It's Complicated:

Herbicide vs. Insecticide vs. Fungicide Resistance Management Strategies

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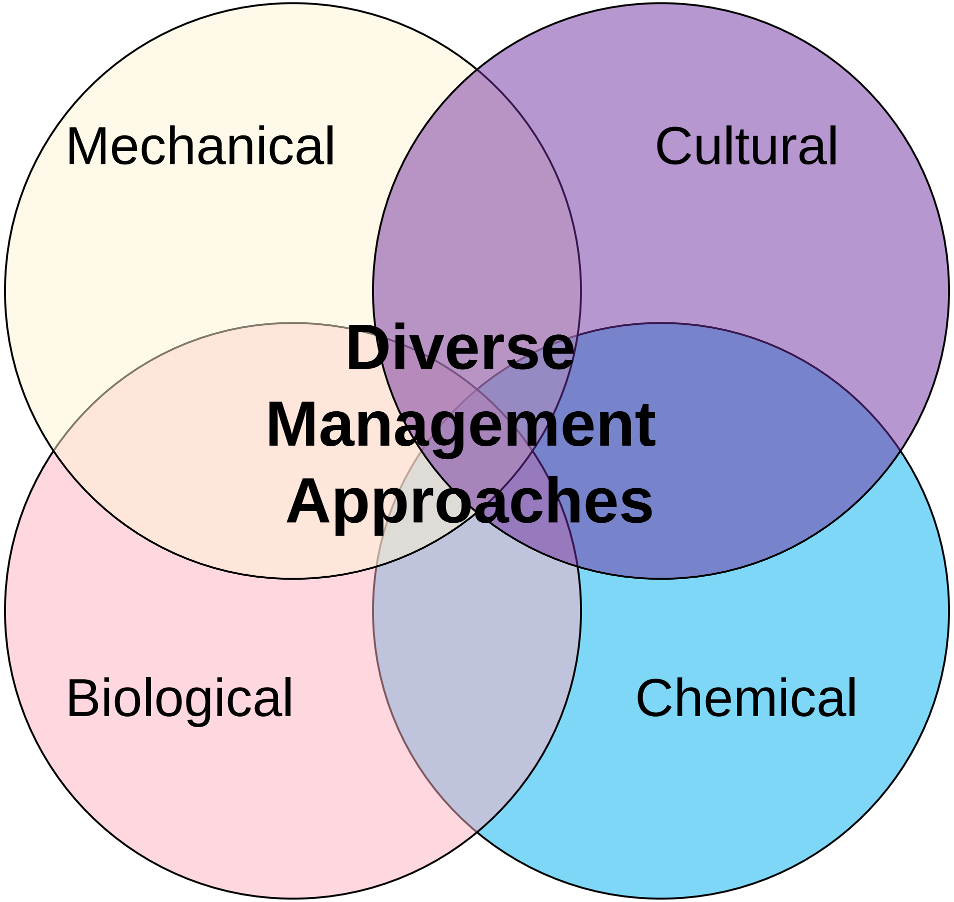
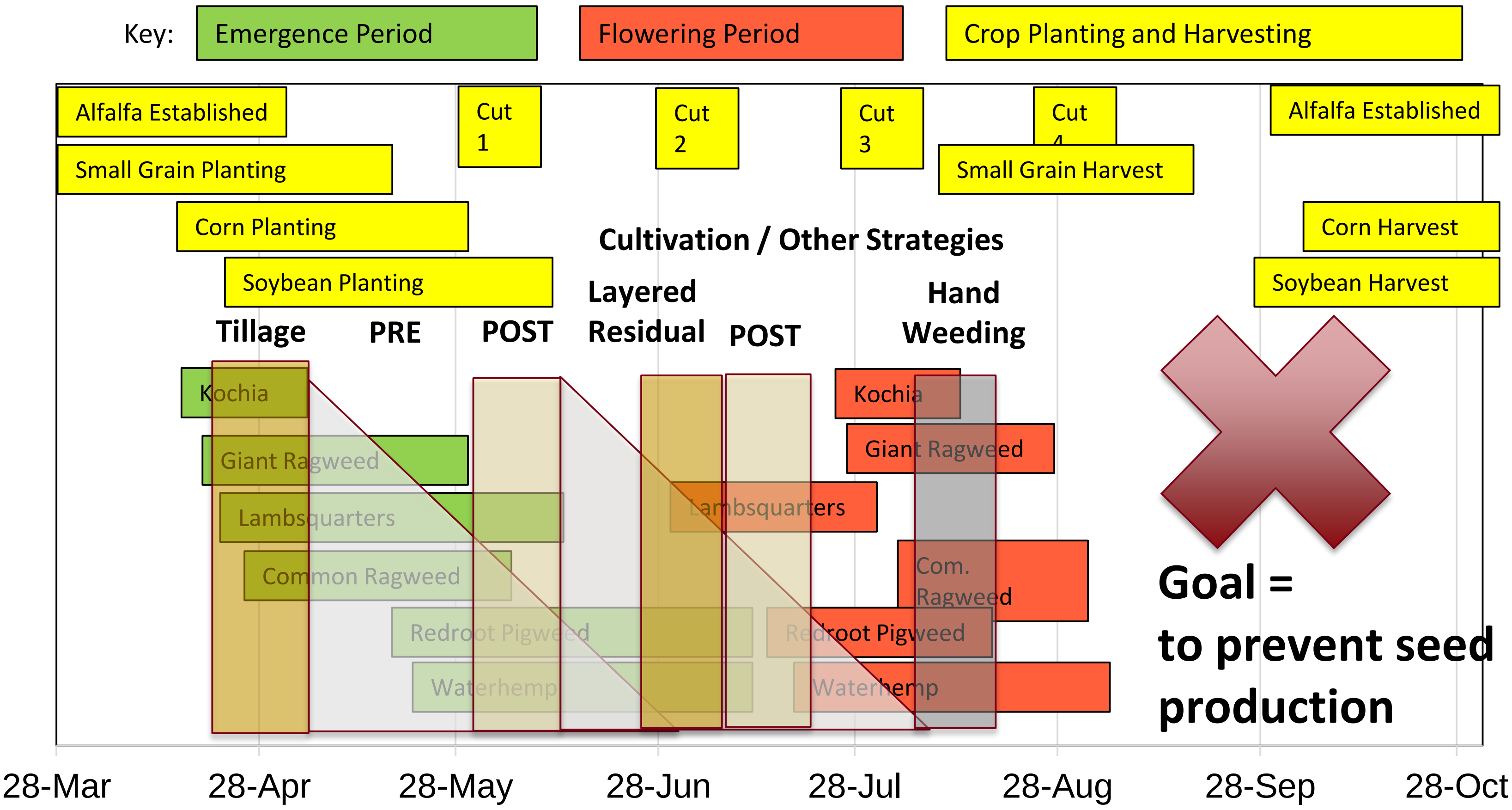
Integrated Pest Management

