

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

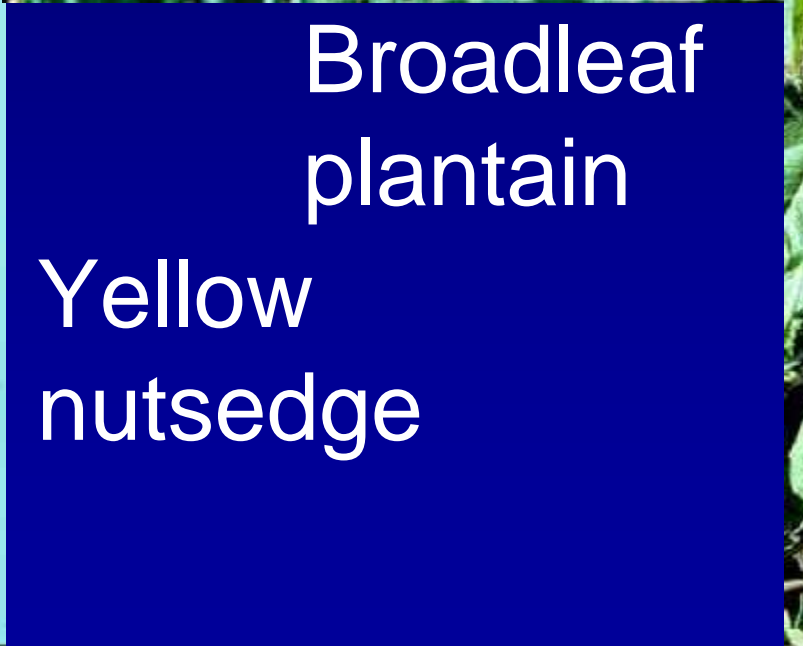
-- where is the food stored?

- **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

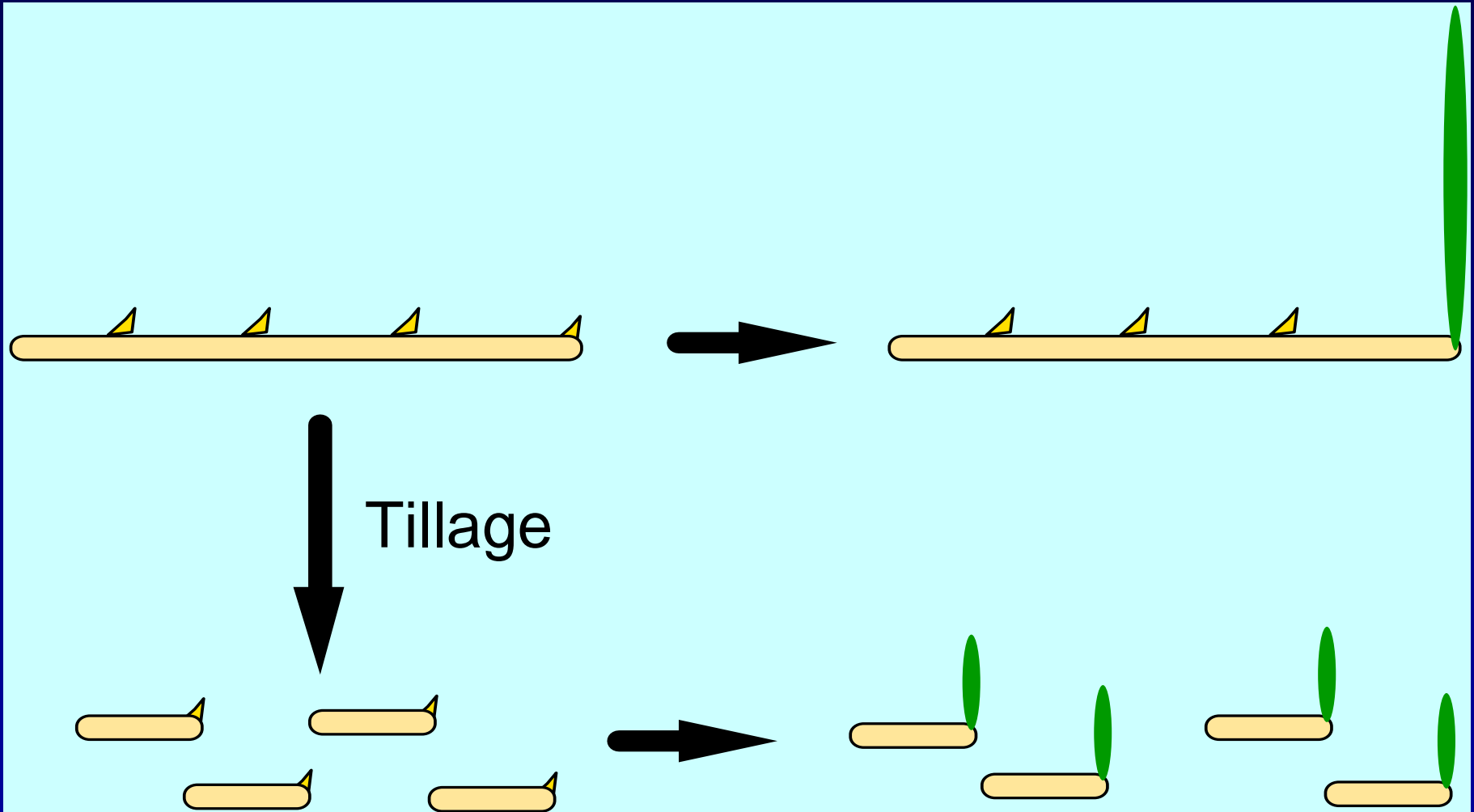
- **Mostly a problem of hay fields and pastures**
- **Usually not competitive the first year**
- **“Easily” eliminated by tillage**
- **Establish from seed**
- **Control in adjacent habitats**

