Weed Management in Rice

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University of California - Davis
Outline

- Introduction
- Weed impact
- Weed IPM in Rice
- Chemical weed control
- Herbicide resistance
# Rice Yield Loss from Heavy, Season-long Weed Interference

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>Potential Yield Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnyardgrass</td>
<td>82</td>
</tr>
<tr>
<td>Bearded sprangletop</td>
<td>36</td>
</tr>
<tr>
<td>Ducksalad</td>
<td>21</td>
</tr>
<tr>
<td>Eclipta</td>
<td>10</td>
</tr>
</tbody>
</table>
Effect of late watergrass competition on rice yields

Gibson et al. 1999
What Rice Farmers Say About Weeds

- Weeds is rank as 1st or 2nd problem in rice
- Weed management in rice is challenging, complex, expensive, and regulated
- Herbicide is the preferred method of controlling weed and it is the first and probably the last line of defense
- Farmers are not quit sure if herbicides are working well – resistant weeds
- Herbicide program vary between fields, no base herbicide treatment program
- Less water means more weeds and more herbicides
- Do we have new herbicides coming down the road
Weed IPM in Rice

Prevention
Best cultural practices
Scouting
Thresholds
Biological control
Herbicides
Ecological intense IPM
Prevention

• Certified seeds
  – 0% red rice
  – 0.01% barnyardgrass, watergrass, springletop
• Clean equipment
• Clean water
• Control weeds on rice levees
Tillage

• Tillage
  – Prevent weed head start
  – Overwintering rhizomes or corms of perennials

• Leveling
  – High spots – more weed germination
  – Low spots – inadequate foliar herbicide coverage

• Straw incorporation
  – Incorporates weed seed and prevents depredation
Rotation

• Other crops
  – Limited options
  – Limited areas

• Pre-planting weed control
  – Stale seeded
  – Minimum tillage

• Dry seeding
  – Drill
  – Broadcast
Water Management

• Important practice for managing rice weeds
• Ideally, continuous flood 4-8” inches deep
  – Suppresses grasses and small flower umbrella sedge
• Foliar absorbed herbicides
  – Require drainage for good coverage
  – Rapid re-flooding to prevent new flush
  – Ability to drain and flood quickly
Weed Biology

• Seed germination dynamics
• Effect of environmental condition on weed growth and development
• Determine weed population threshold
Chemical Weed Management
Challenging, Complex, Expensive, and Regulated
California Rice Weeds - Grasses

- Barnyardgrass
  *Echinochola crus-galli*

- Early Watergrass
  *E. oryzoides*

- Late Watergrass
  *E. Phyllopogon*

- Bearded Sprangletop
  *Leptochloa fascicularis*

- Junglerice, *Echinochloa colona*
California Rice Weeds - Sedges

Ricefield Bulrush
*Schoenoplectus mucronatus*

Smallflower Umbrella Sedge
*Cyperus difformis*
California Rice Weeds - Broadleaves

- California Arrowhead
  *Sagittaria montevidensis*

- Gregg’s Arrowhead
  *Sagittaria longiloba*

- Redstem
  *Ammannia species*

- Monochoria
  *Monochoria vaginalis*

- Ducksalad
  *Heteranthera limosa*

- Waterhyssop
  *Bacopa rotundifolia*

- Common Waterplantain
  *Monochoria vaginalis*
# Rice Herbicide

<table>
<thead>
<tr>
<th>Common name</th>
<th>Trade name</th>
<th>MOA</th>
</tr>
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<tbody>
<tr>
<td>Bensulfuron</td>
<td>Londax®</td>
<td>ALS inhibitor</td>
</tr>
<tr>
<td>Bispyribac-sodium</td>
<td>Regiment®</td>
<td>ALS inhibitor</td>
</tr>
<tr>
<td>Halosulfuron</td>
<td>Sandea®, Sempra</td>
<td>ALS inhibitor</td>
</tr>
<tr>
<td>Penoxsulam</td>
<td>Granite®</td>
<td>ALS inhibitor</td>
</tr>
<tr>
<td>Carfentrazone</td>
<td>Shark H2O®</td>
<td>PROTOX inhibitor</td>
</tr>
<tr>
<td>Clomazone</td>
<td>Cerano®, Bombard®</td>
<td>Carotenoid biosynthesis inhibitor</td>
</tr>
<tr>
<td>Cyhalofop-butyl</td>
<td>Clincher®</td>
<td>ACCase inhibitor</td>
</tr>
<tr>
<td>Pendimethalin</td>
<td>Prowl H2O®</td>
<td>Tublin inhibitor</td>
</tr>
<tr>
<td>Propanil</td>
<td>Stam®, SuperWham®</td>
<td>Photosystem II inhibitor</td>
</tr>
<tr>
<td>Thiobencarb</td>
<td>Abolish®, Bolero®</td>
<td>VLCFA (Very long chain fatty acids)</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>Grandstand®</td>
<td>Synthetic auxin</td>
</tr>
</tbody>
</table>
## Rice Herbicide

