I ILLINOIS

Crop Sciences

COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

MORE THAN MEETS THE I

INTEGRATED WEED MANAGEMENT IN ORGANIC SYSTEMS

Dr. Adam Davis, Prof. & Head







Spinners in soybeans.

Photo: Dale Mutch



Bezzerides tools and mounting frame

Photo: David Vradenburg Sr.



Spring hoes

Photo: David Vradenburg Sr.



Organic soybeans, Wiley farm, 7/23/04.

Photo: Adam Davis





Some reasons to avoid over-reliance on soil disturbance for weed control

- Weed species may not be a good target for cultivation
 - Extended germination period
 - Difficult to uproot
 - Vegetative reproduction
 - Etc.
- Vulnerability to wet soil conditions
- Extra trips through the field
- Destruction of soil organic matter and aggregate stability



Use cultivation to **tune**, rather than **drive**, weed management system

Davis et al. 2012



Integrated weed mgt.

- Not just a set of tools
- Need to know your weeds
- Choose appropriate tactics
- Spread tactics throughout weed life cycles
- Manage for the long-term
- Build weed suppressive cropping systems
- Begin with prevention

Weed-suppressive cropping systems...

- Prevent germination
- Prevent seedling establishment
- Reduce weed competition
- Reduce seedbanks
 - Reduce seed production
 - Prevent seed return
 - increase seed predation
 - increase seed decay

Know your weeds: life history



Artwork: Cherie Earle

Weed life history: I. summer annuals





tall waterhemp (Amaranthus tuberculatus)

Source: Cavigelli et al. 2000

Weed life history: II. winter annuals





marestail (Conyza canadensis)

Weed life history: III. biennials





wild carrot (Daucus carota)

Source: Cavigelli et al. 2000

Weed life history: IV. perennials





Canada thistle (Cirsium arvense)

Source: Cavigelli et al. 2000

Highest priority management targets, by life history

annual

biennial

perennial









rosettes, seedlings > seeds

rosettes > seedlings > adults > seeds

Davis. 2006. Weed Sci. 54: 558-565

Plan rotation phases to disrupt weed life cycles





Target all stages of life cycle



'Many little hammers' (Liebman and Gallandt, 1997)

Artwork: Rich Smith

Summer annual weed – Spring-planted crop



Davis et al. (2005) Integrated weed management



https://drive.google.com/file/d/1tWeFijB dw47KvFdmcuKyJWC3ZrEtBwK5/view

Figure 1. The relationship between field operations for a spring-planted crop (yellow) and life cycle of a summer annual weed (green). Dotted lines show weed management opportunities throughout the year. Source: Adam Davis.

Potential sources of weed management benefits Stage seed decay (Ch. 9), seed predation (Ch. 9), seed aging (Ch. 1), depth A placement of seeds (Ch. 4), loss of seed dormancy (Ch. 1) fatal germination (Ch. 1), allelopathy (Ch. 3), stale seedbed (Ch. 7), В mulch/cover crop (Ch. 3), seed-soil contact (Ch. 2), PRE herbicide (Ch. 8), physical control (Ch. 7), POST herbicide (Ch. 8), crop competition (Ch. 5) С D hand weeding (Ch. 7), swathing (Ch. 7), herbivory (Ch. 9), crop competition (Ch. 5) seed predation (Ch. 9), seed removal with chaff (Ch. 10), mowing (Ch. 7), E stubble burning (Ch. 7), sanitation (Ch. 10), fencerow maintenance (Ch. 10)



Davis et al. (2005) Integrated weed management



https://drive.google.com/file/d/1tWeFijB dw47KvFdmcuKyJWC3ZrEtBwK5/view

Figure 2. The relationship between field operations for a fall-planted crop (orange) and life cycle of a winter annual weed (green) in a no-till system. Dotted lines show weed management opportunities throughout the year. Source: Adam Davis.

Stage Potential sources of weed management benefits

 A seed decay (Ch. 9), seed predation (Ch. 9), seed aging (Ch. 1), loss of seed dormancy (Ch. 1)
 B sanitation (Ch. 10), fencerow maintenance (Ch. 10), fatal germination (Ch. 1), allelopathy (Ch. 3), PRE herbicide (Ch. 8)
 C,D POST herbicide (Ch. 8), crop competition (Ch. 5)
 D hand weeding (Ch. 7), swathing (Ch. 7), herbivory (Ch. 9)
 E herbivory (Ch. 9), mowing (Ch. 7), mulch/cover crop (Ch.3)



Davis et al. (2005) Integrated weed management



https://drive.google.com/file/d/1tWeFijB dw47KvFdmcuKyJWC3ZrEtBwK5/view

Figure 3. The relationship between field operations for a spring-planted crop (orange) and life cycle of a perennial weed (green). Dotted lines show weed management opportunities throughout the year. Source: Adam Davis.