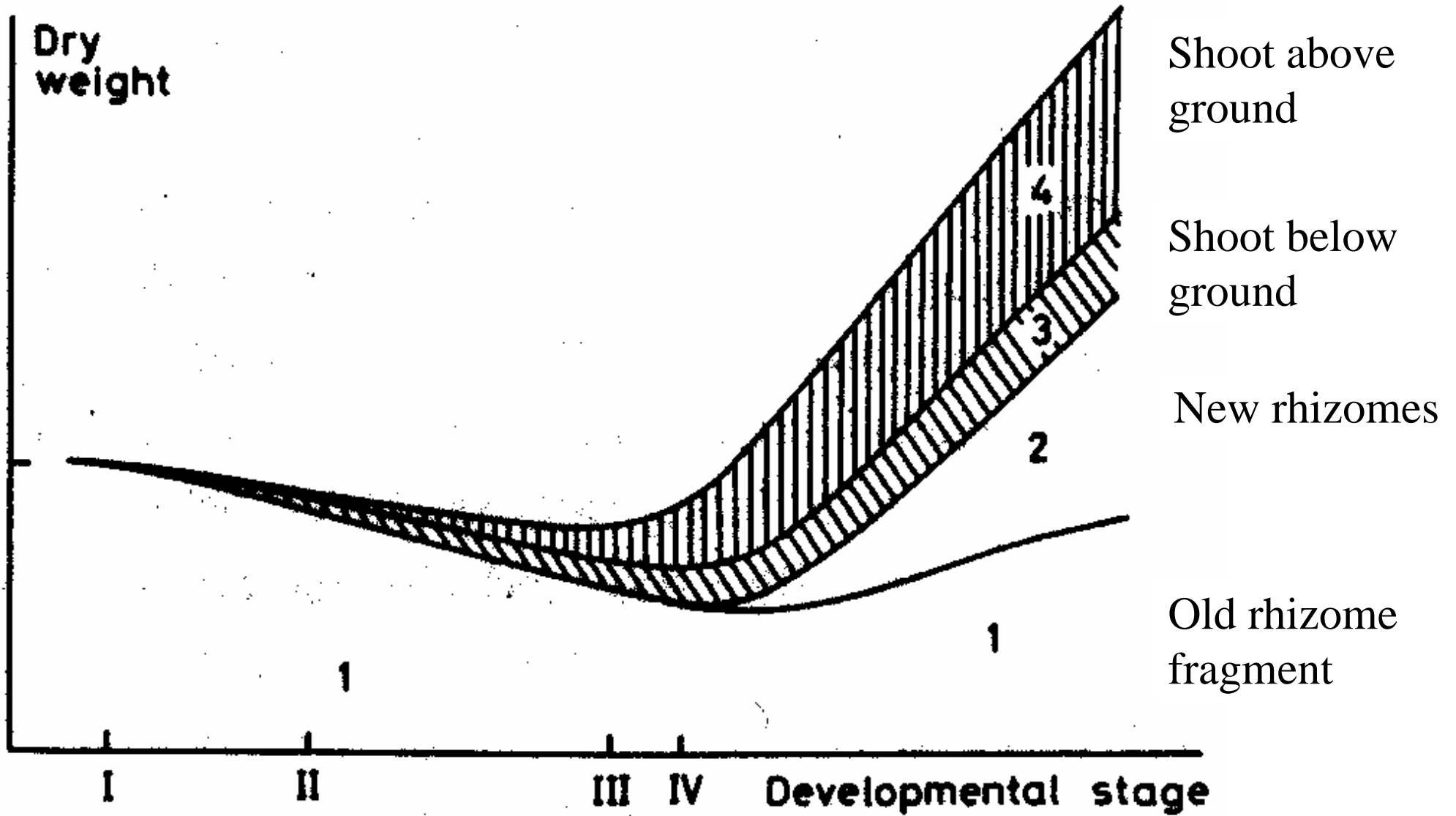
Wandering perennials



- **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

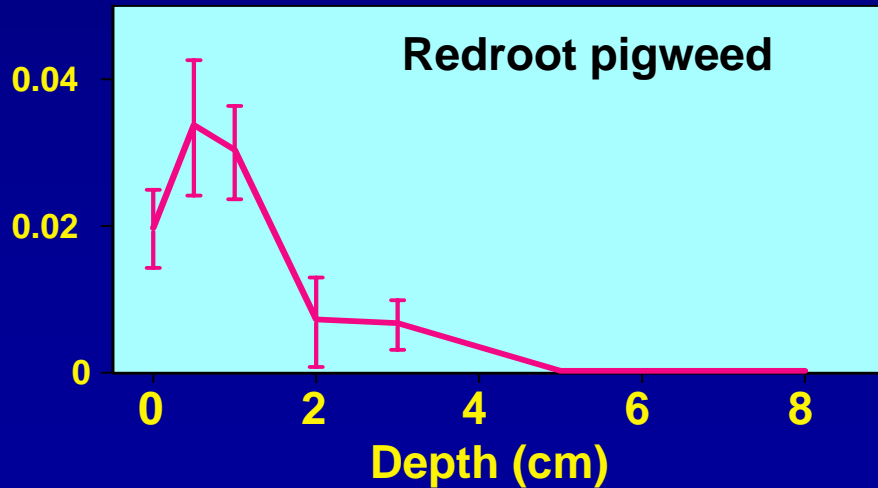
