

# Ecology of Weed Management in Organic Systems

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# Outline

- **Intro – How to think about weeds and weed management**
- **Perennial weeds: exhausting reserves**
- **Seed germination and tillage**
- **Seed survival in the soil and tillage**
- **Season of germination and crop rotation**
- **Seed size, growth rate and the competition between weeds and crops**
- **Nutrients and weed management**
- **Prevention**
- **Conclusions**

# Weeds are plants that thrive in disturbed environments

- **For example, in a farm field**
- **Our crops are mostly annual plants - they live for one season**
- **We kill off natural vegetation & disturb the soil to make conditions suitable for crops**
- **But this also creates habitats for weeds**

Understanding the biology of weeds is a key to their control

- **Managing the weeds without harming your crops depends on the biological differences between the weeds and crops.**

# Ecological weed management requires multiple tactics

- Conventional agriculture relies on a few big hammers (broad spectrum herbicides)



# Ecological weed management relies instead on many little hammers



Crop rotation



Enhanced crop competition



Mulches



Nutrient management



Timing and type of tillage



Cultivation



Any little hammers

- Requires an integrated approach
- Based on the biological characteristics of the weeds present in a particular field

# System re-design

1. Get to know the weed species you have – who they are, how they make a living
  - And your soil, crops, cover crops, pests etc. too
2. Design your system to prevent the weeds from causing problems
  - And supply nutrients, insure crop health etc.
3. Return to 1 (keep learning and tinkering)

Ecological management works best for people who find learning fun.



# Multiple ways to be a weed

- Annuals
  - Summer annuals
  - Winter annuals
- Perennials
  - Stationary perennials
  - Wandering perennials

# Perennial weeds

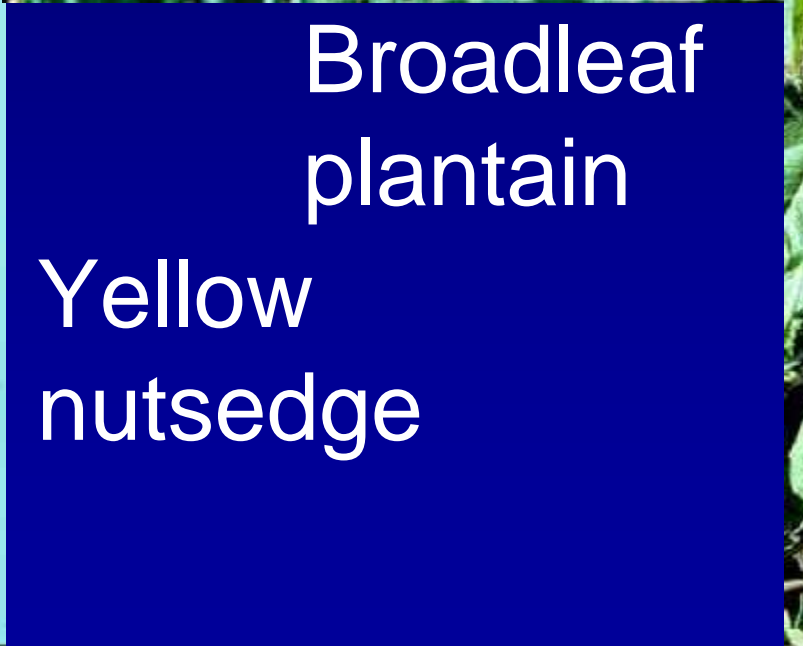
-- where is the food stored?

- **Stationary**

- Taprooted – dandelion, curly dock
- Fibrous rooted – plantain

- **Wandering**

- Bulb – nutsedge, wild garlic
- Shallow storage organ – quackgrass, perennial sowthistle
- Deep storage organ – bindweeds, milkweed



Common  
bindweed

Broadleaf  
plantain

Yellow  
nutsedge



# Stationary perennials

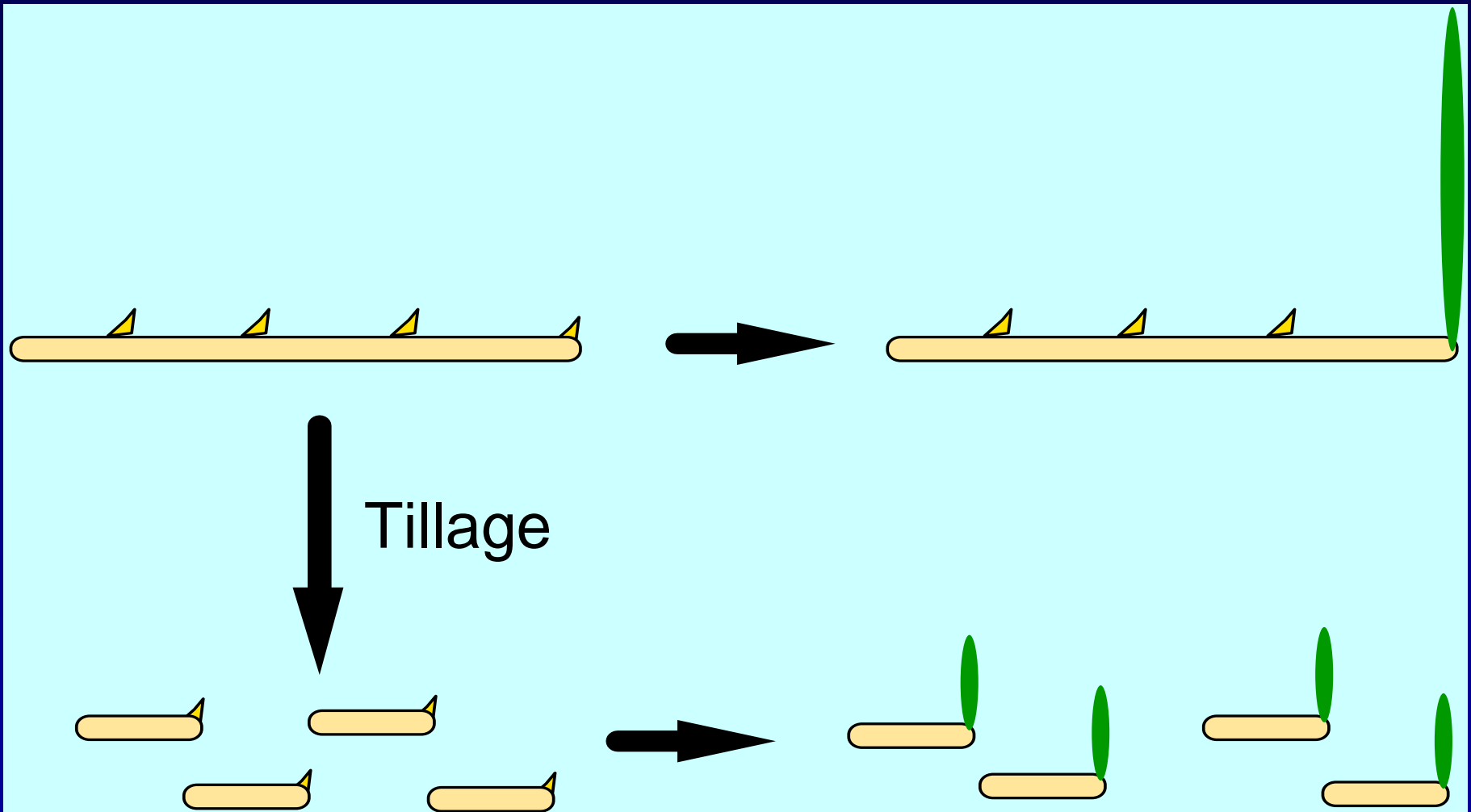
- **Mostly a problem of hay fields and pastures**
- **Usually not competitive the first year**
- **“Easily” eliminated by tillage**
- **Establish from seed**
- **Control in adjacent habitats**

