THE UNIVERSITY of TENNESSEE Extension

Plant Sciences UT

Cover Crops: Crop Rotation, Weed Control and Nutrient Contributions

Annette Wszelaki, Vegetable Specialist

(photo: oregonclover.org)

Overview: Cover crops

- Definitions
- Crop rotation
- Choosing a cover crop
  - Cover crop functions
  - Cover crop costs
  - Nutrient availability
  - Cover crop classification
  - Crops for the Southeast

(Photo from: panoramio.com)

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UT Organic, Sustainable and Alternative Crops

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Cover crops

- Important for preventing nutrient and soil loss
- Grown primarily for soil or agroecosystem improvement rather than for market
- Provide a variety of ecosystem services
- Can also have negative impacts if improperly managed or poor species selection
- Primary fertility and soil management tool available to organic farmers

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Cover crops

- **Cover crop:** “covers” the soil with living plants
- **Green manure:** cover crop grown mainly to be turned under for soil improvement
- **Catch crop:** cover crop grown to “catch” water-soluble nutrients remaining after cash crop harvest to prevent leaching, runoff losses
- Most cover crops serve multiple functions

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Why bother?

- A good rotational sequence can accentuate every possible advantage
- Different crops use soil nutrients differently
- All may alter or be altered by the succeeding or preceding crop
- Time spent planning a rotation is never wasted!
- THINK IT THROUGH!

Well-thought-out crop rotation is worth 75% of everything else that might be done, including fertilization, tillage and pest control.

-Firmin Bear

Incorporating cover crops or green manures in your rotation

- Investment in weed and pest control
- Rotations can make nutrients more available



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Incorporating cover crops or green manures in your rotation

- Vegetable systems have many windows to include cover crops or green manures
  - Example: Between harvest of early planted spring crop and planting of fall crops
    - Buckwheat, cowpeas, sorghum-sudangrass

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Incorporating cover crops or green manures in your rotation

- Plant winter annuals on fields that would lie fallow
- Many vegetable crops can be overseeded with cover crops
  - Select crops that can tolerate shade and traffic

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Choosing a cover crop

- **Step 1:** Identify what function is needed from the cover crop
  - What is limiting production in a given system?
    low fertility?
    poor soil structure?
    weed or pathogen populations?
  - What functions can cover crops serve?

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(Miles and Brown, 2003)

Functions of cover crops

SOIL FERTILITY

- Enhance nutrient availability
- Prevent leaching
- ↑ yields

PESTS

- Smother weeds
- Beneficial habitat
- Reduce diseases

SOIL STRUCTURE

- Increase organic matter
- Slow/prevent erosion

WATER

- Improve infiltration
- Retain moisture
- Protect water quality

Slide courtesy of Gary Bates,
UT Forage Specialist

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Soil fertility

- Provide nitrogen
  - Legumes- symbiotic relationship between legumes and rhizobia bacteria that fix atmospheric nitrogen in plant root nodules
- Scavenge soil nutrients remaining after a cash crop
  - Potentially available to following cash crop
  - Prevents leaching losses, which improves soil fertility and decreases environmental impact
  - Generally non-legumes, primarily grasses

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(Miles and Brown, 2003)

Pest control

- Suppress weeds
  - Through competition, allelopathy, shading, etc.
  - Cereal rye, sorghum-sudangrass, other grasses
  - Rotate cover crops, so that weeds that compete well with that cover crop do not build up
  - Can be used as a killed mulch (mechanically or herbicide) in no-till systems to suppress weeds

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(Miles and Brown, 2003)

Influence of Tillage and Cover Crop on Weed Populations

Tillage	Cover Crop	Weeds/ft^2
Conventional	None	12
None	None	5
None	Rye	0.9
None	Wheat	0.3
None	Barley	0.8

(Putnam et al., 1983)

Relaxed Tillage

Pest control

- Provide habitat for beneficial insects
  - Most applicable in permanent systems (e.g. orchard groundcovers) but also applicable in annual systems

(photos: marabelgroup.com, panoramio.com)

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(Clark, 2007)

Pest control

- Suppress soilborne pests and diseases
  - Some species known for their ability to suppress certain pathogens (e.g. sorghum-sudan or sunn hemp and root-knot nematodes)
  - Others are good hosts for root-knot nematodes (certain clovers)
  - Brassicas used for biofumigation, nematode-trapping effects

Slide courtesy of David Butler,
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(Miles and Brown, 2003)