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Applied to Foliage</th>
<th>Applied in Water</th>
<th>Timing (rice growth stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abolish</td>
<td>Yes</td>
<td>Yes</td>
<td>1-2 lsr</td>
</tr>
<tr>
<td>Bolero</td>
<td>No</td>
<td>Yes</td>
<td>1-2 lsr</td>
</tr>
<tr>
<td>Cerano</td>
<td>No</td>
<td>Yes</td>
<td>0-1 lsr</td>
</tr>
<tr>
<td>Clincher</td>
<td>Yes</td>
<td>No</td>
<td>2 lsr - mt</td>
</tr>
<tr>
<td>Regiment</td>
<td>Yes</td>
<td>No</td>
<td>5 lsr - mt</td>
</tr>
<tr>
<td>SuperWham</td>
<td>Yes</td>
<td>No</td>
<td>3 lsr - mt</td>
</tr>
<tr>
<td>Stam</td>
<td>Yes</td>
<td>No</td>
<td>3 lsr - mt</td>
</tr>
<tr>
<td>Londax</td>
<td>Yes</td>
<td>Yes</td>
<td>0-5 lsr</td>
</tr>
<tr>
<td>Sempra</td>
<td>Yes</td>
<td>Yes</td>
<td>0-5 lsr</td>
</tr>
<tr>
<td>Granite</td>
<td>Yes</td>
<td>Yes</td>
<td>2 lsr - mt</td>
</tr>
<tr>
<td>Grandstand</td>
<td>Yes</td>
<td>No</td>
<td>5 lsr - mt</td>
</tr>
<tr>
<td>Shark</td>
<td>Yes</td>
<td>Yes</td>
<td>2 lsr - mt</td>
</tr>
<tr>
<td>Prowl</td>
<td>No</td>
<td>No</td>
<td>preemergence</td>
</tr>
<tr>
<td></td>
<td>barnyardgrass</td>
<td>watergrass</td>
<td>sprangletop</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Abolish or Bolero</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cerano, Bombard</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Clincher</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Grandstand</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Granite</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Londax</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Regiment</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Shark</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stam or Superwham</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sandea</td>
<td>±</td>
<td>±</td>
<td>-</td>
</tr>
<tr>
<td>Prowl</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+  control
-  no control
±  suppression
R  resistant, poor control
Knowledge for Good Weed Management

• Knowledge of the weed species present
• Knowledge of rice herbicide, their efficacy and behavior
• Knowledge of mixture and sequential treatments
• Herbicide mode of action to prevent herbicide weed resistance
• Interactions with water management and do you have good water management capability
Knowledge for Good Weed Management

- Compatibility in herbicide tank mixing
- Proper adjuvants
- Rice herbicide varietal response
- Knowledge of application requirement
- Environmental conditions
Major Herbicide-Based Weed Control Systems for Rice in California

Permanent Flooding: Granular herbicide into the water at early stages then lower water for foliar herbicide application

Pin-point Flood
Major Herbicide-Based Weed Control Systems for Rice in California

Early Drain-foliar: Pin-point Flood/Leathers’ to spray small weeds, flood again then lower water to expose weed foliage to second spray

Foliar herbicides

Reflood 3”

Follow-up herbicides

Flood, Seed

2LsR 3LsR 1-3 tillers

Early Drain-granule: Apply granular herbicides into the water after reflood (requires ability for rapid reflood)

Granular herbicides

Follow up with foliar herbicide if needed

Seed

Begin drain

Rice 1-2 leaf

3-4in
Drill-seeded - Field is Initially Dry and then Gradually Flooded Deeper

- Drill seeds
- Flush irrigation
- Wait approximately 7 days for preemergence herbicide
- Continue flush irrigation until 2-3 leaf stage
- Early post emergence herbicide
- Post flooding herbicide treatments
Permanent Flood (granular into-water herbicides early, then lower the water to spray foliar herbicides onto weeds)