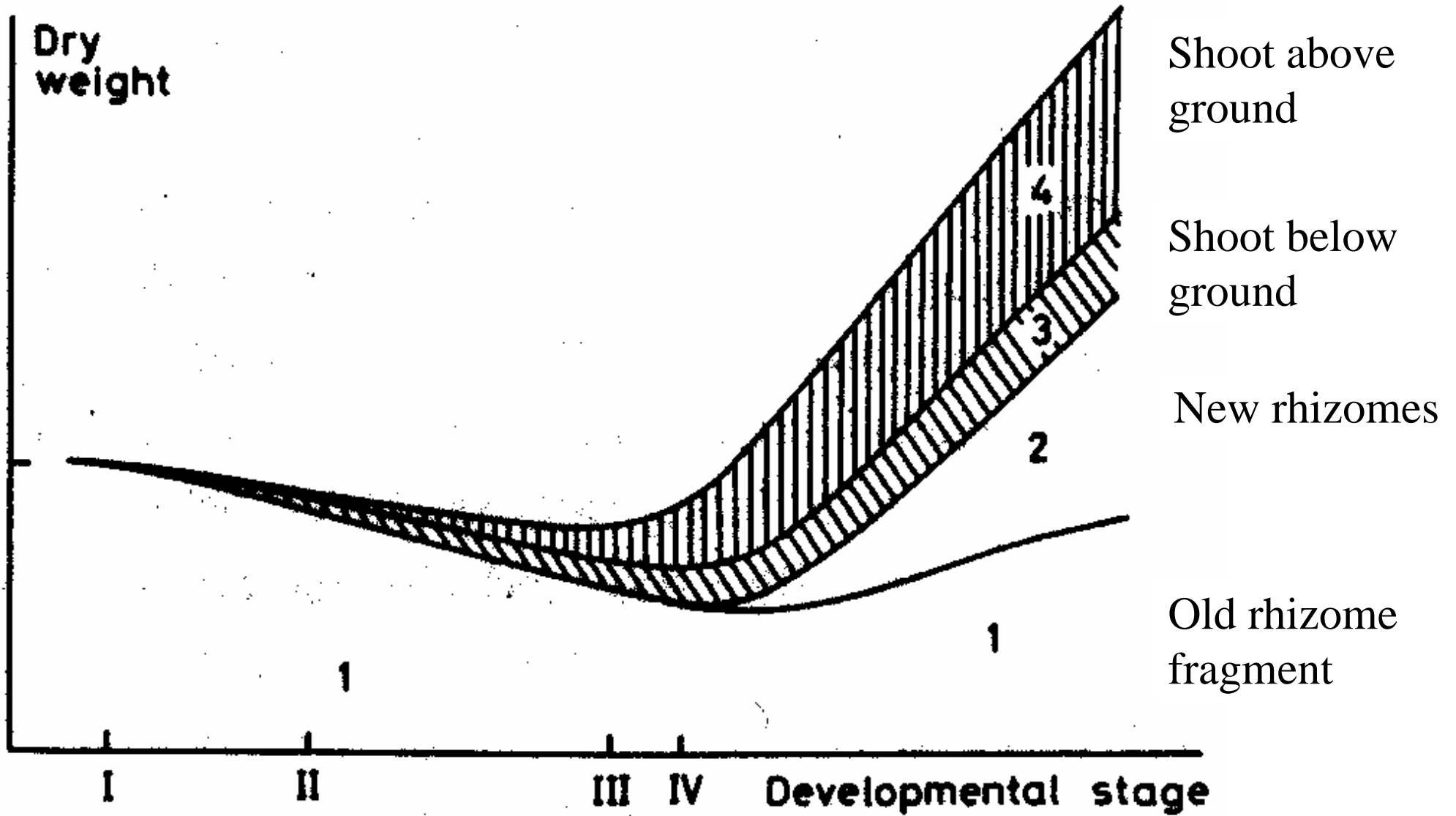
# Wandering perennials



- **Spread by thickened storage roots or by rhizomes (underground stems)**

# Apical dominance in perennials





# Management of perennials

- Key is exhaustion of reserves.
- Time relative to growth – 3 leaf rule
- Shallow roots & rhizomes – chop & bury,
- Deep roots & rhizomes – hit them low and often
- Competitive crops, frequently cultivated crops, short season crops