Brassicas as Biofumigants

Slide courtesy of Gary Bates, UT Forage Specialist

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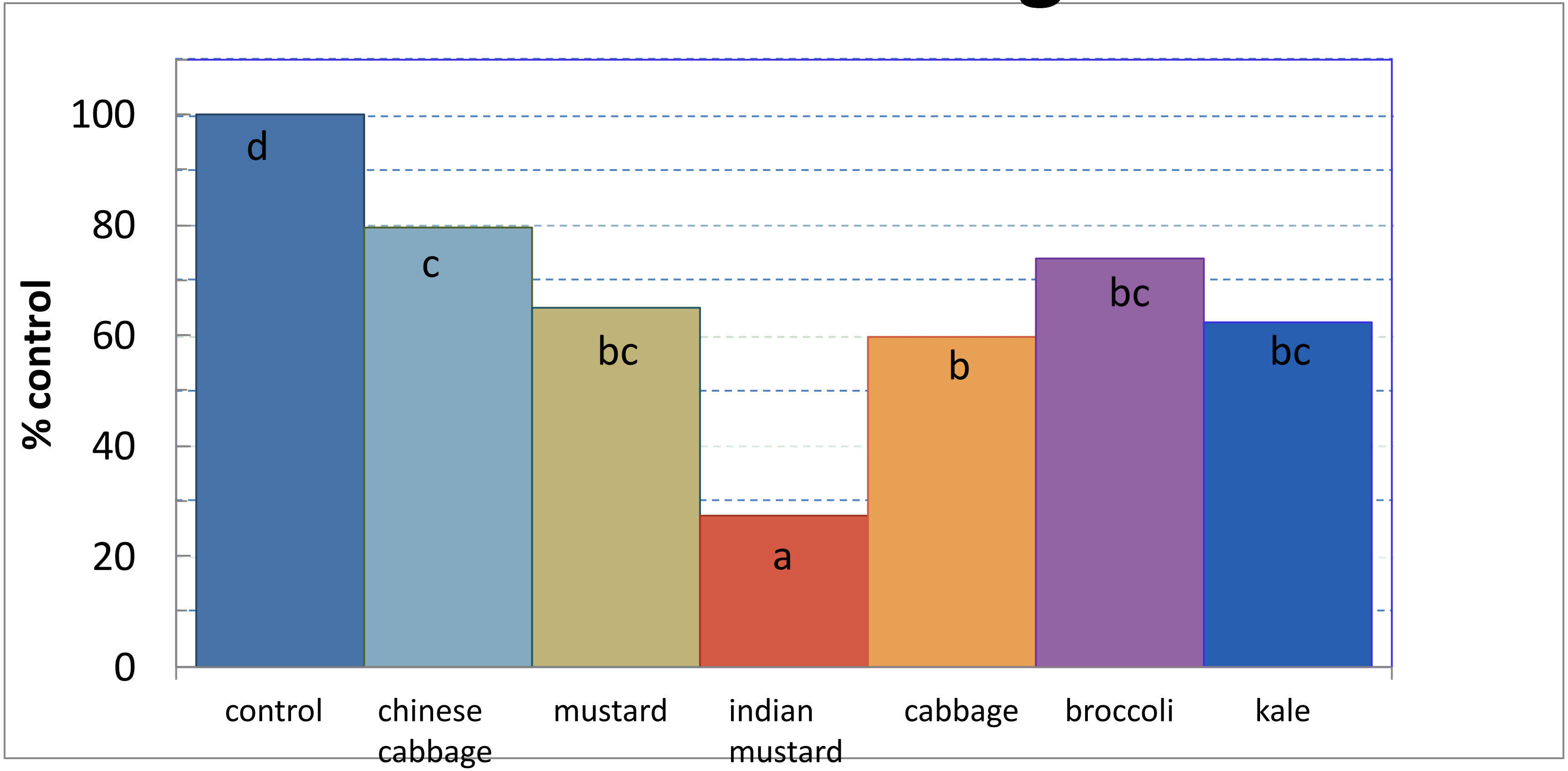
Effect of *Brassica* leaf tissue on *Rhizoctonia solani* growth



Charron and Sams. 1999. J. Amer. Society of Hort. Science. Vol. 124:5. p. 467.

Slide courtesy of Gary Bates,
UT Forage Specialist

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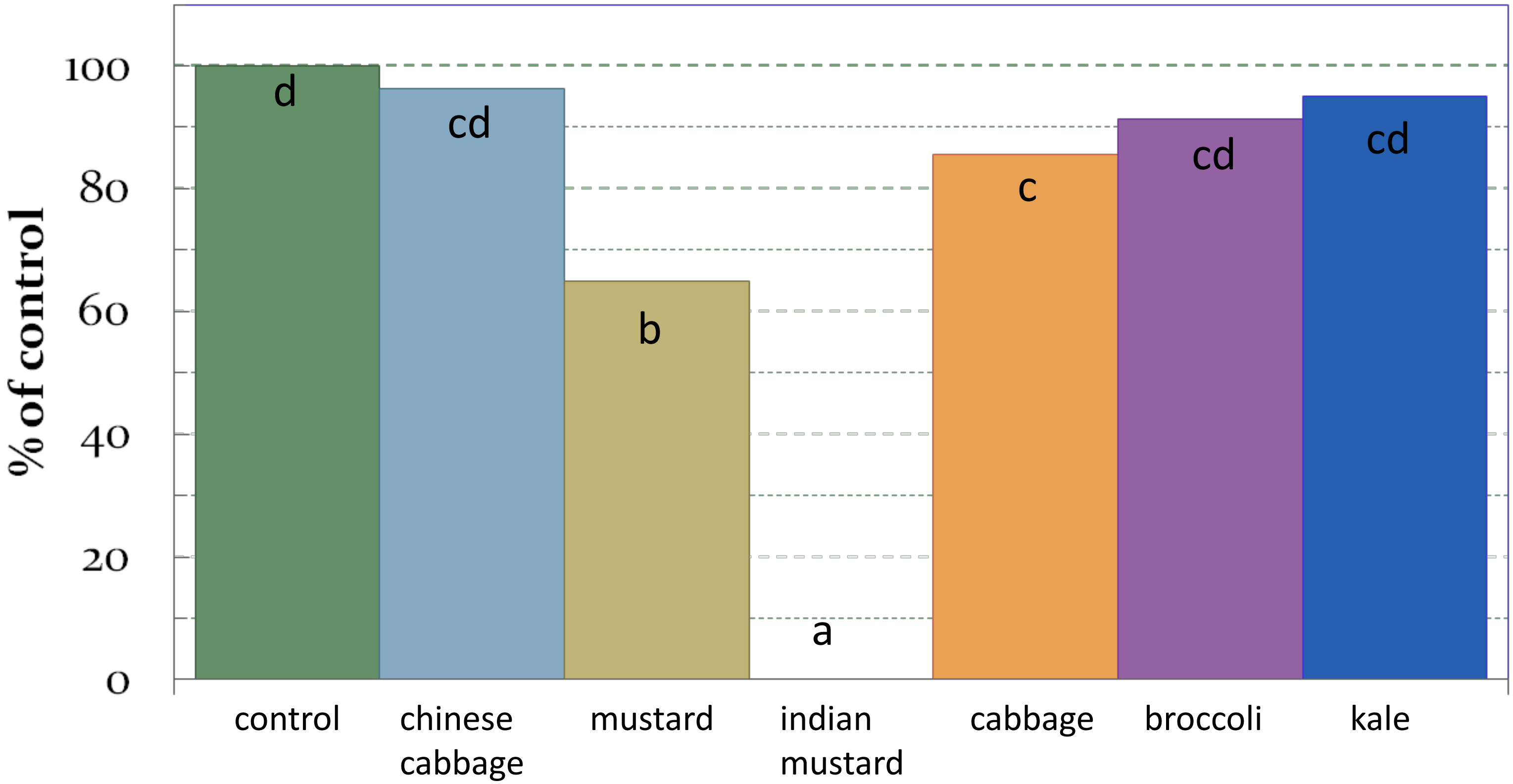
Effect of leaf tissue on *Pythium ultimum* growth



Charron and Sams. 1999. J. Amer. Society of Hort. Science. Vol. 124:5. p. 467.

