Integrated Pest Management for Various Insect Pests in Grass and Alfalfa

UCCE-Tom Getts

Some Slides and Data Courtesy of:
Steve Orloff UCCE, Nicole Stevens UCCE, Rachael Long UCCE
and Brad Hanson UC Davis
****In the following presentation any mention of pesticide or pesticide trade name is not an recommendation by the University of California. Pesticides are mentioned by trade name for informational purposes only. Mention of any pesticide is not a guarantee of their effectiveness or an endorsement of other pesticides not mentioned. When ever using a pesticide make sure to read and follow the entire label.
Outline

• Defining Integrated Pest Management
• Principles of IPM
• Pesticide Resistance
• Utilizing IPM for Insect Management
  • Armyworms
  • Grasshoppers
  • Alfalfa Weevils
What is a Pest?

• A organism which you don’t want
• Typically which causes damage
• Insect, Weed, Pathogen, Vertebrate, Nematode, etc.
• All are pests - in the eye of the beholder
IPM

- Integrated Pest Management, or IPM, is a process you can use to solve pest problems while minimizing risks to people and the environment. IPM can be used to manage all kinds of pests anywhere - in urban, agricultural, and wildland or natural areas.
A Process....

• Long term system wide approach to pest management

• Dependent on information!

• Know the ecosystem involved
  • Crop, land, soil, water, social aspects, economic aspects, pests, beneficial, lifecycle, etc.

• Not pest control

• Pest management
Step One

- Pest Identification!
  - Books, Internet, People

- Knowledge!
  - Lifecycle
  - Habitat
  - Damage potential

- Help choose best management options...

Photo courtesy of: http://acmeexterminating.com/images/free_pest_id.jpg
Step Two

• Monitoring
  • Assess the number of pests
  • Assess damage and potential damage
• Assess beneficials
Economic Thresholds

• When is management needed?
• 1 A rated weed = yes
• 1 Armyworm = no
• Monitoring
  • Action number
  • When to treat!
• Developed through research
  • Also experience
  • Know your field/operation

Photo Courtesy of: Google Images
Management

- Multiple approaches
  - Cultural
  - Biocontrol
  - Mechanical
  - Chemical

Photo courtesy of: Deere.com
Choosing a Pesticide

• IPM - Choose most selective!
• But also to minimize off target impacts
  • People
  • Crops
  • Organisms
• Spot vs broadcast
• Baits vs sprays
• Also needs to be practical and economical

Photo courtesy of: UC IPM
Pesticide resistance

• Repeated selection pressure
  • Over and over
  • Same active ingredient

• Mode of action
California

- Italian ryegrass resistance
  - 4 modes of action
- Horseweed and Hairy fleabane
  - 2 modes of action
- 30 unique cases of resistance
Armyworm Insecticide Resistance

- **Beet Armyworm (Spodoptera exigua)**
  - 47 cases USA
  - 14 different active ingredients
  - 525 cases worldwide
  - 39 different active ingredients

- **Fall Armyworm (Spodoptera frugiperda)**
  - 55 cases USA
  - 23 active ingredients
  - 121 cases worldwide
  - 33 active ingredients

- [https://www.pesticideresistance.org/search.php](https://www.pesticideresistance.org/search.php)
Pesticide Resistance

• UC IPM
  • Avoid
  • Delay
  • Reversal

• How?

• Switch up selection pressure!
  • Physically
  • Culturally
  • Chemically
    • Mode of action

Photo courtesy of: Sports stack exchange
Armyworms!

- Lepdopetera Species
- Beet armyworm
- Western yellow striped armyworm
- True armyworm
- Fall Armyworm?
Beet Armyworm

• Native Southeast Asia
• Discovered US 1876
  Throughout North America

Image courtesy of: Byrain at https://bugguide.net/node/view/693747

Map courtesy of: http://mothphotographersgroup.msstate.edu/large_map.php?hodges=9665
Western Yellow Striped Armyworm

- Mainly Western US
- Native Species

Map courtesy of: Moth photographers group

Image courtesy of: John Davis bugguide.net

Image courtesy of: Oregon State
True Armyworm

- All throughout world and North America
Fall Armyworm?
Biology

- Moths - Nocturnal
- Lay eggs 20-400 in mass
- Up to 2,000 eggs per female
  - Beet armyworm and Western yellow striped upper side of leaf. Cottony covering.
  - True Armyworm - rolled in grass
- Typically hatch 1-2 weeks