# Annual weeds

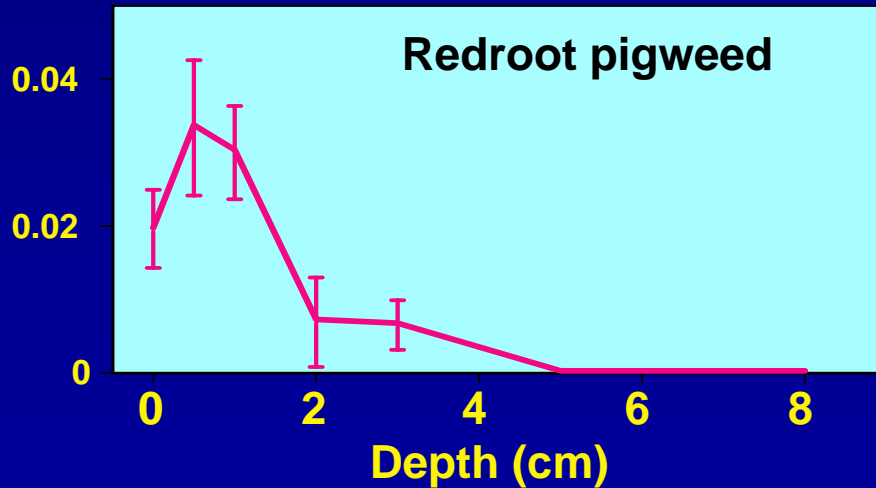
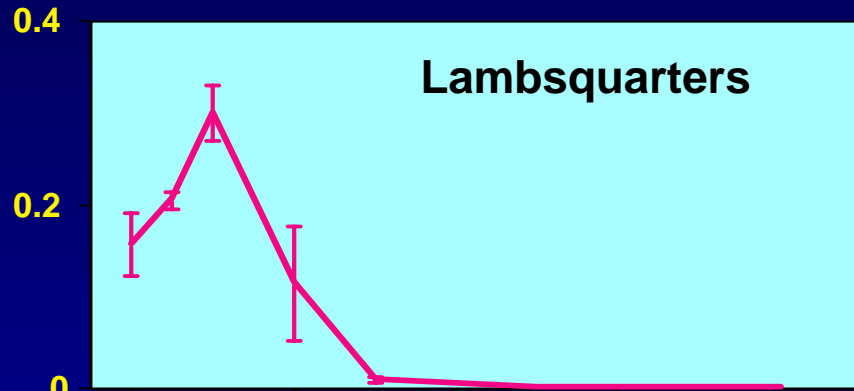
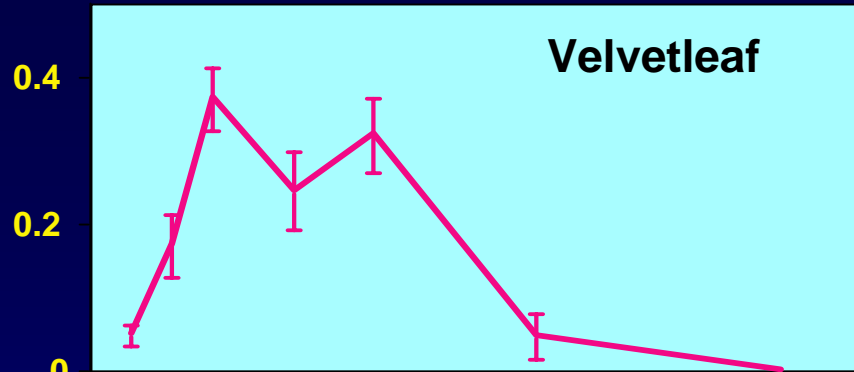
- **Live less than one year**
- **Establish from seed each year**
- **Seeds/seedlings are critical stages**

# Seeds of most weeds are tiny – why?

- • **Disturbed environments are risky**
- **Tiny seeds spread the risk over many offspring**
- **Seedlings can be small because in a recently disturbed environment they have little competition.**
- **Seedlings have limited resources**

Small seeded species only emerge if near the soil surface

Proportion emerging



# Germination cues

- **Seedlings compete poorly with established plants**
- **So weed seeds need to know when other plants are absent**
- **Respond to cues associated with**
  - **absence of plants**
  - **Near-surface conditions**
  - **soil disturbance**

Light promotes germination of most weed species

<u>Species</u>	<u>% Germination</u>	
	Light	Dark
Redroot pigweed	98	14
Annual bluegrass	89	1
Purslane	28	12



Common  
purslane

Redroot  
pigweed



# Warm temperatures

## Redroot pigweed

<b>Location</b>	<b>68° F</b>	<b>95° F</b>
<b>New York</b>	<b>6</b>	<b>93</b>
<b>N. Dakota</b>	<b>23</b>	<b>80</b>
<b>Minnesota</b>	<b>15</b>	<b>100</b>

# Day/night temperature fluctuation

<b>Species</b>	<b>%Germination</b>	
	<b>+Fluct.</b>	<b>-Fluct</b>
<b>Chickweed</b>	<b>93</b>	<b>47</b>
<b>Curlydock</b>	<b>100</b>	<b>0</b>





Curly dock

Common  
chickweed



# Response to chemical environment

- **Absence of volatiles (like ethanol and acetone)**
  - Velvetleaf, tall morningglory
- **Presence of nitrate**
  - lambsquarters