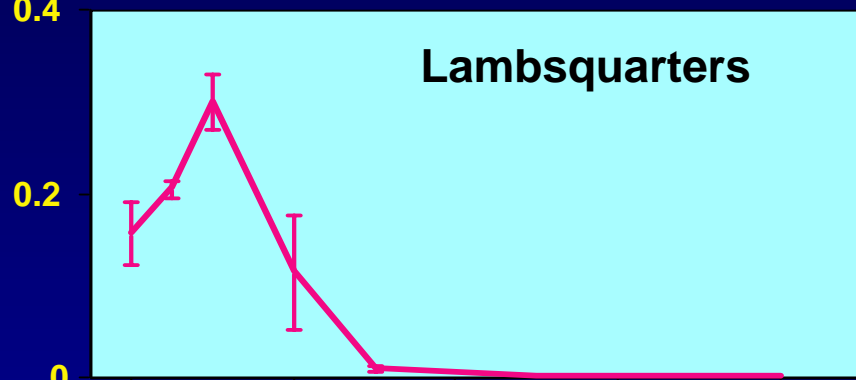
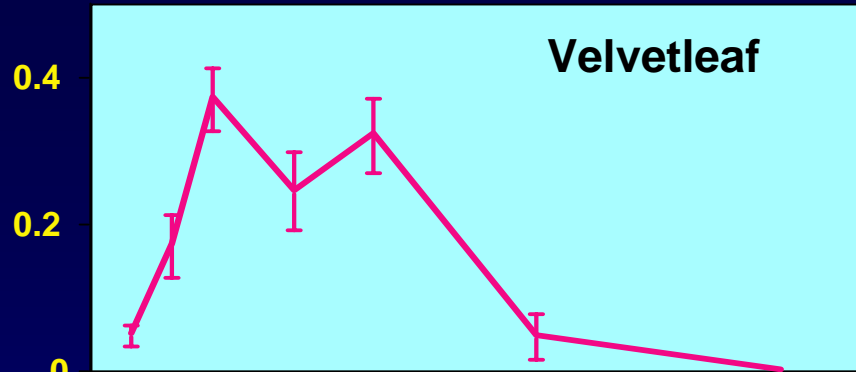
- **Live less than one year**
- **Establish from seed each year**
- **Seeds/seedlings are critical stages**

