2017 Urban and Small Farms Conference Program

Wednesday, February 22, 2017

Time	Commercial Producer Track	Beginning Farmer Track
7:30 AM	**Registration Open**	
	Vegetable *Organized by: Dan Drost*	**Soils/Fertility/Nutrition** *Organized by: Grant Cardon*
8:00 AM	**Tomato Variety Trial 2016: Challenging results! -** Taun Beddes, USU **pg. 1**	**Principles of Basic Soil Science -** Dr. David Tarkalson, USDA-ARS **pg. 39**
8:30 AM	**Transplants, Mulches and Row Covers: Are they worth the bother? -** Dan Drost, USU **pg. 6**	
9:00 AM	**Tomato/Pepper Diseases: What's commonly out there? -** Claudia Nischwitz, USU **pg. 10**	**Soil Nutrients and Cycling: The big 3 and availabitily issues in calcareous soil -** Dr. Jim Ippolito, Assoc. Prof., CSU **pg. 47**
9:30 AM	**Organic Tomato Production** - Liz Maynard, Purdue University **pg. 20**	
10:00 AM	**BREAK**	
10:30 AM	**Tomato & Pepper Nutrition: What's needed? -** Liz Maynard, Purdue University **pg. 26**	**Soil and Plant Testing: Taking good samples, which tests to use and how often to test, report interpretation/ nutrient recommendations, etc. -** Dr. Grant Cardon, USU **pg. 56**
11:00 AM	**To Shade or Not to Shade: Improving tomato/pepper fruit quality -** Dan Drost, USU **pg. 30**	**Nutrient Sources: How to choose them to meet plant nutrient need in tradional, organic, or mixed management settings -** Dr. Bryan Hopkins, BYU **pg. 70**
11:30 AM	**Biochar and Tomatoes: What we're learning -** Britney Hunter, USU **pg. 35**	
Noon	**Lunch Break**	

Session Target
Beginning Farmer
General Audiences
Experienced Producers
Beginning Farmer Limited English Speaking

2017 Urban and Small Farms Conference Program

Time	Utah Berry Growers *Organized by: Brent Black*	Vegetable Pest Management 101 *Organized by: Cami Cannon*	Beginning Farmer IRC Track *Organized by:Sarah Heller*
Noon	**Lunch Break**		
1:00 PM	**Spider Mite Management in Berries and Update on Spotted Wing Drosophila -** Diane Alston, USU **pg. 83**	**Weed Management Basics -** Matt Palmer, USU **pg. 123**	**Introduction -** Sarah Heller
1:30 PM	**Bees and Pollination -** Corey Andrikopoulos, USU **pg. 89**	**Insect and Mite Pest Management of Cole Crops & Tomatoes -** Cami Cannon, USU **pg. 130**	**Honey and Chickens** - James Barnhill, USU **pg. 166**
2:00 PM	**Raspberry Varieties for the South -** Rick Heflebower, USU **pg. 96**	**Common Insect and Mite Pests of Corn and Squash -** Diane Alston, USU **pg. 140**	
2:30 PM	**BREAK**		
3:00 PM	**Freeze Protection Strategies/Tunnel Update** - Brent Black, USU **pg. 99**	**Diseases of Onions and Cucurbits Plus Curly Top Update -** Claudia Nischwitz, USU **pg. 145**	**Season Extension** - Dan Drost, USU **pg. 167**
3:30 PM	**Alternative Crops -** Brandon Willis, USU **pg. 106**	**Understanding and Promoting Soil Health: Facts vs. Myths** Michael Domeier - State Soil Scientist and Meredith Albers - Resource Soil Scientist **pg. 152**	
4:00 PM	**Berry Production in Pennsylvania** - Kathy Demchak, Penn State **pg. 111**	**Hands-On Learning: Pest ID, pesticide labels & safety, monitoring basics, and resources -** Marion Murry, IPM Project Leader Drew Matthews, Compliance Specialist UDAF Cami Cannon, Vegetable IPM Associate **pg. 159**	**Food Safety** - Karin Allen, USU **pg. 172**
4:30 PM	**Participant Survey** - Brent Black, USU		
5:00 PM			

Tomato Variety Trials for 2016

Biographical Information:
Taun Beddes
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Taun Beddes has been with USU Extension for almost 10 years as a horticulturist. He primarily spends time working with commercial fruit and vegetable growers in Utah County and along the Wasatch Front. He additionally assists commercial pesticide applicators and hobby horticulturists. Most of his current research includes vegetable varietal trialing and gauging fruit tree rootstock performance.

Session Description:
Cover the results from the first year of a 2 year tomato variety trial.

Tomato Trial 2015

Year 1 of a 2 year trial

Methods

- Trial sandwich and 'Early Girl' type tomatoes.
- Ripening patterns
- Total ripe fruit
- Fruit size and consistency

Cultivars

Arbason
- 7-9 oz. fruit
- Resistant to multiple diseases
- Indeterminate

Celebrity
- 7-8 oz. fruit
- AAS Winner
- Resistant to multiple diseases
- Determinate

Varieties

Charger
- Resistant to multiple diseases
- 10-14 oz. fruit
- Determinate

Early Girl (Bush)
- 6-8 oz. fruit
- Early
- Resistant to multiple diseases

Cultivars

Estiva
- 6-7 oz. fruit
- Resistant to multiple diseases
- Reportedly productive

Frederik
- 7-9 oz. fruit
- Greenhouse cultivar
- Indeterminate

Cultivars

Mountain Fresh
- 8-16 oz. fruit
- Disease resistant, tolerates cool, wet weather
- Reportedly productive