Slide courtesy of Gary Bates,
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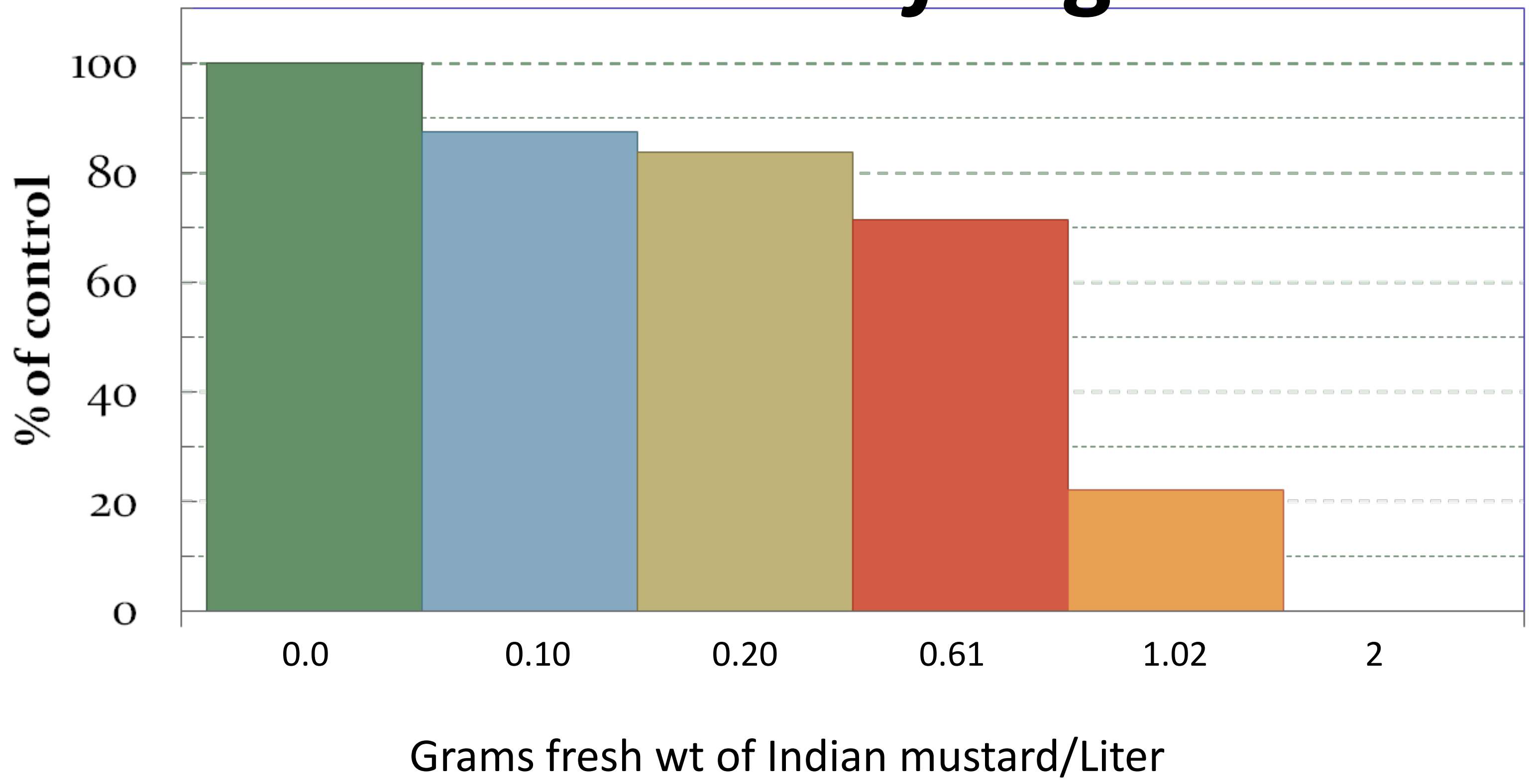
Effect of Indian mustard on *Sclerotium rolfsii* growth



Harvey and Sams. 2002. J. Amer. Society of Hort. Science. Vol. 127:1. p. 27.

Slide courtesy of Gary Bates,
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Soil structure

- Increase soil organic matter and soil biological activity
  - Major influence on most soil properties (bulk density, porosity, nutrient and water holding capacity, etc.)
  - High biomass producing cover crops, generally grass species
  - Solubilize less soluble nutrients such as phosphorus
- Prevent soil erosion
  - Covers soil during fallow periods, preventing loss of soil and associated nutrients
  - Rapidly growing species are best, but most cover crops fill this role

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(Miles and Brown, 2003)

Water

- Protect water quality
  - Prevent erosion
  - Scavenge nutrients
- Improve soil drainage
  - Deep-rooted cover crop species can break through compacted soil layers and improve drainage
  - Organic matter improves soil aggregation
  - Bell beans, clovers, cereal grains, etc.
- Conserve soil moisture

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(Miles and Brown, 2003)

Choosing a cover crop

- Step 2: Identify the cover crop planting niche
  - Where does the cover crop fit in the crop rotation?
    - Warm-season or cool-season
    - Other climatic variables
      - Precipitation
      - Temperature (summer highs, winter lows)
      - Day-length
    - Compatibility with previous and subsequent cash crops
  - Define timing of critical cash crop operations, so that cover crop management does not conflict

Slide courtesy of David Butler, UT Organic, Sustainable and Alternative Crops

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(Miles and Brown, 2003)

Choosing a cover crop

- Step 3: Select cover crop that meets goals and requirements of steps 1 & 2
  - Consider benefits and drawbacks (perfect fit unlikely)
  - Consider cost and availability of seed (especially with organic and untreated seed)
  - Consider management costs (field operations needed to plant, kill, etc.)