Image courtesy of: Oregon State, and UC IPM
Biology continued

• Western Yellow Striped and Beet Armyworm
  • 2-3 weeks until mature

• True Armyworm
  • Typically 3-4 weeks until mature

• Central Valley
  • Up to 5 generations

• Intermountain Region
  • Only 2 maybe 3 generations

Photo courtesy of: UC IPM
Biology continued

• Appears in Intermountain Region July and August
• Second generation causes most damage
• Damage typically arises 2-3 weeks after second cutting
• Full life cycle can be from 4-6 weeks depending on temperature
• Generations can be concurrent!
Winter

• Do not overwinter in harsh climates
  • No definition of “harsh” climate in literature
  • Migrates in from warmer areas
  • Overwinters as pupa in soil
Damage

- Defoliation of the crop
- Skeletonize alfalfa leaves
  - Cause flagging in field
- Grass eaten often avoids midvein
- Voracious feeder
Damage

• Study looking at fall armyworm feeding
• 80% of total foliage consumed in last instar

Figure courtesy of: Kathy L. Flanders Auburn University
Management

- Populations are cyclic
- Not a pest every year
- Not typically a large pest in the Intermountain Region
- Often controlled by natural predators!
- Warm winter, wet spring can lead to increased populations
Predators

- Big-eyed bugs
- Spiders
- Minute pirate bug
- Damsel bugs
- Lacewings
Viruses

- Infected Armyworm

Photo Courtesy of: WSU
Parasites

• At least 10!
• Parasitic wasp (*Hyposoter exigua*)
• Often manages population
• Doesn’t kill young instars....
• But kills larva before last instar
Management

• HIGH populations this year!
• Look for “frosting” on fields
• Look for birds
• Moths flying
• Ultraviolet/backlight traps
• And MONITOR!

Photo courtesy of UC IPM
Monitoring Pasture/Grass

- **Ground Search!**
  - Late July through fall
  - 15 sites/30 acres pasture
  - Every 5-7 days
  - Under grass, around crowns, in cracks
- **Economic threshold**
  - Oregon State 5-10 /sq. ft.
  - Other states 2-4/sq. ft.
  - California no established threshold
  - Use judgment

Photo courtesy of: UC IPM
Monitoring Alfalfa

• Sweep 15 inch net 2-3 times/week
  • 4 sections each field
  • 5 sweeps per section
• Evening and early mornings
• Identify
• Determine if parasitized!
• Threshold
  • 15 or more non-parasitized Armyworms longer ½ inch/sweep

Photo courtesy of: UC IPM
Parasitized Video

- [http://ipm.ucanr.edu/PMG/r1900711.html](http://ipm.ucanr.edu/PMG/r1900711.html)

Image courtesy of: UC IPM
Control options

• Cut the field
  • Creates inhospitable environment
  • If worms are large - may be problem after cutting
  • Under windrows feeding can occur
  • If threshold reached cut within 2 days or spray

Image courtesy of: Steve Orloff
Insecticide options

• Organic
• BT (bacillus thuringiensis)
  • Agree WG or Xentari DF
  • Apply to first two instars
    • Multiple applications may be needed
  • Does not harm beneficial insects

Photo courtesy of: UC IPM
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Grasshoppers

• Over 200 species in California
• Huge legs!
• Easy to identify
• Sporadic pest, with boom and bust population dynamics
Biology

- Eggs laid in pods during the fall (not in tilled fields)
- 1-4 pods/female
- 20 to 100 eggs per pod
- Top 2 inches soil
- Most overwinter as eggs, some as nymphs
- Hatch in spring
- 5 to 6 molts before maturity (30-40 days)
- Adults live 2-3 months
- One generation per year
## Instar Sizes

### General Sizes of Grasshopper Stages

<table>
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**Note:** size is approximate, and depending on species, can vary by 1/4 to 1/2 inch.
Weather Impacts Populations