New Girl
- 4-6 oz. fruit
- Improved 'Early Girl'
- Indeterminate

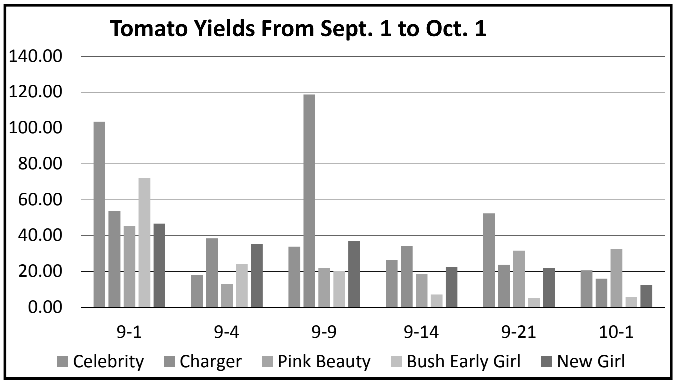
Cultivars

Pink Beauty
- Pink blushed fruit
- Fewer blemishes on fruit
- Excellent Flavor
- Indeterminate, 6-8 oz. fruit

Valley Girl
- Improved 'Early Girl'
- 6-8 oz. fruit
- Indeterminate
- Disease resistant

Methods

- Planted in mid May
- Monitored for pests and diseases
- Drip irrigated under plastic mulch
- Tomatoes trellised
- Harvest began September 1



Year 1 Results: Celebrity

• Medium Acidity • Cracking (10-20%)	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	5.89	2.36	2.75		
Last Harvest	6.73	2.38	2.82		
Average	6.31	2.37	2.79	560.72	6.23

Year 1 Results: Charger

• Peaked 8 days later than Celebrity • Medium acid, slightly less flavor	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	6.77	2.40	2.44		
Last Harvest	6.53	2.83	2.87		
Average	6.66	2.61	2.65	626.62	6.95

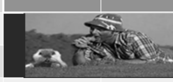
Year 1 Results: Mountain Fresh

• Popular East Coast production variety	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	7.26	2.43	2.87		
Last Harvest	5.77	2.84	2.67		
Average	6.51	2.64	2.77	433.67	4.81

Year 1 Results: Pink Beauty

• Rose blush • Greater sugar content	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	8.25	2.37	2.66		
Last Harvest	7.74	2.25	2.35		
Average	7.95	2.31	2.51	468.22	5.20

Year 1 Results: Estiva

• More acidic • Gopher bate	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	5.69	2.35	2.64		
Last Harvest	4.75	2.48	2.42		
Average	5.22	2.42	2.53	543.46	6.04

Year 1 Results: Arbason

• Low acidity, sweet	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	4.80	2.19	2.48		
Last Harvest	4.57	2.29	2.48		
Average	4.69	2.24	2.48	534.87	5.94

Year 1 Results: Frederick

• Medium Acidity • Meaty	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	4.96	2.31	2.50		
Last Harvest	4.53	2.21	2.40		
Average	4.75	2.26	2.45	543.66	6.04

Year 1 Harvest: New Girl

• Best of the "Girl" types	Individual Fruit Average			Total Yield (Lbs.)	Pounds Per Row-Foot
	Weight (OZ)	Height (Inches)	Width (Inches)		
Beginning Harvest	4.87	2.14	2.86		
Last Harvest	3.05	1.95	1.08		
Average	3.96	2.05	1.97	385.81	4.28

2016

- Continue on
- Cultivars:
  - Arbason
  - Celebrity
  - Charger
  - Frederick
  - Pink Beauty
  - Mountain Fresh
  - Hamson (DX 5212)
- No “Girl” types

Curly Top Virus

Curly Top

2016 Results

- 50% - 70% plant death by September
- 50% - 90% reduction in yield
- Off flavored fruit

2017

- Try again
- Focus on Charger, Celebrity and Pink Beauty
- May try a single year of
  - Quali T 23,
  - Improved Celebrity or
  - Champion or
  - Mountain cultivars
- For commercial use, determinate girl types are less useful
- Focus and define market
  - Pink Beauty

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Transplants, Mulches and Row Covers: Are they worth the bother?

Biographical Information:
Daniel Drost
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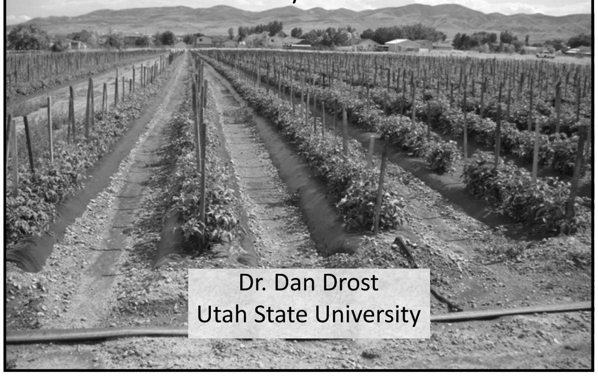
Dr. Drost is a Professor of Horticulture and Extension Vegetable Specialist in the Department of Plants, Soils and Climate at Utah State University. Dan has extension, research and teaching responsibilities that focus on small farms issues and addresses plant growth and crop production that impact Utah's commercial vegetable farms. Dr. Drost grew up on a diverse crop-livestock farm in Michigan and has a master's degree in horticulture from Michigan State University and a PhD in vegetable crops from Cornell University.

Session Description:

Focus on how these technologies influence crop establishment and growth in tomato and peppers.

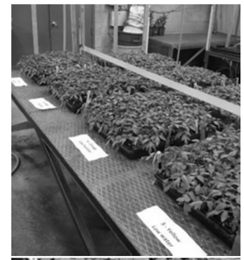
Transplants, Mulches & Row Covers: Are they worth it?