(photo: ucanr.org; Miles and Brown, 2003)

Slide courtesy of David Butler,
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Cover crop costs

- Direct costs
  - Seed
  - Establishment (e.g. tillage, drilling, irrigation)
  - Termination (e.g. mowing, tillage, rolling/crimping, herbicide)

Slide courtesy of David Butler, UT Organic, Sustainable and Alternative Crops

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(Snapp et al., 2005)

Cover crop costs

- Indirect costs
  - Interference with following cash crop
    - Soil temperature
    - N release
    - Residue
  - Management issues
    - Difficult termination
    - Weediness

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(Snapp et al., 2005)

Cover crop costs

- Opportunity costs
  - Cost of forfeit income if a cash crop alternative was feasible
  - Can be the most important limitation

Slide courtesy of David Butler, UT Organic, Sustainable and Alternative Crops

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(photo: trekearth.com; Snapp et al., 2005)

Nitrogen availability

- N acquired through fixation or plant uptake
- Availability to subsequent crop is variable
  - 10% to more than 50%
  - Transformation from unavailable N to available controlled by interaction of factors:
    - Environment
      - Increases with temperature and moisture
      - Increases with lighter, more aerated soils
    - Management
      - Incorporation > mowing > rolling
    - Tissue quality
      - C:N ratio, lignin, etc. (slower decomposition = slower N release)

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(Seiter and Horwath, 2005)

Carbon to nitrogen ratio

- Important property affecting cover crop residue persistence, nutrient release, etc.
  - High C:N ratio
    - Greater persistence as surface mulch, slower nutrient release
    - In general: grasses > broadleaves > legumes
    - Increase with maturity
  - Low C:N ratio
    - Quicker nutrient release and breakdown, poor persistence
    - Unlikely to tie-up soil nutrients

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Cover crop classes

- Cool-season annuals
  - Legumes vs. non–legumes (grasses & broadleaves)
  - Winter-hardy vs. non-hardy
- Warm-season annuals
  - Legumes vs. non-legumes
    - Grasses
    - Broadleaves
- Perennials and biennials/ley/sod crops

(photo: winemakermag.com)

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Life Cycles

<u>Annuals</u>
- germinate, grow, bloom in 1 growing season
- usually easier to kill

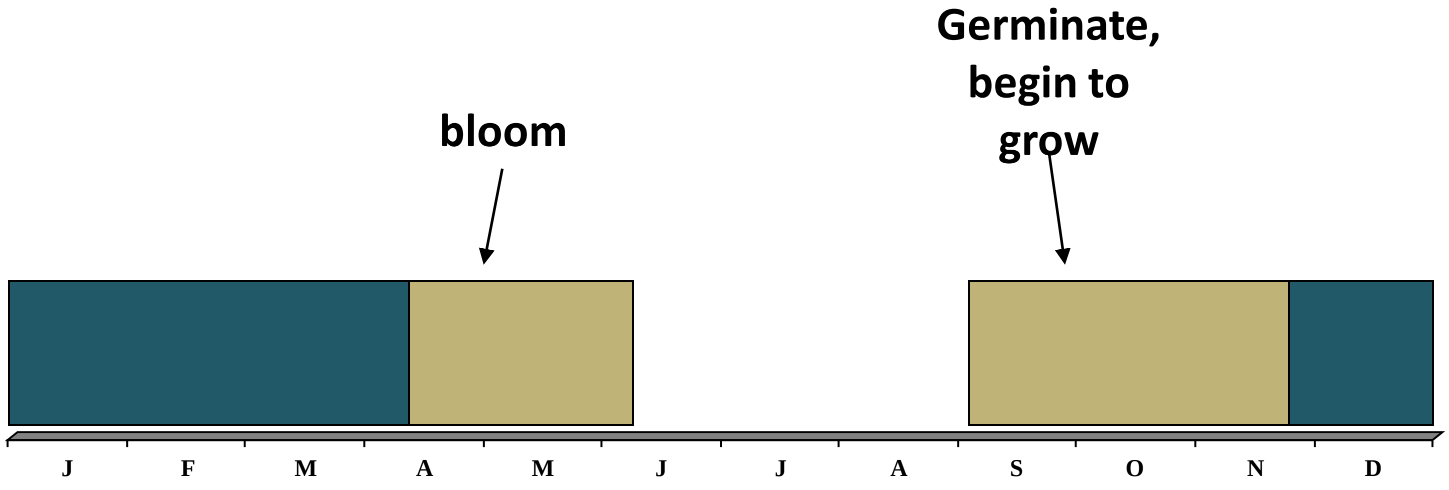
<u>Biennials</u>
- take 2 years to complete life cycle
- vegetative 1st year, flower 2nd year