Velvetleaf

Lambsquarters

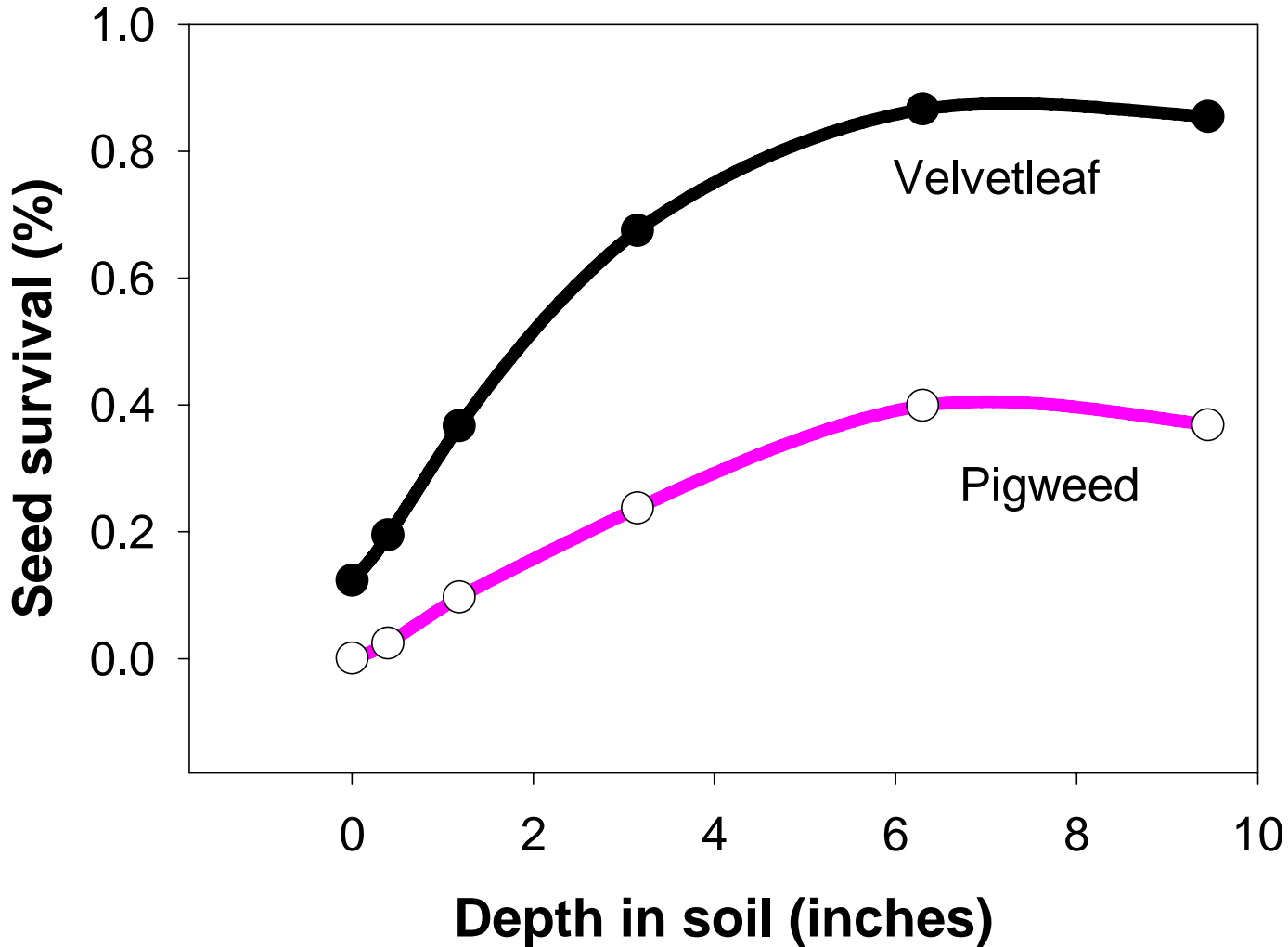


# Consequences

- **Can use tillage to flush seeds out of the soil**
  - **Cultivated fallow**
- **Conversely, soil cover and absence of tillage suppresses germination of weed seeds**
  - **Stale seedbed**
  - **Mulch**
  - **Dense crop canopy**

# Seed longevity

Species	Loss per year (%)	
	Cultivated	Uncultivated
Lambsquarters	31	8
Annual bluegrass	26	22
Common chickweed	54	32
Common groundsel	High	45