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

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

Day/night temperature fluctuation

Species	%Germination	
	+Fluct.	-Fluct
Chickweed	93	47
Curlydock	100	0



Curly dock

Common
chickweed



Response to chemical environment

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



Velvetleaf

Lambsquarters

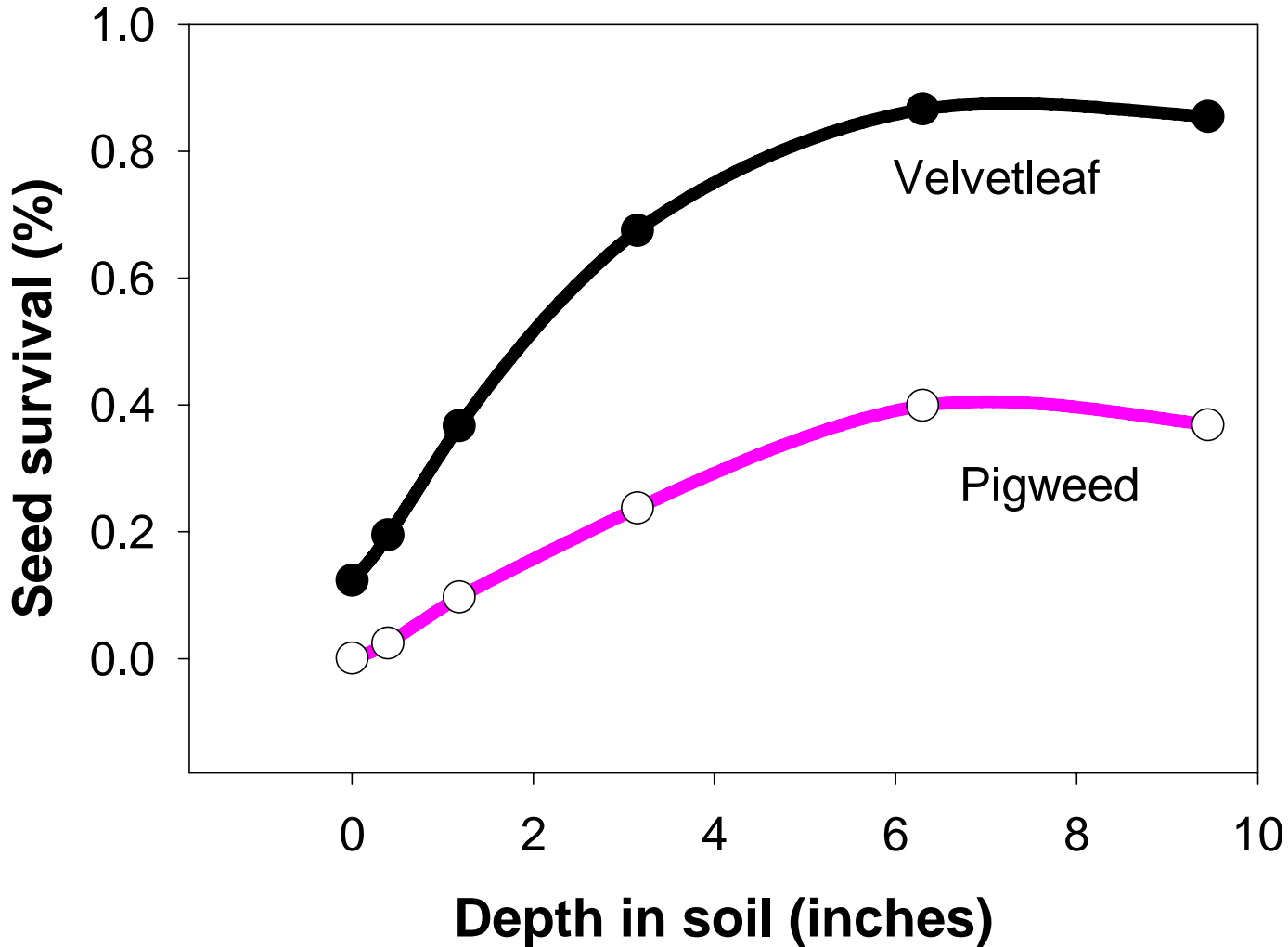