<u>Perennials</u>
- live more than one year
- more difficult to kill

Slide courtesy of Gary Bates,
UT Forage Specialist

Life Cycles

Cool season plants



Slide courtesy of Gary Bates,
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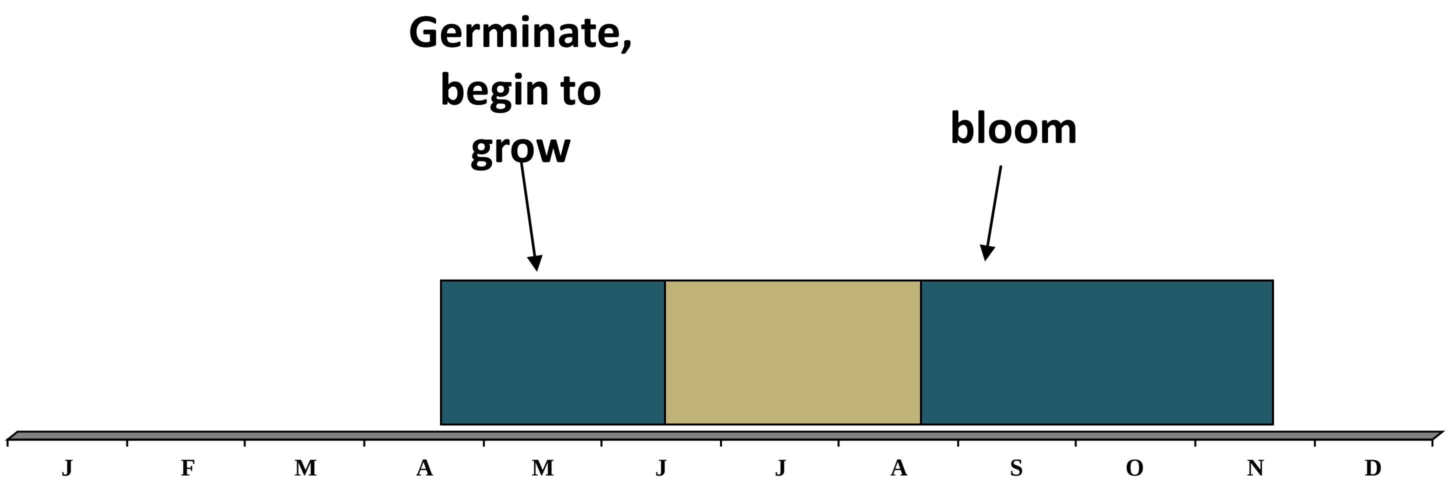
Life Cycles

Warm season plants



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Cool-season annual legumes

- Crimson clover *(Trifolium incarnatum)*
  - N contribution 70 to 150 lbs/acre
  - Planted in mid-fall in TN, rapid spring growth
  - Grows well mixed with small grains (e.g. rye, triticale, wheat)
  - Good pollen source for bees
  - Not winter-hardy in colder climates (zone ~ 6 +)

Slide courtesy of David Butler, UT

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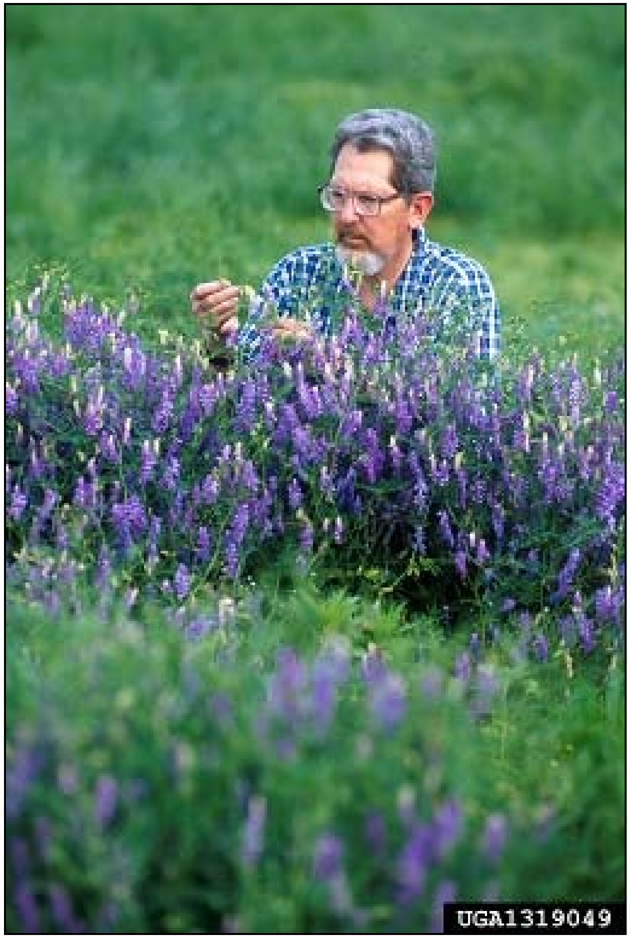
(Clark, 2007; photos: oregonclover.org)

Cool-season annual legumes

- Hairy vetch *(Vicia villosa)*
  - N contribution 100 to 150 lbs/acre
  - Planted in mid-fall in TN
  - Grows well mixed with small grains (e.g. rye, triticale, wheat)
  - Quickly smothers spring weeds
  - Hard-seeded, can become a weed problem
  - Very winter hardy (zone ~ 4 +)



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(Clark, 2007; photo: USDA-ARS)

Cool-season annual legumes

- Winter Pea *(Pisum sativum* ssp. *arvense)*
  - N contribution 90 to 150 lbs/acre, as much as 300 lb/acre reported
  - Planted in mid-fall in TN
  - Low water use
  - Not as winter hardy as hairy vetch or crimson clover (zone ~ 7 +)

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: agronomy.ifas.ufl.edu, seedsofchange.com)

Cool-season annual legumes

- Lupin (*Lupinus albus*, *L. angustifolus*, etc.)
  - N contribution 100 to 150 lbs/acre
  - Aggressive taproots
  - Easy to kill mechanically
  - Not as winter hardy as hairy vetch or crimson clover (zone ~ 7 +; no farther north than the TN valley)

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: edamameseed.com; ucdavis.edu)

Cool-season annual legumes

- Fava or bell bean *(Vicia faba)*
  - Grows well in cool conditions
  - High biomass producer
  - Deep taproot
  - Over 100 lbs N/acre
  - Not as winter hardy as other cool-season legumes (~ zone 8 +)
  - Can be managed as a winter-killed cover in TN