Seeds  
survive  
better  
deep  
in the  
soil

# Death near the soil surface

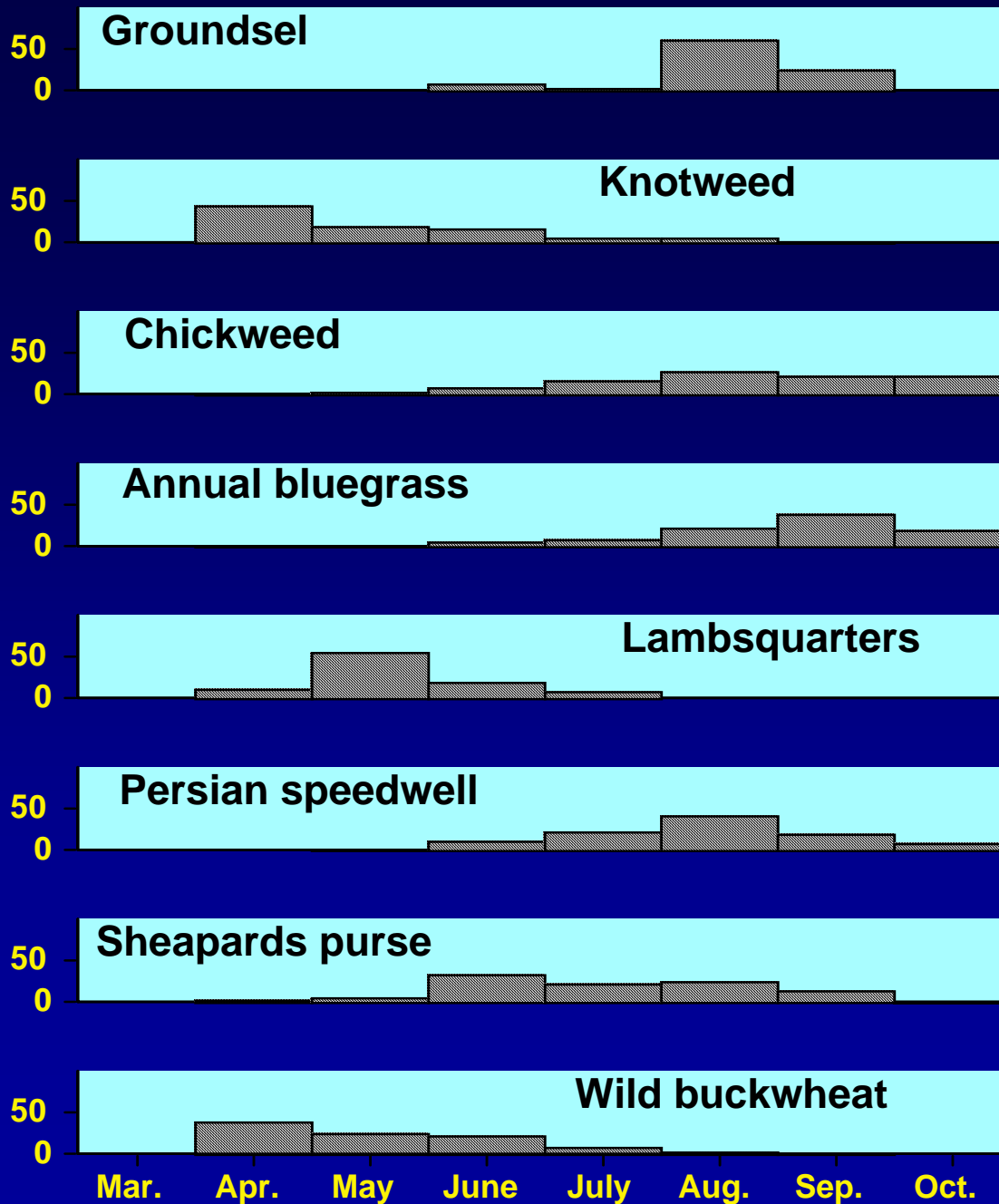


- Seed predation
- Wetting and drying
- Freeze-thaw

# Plowing vs. minimum tillage?

- Small seeded species with short lived seeds
  - plow them under
    - Most will die before they find their way to surface again
    - Example: hairy galinsoga
- Large seeded species with long lived seeds
  - keep them near the surface
    - Their mortality will be greater at the surface
    - And most that are tilled under will come back to bother you later
    - Example: velvetleaf





Weeds  
emerge at  
different  
times of  
year

# Seed dormancy

- Seasonal emergence is controlled by seed dormancy
- Ragweed germinates mostly in the spring
- Hot weather induces dormancy so it stops germinating in the summer
- Cold weather breaks dormancy
  - Could germinate in mid-winter but soil is too cold
- Germinates in spring when the soil starts to warm

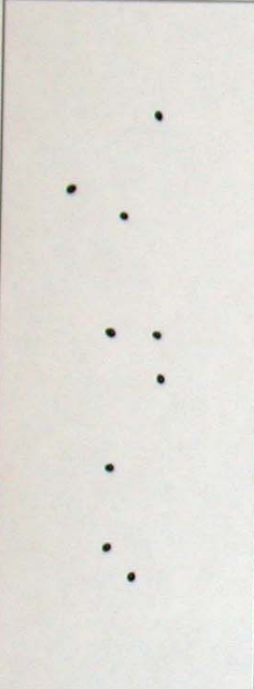
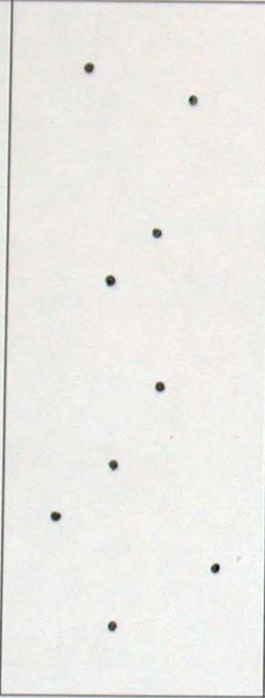

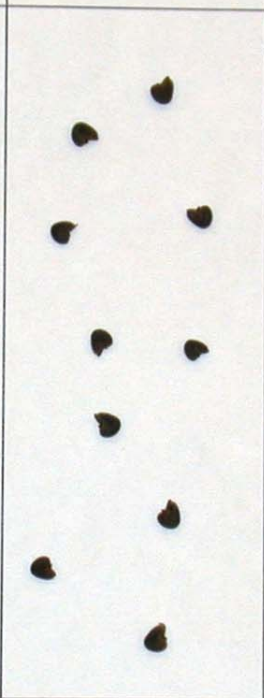
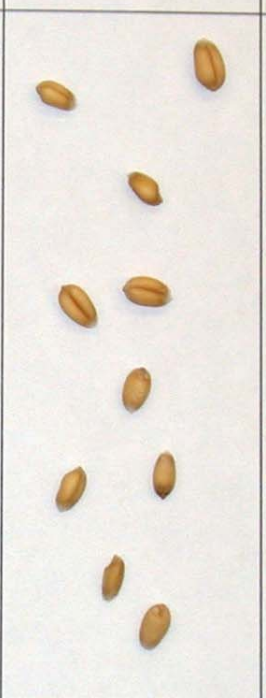
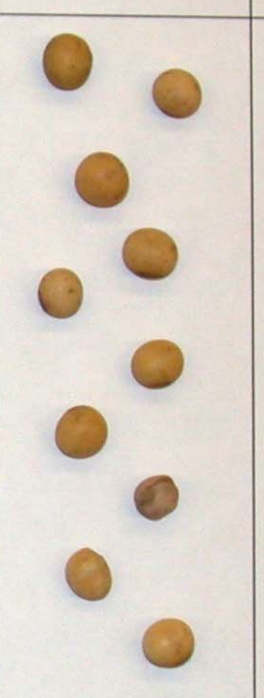

# Rotate spring, summer and fall planted crops

- This favors different suites of species in different years
- Prevents build-up of any one species.
- Fall germinating species get wiped out by spring tillage
- Spring germinating species get wiped out by summer tillage
- Spring germinating species get suppressed by competition from overwintering crops

# More advantages of crop rotation

- Can use different cultivation methods in different crops
- Short season crops can be harvested before weeds go to seed.– break the life cycle
  - Also allow extra soil disturbance to deplete perennials
- High value crops that are worth hoeing also can break reproductive cycle of some species

# Crop seeds are mostly much larger than weed seeds

Redroot Pigweed	Lambsquarters	Giant Foxtail	Velvetleaf	Wheat	Soybeans	Corn
						
Average seed weight (n = 10)						
0.6 mg	0.7 mg	1.7 mg	10.1 mg	38.6 mg	150.8 mg	283.8 mg