• Spring
  • Cold - decrease
  • Warm/Dry - increase
  • Wet - fungus
• Fall
  • Warm - more eggs
  • Cold - less eggs
• Drought
  • Negatively impacts populations
  • Can cause movement
• Cold winters - no effect
• Various species impacted differently

Photo courtesy of:
http://www.weatherclipart.net/free_weather_clipart/clip_art_illustration_of_a_bright_sun_with_a_rain_cloud_hovering_over_0515-1011-0603-3308_SMU.jpg
Vegetation Consumed

- Some species
  - Grass specific
  - Broadleaf specific
  - Generalist

- Moist vegetation is more palatable
  - Readily move to find food

Photo courtesy of: http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=7743
Movement

- Nymphs will walk to more desirable vegetation
- Adults can fly 15 miles or more
- One source in Wyoming states swarms move over 60 miles
- Adults can “swarm”
- Typically starts in rangeland can move to cropland

Damage

• Consume massive amounts of foliage
• Estimates - 30 to 250% of body weight per day
• Cows - 1.5-2.5% of their body weight
• 30 lb grasshoppers consume the same forage as a 600 lb steer

Photo courtesy of: http://entomology.k-state.edu/images/alfalfa-pests/grasshopper.tif
Management

• Area wide approach
• Coordinated effort
• Monitor
• UC IPM
  • Control on rangeland and field edges before move into crops!
Economic Thresholds Range

- Oregon Rangeland
  - 8 or more/square yard
  - USDA Aphis Standard before assistance
- California - no threshold
- Wyoming Rangeland
  - Less than 8/square yard - Not economic
  - 8-15/square yard - Potentially economic
  - 15-20/square yard - Economic
- Economic threshold vary by species, time, developmental stage, crop, cost, etc.
### Economic Thresholds Nebraska

**Table 1. Treatment guidelines based on number of grasshoppers (nymphs and adults) per square yard.**

<table>
<thead>
<tr>
<th>Grasshopper Population</th>
<th>Within Fields</th>
<th>Field Borders</th>
<th>Treatment necessary?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-economic</td>
<td>0-2</td>
<td>5-10</td>
<td>No</td>
</tr>
<tr>
<td>Light</td>
<td>3-7</td>
<td>11-20</td>
<td>Uncertain – depends on size, species, type of crop</td>
</tr>
<tr>
<td>Moderate</td>
<td>8-14</td>
<td>20-40</td>
<td>Probably</td>
</tr>
<tr>
<td>Abundant</td>
<td>15 or more</td>
<td>41 or more</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Grasshopper Control

• Mechanical
  • Cultivation
    • Eggs do not persist in cultivated fields
  • Mowing
    • Eliminates food source
    • Double edge sword

Photo courtesy of: https://www.haugimp.com/
Grasshopper Control

- Biological
  - Birds, spiders, rodents, fungal pathogens (various species)
  - Nolo bait or Semaspore bait, etc.
    - Protazoa infect grasshoppers/Mormon crickets
    - Deformities, slows growth
    - Does not stop feeding immediately!
    - Needs reaplication

Insecticidal Control Rangeland

- RAAT Treatments (Reduced Area-Agent Treatments)
  - Only treat part of acreage 35-80%
- Rangeland treatments
- Reduce cost of treated acreage
- Insects move from untreated to treated residual activity
- Provide haven for beneficial insects/food for birds
- UC IPM - treat young grasshoppers outside of crops
Wyoming Studies

- Products used in study
  - Carbaryl, Malathion, Dimilin
- Applications made to early instars!!
- Dimilin only effective on first three instars
- Blanket/Broadcast treatments
  - 85-99% grasshopper control
- RAAT Treatments
  - 75-90% grasshopper control
  - 50% of the cost
- Information courtesy of the University of Wyoming
  - Dr. Alex Latchininsky
Insecticides

• Generally much more effective on nymphs
• Dimilin only effective on first three instars - Timing!
• Pyrethroid better on adult grasshoppers
  • Not very selective
  • More non-target impacts

Photo courtesy of: The University of Wyoming
Buffer Zone with Baits

• Non-vegetated zone
  • 60 ft. zone
• Utilize carbaryl baits
• As hoppers migrate to fields eat the baits
## Select Insecticides for Grasshoppers (product/acre)