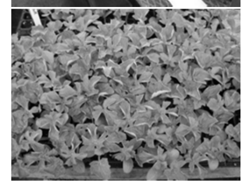


Dr. Dan Drost
Utah State University

Why Transplants

- More Uniform Seed Germination
- Less Variability
- Earlier Start
- Extends Production season
- Earlier-Enhanced Yields





Growing Plants Not for Everyone

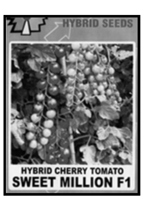
- Expensive (facilities, time, etc)
- Quality Issues
- Need lots of plants and types
- Some Plants are Harder to Grow or Transplant
  - Root Crops (carrot, beet; ???)
  - Leafy Biennials (dill)
  - Those that Grow Quickly (lettuce, spinach)
  - Cucurbits (melon, cucumber, squash)

Production Difficulties

Easy	More Difficult	Most Difficult
Broccoli	Cauliflower	Cucumber
Brussels Sprouts	Celery	Muskmelon
Cabbage	Eggplant	Squash
Lettuce	Onion	Watermelon
Tomato	Pepper	

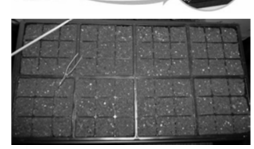
When to Grow Plants?

- If using Expensive Hybrids
- Plants needed for Your Production Schedule
- Unique Plants or Production Approaches



Transplant Success Depends on…….

- Seed Source
- Trays; Flats; Cell Size
- Growing Medium
- Nutrition
- Light
- Temperature
- Moisture
- Hardening



Common Production Issues

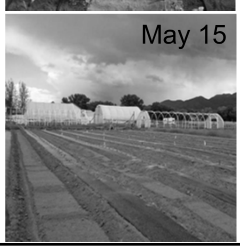
- Poor Plant Performance
- Non-uniform Growth
- Hypocotyl Elongation

To Harden (Condition) or ……

- Pre-conditions plants to cope with field stress
- Increases plant tolerance to cold, heat, water shortages
- Question? Do they work?

- Commonly used hardening approaches:
  - Reduce water or fertilizer
  - Subject to cooler temperatures
  - Brush or shaking

Tomato/Pepper Transplant Performance



Tomato (spring or summer – Cold or Hot)

Apr7	Unheated; High Tunnel; No protection (28 days)				
	Control	Brush	Cold	Fert	Water
DW	5.0	4.6	3.7	4.9	4.3
LA	419	364	270	377	328

Jul8	Field planted on black plastic (17 days)				
	Control	Brush	Cold	Fert	Water
DW	12.1	11.3	7.5	11.4	11.3
LA	968	839	585	831	860

Peppers (spring or summer – Cold or Hot)

Apr7	Unheated; High Tunnel; No protection (32 days)				
	Control	Brush	Cold	Fert	Water
DW	1.20	1.30	0.95	1.06	1.13
LA	86	96	77	88	88

Jul18	Field planted on black plastic (33 days)				
	Control	Brush	Cold	Fert	Water
DW	11.9	11.8	11.6	10.8	9.5
LA	1246	1169	1148	1046	966

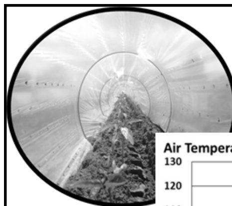
Transplant Conclusions

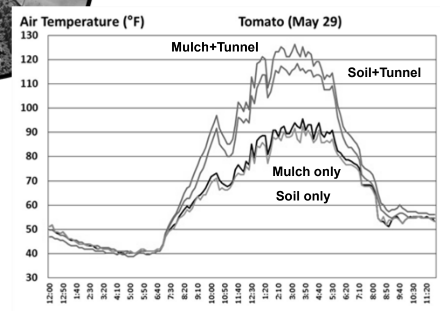
- None of the conditioning treatments preformed better than controls.
- Nutrient starving, cold, and low water adversely affect tomato and pepper.
- Brushing helps keep plant compact.

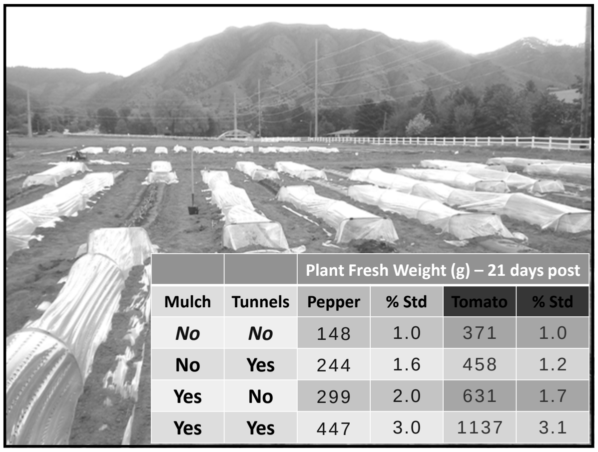
Tomato and Pepper: Mulches & Row Covers

- Planting Dates:
  - Pepper (TomCat) May 16 – Reemay Cover
  - Tomato (Sunbrite) May 17 – Perf Plastic
- Plastic vs. Bare Soil; ± Row Cover (plastic/Reemay)
- Growth Measurements (June 8-10)
  - Fresh/Dry Weight
  - Leaf Number/Leaf Area
  - Temperature monitored

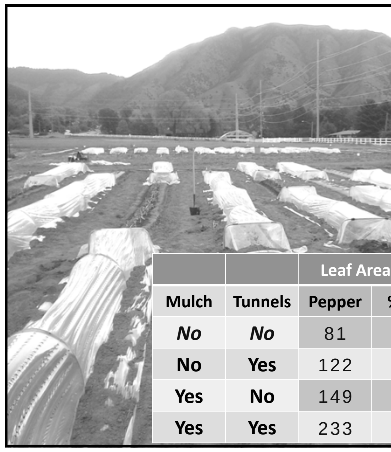
Soil and Air Temperature



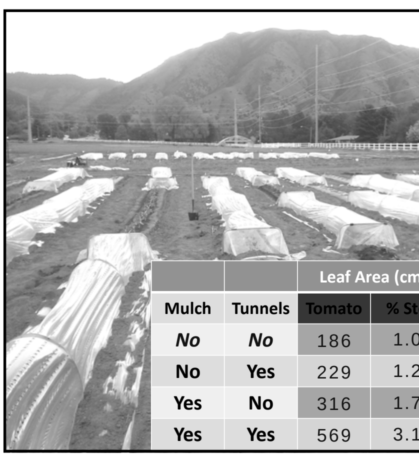




		Plant Fresh Weight (g) – 21 days post			
Mulch	Tunnels	Pepper	% Std	Tomato	% Std
No	*No*	148	1.0	371	1.0
No	Yes	244	1.6	458	1.2
Yes	No	299	2.0	631	1.7
Yes	Yes	447	3.0	1137	3.1