Slide courtesy of David Butler, UT

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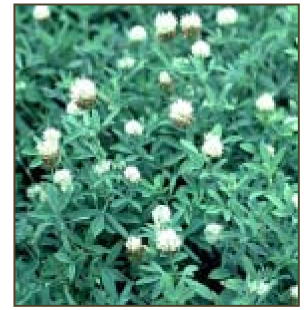
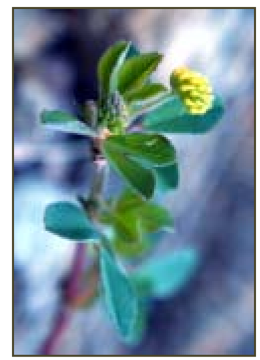
(Clark, 2007; photos: ofrf.org, wikimedia.org)

Other cool-season annual legumes

- Berseem clover *(Trifolium alexandrinum)*
- Balansa clover (*Trifolium michelianum)*
- Medics *(Medicago spp.)*
- Common vetch *(Vicia sativa)*
- Red clover* *(Trifolium pratense)*
- Sweet clover* *(Melilotus officinalis and M. alba)*

*biennials






Slide courtesy of David Butler, UT

(Clark, 2007; photos: USDA-ARS; tamu.edu, nps.gov, permaculture.org.au, dnr.wi.gov, www.uwyo.edu, potash-info.com)

Cool-season non-legumes

- Rye (*Secale cereale*)
  - **Should not be confused with annual (*Lolium multiflorum*) or perennial ryegrass (*Lolium perenne*)**
  - Very cold hardy
  - Good nutrient scavenger
  - High early season biomass
  - Allelopathic (DIBOA)
- Other cereal grains
  - Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), triticale (× *Triticosecale)*
  - Certain oat (*Avena sativa*) cultivars can be used when winter-kill is desired
- Good for building organic matter

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: ces.ncsu.edu, tamu.edu)

Cool-season non-legumes

- Brassicas
  - Mustards *(Brassica juncea, Sinapsis alba, B. carinata, B. nigra)*
  - Rapeseed & canola *(B. napus, B. rapa, B. campestris)*
  - Oilseed & tillage radish *(Raphanus sativus)*
  - Arugula *(Eruca sativa)*
  - Pest suppression
  - Potential biofumigants
  - Good nutrient scavenging ability
  - Winter hardiness varies
  - Attract beneficial insects at bloom

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: plantsolutionsltd.com, USDA-SARE)

Tillage Radish

- Breaks up compaction
- Controls winter annuals
- Captures N in the fall- releases in the spring
- 16" deep 40 days after planting
- Subsoils without bringing rocks to surface
- Shown to increase corn yield in OH

Information and photo courtesy of Steve Groff, Cedar Meadow Farm

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Winter-kill
when temperatures
drop to the mid-teens
on successive nights
Information and photo courtesy of Steve Groff,
Cedar Meadow Farm

Cool-season non-legumes

- Annual ryegrass *(Lolium multiflorum)*
  - Good nutrient scavenging
  - Good biomass production with sufficient N and moisture
  - Residue does not persist as well as cereal grains
  - Not as cold hardy as cereal rye
  - Can become a weed

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: osu.edu;tennesseeturfgrassweeds.edu)

Cool-season non-legumes

- Phacelia (*Phacelia tanacetifolia*)
  - Native to CA, but developed as cover crop in Europe
  - Good catch crop, smother crop, and pollen source
  - Can be grown as summer or winter annual, though not hardy below ~ 20 F

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: kentagextension.blogspot.com; larnerseeds.com)

Warm-season legumes

- Sunn hemp *(Crotalaria juncea)*
  - Rapid biomass and N production (120 lbs N/acre in 9 weeks)
  - Does best in very warm conditions
  - Limited by seed cost and availability in U.S.
  - Suppressive to root-knot and reniform nematodes

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: J. Cotton Sci.)

Warm-season legumes

- Bean-like
  - Cowpea *(Vigna unguiculata)*
  - Velvet bean *(Mucuna pruriens*)
  - Soybean *(Glycine max*)
  - Hyacinth bean (*Lablab purpureus*)
  - Jack bean (*Canavalia ensiformis*)
- High biomass and N production
- Work well mixed with warm-season grasses
- Pest suppression and allelopathy vary

Slide courtesy of David Butler, UT

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(photos: J. Cotton Sci.; velvetbean-mucuna.com; cilr.uq.edu.au)

Warm-season non-legumes

- Sorghum-sudangrass hybrid *(Sorghum bicolor x S. bicolor* var. *sudanense)*
- Very high biomass production, great for building soil organic matter
- High allelopathy and very competitive with weeds
- Suppressive against some pathogens and nematodes

Slide courtesy of David Butler, UT

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(Clark, 2007; photos: agroatlas.ru)

Warm-season non-legumes

- Millets
  - Pearl millet *(Pennisetum glaucum)*, Japanese millet *(Enchinochloa frumentacea)*, & German (foxtail) millet *(Setaria italica)*
  - High biomass
  - Very tolerant of drought, heat, low fertility

Slide courtesy of David Butler, UT

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(photos: preferredseed.com, uga.edu, hffinc.com)

Warm-season non-legumes

- Buckwheat *(Fagopyrum esculentum)*
  - Rapid growth (maturity in 45 days)
  - Good smother crop
  - Attracts pollinators
  - Can seed easily and become weedy if not well-managed

Slide courtesy of David Butler, UT

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(photos: cornell.edu)

Warm-season non-legumes

- Sesame (*Sesamum indicum*)
  - Likely to be suppressive against root-knot nematodes and some pathogens
  - Prefers very warm conditions
  - Extensive root system

(photo: ksu.edu)

Slide courtesy of David Butler, UT

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Perennial/ley/sod crops

- Longer fallow periods
- Build soil organic matter
  - Root biomass
- Legumes contribute high N
- Used for grazing, haying, etc
- Options
  - Alfalfa, red clover, white clover
  - Orchardgrass, tall fescue, etc.