Possible Treatments
Cerano or Bombard; (DOS – 1.5 lsr)
Bolero Ultramax (1-2 lsr)
Granite GR (2-3 lsr)

Possible Treatments
Propanil
Regiment
Early Drain-foliar ("Pin-point", "Leathers"): to spray weeds while they are small; later lower water for second spray

Possible treatments
- Clincher (2-3 lsr)
- Super Wham + Clincher (2-3 lsr)
- Granite SC (2-3 lsr)
- Clincher + Granite SC (2-3 lsr)
- Regiment+Abolish (3-4 lsr)
Herbicide Combinations

• Purpose is to broaden spectrum or synergize weed control
• Tank mixes can be used when two or more herbicides are compatible
• May reduce application costs and possibly rates
• Avoid antagonism that may result in loss of control of injury to rice
Herbicide Sequential Application

• Used to achieve broad-spectrum weed control
• Instead of tank mix due to differences in timing, water management, antagonism, and other factors
• Use different modes of action to protect against resistance management
Herbicide Behavior

- Activity – Foliar vs. soil
- Application windows
- Translocation
- Residual activity
- Resistance and mechanism of action
Foliar Versus Soil Activity

• Many newer herbicides are only active as foliar sprays
• Generally, granular herbicides are active through the soil and taken up by the root
• Some herbicides have soil and foliar activity
  – Abolish, Londax
• Need to understand for water management
Contact or Translocated

• Does the herbicide move in the plant?
• Contact herbicides move very little from point of impact and kill only that part of the plant that is contacted by the spray (Shark, SuperWham, Stam)
• Translocated herbicides move from the site of uptake to other parts of the plant to kill the growing point (Grandstand)
• Some herbicides move small distances (Clincher, Regiment)
• Cerano moves but only upward
• Prowl – no movement in the plants
Relative Herbicide Mobility in Plants

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Translocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abolish</td>
<td>1</td>
</tr>
<tr>
<td>Bolero</td>
<td>1</td>
</tr>
<tr>
<td>Cerano</td>
<td>6</td>
</tr>
<tr>
<td>Clincher</td>
<td>4</td>
</tr>
<tr>
<td>Regiment</td>
<td>4</td>
</tr>
<tr>
<td>SuperWham</td>
<td>3</td>
</tr>
<tr>
<td>Stam</td>
<td>3</td>
</tr>
<tr>
<td>Londax</td>
<td>4</td>
</tr>
<tr>
<td>Sempra</td>
<td>4</td>
</tr>
<tr>
<td>Granite</td>
<td>4</td>
</tr>
<tr>
<td>Grandstand</td>
<td>8</td>
</tr>
<tr>
<td>Shark</td>
<td>2</td>
</tr>
<tr>
<td>Prowl</td>
<td>0</td>
</tr>
</tbody>
</table>
Window of Application

• Important to remove weeds before competition affects yield
• Herbicides vary widely in their ability to kill weeds of different sizes and their safety to rice at different growth stages
• Label timing is meant to lessen damage to rice and maximize weed control
  – Cerano, Bolero, Abolish very narrow windows
  – Many newer herbicides have broader windows
    • Important when weed control is delayed or as clean-up
# Timing of Herbicide Application

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Timing Window</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abolish</td>
<td>1-2 lsr</td>
</tr>
<tr>
<td>Bolero</td>
<td>1-2 lsr</td>
</tr>
<tr>
<td>Cerano</td>
<td>0-1 lsr</td>
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<tr>
<td>Regiment</td>
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<tr>
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</tr>
<tr>
<td>Sempra</td>
<td>0-5 lsr</td>
</tr>
<tr>
<td>Granite</td>
<td>2 lsr - mt</td>
</tr>
<tr>
<td>Grandstand</td>
<td>5 lsr - mt</td>
</tr>
<tr>
<td>Shark</td>
<td>2 lsr - mt</td>
</tr>
<tr>
<td>Prowl</td>
<td>Delayed preemergence</td>
</tr>
</tbody>
</table>
Residual Activity

• Important attribute in preventing re-infestation by new flushes of weed germination
  – Generally determined by strength of soil adsorption and rate of herbicide degradation
  – Much more important for early applications before rice canopy is capable of shading out weeds
• Mixing a residual herbicide with an early application of a foliar herbicide such as propanil can sustain control long enough for rice canopy to close
• Be aware of resistance selection with residual herbicides
## Herbicide Residual Activity