		Leaf Area (cm²)		Leaf Number	
Mulch	Tunnels	Pepper	% Std	Pepper	% Std
No	*No*	81	1.0	13	1.0
No	Yes	122	1.5	19	1.5
Yes	No	149	1.9	21	1.6
Yes	Yes	233	2.9	24	2.1



		Leaf Area (cm²)		Leaf Number	
Mulch	Tunnels	Tomato	% Std	Tomato	% Std
No	*No*	186	1.0	12	1.0
No	Yes	229	1.2	14	1.1
Yes	No	316	1.7	15	1.2
Yes	Yes	569	3.1	19	1.6

Mulch & Covers Conclusions

- **Goal**: Grow bigger plants that should produce more later in season.
- Plants grown under row covers subjected to very high temperatures.
- Hi temperatures however did not affect tomato or pepper growth.

Tomato/Pepper Diseases: What's commonly out there?

Background information:

Claudia Nischwitz
Utah State University
5305 Old Main Hill
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I am the extension plant pathologist at USU. I work mostly on management and identification of vegetable diseases and do diagnostics.

Session Description:

Presenting on the diseases of peppers and tomatoes that occur in Utah

Tomato/Pepper Diseases: What's Commonly Out There?

Claudia Nischwitz

Associate Professor and Extension Specialist

Email: claudia.nischwitz@usu.edu

UtahStateUniversity COOPERATIVE EXTENSION

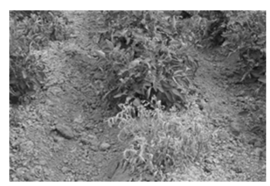
Curly top

Curly top

- Tomatoes and peppers
- Other hosts: Beans, pumpkins, gourds, beets and spinach
- Causal agent: Curtoviruses
- Transmitted by beet leafhopper

Curly top

- Symptoms (tomato):
  - Leaf margins turn upwards
  - Leaves turn yellow with purple veins
  - Premature fruit ripening
  - Stunted plants



http://wrir4.ucdavis.edu/Photos/FRCs/drec/pages/Tomato%20Curly%20Top%20Virus.htm

http://www.growingproduce.com/vegetables/virus-slams-california-tomatoes/

Curly top

- Symptoms (pepper):
  - Plants are yellow and stunted
  - No marketable fruit

http://wrir4.ucdavis.edu/PHOTOS/pest/pages/Beet%20Curly%20Top%20Virus%20on%20Bell%20Peppers%20NM.htm

http://www.growingmagazine.com/fruits/new-approaches-in-virus-resistance-development/

Curly top

- Management:
  - Floating row covers for young transplants
  - Shade cloth
  - Good weed control

Tomato spotted wilt virus

Tomato spotted wilt virus

- TSWV is an important pathogens of tomato, pepper, tobacco and peanut in the U.S.
- The virus is transmitted by thrips
- Thrips have to acquire the virus as larvae to be able to transmit it as adults. Once larvae are infected, thrips carry and transmit the virus throughout their entire lifespan

Tomato spotted wilt virus

- *TSWV* is not seedborne
- Plants get infected early in the season
- Symptoms:
  - Necrotic spots on leaves
  - Stunting of plants
  - Necrotic rings on immature fruit
  - Chlorotic ringspot on mature fruit

Tomato spotted wilt virus




Tomato spotted wilt virus


Tomato spotted wilt virus

- Management:
  - Resistant varieties (Finish Line, Fletcher, Crista, Red Defender, BHN 602 and Picus)
  - Reflective mulch
  - Insecticides (potential resistance problems)

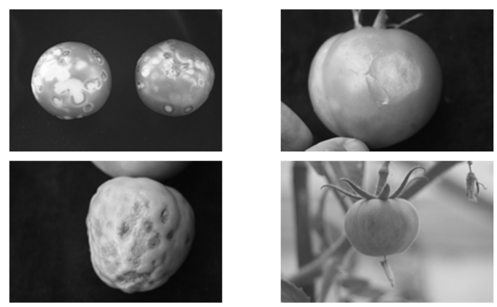
Tobacco mosaic virus/Tomato mosaic virus

Tobacco/Tomato mosaic virus

- Seedborne in tomato and other plants
- Transmitted by handling infected plants or tobacco
- Survives 50 years in plant debris, contaminated pots etc.
- Disinfecting pots and tools
- Change gloves

TMV on tomato

TMV/ToMV on tomato



TMV on pepper

TMV/ToMV - Management

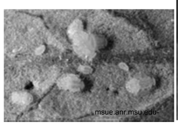
- Use certified seed
- Resistant varieties
- Disinfecting pots and tools
- Replace plant substrate in greenhouse beds
- Change gloves frequently

TMV/ToMV - Management

Liberibacter

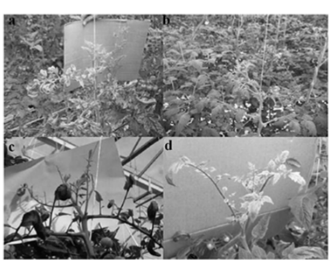
Candidatus Liberibacter solanacearum

- Infect tomatoes and peppers
- Other hosts: potatoes (Zebra chip disease)
- Causal agent: non-culturable bacterium Candidatus *Liberibacter solanacearum*
- Transmitted by potato psyllid