Slide courtesy of David Butler, UT

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(photos: uga.edu; uvm.edu; nrcs.usda.gov)

Evaluating Fall Planted Cover Crops for Organic Systems in East Tennessee

Mary Rogers, Brandon Smith & Annette Wszelaki

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Evaluating Fall Planted Cover Crops for Organic Systems in East Tennessee

- Timing is critical for proper cover establishment
- Cover crop choice is important
  - Grain versus legume
- Choosing a grain-legume biculture may maximize the benefits of both crop types

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Objectives:

1. Determine if grain crop/legume biculture results in increased biomass and higher nitrogen than monoculture plantings;
2. Determine effect of planting data on crop growth, soil cover and percent carbon and nitrogen content.

Methods

- Study carried out in 2008 and 2009
- Grains:
  - soft red winter wheat
  - winter rye
  - winter barley
  - winter triticale
  - spring oats , untreated

  (Sources Albert Lea Seed House, Albert Lea, MN, Knox Seed and Greenhouse)
- Legumes:
  - crimson clover
  - medium red clover
  - ladino clover
  - Austrian winter pea
  - hairy vetch

  (Source Seven Springs Farm, Check, VA)

Methods

- Treatments included all crops in monoculture and all possible grain x legume combinations and a no-crop check plot (36 treatments
- The planting rate was 120 lbs/acre for all the grains used in monoculture and 30 (C), 4 (L), 10 (r), 40 (V) and 120 (A) lbs/acre for the legumes
- The planting rate was 60 lbs/acre for all the grains used in biculture and 15, 2, 5, 20 and 60 lbs/acre for the legumes
- Field (160 ft x 305 ft) spaded with an Imants Spader (Imants, Reusel, The Netherlands) and cultipacked with a Brillon seed cultipacker (Brillion, WI)
- Plots were 64” wide by 20’ long and seeds were planted 1” deep with a 64”-wide Almaco light duty grain drill (Almaco, Nevada, IA)

Methods

- Prior to planting, legume seed was separated and inoculated
  - vetch: N-Dure (*Rhizobium leguminosarum* biovar *viceae*)
  - clover: N-Dure (*Sinorhizobium meliloti* and *Rhizobium leguminosarum* biovar *trifolii*)
  - Austrian winter pea: Guard-N (*Bradyrhizobium* sp. and *Rhizobium leguminosarum*)

    (Source INTX Microbials, LLC, Kentland, IN)

Methods

- Planting dates in 2008: 16 Sept, 13 Oct and 19 Nov; in 2009: 25 Sept, 21 Oct and 12 Nov
- In mid-April of the following spring (2009 and 2010), population density was measured by diagonal transect, collecting 10 samples per plot to determine % percent cover
- A 1 ft^2 quadrant was tossed at random to collect biomass
- Biomass was dried, ground and analyzed for carbon and nitrogen content
- Analysis was done using a NC analyzer (Flash 2000, Thermo Scientific, Waltham, MA).

% Nitrogen 2009

Crop	September	October	November
A	0.85 ± 0.07	0.74 ± 0.05	--
BA	0.35 ± 0.07	0.31 ± 0.06	--
OA	0.68 ± 0.09	0.79 ± 0.05	0.90 ± 0.2
TA	0.32 ± 0.05	0.34 ± 0.06	0.55 ± 0.2
RA	0.47 ± 0.09	0.42 ± 0.05	0.60 ± 0.1
WA	0.28 ± 0.07	0.43 ± 0.06	0.64 ± 0.1
C	0.58 ± 0.05	0.59 ± 0.05	--
L	--	--	--
r	0.34 ± 0.09	0.48 ± 0.09	--
V	0.85 ± 0.05	0.86 ± 0.09	0.64 ± 0.1
B	0.28 ± 0.05	0.25 ± 0.04	--
O	0.28 ± 0.09	--	--
T	0.40 ± 0.05	0.32 ± 0.04	--
R	0.54 ± 0.05	0.32 ± 0.05	0.6 ± 0.2
W	0.21 ± 0.05	0.21 ± 0.04	0.6 ± 0.1

% N and C of grain and legume monocultures by planting date

Month	Crop type	% nitrogen	% carbon	C:N
Sept	grain	0.29 ± 0.0 **b**	7.7 ± 0.7 **ab**	26.6
Sept	legume	0.73 ± 0.2 **a**	7.1 ± 0.8 **ab**	9.7
Oct	grain	0.27 ± 0.0 **b**	7.8 ± 0.5 **a**	28.9
Oct	legume	0.66 ± 0.0 **a**	7.8 ± 0.1 **a**	11.8
Nov	grain	0.58 ± 0.1 **ab**	8.5 ± 0.1 **a**	14.7
Nov	legume	0.64 ± 0.4 **a**	5.3 ± 2.8 **b**	8.3
month (p; df)		p = .6009; 2, 9	p = .7275; 2, 9	
crop type		p = .0015; 1, 9	p = .0120; 1, 9	
month*crop type		p = .0260; 2, 9	p = .4353; 2, 9	

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% soil cover by planting date

Crop	September	October	November
BA	90.0 ± 0.0	100.0 ± 0.0	40.0 ± 5.8
TA	100.0 ± 0.0	100.0 ± 0.0	73.3 ± 14.5
C	100.0 ± 0.0	86.7 ± 6.7	0.0 ± 0.0
OC	100.0 ± 0.0	90.0 ± 0.0	0.0 ± 0.0
TC	100.0 ± 0.0	95.0 ± 5.0	53.3 ± 8.8
RC	100.0 ± 0.0	100.0 ± 0.0	70.0 ± 17.3
WC	100.0 ± 0.0	80.0 ± 0.0	83.3 ± 8.8
WL	100.0 ± 0.0	70.0 ± 20.0	70.0 ± 11.5
V	100.0 ± 0.0	95.0 ± 5.0	33.3 ± 12.0
RV	93.3 ± 6.7	95.0 ± 5.0	100.0 ± 0.0
WV	93.3 ± 6.7	100.0 ± 0.0	80.0 ± 0.0