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Active</th>
<th>Chemical group</th>
<th>Alfalfa</th>
<th>Grasses</th>
<th>Rangeland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sevin 4F</td>
<td>Carbraryl</td>
<td>1-A</td>
<td>NO</td>
<td>NO</td>
<td>1 pint</td>
</tr>
<tr>
<td>Malathion 57</td>
<td>Malathion</td>
<td>1-B</td>
<td>1.5-2 pints</td>
<td>1.5-2 pints</td>
<td>1.5-2 pints</td>
</tr>
<tr>
<td>Besige</td>
<td>chlorantraniliprole and lambda cyhalothrin</td>
<td>28+3</td>
<td>6-10 oz</td>
<td>6-10 oz</td>
<td>6-10 oz</td>
</tr>
<tr>
<td>Baythroid XL</td>
<td>cyfluthrin</td>
<td>3</td>
<td>2-2.8</td>
<td>2.6-2.8</td>
<td>2.6-2.8</td>
</tr>
<tr>
<td>Warrior 2</td>
<td>lambda cyhalothrin</td>
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<td>1.28-1.92 oz</td>
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</tr>
<tr>
<td>Mustang</td>
<td>zeta-cypermethrin</td>
<td>3A</td>
<td>3-4.3 oz</td>
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<td>3-4.3 oz</td>
</tr>
<tr>
<td>Dimilin 2l</td>
<td>diflubenzuron</td>
<td>15</td>
<td>NO</td>
<td>.75-1oz</td>
<td>.75-1oz</td>
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<tr>
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<td>28</td>
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<tr>
<td>Steward</td>
<td>Indoxacarb</td>
<td>22</td>
<td>6.7-11.3 oz</td>
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<td>NO</td>
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<td>Insecticide</td>
<td>Active Component</td>
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Alfalfa Weevils
Alfalfa Weevils (Egyptian, Western, and Eastern strains)

• Yield and quality loss, first and sometimes second cutting
• 1 generation/year (sometimes 2)
• Likely all same species (look alike but behavioral differences)
• Introduced pest from Eurasia (early to mid 1900’s)
Weevil Biology

- Mating occurs late fall or early spring
  - Eggs laid on stem
  - Hatch late March early April

- 4 instars over 3-4 weeks
  - First pale in color to green

- Spin cocoons 1-2 weeks adults emerge
  - Small amount of feeding
  - Enter resting period

Photo courtesy of: UC IPM
### Alfalfa Weevil Behavioral Differences

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Western</th>
<th>Egyptian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate preference</td>
<td>Cool, cold</td>
<td>Hot, dry</td>
</tr>
<tr>
<td>Migrate out of fields</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Aggregate during summer aestivation</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Pupate</td>
<td>In leaf litter</td>
<td>On plant</td>
</tr>
<tr>
<td>Population peak</td>
<td>1-3 weeks later</td>
<td>1-3 weeks earlier</td>
</tr>
<tr>
<td>Biocontrol, by parasitoid wasps</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Wolbachia, endosymbiotic bacterium*</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

*May account for behavioral differences
Biocontrol (Surveys in 2004-2005)

Parasitism by wasps:
• Central Valley: 0-14%
• Intermountain Area: 15-17%

Soil dwelling fungus, *Zoophthora phytonomi* (warm, moist conditions)
• Central Valley: <1% in 2004, 30% in 2005
• Intermountain Area: 0% in both years
Management Practices, Cultural:

- Early harvest: Yield loss to first and likely damage under windrows
- Overseeding: Other forages, but changes forage quality (know markets)
- ‘Sheeping-off’: Need sheep and may not reduce to economical levels
Insecticides: 4 MOA’s for Weevils in Alfalfa

➢ OP’s: Lorsban, Malathion, Imidan
➢ Pyrethroids: Mustang, Warrior, Baythroid
➢ Steward
➢ Entrust (organic, suppression only, 70%)
### % Alfalfa Weevil Mortality from Baythroid & Warrior

<table>
<thead>
<tr>
<th>Field Site</th>
<th>Recommended Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic field</td>
<td>92%</td>
</tr>
<tr>
<td>Conventional Fields 1-4</td>
<td>3-15%</td>
</tr>
</tbody>
</table>