Liberibacter - Pepper

Liberibacter - Tomato



nwdistrict.ifas.ufl.edu

Liberibacter - management

- Scouting for potato psyllids
- Controlling psyllids with imidacloprid starting early in the season
- Good weed management
- Once a plant is infected there is no cure

Bacterial spot

Bacterial spot of pepper and tomato

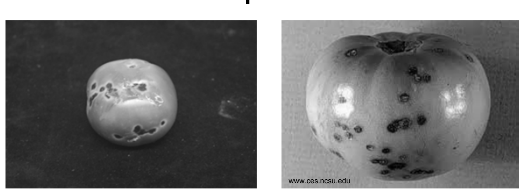
- Caused by several species of *Xanthomonas*
- Bacteria are seedborne and they can survive in plant debris (primary infections)
- Spread from plant to plant: splashing water, wind and humans
- Symptoms:
  - Infected seedlings may not show symptoms but leaves can turn yellow and fall off
  - Older plants show develop brown, necrotic spots on leaves and fruit with a yellow halo

Bacterial spot of pepper and tomato

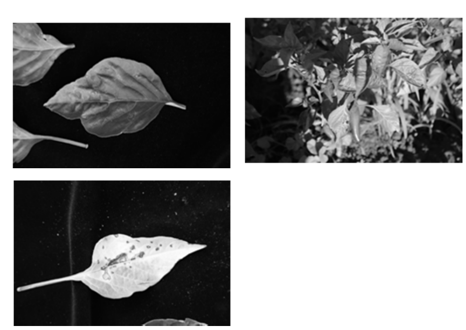
- Leaves eventually die
- Tomato: Dead leaves remain on plants
- Pepper: Dead leaves fall off

Bacterial spot - tomato

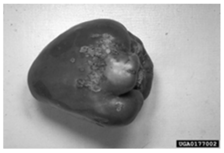
Bacterial spot - tomato

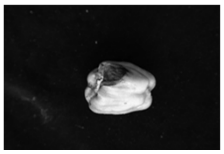


Bacterial spot - pepper



Bacterial spot - pepper





Bacterial spot - management

- Use certified disease-free seed or transplants
- Remove tomato and pepper plant debris from fields
- Crop rotation for one-two years
- Application of copper products when first spots are observed (several states have problems with bacteria resistant to copper)
- Resistant varieties:
  - Pepper varieties depending on the bacterial races present
  - No resistant tomato varieties

Verticillium wilt

Verticillium wilt

- Soilborne pathogen; Microsclerotia can stay viable in soil up to 10 years
- Hosts: many vegetables including tomato, pepper
- Conditions for infection: Moist soil, temperatures 70-81F; stops growing at 90F
- Transmission: Infected transplants or seed potatoes, soil cultivation and wind and water

Verticillium wilt – Symptoms

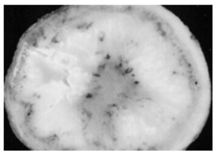
- Vascular discoloration when stems are cut
- Wilting of plants
- Symptoms may only appear on one side of plant
- Yellowing of leaves, leaves turn brown and dry
- Tomato: Yellowing of lower leaves in a v-shape

Verticillium wilt

http://www.omafra.gov.on.ca/IPM/english/tomatoes/diseases-and-disorders/verticillium-wilt.html

Verticillium wilt

http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Pages/VerticilliumWilt.aspx



http://www.extension.umn.edu/garden/yard-garden/vegetables/verticillium-wilt-of-tomatoes-and-potatoes/

Verticillium wilt – Management

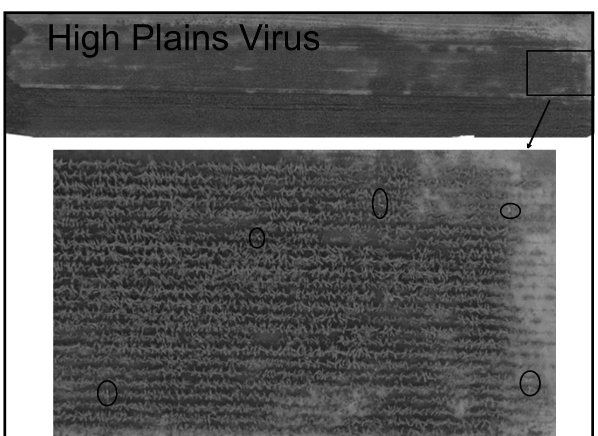
- Resistant varieties (descriptions of varieties have a “V” in disease resistance category)
- Disease-free transplants
- Remove and destroy infected plant material
- Fumigants (pre-plant):
  - Telone C-17 (restricted use)
  - Vapam HL (restricted use)
  - K-Pam HL (restricted use)

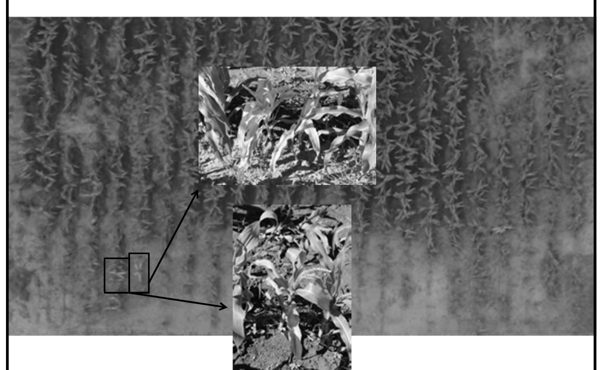
Application examples for UAVs

Early detection of problems in the field

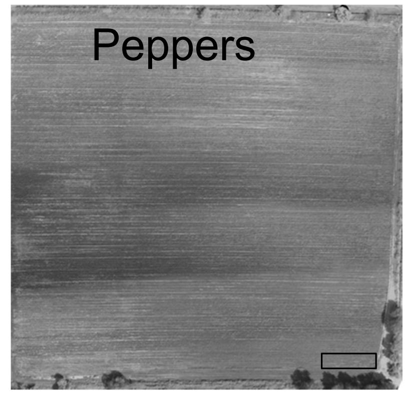
- Planting problems
- Potential disease problems