Consequences

- **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

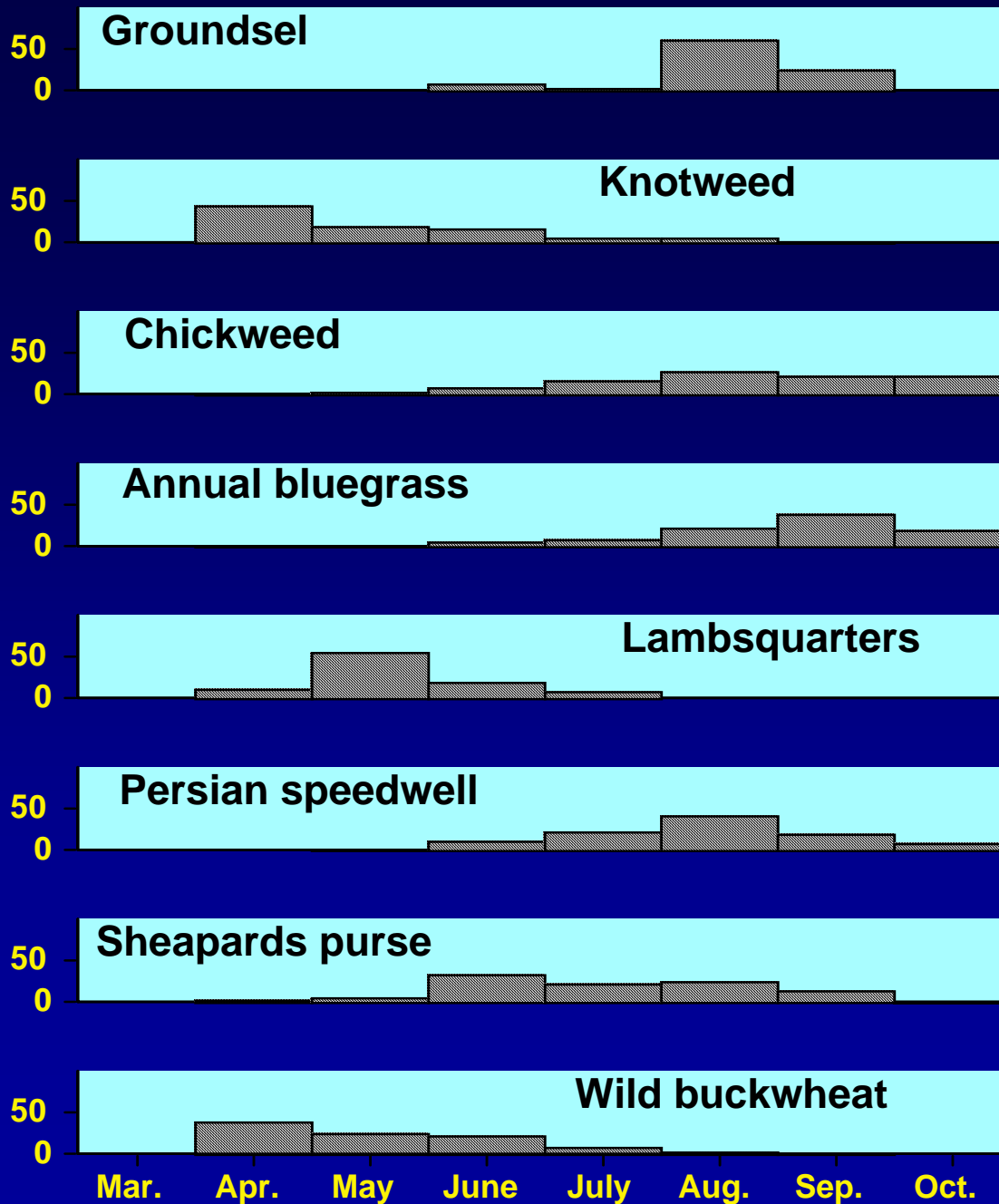
Death near the soil surface



- 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

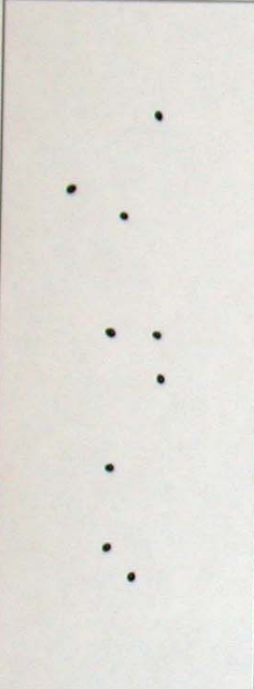
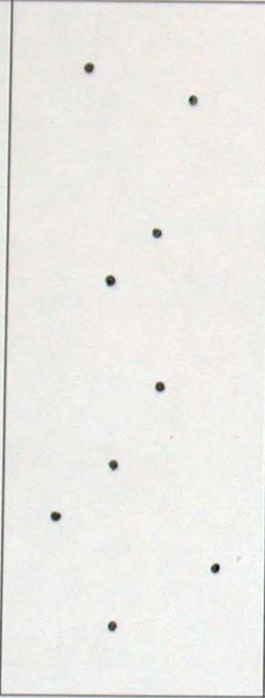

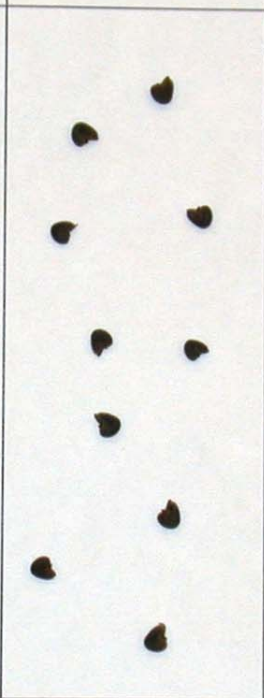
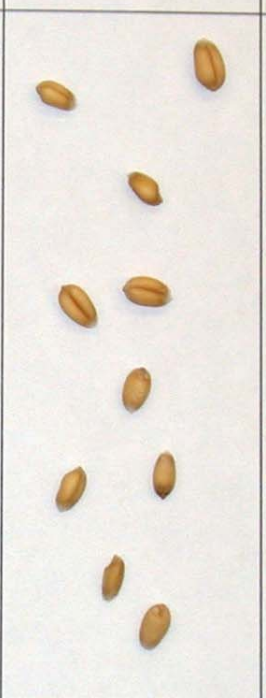
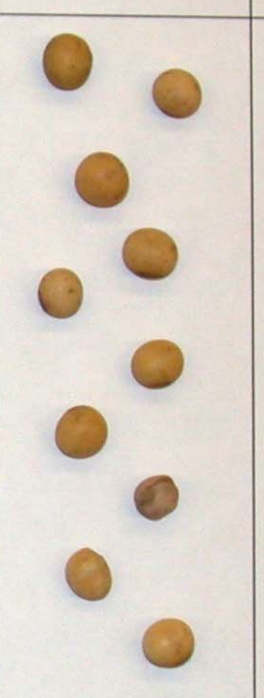