Orloff et al. 2016. Alfalfa and Forage Blog, Alfalfa weevil resistance to pyrethroid insecticides found in Intermountain alfalfa fields.
<table>
<thead>
<tr>
<th>Treatment and Rate</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>--</td>
</tr>
<tr>
<td>Imidan 70W</td>
<td>16 oz</td>
</tr>
<tr>
<td>Imidan 70W+Dimethoate</td>
<td>16 oz+1 pt</td>
</tr>
<tr>
<td>Lorsban</td>
<td>2 pt</td>
</tr>
<tr>
<td>Warrior II</td>
<td>1.92 oz</td>
</tr>
<tr>
<td>Warrior II+Lorsban</td>
<td>1.92+2 pt</td>
</tr>
<tr>
<td>Steward</td>
<td>5 oz</td>
</tr>
<tr>
<td>Steward</td>
<td>8 oz</td>
</tr>
<tr>
<td>Malathion 5E</td>
<td>1.5 pt</td>
</tr>
<tr>
<td>Steward+Lorsban</td>
<td>5 oz+1.5 pt</td>
</tr>
<tr>
<td>Steward+Warrior II</td>
<td>5 oz+1.92 oz</td>
</tr>
<tr>
<td>Steward+Malathion</td>
<td>5 oz +1.5 pt</td>
</tr>
<tr>
<td>Steward+Dimethoate</td>
<td>5 oz+1 pt</td>
</tr>
<tr>
<td>Steward+Imidan</td>
<td>5 oz+12 oz</td>
</tr>
</tbody>
</table>

Orloff, 2017, Siskiyou County, Treated 5/8/17
Note: Baythroid and Lannate short residuals for weevil control, Sevin burns foliage
Alfalfa Weevil Numbers in Untreated Control Plots

Weevils per sweep vs Date

Date: 5/12, 5/14, 5/16, 5/18, 5/20, 5/22, 5/24, 5/26, 5/28, 5/30
The bar chart shows the percent larval control at 10 days for different treatments:

- Imidan 70-W 16 oz
- Lorsban 32 oz
- Warrior 1.92 oz
- Warrior 1.92 oz + Lorsban 32 oz
- Malathion 8E 1.5 pt
- Steward 5 oz
- Steward 8 oz
Percent Larval Control

- Imidan 70-W 16oz
- Lorsban 32oz
- Warrior 1.92oz
- Warrior 1.92oz + Lorsban 32oz
- Malathion 8E 1.5pt
- Steward 5oz
- Steward 8oz

15 Days
First Cutting Yields Steward Treatments
0.4 tons/ac yield increase

- Control: A
- Steward 5oz: B
- Steward 8oz: B
Cost of Select Insecticides per Acre for Weevil Control

If hay $200/ton and spray costs $20, only need 0.1 tons yield increase to justify spray
(Orloff data shows 0.4 tons/ac yield increase from spray)
Economic Threshold Levels

- Spray Timing: Monitor weevils and time sprays to get good control (too early and may have to treat 2x).

- Current threshold: 20 weevils per sweep (likely closer to 8-10 weevils per sweep as value of hay is higher than in 1970’s).
• For stubble stands that are too short to sweep, monitor visually for weevil damage.
Alfalfa can recover (regrow) from weevil damage, depending on weevil pressure and time to first cutting (doesn’t stunt growth, except perhaps stubble fields).
Future Research Needs

• New insecticide chemistries (ai’s) for alfalfa weevil control

• Re-evaluate weevil threshold levels

• Understand weevil strains in California

• Develop resistant plant varieties: Plant incorporated protectants such as increased tannins for weevil resistance and better feed value (less bloat)

Focus of current work with a CA DPR grant awarded to Dr. Godfrey (now managed by D. Putnam and R. Long, 2016-19).
This presentation is dedicated to our colleague and friend, Steve Orloff. May you be surfing an eternal wave!
Sources

- http://www2.ipm.ucanr.edu/WhatIsIPM/
- http://ipm.ucanr.edu/PMG/r785300611.html
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- https://extension.umd.edu/learn/grasshoppers-life-cycle-and-control