- Stage Potential sources of weed management benefits
 - tillage (Ch. 4), PRE herbicide (Ch. 8)

А

- B physical control (Ch. 7), POST herbicide (Ch. 8), crop competition (Ch. 5)
- C hand weeding (Ch. 7), swathing (Ch. 7), herbivory (Ch. 9), crop competition (Ch. 5)
- D mowing (Ch. 7), fall herbicide application (Ch. 8), seed predation (Ch. 9)



Use a diverse set of tools





Manage weed seedbanks





Davis et al. (2005) Integrated weed management

Weed seedbank is persistent, but don't give up!

Weed species	Years for 50% reduction in seedbank (Burnside et al. 1996)	Years for 50 % reduction in seedbank (Davis et al. 2016)
common lambsquarters	12	2
velvetleaf	8	2.4
smartweed	4	0.5
redroot pigweed	4	1.8
common ragweed	2.5	0.7
giant foxtail	< 1	1
kochia	< 1	0.12
		^

The way these data were I I estimated was biased in towards longevity (stored al in glass jars).

I have more confidence in these numbers (seeds allowed to germinate and exposed to predators).



Davis et al. 2016

Tillage as one-time rescue for massive seed input



Photo: Adam Davis



Percentage of seeds at depth

Mohler (2001)

How can we target the weed seedbank?

• Reduce persistence:

- Conservation biocontrol
 - decay by soil/seed microbes
 - post-dispersal seed predation
- Depth control
 - Fatal germination
 - Stale seedbed
- Reduce inputs
 - Competitive crop cultivars
 - Pre-dispersal predation
 - Damage seeds





Combine harvesters are one of the most efficient weed seed dispersal

devices ever invented.





2 m



The Harrington "Seed destroyer": will it work here too?



https://will.illinois.edu/agriculture/note/42130



Weight: 12,000 lbs; tow hitch wt: 992 lbs Engine: Cummins QSB6.7, 205 hp @ 1800 rpm Cage mill: 188 hp @ 1400 rpm Harvest speed: no restriction Source: DeBruin Engineering, Australia

www.debruinengineering.com.au



Waterhemp (Amaranthus tuberculatus) seed after HSD treatment

Photo: Nick Hausman


In stationary trials, the HSD reduced weed seed viability by ≥ 99%



Shergill et al. 2020

Weed seed capture varies by species, year, harvest date



Lazaro et al. in press

HSD reduced waterhemp seed return by 70 to 80%



Davis et al., unpubl.

HSD reduced waterhemp seedling emergence following HSD in soybean



Davis et al., unpubl.



Cropping system diversification to build weed suppressive cropping systems



IDEA Farm Network Field Day, Lily Lake IL, 8/30/17



buckwheat 8/30/17 Lily Lake, IL



sorghum sudangrass 8/30/17 Lily Lake, IL



Crop-centric fertility



Nitrogen synchrony in row crop ecosystems



Figure 4. Nitrogen synchrony in row crop ecosystems. Source: Cavigelli et al., 1998.





Rasmussen 2002

Green manures for allelopathy



FIGURE 1. Germination inhibition (A) and radicle inhibition (B) of seeds in Experiment 1 as a function of seed mass and taxonomic class (monocot vs. dicot). Eighteen weed and 44 crop accessions were exposed to a 2% aqueous extract of Marathon red clover or distilled water. See text for methods of calculating germination inhibition and radicle inhibition. Conklin et al. 2002. Plant & Soil. 238: 245-256 Liebman & Sundberg. 2006. Weed Sci. 54:340-345.





Counterclockwise, from top right: roller being used to kill hairy vetch cover crop; close-up of roller showing blades for crimping stems; dead vetch residue several days after rolling.

Photos: Dale Mutch







Davis (unpublished)



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RESEARCH ARTICLE

Increasing Cropping System Diversity Balances Productivity, Profitability and Environmental Health

Crop rotation

Marsden Farm Boone, IA Dr. Matt Liebman, PI



Davis et al. 2012 PLOS ONE 7(10): e47149



Davis et al. 2012 PLOS ONE 7(10): e47149



Marsden Farm

with red clover, early fall after summer's growth









Diverse crops can provide year-long cover to seed predators



Heggenstaller et al. (2006)













after Liebman and Staver, 2001

Disruption of weed life cycles





Physical control







Adding sunflowers into a crop rotation can help clean up a weed field because sunflowers can be cultivated very aggressively.





Source: Phil Sarver

Flame-weeder with tent shields to concentrate heat



Source: Adam Davis



Source: Bo Melander



Competitive crop cultivars


Integrated weed management Is an investment

Economic submodel



Liebman and Davis (2009)

Hand weeding intra-row weeds:

ROWN

200-500 hours per hectare in carrot and direct sown onion and leek

Melander and Rasmussen, 2001

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DIAS



Liebman and Davis (2009)



The most important weed management tool on your farm









Thoughtful weed management

- Weed community
 - biology of dominant species
 - spatial distribution on farm, population densities
- How are weeds defeating current mgt. system?
 - emergence timing
 - resistance
 - overwhelming seedbank
 - competition
- What individual tools have an effect on problem weeds?
- How can these tools be combined, and varied over time, to be effective for years to come?
 - Use cultivation to tune, not drive, weed management system
 - De-emphasize 'big-hammer' approaches
- Pay attention, and adjust strategy: adaptive management