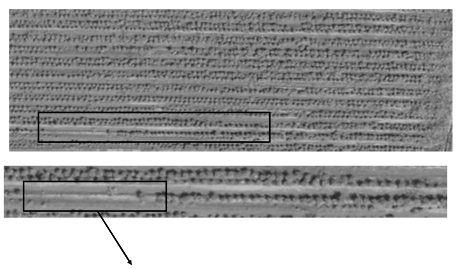
High Plains Virus





Planting problems





~30 plants missing

5-7 peppers per plant

2 rows of peppers per bed

Bell pepper size	Peppers per box
Extra large	45-55 (6.5-11 plants)
Large	60-70 (9-14 plants)
Medium	75-85 (12-17 plants)
Small	90 (13-18 plants)

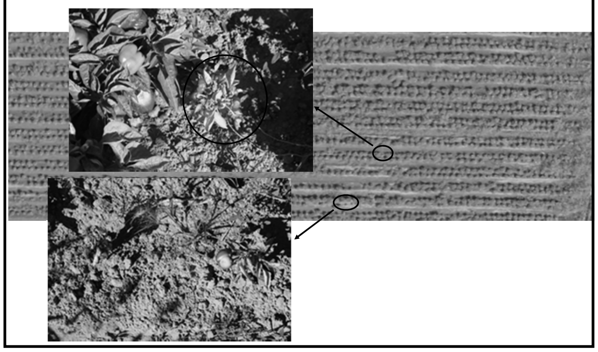
Plants per acre	Cartons per acre (theoretical)			
	Sm	med	lg	ex lg
10,000 (18 in)	550-770	580-930	770-1,000	900-1,500
14,000 (14 in)	770-1,080	930-1,300	1,000-1,600	1,500-2,100
26,000 (12 in)	1,400-2,000	1,600-2,400	1,850-3,000	2,300-4,000

Disease problems

Disease problems

- Detect diseased plants
- Contact Extension personnel or crop consultant for identification and management options
- Minimize spread and yield loss due to early detection

Example: *Candidatus* Liberibacter solanacearum



Thank you for listening! Questions?

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Organic Tomato Production

Background Information:

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Liz Maynard serves as a Purdue Extension specialist for vegetable crops in Indiana. Her research and extension focus on cultural practices for sustainable vegetable production. Recent projects include extending production of vegetables in fall, winter, and spring using protective structures including high tunnels, managing soil fertility on organic vegetable farms, and sweet corn variety evaluation.

Session Description:

This presentation will highlight keys to successful organic tomato production from seeding to harvest. Discussion will include transplant production, soil fertility, weed management, irrigation options, and more.

Organic Tomato Production Considerations
Liz Maynard, Purdue University

Successful organic tomato production involves attention to variety selection, transplant production, soil fertility, support and training, pest management, irrigation, and harvest and postharvest operations.

Choice of variety can make or break a crop. First ask: what do your customers want? What do they value? Consider the type of tomato: beefsteak, roma, cherry, etc.; the color; the importance of flavor and texture; and the desired appearance and shelf life. Look for varieties that will perform well in your location and production system. Consider typical days to harvest and duration of harvest; plant size and growth habit; high or low temperature tolerance. Varieties often differ in susceptibility to fruit quality troubles such as cracking, rough skin, uneven color development and cat-facing. If these issues are a problem, look for less susceptible varieties. Disease resistance is also important. Some varieties have a strong genetic resistance to particular pathogens, usually identified in seed catalogs. Other varieties have reduced susceptibility or aren't as affected as much by a disease, but this characteristic may not be listed in seed catalogs. For diseases that prevail in your operation, look for resistant and less susceptible varieties.

The goal in transplant production is to develop a healthy seedling that is poised to establish and grow when planted in the production site. Common practice involves seeding 5 to 7 weeks before transplanting. A disease-free growing medium is important. Seeds should germinate quickly from moist medium kept at 85°F. Once seeds are up, temperatures between 65° and 80°F are optimum and adequate light is important. Soil kept moist enough to prevent plant stress but not too wet \will lead to a strong root system. Depending on the growing medium used, seedlings may need additional nutrients during production. A compost-based growing medium may contain enough nutrients to support the plants for several weeks. However, in a peat-based growing medium with no fertilizers added other than lime, seedlings may experience nutrient deficiency soon after the first true leaf emerges. Nutrients can be supplied by mixing into the growing medium before planting, by mixing products such as fish emulsion with irrigation water weekly or more frequently, or by top-dressing flats. Commercial laboratories can test compost and growing media for nutrient content, soluble salt level, and pH. Results from tests conducted before seeding are useful in planning transplant production. Resources spent on growing healthy transplants will pay dividends down the road.

Methods for preparing the production field will vary depending on the crop rotation, size of field, whether raised beds and/or plastic mulch are used. A standard soil test for pH and nutrients, including micronutrients, will be very helpful in planning soil amendments. Some labs also provide a more extensive test of soil health that can be useful for long term planning. Specific recommendations for soil amendments will vary. Soil pH between 6 and 7 is acceptable. Plan to add some form of organic matter to the soil every year: a cover crop, plant residues, and compost are some examples. Assess the potential nitrogen release from the soil and plant residues, and determine whether it is adequate for the crop; if not, plan additional amendments. Estimating nitrogen release from soil organic matter, cover crops, and organic fertilizers is an imprecise calculation, so be prepared to monitor plants during the season and adjust plans if there seems to be excess or inadequate nitrogen. If the soil test indicates that phosphorus, potassium or other essential elements are lacking, plan to add amendments that will build up the soil supply. If phosphorus and potassium are adequate, plan to add amendments that will replace the amount that will be removed by the harvested tomatoes so that soil fertility does not decline. Soil amendments can be applied and incorporated before planting, or a portion applied before planting and the remainder applied in topdressing, sidedressings, and/or in irrigation water. The key is that the nutrients are in the soil, in the root zone, before the plant needs them.