# Seed size controls growth rate

<b>Species</b>	<b>Seed weight (mg)</b>	<b>Initial growth rate (mg/d)</b>	<b>Relative growth rate (mg/mg/d)</b>
<b>Lambsquarters</b>	<b>0.41</b>	<b>0.14</b>	<b>0.35</b>
<b>Velvetleaf</b>	<b>7.8</b>	<b>1.9</b>	<b>0.24</b>
<b>Cocklebur</b>	<b>38</b>	<b>7.1</b>	<b>0.19</b>
<b>Sunflower</b>	<b>61</b>	<b>12</b>	<b>0.20</b>
<b>Soybean</b>	<b>158</b>	<b>24</b>	<b>0.16</b>

# Enhance the crop's head start!

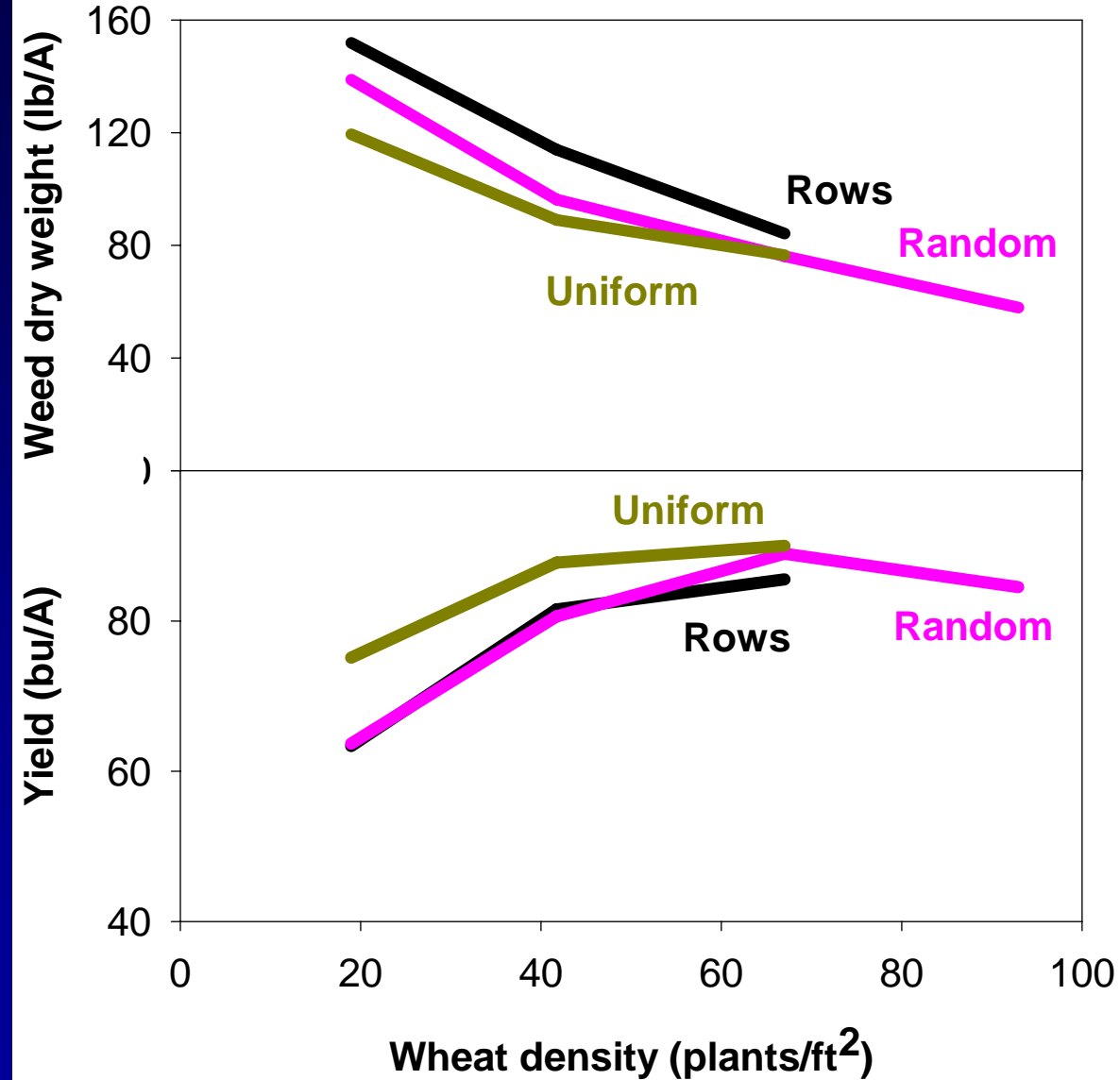
- Plant when crop will emerge and grow quickly
- Breed for larger seed size?
- Use transplants for small seeded vegetables
- Don't delay between seedbed prep and planting
- Or use a stale seedbed and kill the weeds right before planting

# Take advantage of the crop's head start

- High density planting
- Space plants for quick canopy closure
  - Trade-offs with cultivation
- Use competitive cultivars
  - Put the competitive cultivars in the weediest fields/beds
- In-row cultivation