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Residual (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abolish</td>
<td>20-25</td>
</tr>
<tr>
<td>Bolero</td>
<td>20-25</td>
</tr>
<tr>
<td>Cerano</td>
<td>5 in water</td>
</tr>
<tr>
<td>Clincher</td>
<td>0</td>
</tr>
<tr>
<td>Regiment</td>
<td>0</td>
</tr>
<tr>
<td>SuperWham</td>
<td>0</td>
</tr>
<tr>
<td>Stam</td>
<td>0</td>
</tr>
<tr>
<td>Londax</td>
<td>35-40</td>
</tr>
<tr>
<td>Sempra</td>
<td>35-40</td>
</tr>
<tr>
<td>Granite</td>
<td>60</td>
</tr>
<tr>
<td>Grandstand</td>
<td>0</td>
</tr>
<tr>
<td>Shark</td>
<td>5-8</td>
</tr>
<tr>
<td>Prowl</td>
<td>20 days dry, 5 days in water</td>
</tr>
</tbody>
</table>
Herbicide Resistance

- The ability of a weed biotype to survive treatment with a given herbicide to which the weed species is normally susceptible
- Herbicides are not mutant
Herbicide resistance is associated with:

- Mono culture
- Mono herbicide situations or using herbicide with the same mode of action
- No or little IPM practices are used
- Weeds emerged in narrow time window
Altered Site of Action

• Inability of a herbicide to bind to the site of action due to a genetic and conformational difference at the binding site compared to susceptible biotypes
Susceptible Plant

Herbicide

ALS-enzyme

ALS-enzyme-herbicide complex
Active Site Resistance

[Graph showing the relationship between herbicide rate and survival rate of plants, with a sharp decrease in survival rates as herbicide rate increases, indicating active site resistance.]
None Active Site Resistance

• Enhanced detoxification
• Reduced translocation
• Sequestration
None Active Site Resistance

![Graph showing survival plants (%)](image)

- **Survival plants (%)**
- **Herbicide rate (X use rate)**
- **Herbicide use rate**
- **Resistant plants**
# Herbicide Resistant

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Weed Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abolish</td>
<td>Yes</td>
</tr>
<tr>
<td>Bolero</td>
<td>Yes</td>
</tr>
<tr>
<td>Cerano</td>
<td>Yes</td>
</tr>
<tr>
<td>Clincher</td>
<td>Yes</td>
</tr>
<tr>
<td>Regiment</td>
<td>Yes</td>
</tr>
<tr>
<td>SuperWham</td>
<td>Yes</td>
</tr>
<tr>
<td>Stam</td>
<td>Yes</td>
</tr>
<tr>
<td>Londax</td>
<td>Yes</td>
</tr>
<tr>
<td>Sempra</td>
<td>Yes</td>
</tr>
<tr>
<td>Granite</td>
<td>Yes</td>
</tr>
<tr>
<td>Grandstand</td>
<td>No</td>
</tr>
<tr>
<td>Shark</td>
<td>No</td>
</tr>
<tr>
<td>Prowl</td>
<td>No</td>
</tr>
</tbody>
</table>
Resistant Weed Screening Program

- Grower submit seed samples of potentially resistant Weeds
- Use the submission form for each weed seed sample
- Provide enough seeds for testing with needed information on the submission form
- Best timing of collection is when the seed easily falls off the seed head by gentle agitation in a paper bag
- Allow seed to dry in the paper bag to prevent molding
- Provide as much information as possible for each sample submitted so we can develop a database that may help determine the development of resistance and spread over time
- We will keep individual grower information for our own purposes and any reporting of results will not identify individual growers
- Send or drop off samples at the Rice Experiment Station in Biggs

Rice Experiment Station
955 Butte City Hwy (162)
PO Box 306
Biggs CA 95917
Conclusions

• Weed identifications is critical to select the best and most profitable weed control program.
• Higher yield generally obtain when weeds are control early in the growing season.
• Multiple herbicide application are generally require.
• Excellent weed control and rice yield usually obtained with residual herbicide, however, timely sequential application of postemergence herbicide would give good results.
Conclusions

• Be aggressive with weeds
• Apply herbicide to young actively growing weeds
• Use Multiple MOA
• Do not get locked into a standard herbicide program
• If you have several field, it is important to recognize that every field is different
• Use Integrated Weed Management (IPM) practices as much as possible
• Consider rotational crop when it is make sense
Herbicide Resistance

• Scouting and monitoring
• Mode of resistance
• Negative resistance

Study the molecular base and mode of resistance

Questions