Unwanted vegetation – weeds, crops or cover crops – is usually worked into the soil or otherwise cleared out two to four weeks before planting. This allows time for initial decomposition of the material and prevents carryover of some pests that may be present. The final planting bed is prepared within a week of planting. If a stale seedbed is part of the weed management plan, prepare the planting beds a few weeks in advance and provide moisture so that a flush of weeds germinates. Use very shallow cultivation or other means to kill the small weeds with as little soil disturbance as possible. If raised beds and/or plastic or paper mulch are used, they will be made/applied as part of the final pre-planting activities.

Transplanting after the frost-free date and, ideally, when soil temperatures are above 60°F is desirable. Before transplanting, condition seedlings to reduce transplant shock. Reduce the growing temperature, reduce watering, and increase light levels for several days to a week before transplanting. Keep the plants outside for a few days before they go to the field. When transplanting provide water right away and if soil fertility is low consider supplying some nutrients (e.g. fish emulsion) in the transplant water. If the soil is not moist before transplanting, irrigate so that transplant roots will have moist soil to grow into.

Depending on the variety of tomatoes and particular production system, supporting and possibly pruning the plants will be important. Tomato plants can be categorized into two main growth habits: determinate and indeterminate. On determinate plants, the main stem and each branch (sucker) produce leaves alternating with flower clusters until eventually the stem or branch 'terminates' in a flower cluster. After that terminal cluster, the stem or branch does not get any longer; any new growth comes from new branches that develop where leaves attach. Some determinate varieties are quite short and can easily be grown without support; they tend to be the earliest varieties and in a long growing season yield will drop off towards the end of the season. Other determinate varieties are tall enough that they usually require support. In a 120-day growing season these varieties will still be producing up to a killing frost. In some production systems, the lower branches (suckers) on these larger determinate varieties are pruned off. On indeterminate plants, the main stem and branches produce one flower cluster every three leaves, and the stems and branches will continue producing leaves and flowers until something kills them. Indeterminate varieties almost always are supported, and often are pruned to one or two stems by removing suckers when they are small.

Common support systems for determinate varieties include the stake-and-weave system– where plants are held upright by a series of horizontal strings attached to stakes placed between plants in the row–and individual metal cages for each plant. For indeterminate varieties, the stake-and-weave system can be used, or when plants are pruned to one or two stems, each stem can be supported by tying to a stake, or by attaching to a string that is then attached to a structure above the plants (e.g. a greenhouse or framework in the field). For both indeterminate and determinate varieties, systems that involve removing suckers result in larger average fruit size and reduced total yield over the season. In some cases, removing suckers increases early yield and in some cases it does not. Choosing the best support system (or no support) for tomatoes for a particular operation means taking into consideration the varieties to be grown, labor needs and availability, desired fruit size and quality, intensity of management, and farm equipment and layout.

Irrigation and water management is important for yield and fruit quality. While avoiding crop stress is important throughout the season, the most critical period for fruit quality is during fruit expansion. Maintaining an even level of soil moisture as fruit grows will reduce blossom end rot and cracking. To take guess work out of water management growers need a way to assess soil moisture in the root zone–whether by feel, with a tensiometer, or other moisture sensor–and a way to estimate gallons of water or acre-inches applied in irrigation. As a rule of thumb, the soil moisture should be at more than 50% available soil moisture, and soil water tension not dryer than -0.45 bars. In the early part of the season when plants are small and it isn't as hot, ½ inch of water a week 13,577 gal/A) may be enough. In mid-July 1 2/3 inches a week (44,638 gal/A), or nearly ¼ inch a day may be needed. In addition to supporting crop growth, soil moisture is also necessary for the soil biological activity that drives nutrient cycling and other processes.

Weed management in organic tomatoes usually involves some combination of mulch, handweeding and hoeing, and mechanical cultivation. The aim of weed management is to prevent unacceptable reduction of crop yield and crop quality in the current year and also reduce resources used for weed management in the future. Plastic, paper, and straw or leaf mulches all can effectively suppress weeds. Plastic mulch must be removed at the end of the growing season. It is important to confirm that biodegradable mulches will not leave behind prohibited substances; they must be approved for use in organic production. Mulches influence soil temperature and moisture in addition to suppressing weeds. Typically dark-colored synthetic mulches increase soil temperature. Light-colored mulches and mulches of organic material usually reduce soil temperature and so are best applied after the soil has warmed. A benefit of straw or leaf mulches is that they contribute organic matter to the soil as they break down. If rows are far enough apart, a low-growing intercrop can be established between rows and managed by mowing. This 'living mulch' will use significant amounts of water and so the system isn't suitable everywhere. Weeds that emerge more than 6 weeks after transplanting are less likely to reduce yield, but their seeds will result in bigger weed problems in future years. Preventing seed production and introduction of weed seeds into the field is a strategy many experienced organic growers use to reduce time spent on weed management in the long run.

As mentioned above, variety selection is an important component of disease management in organic tomato production. However, not all diseases can be managed that way. In order to select other management options, first determine what the disease is. Learn the environmental conditions that favor its development and spread. Understand how it overwinters and how it can be introduced to your farm. Identify other crops, cover crops, and weeds on your farm that may harbor the disease. There may be fungicides approved for use in organic production that can be used to help control the disease. Use this information to put together a plan that reduces the amount of initial disease inoculum, makes the environment less favorable for growth and spread, and limits the negative impact on your crop. Remember that the plant itself has some defenses against disease, and it can best activate those defenses if it is otherwise healthy.

Insects and mites are serious problems in some crops and not such a problem in others. Identifying the insect, learning its biology, and observing when and how much damage it creates are important for making decisions about whether and how to manage. Organic insect management strategies include physical removal, promoting natural enemies, exclusion, crop rotation, trap crops, trapping, heat, and if necessary, pesticides approved for use in organic production.