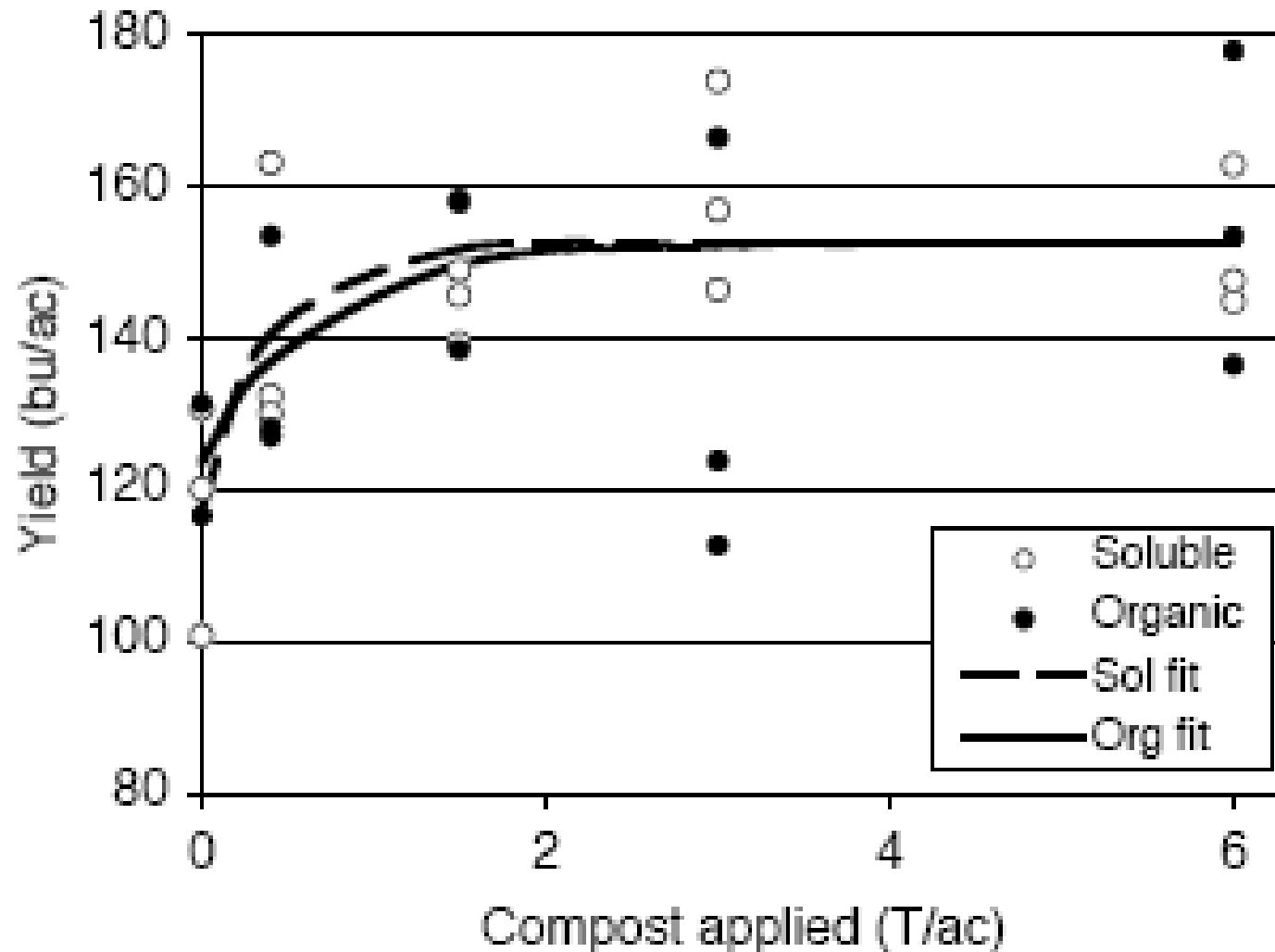
# Using crop competition

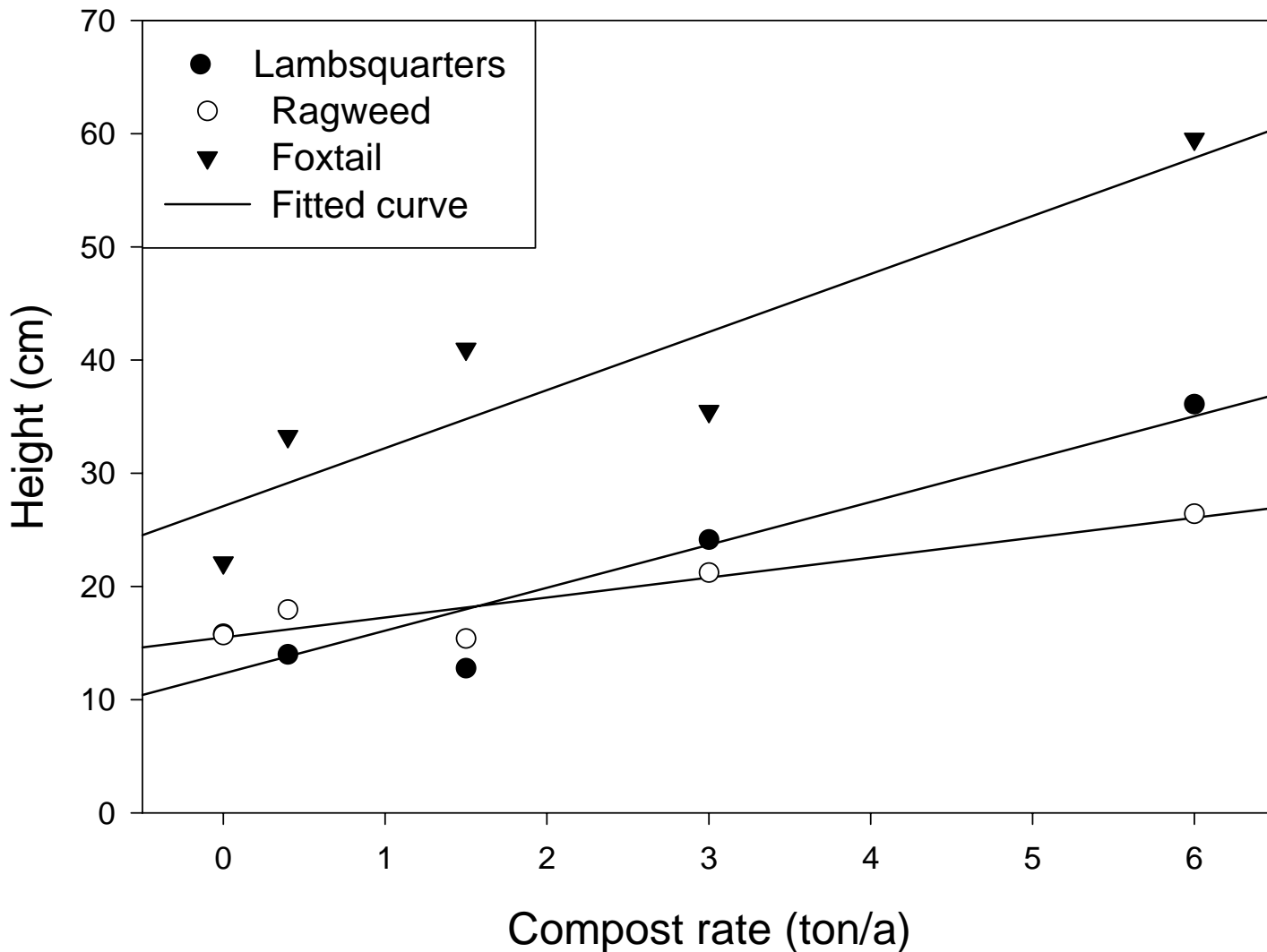


# Nutrients and weeds

- A lot of mythology and not much data
- Weeds are nutrient sponges
  - Avoid pulsed release of nutrients
- Most agricultural weeds are highly responsive to N and P
  - Over fertilization leads to weed problems

# Response of corn to compost





Response  
of weeds  
to  
compost

# Prevention

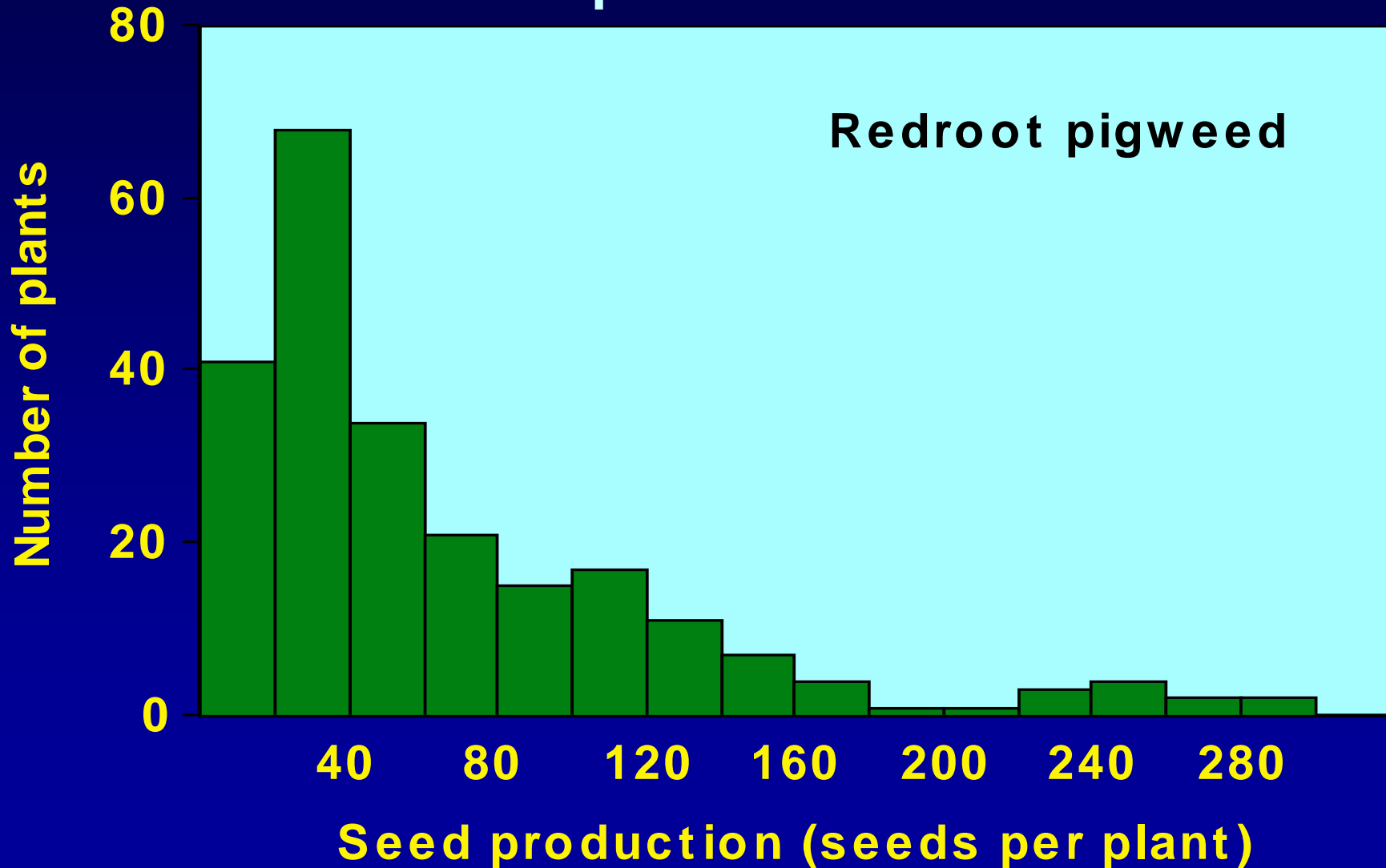
# Seed production

- **A big lambsquarters can produce 100,000 seeds**
- **A big redroot pigweed can produce 250,000 seeds**

# Hairy galinsoga, 40,000 seeds



# Most seeds come from a few large plants





# Most agricultural weeds depend on humans for dispersal

- **In feed grain -- velvetleaf**
- **In manure**
- **On tractor tires and tillage machinery**
- **On combines**
- **Contaminated seed**

# Some key points

- **Breaking up perennials promotes sprouting**
- **Tillage, surface conditions, and absence of plants stimulates germination**
- **Species have characteristic seasons**
- **Seeds often persist in the soil for many years; they die at a constant rate, survive better when buried**
- **Produce many small seeds**
- **Seed size controls depth of emergence, ability to emerge through mulch, and growth rate**
- **It is easy to bring in “new” weed species**

# Opportunities for control

- **Breaking up perennials increases sprouts but each sprout is weaker**
- **Can use cultivation to flush weeds out of the soil**
- **If seeds miss their annual opportunity, many may die before next year; more die with tillage**
- **The difference in seed size between crops and weeds provides opportunities for control**
- **Avoid seed production**
- **Guard against invasion of “new” weeds**