How do you decide when to manage a Pest:

Core Principles of IPM

- **Identify** and **Monitor** Pests
- **Preventive** Management
- Action **Thresholds** / Economics
- Select Appropriate **control** measures


Mechanical
Cultural
Diverse
Management
Approaches
Biological
Chemical



Adapted from Werle et al. 2014, Goplen et al. 2017, Weedometer 2008

Economic Threshold

ET is a time to take action.

“. . . the population density at which control action should be determined (initiated) to prevent an increasing pest population (injury) from reaching the economic injury level."

Source: Stern, V. M., R. F. Smith, R. van den Bosch, and K. S. Hagen. 1959. The integrated control concept. Hilgardia 29:81101.

Economic Threshold

Nominal threshold

- Based on a practitioner's experience
- Represent many published ET’s
- **Not based** on a calculated ***Economic Injury Level*** (EIL).
- Are more progressive than using no ET at all

Objective threshold

- These **are based** on calculated ***Economic Injury Level*** (EIL).
  a) fixed ETs,
  a) descriptive ETs,
  b) dichotomous ETs

Source:

- *Pedigo, L. P., S. H. Hutchins, and L. G. Higley. 1986. Economic injury levels in theory and practice. Annu. Rev. Entomol. 31:341368.*
- *Poston, F. L., L. P. Pedigo, and S. M. Welch. 1983. Economic injury levels: reality and practicality. Bull. Entomol. Soc. Am. 29:4953.*

Economic Threshold

Plant Disease:

- Detection – Warning – Action thresholds
- Models forecasting RISK
- Maximize expected net returns
- **Preventive vs Curative**

Weed:

- Long-term approach - deplete seedbank
- Field history and Species present
- Scout for Density and Competition
- **Preventive**

Insect:

- Many Nominal and Objective ET's
- Scouting protocols based on ET
- Timely management and increased efficiencies
- **Responsive** to current observations

Chemical Strategies

Plant Disease:

- Host – Pathogen - Environment
- Protect plant from infection
- Single-site or Multi-site fungicide

Insect:

- **Single** or Multiple Target species
- Narrow vs Broad-spectrum
- Resurgence or Multiple generations

Weed:

- Number of weed species
- How many Active Ingredients needed
- Timing strategies

Over Reliance on Chemical Classes can result in resistant pest populations

- ***Pesticide resistance*** *is a change in response by pest population over time.*
- ***Pesticide tolerance****, there is no change overtime*

  Inherent tolerance - baseline susceptibility before exposure to pesticide.

