Integrated Weed Management

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12 miles West of Hardin, MT
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Outline for Today’s Lecture

• Review of concepts
  - What is a weed?
  - Why do we have weeds?

• Conventional approaches to weed management
  - Limitations

• Introduction to Integrated Weed Management (IWM)
What is a Weed?

Source: WSSA web site. Ian Heap
What is a Weed?

A plant that is growing where it is not wanted

Roberts et al. 1982. Weed Control Handbook

Weed science focuses on mitigating the negative impacts of weeds on crops

Landis et al. 2005. Weed Science
Weed Management is Achieved Through...
Problems With Conventional Weed Management

- Unintended effects
  - Erosion - mechanical control-
  - Soil and groundwater contamination - chemical control-

Weed resistance
Herbicide Resistance is NOT due to

1. Sprayer skips or plugged nozzles
2. Weather problems that cause poor control
3. Plants that are ‘naturally tolerant’ to the herbicide
4. Genetic changes caused by the herbicide
Herbicide Resistance is

The ability of a plant to survive and reproduce after treatment with a dose of herbicide that would normally kill the plant.
The sky is falling!
Herbicide Resistance

311 Resistant Biotypes, 183 Species (110 dicots and 73 monocots) as of October 3rd, 2006

Source: International Survey of Herbicide Resistant Weeds (http://www.weedscience.org)

Source: Dr. Ian Heap
www.weedscience.com
Herbicide Resistance in Montana

Kochia

Russian thistle

Green foxtail?

Wild oat

Persian darnel
History of Wild Oat Resistance in Montana

Beginning of Time

1970
Far-go

1996
Resistance to Assert

1990s
Resistance to Far-go

2004
ACCase Cross Resistance (Hoelon, Puma, Discover)

2000s
Multiple resistance (Far-go, Avenge & Assert)

2005
Axial

Multiple Resistance (Avenge and Far-go)

2006
Resistance to Axial

Early 1990s
Assert

Avenge
Where do Resistant Weeds Come From?

It’s all about selection…..

One in one million, billion, trillion….?
DNA
Resistance
passed on
to next generation
Herbicide
application:
selection pressure
for resistant plants
DNA mutation: allows resistance to a herbicide
Reproduction
(sets seeds)
Succeeding generations are also resistant
Herbicide application: selection pressure
Resistance passed on to next generation
Selection Pressure and Resistance

“Better” herbicide = more chance of selecting for resistance
How Can We Prevent the Selection of Resistant Biotypes?

Don’t rely just on that “great” herbicide

Incorporate other mortality factors:
* Herbicides
* Mechanical practices
* Cultural practices
* Biological factors
Problems With Conventional Weed Management

- Unintended effects
  - Erosion - mechanical control-
  - Soil and groundwater contamination - chemical control-
  - Weed resistance

We are living in a changing world

- Global climate change
Carbon Dioxide Variations

The Industrial Revolution Has Caused A Dramatic Rise in CO₂

Year (AD)

CO₂ Concentration (ppmv)

Thousands of Years Ago

Ice Age Cycles
Percent Soil Moisture Reduction
June-August
Growth Response, Past to Present $[\text{CO}_2]$
Elevated $[\text{CO}_2]$ Enhances Dandelion Reproduction

Elevated $[\text{CO}_2]$ Enhances Dandelion Reproduction

Who cares? We still got herbicides

Can changes in $[CO_2]$ and $T^o$ affect chemical control?

Source: USDA photo gallery
Growth Following Herbicide Application
- Greenhouse -

After Ziska and Teesdale, 2000

* = Death plant

Growth (g/day)

Low (365) [CO₂]
C. lambsquarters

High (723) [CO₂]

Low (365) [CO₂]
Redroot pigweed

High (723) [CO₂]

Low (388) [CO₂]
Quackgrass

* = Death plant
Finale (Glutamine synthase inhibitor)

- $T^o$ and $CO_2$ - Reduce efficacy
Problems With Conventional Weed Management

- Unintended effects
  - Erosion - mechanical control-
  - Soil and groundwater contamination - chemical control-
  - Weed resistance
- We are living in a changing world
  - Cropping systems highly simplified and predictable
    - Weeds with biology similar to crop are difficult to control (we’ll talk about this on Wednesday)
Problems With Conventional Weed Management

✓ Unintended effects
  • Erosion – mechanical control-
  • Soil and groundwater contamination – chemical control-
  • Weed resistance

✓ We are living in a changing world

✓ Simplified and predictable
  • Weeds with biology similar to crop are difficult to control (we’ll talk about this on Wednesday)

On the long-term, large hammers evidently don’t work:

We still have weed problems!
What is a Weed?

A plant that is growing where it is not wanted

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Weed science focuses on mitigating the negative impacts of weeds on crops

Landis et al. 2005. Weed Science
Any Problem with this Definition?
What is a Weed?

A plant that is successful in colonizing disturb, but potentially productive sites and at maintaining their abundance under conditions of repeated disturbances


Search the causes of why we have weeds
Disturbance

• A discrete event that disrupts ecosystem, community or population structure

• Changes resources, substrate availability or the physical environment

Pickett and White, 1985
Why Do We Have Weeds?

Disturbance

Light

Water

Nutrients

Space
Why Do We Have Weeds?