Rotate spring, summer and fall planted crops

- 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

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

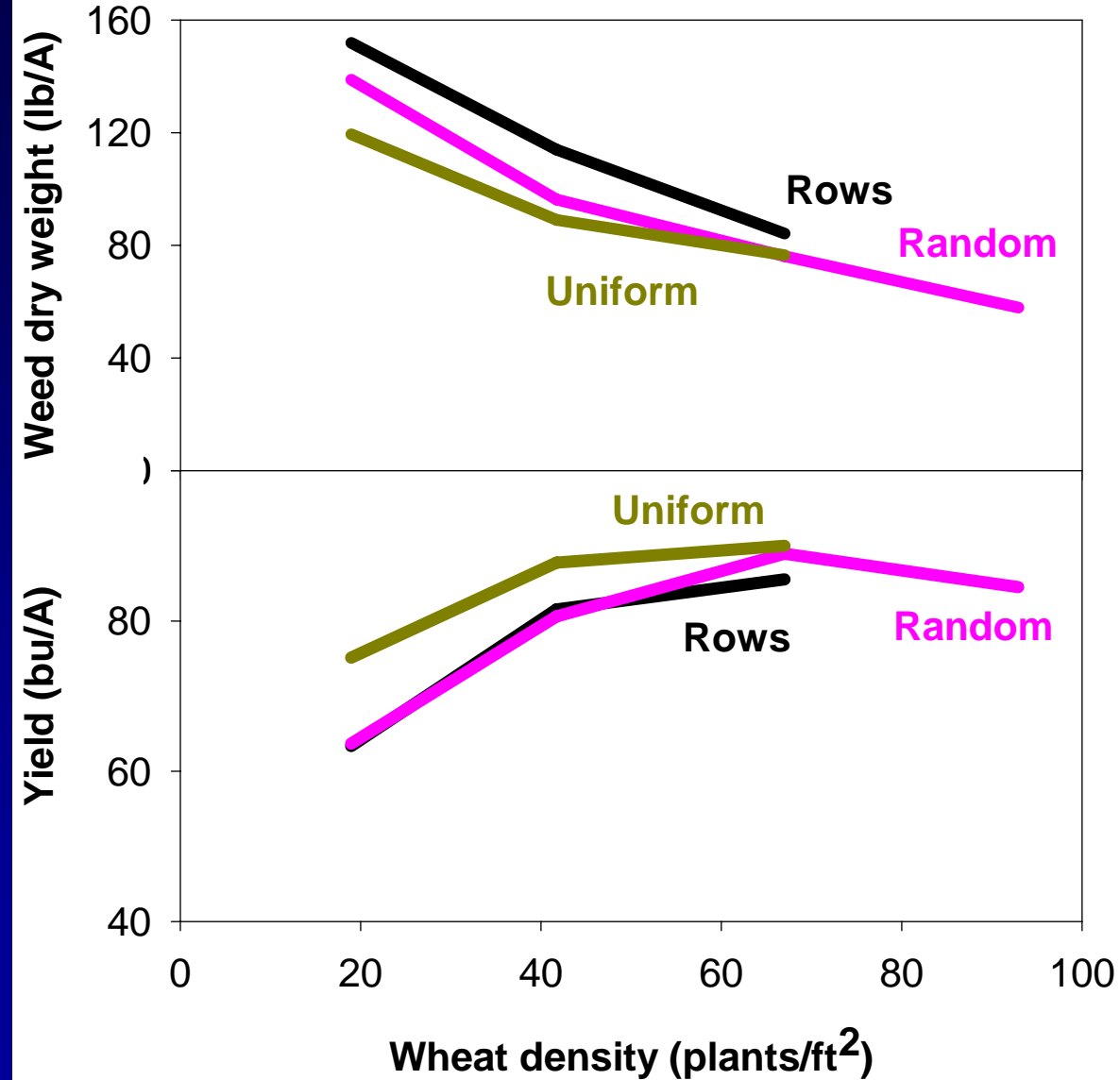
Enhance the crop's head start!

