>
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<tr>
<td></td>
<td>Glyphosate 9</td>
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<tr>
<td><strong>Wheat</strong></td>
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<tr>
<td></td>
<td>Affinity BS 2</td>
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<td></td>
<td>Starane 4</td>
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<tr>
<td><strong>Corn</strong></td>
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<tbody>
<tr>
<td><strong>Corn</strong></td>
<td></td>
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<tr>
<td></td>
<td>Status 4, 19</td>
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<td>Glyphosate 9</td>
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<td><strong>Sugar beets</strong></td>
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<td>Nortron SC 16</td>
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<td></td>
<td>Glyphosate 9</td>
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<td>Outlook 15</td>
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<td><strong>Wheat</strong></td>
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<td></td>
<td>Axial XL 1</td>
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<td></td>
<td>Huskie 5, 27</td>
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<tr>
<td><strong>Corn</strong></td>
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<td>Prowl 3</td>
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<td></td>
<td>Glyphosate 9</td>
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<td></td>
<td>Callisto 27</td>
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</tbody>
</table>
Consider Where Glyphosate is Used

- Labeled for use in >40 crops or sites
- Other Roundup Ready crops.
- Pre-emergence or “Clean Sweep” applications in non-RR crops.
- Shielded/hooded sprayer & wiper applications
- Spot applications likely not a problem
- Non-crop applications
  - Ditchbanks
  - Roadsides
  - Waste areas
Use the Full Labeled Rate

✓ Labeled rate- A rate or range of rates set by herbicide manufacturers to consistently provide effective control of weed species across growth stages and site conditions.

✓ Routine exposure to low herbicide rates can allow a portion of the weed population to survive, leading to the evolution of herbicide-resistant populations.
Use the Full Labeled Rate

✓ Low rates may be due to:
  ✓ Intentional use of below-labeled rates
  ✓ Spraying plants larger than those recommended on the label
  ✓ Inadequate coverage of weeds because of size, density and/or crop cover
  ✓ Inaccurate sprayer calibration, faulty equipment, or mixing errors.
Alternatives to Management of Herbicide Resistant Weeds
Herbicide Resistant Weed Management Alternatives

✓ Impose government regulation- requires growers to comply with specified weed management practices
  ✓ Enforced with noncompliance penalties.
  ✓ EPA or ISDA enforced
✓ Worst of the worst as a management alternative
Herbicide Resistant Weed Management Alternatives

✓ Use incentive schemes (public or private)-
  ✓ Offers payments or rebates to alter behavior.
  ✓ More popular with growers than regulation, but requires funds to implement
  ✓ Suffer from high monitoring costs and inflexibility.
  ✓ Mixed record of success in agriculture due to a lack of targeting and unproductive spending.
Herbicide Resistant Weed Management Alternatives

✓ Privatize the rights to the resource in question
  ✓ Prescription-based herbicide usage
  ✓ This approach is considered technically and economically infeasible
Herbicide Resistant Weed Management Alternatives

✓ Community-based approach (CBA)
  ✓ Grass roots effort
  ✓ Growers actively design the management program
  ✓ Oversee implementation from the bottom up
    ✓ Universities, industry, and government provide technical and financial assistance.
Herbicide Resistant Weed Management Alternatives

Community-based approach (CBA)
- Program led by growers themselves
- Implementation and compliance requires significant design and monitoring effort and cost
- Clear description of the relevant stakeholders
Herbicide Resistant Weed Management Alternatives

- Community-based approach (CBA)
  - Examples of community-based resource management in agriculture
    - Cooperative Weed Management Areas (CWMA)
    - Watershed management
    - Pest eradication programs - boll weevil
    - Health Sciences
Keys to CBA Success

✓ Establish clearly defined boundaries
  ✓ Geographic area
  ✓ Parties within the boundary who need to be involved.

✓ Find common ground on the cost and benefit of rules to live by

✓ Involve as many as possible in decision-making process of resistant-management strategies used
Keys to CBA Success

- Conduct effective monitoring of participants activities
- Institute sanctions for those not complying with CBA rules.
- Create mechanisms of conflict resolutions that are cheap and easy to address.
It takes more than yourself using resistance management practices to prevent the spread of resistant weeds
Scouting For Resistant Weeds

 ✓ More than one species not controlled is likely not due to resistance.
Scouting For Resistant Weeds

✓ If it’s an individual species, especially later in the season
✓ Other weed species have been killed
✓ Spatial pattern consists of multiple plants of same species in a patch.
Scouting After a Herbicide Application

- Begin 7 to 14 days after (each) application, and continue at regular intervals until harvest.
- Move across the field in a pattern covering the area.
Scouting After a Herbicide Application

- Identify and record weed species present.
- Determine if plants survived previous application or emerged later.
- Observe individual plant responses
- Consider previous field history to understand changes.
Questions?

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