Herbicide Resistance Management

Herbicide Resistance Action Committee (HRAC) **Recommendations**

1. **Avoid continued use** of the same herbicide or herbicides having the **same site of action** in the same field, unless it is integrated with other weed control practices
2. **Limit** the number of **applications** of a single herbicide or herbicides having the **same site of action** in a **single growing season**
3. Where possible, **use mixtures or sequential treatments** of herbicides having a **different site of action** but which are active on the same target weeds
4. Use **non-selective herbicides** to control **early flushes of weeds** (prior to crop emergence) and/or weed escapes
5. To retain these valuable tools, chemical rotation must be employed in association with **other weed control measures**

HRACGlobal.com

Fungicide Resistance Management

Fungicide Resistance Action Committee (FRAC) Recommendations

1. Use different modes of action applied as: **Alternate** Fungicides or Fungicide **Mixtures**
2. Reasons for Fungicide tank mixes:
   a) ***Improved disease control***
      - broaden the spectrum of disease control
      - increase the effectiveness by taking advantage of additive or synergistic interactions

   b) ***Disease control security when resistance is present.***
      - user may not be aware of the resistance status of the population

   c) ***Resistance management.***
      - at least **two components** of the mixture **have activity** against the field populations of the target pathogen **when used alone**,
      - components of the mixture **must not be cross-resistant**
      - **dose rates** of each AI in the mixture should provide **sufficient control when used alone**
      - Common mixtures are ***Single-site fungicides*** mixed with ***Multisite fungicides*** (with low resistance risk)

www.frac.info

Insecticide Resistance Management

Insecticide Resistance Action Committee (IRAC) **Recommendations**

1) **Rotation of Insecticide Modes of Action** is considered the **most effective IRM approach**.
2) **If Considering Insecticide Mixtures** for insect management:
    - Insecticide Mixture is **pest management**, not resistance management.
    - **Broadens the range of pests** controlled
    - Insecticide mixtures still **require rotation strategies** with additional mode(s) of action for IRM
    - **Do Not Rely** on a **Single Mixture**.
3) **If using mixtures for IRM**, Consider the following :
    - **Individual insecticides** selected for use in mixtures **should be highly effective**
    - **Apply at the rates** at which they are **individually registered** for use against the target species.
    - **Do Not Use Mixtures** with the **same** IRAC **Mode of Action** classification
    - Be aware of **Cross - Resistance** issues
    - **Mixtures** become **less effective if resistance is already developing** to one or both active ingredients

www.irac-online.org

Insecticide Resistance

The speed at which resistance develops is affected by:

- how fast the insects reproduce
- the migration and host range of the pest
- availability of nearby susceptible populations
- persistence and specificity of the crop protection product
- rate, timing and number of applications made
- Innate ability of an insect species to adapt to toxins

Insecticide-resistant aphids

Species	Insecticides resisted
Green peach aphid	BPU, C, **Nic**, OC, **OP**, **Py**
Cotton/melon aphid	C, OC, **OP**, **Py**
Greenbug	**OP**
Hop aphid	C, **OP**, **Py**
Currant-lettuce aphid	C, OC, **OP**
Rosy apple aphid	C, **OP**, **Py**
Potato aphid	C, **OP**, **Py**
Cowpea aphid	Nic, C, **OP**, **Py**
Bean aphid	C, **OP**
Buckthorn aphid	C
Turnip aphid	**OP**, **Py**
Bird cherry-oat aphid	**OP**
Spotted alfalfa aphid	C, **OP**

Aphids

- Short generation time
- Numerous generations/year
- High reproductive rate
- “clones”

BPU: benzoylphenyl ureas;
C: carbamates;
Nic: nicotine/neonics;
OC: organochlorines;
OP: organophosphates;
Py: pyrethroids

Foster et al. 2007

Summary: Resistance Management

- Integrated Pest Management Principles
- Diversify Management Strategies
- Rely on Economic Thresholds for Guidance
- Chemical Control – Resistance Management
- Pesticide Mixtures ?
  - Weeds and Diseases – Yes
  - Insects – NOT preferred

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