- 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

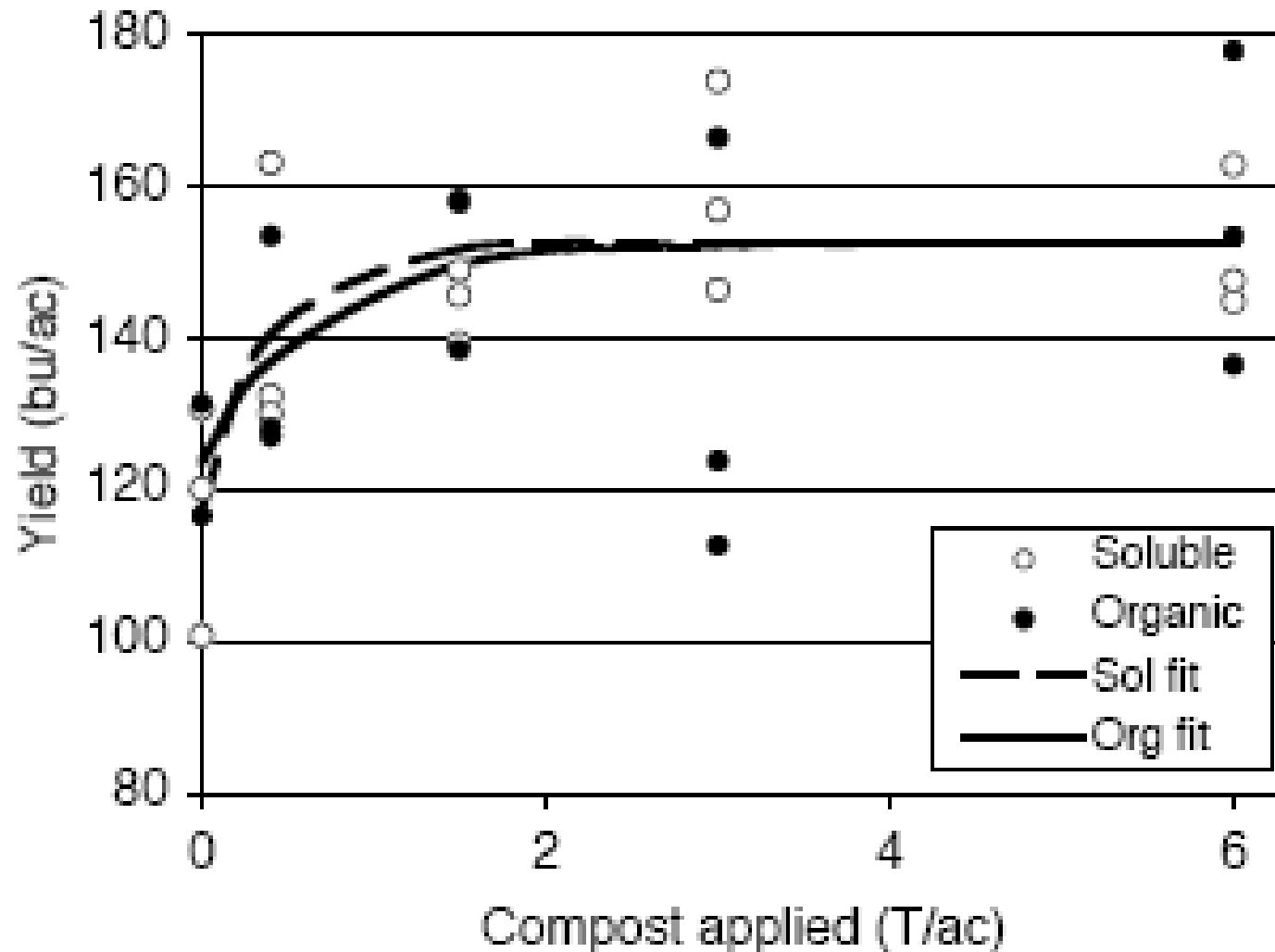
Using crop competition

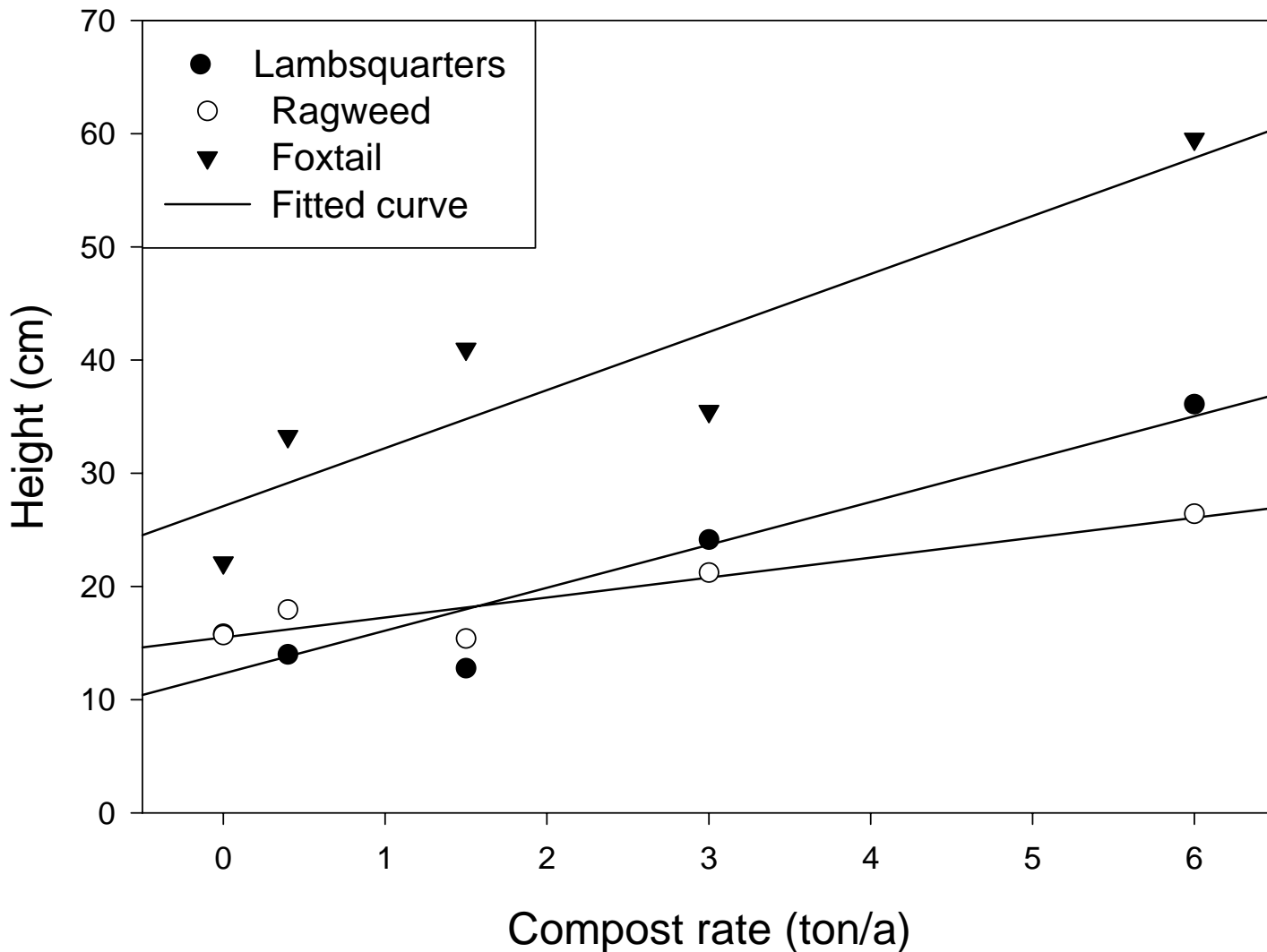


Nutrients and weeds