Because we create the environments where weeds thrive!
Weed Management is Achieved Through

“large hammer”
Alternative Approach to Weed Management

- Replace a “few large hammer” with “many little hammers” (herbicides, tillage, crop rotation, pathogens, insects, cover crops, etc)
- Alone, each factor may have a small effect. Together, these factors may provide sufficient control

Liebman and Gallandt 1997

Integrated Weed Management
Integrated Weed Management

Cultural
Mechanical
Biological
Chemical

Integrated Weed Management
A Brief Summary

- Problems with traditional approaches to weed management.
  - Among others:
    - Resistance
    - Global climate change
  - Definition of a weed
    - Plants that thrive in frequently disturbed environments
  - Understand why we have weeds
- Replace a “few large hammers” with “many little hammers”
- Develop and Integrated Weed Management program
Integrated Weed Management

Cultural + Mechanical + Biological + Chemical

Integrated Weed Management
Integrated Weed Management

• Set of cultural, mechanical, biological and chemical control practices to
  - Limit the introduction and spread of weeds
Prevention

• Plant clean and certified seed
• Clean equipment between fields
• Manage buffer areas and field margins
• Prevent seed production by established weed populations
Standard weed management conducted at the field level

270% expansion over 6 years

Standard weed management + weed shed prevention

24% expansion over 6 years

After H. Beckie, Agri-Food Canada @ Saskatoon
Integrated Weed Management

• Set of cultural, mechanical, biological and chemical control practices to
  - Limit the introduction and spread of weeds
  - Help the crop compete with weeds
Disturbance

Light

Water

Nutrients

Space
Goal

• Manage cropping systems (not just weeds!) so that the resources made available through disturbances are captured by crop and not by weeds
Weed Management
Weed Management
Integrated Weed Management

- Crop rotation
- Time of emergence
- Time of control
- Herbicides
- Resource management
- Crop variety
- Seeding density
- Row spacing
Spring Wheat Yield Response

After Holman and Bussan

Persian darnel density (seedlings/m²) vs. Spring Wheat Yield (kg/ha)
Crop Seed Size

Stougaard and Xue. 2004. Weed Sciences 52: 133-141
Relative Time of Emergence

![Graph showing the relationship between Downy Brome populations and wheat yield loss. The graph compares the emergence of Downy Brome over 0-14 days and 21-35 days after wheat.]
Row Spacing and Seeding Rate

20 site-years in Oklahoma

Epplin et al. 1996
N Placement on Downy Brome

Wyoming

No. or lb/acre

Downy brome

Plants

Dry wt.

Miller 1990
A Tricky Question
• Late but appropriate weather conditions
• Winter wheat: 3 - 4 leaf stage
• Downy brome 3 - 4 leaf to 2 - 5 tiller growth stage
1. Untreated - control
2. Oly 0.61 oz/A - Fall
3. Oly 0.61 oz/A - Fall + Oly 0.61 oz/A - Spring
4. Oly 0.61 oz/A - Fall + OlyFlex 3.5 oz/A - Spring
5. Oly 0.61 oz/A - Fall + Osprey 3.2 oz/A - Spring
6. OlyFlex 3.5 oz/A - Fall
7. OlyFlex 3.5 oz/A - Fall + Osprey 3.2 oz/A - Spring
8. Maverick 0.5 oz/A Fall
9. Maverick 0.66 oz/A Spring
No significant differences between treatments

No fertilization: yield potential may not have been realized
Integrated Weed Management

- Set of cultural, mechanical, biological and chemical control practices to
  - Limit the introduction and spread of weeds
  - Help the crop compete with weeds
  - Keep weeds "off balance"
Crop Rotation

“Rotation of crops, when accompanied by care in the use of pure seed, is the most effective means yet devised for keeping land free of weeds.”

Leighty (1938)
Crop Rotation and Cheatgrass Density

Downy brome density (no. m$^{-2}$)

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<th>Year</th>
<th>Wheat-rapeseed, no-till</th>
<th>Wheat-rapeseed, till</th>
<th>Continuous wheat, no-till</th>
<th>Continuous wheat, till</th>
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(After Blackshaw 1994)
Year 1 – W. Wheat – herbicide

Year 2 – Chem. Fallow –

Year 3 – W. Wheat – canopy

Year 4 – Chem. Fallow –

Overall Impact
Year 1 - W. Wheat -
herbicide [J F M A M J J A S O N D]
canopy

Year 2 - Chem. Fallow -
[J F M A M J J A S O N D]

Year 3 - W. Wheat -
[J F M A M J J A S O N D]

Year 4 - Chem. Fallow -
[J F M A M J J A S O N D]

Year 1 - W. Pea -
cultivation

Year 2 - W. Wheat -
[J F M A M J J A S O N D]

Year 3 - Lentils -
[J F M A M J J A S O N D]

Year 4 - Barley -
[J F M A M J J A S O N D]

Overall Impact

Overall Impact
In Summary

• Why we have weeds?
  - Disturbances, resources, & propagules

• Integrate “many little hammers”

• Goals of Integrated Weed Management
  - Limit the introduction and spread of weeds
    • Prevention
  - Help the crop
    • Resource competition
  - Keep weeds "off balance"
    • Crop rotation
Question?