% soil cover by planting date

Crop	September	October	November
B	86.7 ± 8.8	90.0 ± 10.0	46.7 ± 26.0
T	93.3 ± 6.7	95.0 ± 5.0	96.7 ± 3.3
R	90.0 ± 10.0	90.0 ± 10.0	93.3 ± 6.7
W	76.7 ± 3.3	90.0 ± 5.8	76.7 ± 8.9
A	76.7 ± 6.7	75.0 ± 5.0	13.3 ± 3.3
L	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
OL	3.3 ± 3.3	0.0 ± 0.0	0.0 ± 0.0
r	50.0 ± 17.3	10.0 ± 10.0	0.0 ± 0.0
Or	33.3 ± 6.7	15.0 ± 5.0	0.0 ± 0.0
O	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

% soil cover by grain crops

Month	Crop type	% soil cover 2009	% soil cover 2010
Sept		63.0 ± 2.0 **a**	28.2 ± 2.8 **b**
Oct		63.7 ± 2.4 **a**	47.9 ± 2.8 **a**
Nov		50.0 ± 2.0 **b**	43.2 ± 2.9 **a**
	B	64.0 ± 2.7 **b**	22.1 ± 3.6 **b**
	O	0.0 ± 2.7 **c**	26.9 ± 3.7 **b**
	R	79.0 ± 2.7 **a**	53.9 ± 3.6 **a**
	T	76.0 ± 2.7 **ab**	51.6 ± 3.6 **a**
	W	75.6 ± 2. 7**ab**	44.3 ± 3.6 **a**
month (p; df) culture (p; df) month*culture		p = .0008; 2, 23 p <.0001; 4, 23 p = .0197; 8, 23	p = .0001; 2, 28 p <.0001; 4, 28 p = .0267; 8, 28

% soil cover by legume crops

Month	Crop type	% soil cover 2009	% soil cover 2010
Sept		28.3 ± 2.4 **a**	65.1 ± 4.3 **a**
Oct		25.9 ± 3.0 **a**	50.9 ± 4.3 **b**
Nov		6.4 ± 2.4 **b**	26.2 ± 4.4 **c**
	A	23.3 ± 3.4 **b**	61.7 ± 4.8 **a**
	C	34.2 ± 3.2 **b**	65.4 ± 4.9 **a**
	L	0.2 ± 3.7 **d**	19.8 ± 4.8 **b**
	R	6.5 ± 3.1 **c**	25.5 ± 4.9 **b**
	V	36.6 ± 3.4 **a**	64.6 ± 4.8 **a**
month (p; df) culture (p; df) month*culture		p <.0001; 2, 23 p <.0001; 4, 23 p = .0013; 8, 23	p <.0001; 2, 28 p <.0001; 4, 28 p =.4722; 8, 28

% soil cover by mono- and bicultures

Month	Crop type	% soil cover 2009	% soil cover 2010
Sept	monoculture	68.3 ± 7.0 **bc**	59.0 ± 5.3 **bc**
Sept	biculture	86.9 ± 2.7 **a**	86.9 ± 2.1 **a**
Oct	monoculture	65.5 ± 8.5 **cd**	81.3 ± 3.4 **ab**
Oct	biculture	84.4 ± 3.7 **ab**	86.0 ± 2.8 **a**
Nov	monoculture	36.0 ± 7.5 **e**	52.0 ± 7.7 **c**
Nov	biculture	52.7 ± 3.8 **de**	68.3 ± 3.8 **bc**
month (p; df) culture (p; df) month*culture		p = .0004; 2, 8 p = .0072; 1, 8 p = .3919; 2, 8	p = .0076; 2, 10 p = .0023; 1, 10 p = .2610; 2, 10

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Plant height of grains

Month	Culture type	Plant height (cm) 2009	Plant height (cm) 2010
Sept	monoculture	71.5 ± 8.4 a	60.8 ± 5.0 c
Sept	biculture	70.7 ± 3.7 a	66.8 ± 4.0 bc
Oct	monoculture	67.9 ± 10.3 a	74.9 ± 5.0 abc
Oct	biculture	68.7 ± 4.6 a	82.3 ± 4.0 a
Nov	monoculture	41.2 ± 8.4 b	77.6 ± 4.9 ab
Nov	biculture	36.9 ± 3.7 b	80.7 ± 4.0 ab
month (p; df) culture (p; df) month*culture		p = .0007; 2, 8 p = .7837; 1, 8 p = .8945; 2, 8	p = .0123; 2, 8 p = .0944; 1, 8 p = .4247; 2, 8

Plant height of legumes

Month	Culture type	Plant height (cm) 2009	Plant height (cm) 2010
Sept	monoculture	32.5 ± 5.8 **a**	45.3 ± 4.0 **b**
Sept	biculture	42.8 ± 2.8 **a**	52.4 ± 4.0 **ab**
Oct	monoculture	29.5 ± 7.4 **ab**	45.7 ± 4.0 **b**
Oct	biculture	39.8 ± 3.4 **a**	55.2 ± 2.5 **a**
Nov	monoculture	8.8 ± 6.0 **c**	45.3 ± 2.6 **b**
Nov	biculture	14.1 ± 2.8 **bc**	47.6 ± 2.5 **b**
month (p; df) culture (p; df) month*culture		p = .0009; 2, 8 p = .1263; 1, 8 p = .9887; 2, 8	p = .1262; 2, 8 p = .0158; 1, 8 p = .4280; 2, 8

Things to Consider:

- Crop to be planted
- Maturity differences between cover species
- Ease of killing
  - mowing versus rolling
- End goal (nitrogen, weed control, disease suppression)

Slide courtesy of Gary Bates,
UT Forage Specialist

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Thank you! Questions?

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TN Horticultural Expo: January 26-28

Organic Crops Field Tour: April 26

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