- 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

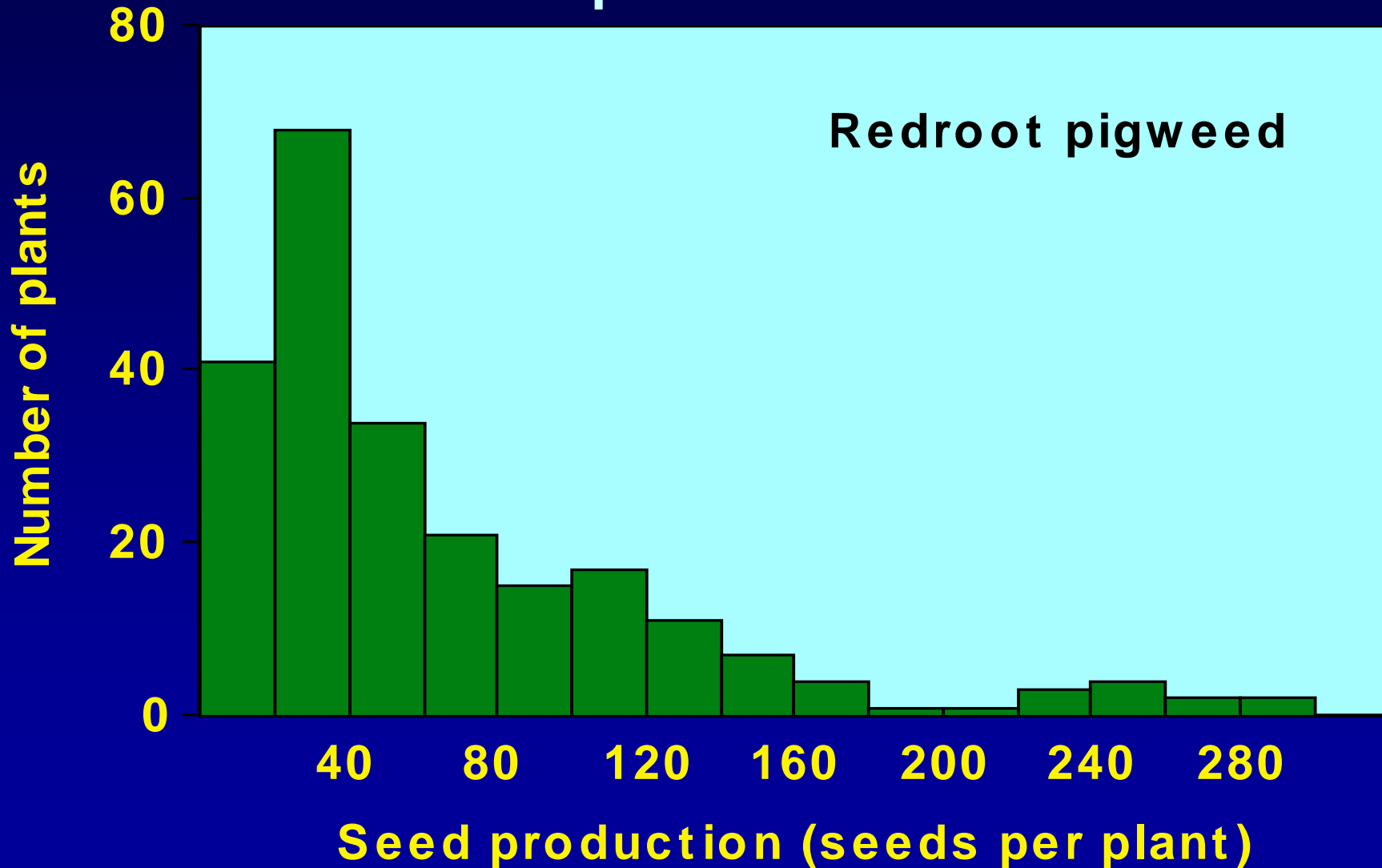
Seed production

- **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**