Some of the most common problems in tomato production are not caused by pathogens or insects, but rather are physiological disorders or disruptions to the plant physiology. Curled leaves are one example. When leaflet edges curl upwards and stay that way, it is often a symptom of physiological leaf roll. This is usually associated with pruning, that is, removal of suckers. Some varieties are more likely to show it than others. It usually shows up on the lower leaves, those near the part of the plant that was pruned. Leaves that curl remain curled, but new growth is normal.

Sometimes curling, twisting, narrowing, and deformation of leaves shows up on young leaves at the top of the plant or ends of branches. As those leaves expand in the normal course of development, they remain narrow, may be thickened, and the shape of leaflets is distorted from normal. Eventually new leaves develop that are normal, but close inspection will reveal that the originally deformed leaves retain an odd shape. These can be symptoms of injury from an herbicide that has growth regulator activity. Tomatoes are quite sensitive to these chemicals and leaves show symptoms at a very low dose. When tomatoes are grown near where applications are made to lawns, woody plantings, or agricultural crops, it is not uncommon to see these symptoms. In severe cases, tomato flowers may be injured and fail to set fruit, or fruit may be deformed. If certified organic growers suspect injury of this type, they should contact their certification agent to learn what to do.

Several fruit disorders fall into the category of physiological problems. We have already mentioned cracking in relation to variety choice and water management. Maintaining healthy foliage to shade fruit can also help. Picking before completely ripe can be effective for varieties that tend to split late in the ripening stage.

Blossom-end rot can also be reduced by proper water management. This problem occurs when the blossom-end of the developing tomato does not get enough calcium. Cells die and eventually that end of the tomato turns brown or black. Calcium moves into the tomato plant with water that is taken up by roots; when the water supply is uneven the calcium supply is uneven. Other situations that interfere with calcium movement to the fruit include excess nitrogen, potassium, and magnesium. A limited or unhealthy root system also makes tomatoes more likely to have blossom-end rot.

Cat-facing is considered a defect in a standard round red tomato, but is common and almost expected in some specialty varieties. Cat-faced fruit have multiple and often uneven locules, large scars on the blossom end, and may have channels into the fruit or a marked kidney shape. Cat-facing is more prevalent in large-fruited varieties. The disorder is established very early in development of the flower. Cool temperatures several weeks before flowers open promote cat-facing in fruit that develop from those flowers. Variety selection is probably the best way to avoid this problem.

Tomatoes can fail to color properly in a variety of ways, but one of the more common troubles is sometimes called ‘yellow shoulder disorder.’ The top of the fruit stays yellow and hard. Internal white tissue may be associated with the surface yellowing. Multiple factors seem to be involved. Varieties with the 'uniform ripening' gene are less affected. Maintaining good foliage cover to prevent heating of the fruit seems to help. Making sure that there is adequate potassium available to the plant seems important, as does adequate phosphorus.

Harvest and grade tomatoes to please your customers. If stems aren't necessary for appearance, remove them to reduce damage to other tomatoes. Practices vary regarding whether tomatoes are washed. If they are, consider treating the water with a sanitizer approved for use in organic production to minimize cross contamination. Cool tomatoes soon after harvest. Store tomatoes at 50°-55°F and 90-95% relative humidity. Temperatures below 50°F will lead to chilling injury, meaning tomatoes won't ripen properly and decay is more likely.

When the tomato season has ended, reusable stakes, cages, transplant flats, and transplant equipment can be washed and sanitized. Depending on the size of the field, work tomato plant material into the soil, or pull and remove plants from the growing area. Seed a cover crop and/or add organic matter. If fall is the regular time for soil testing, collect samples and send them in.

Additional Information

Organic production and marketing in the US are regulated by the USDA Agricultural Marketing Service through the National Organic Program, under the authority of the Organic Foods Production Act of 1990. Information about regulation is available from the USDA. website at https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program.

Materials used in organic production must be natural and not prohibited by NOP, or if not natural, must be approved for a specific use by NOP. The Organic Materials Review Institute (OMRI) maintains lists of generic materials and brand-name products that are permitted for use in organic production. See http://www.omri.org/.

The national Extension website has a variety of resources: extension.org .

The National Agricultural Statistics Service is conducting the 2016 Certified Organic Survey . Visit the website to request a survey if you are certified organic and have not received one.

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Tomato & Pepper Nutrition: What's needed?

Background Information:

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Liz Maynard serves as a Purdue Extension specialist for vegetable crops in Indiana. Her research and extension focus on cultural practices for sustainable vegetable production. Recent projects include extending production of vegetables in fall, winter, and spring using protective structures including high tunnels, managing soil fertility on organic vegetable farms, and sweet corn variety evaluation.

Session Description:

Producing high quality tomatoes and peppers requires attention to plant nutrition. This session will review the nutrients required by tomatoes and peppers, sources of those nutrients, and assuring nutrients are available when the plant needs them.

Tomato and Pepper Nutrition – What's Needed

Liz Maynard, Purdue University

A healthy green plant is about 90 to 95% water. The remaining 5-10%, or dry matter, is made of various compounds manufactured by the plant: carbohydrates (sugars and starch, and cellulose), lipids (fats, carotenoids, and more), proteins, other compounds, and minerals. Plants manufacture the compounds using minerals absorbed by the roots, carbon dioxide taken in by the leaves, and water taken up by the roots.

If the dry matter is broken down into individual chemical elements, we find that most of it is carbon, oxygen and hydrogen: those elements form the chemical backbones of the carbohydrates and other compounds. Plants obtain these three elements from the air and water.

The dry matter also contains fourteen other 'essential elements,' or basic building blocks, without which a plant can't grow and develop. These elements enter plants primarily through the roots. They are dissolved in the water in the soil, and plant roots absorb them from the soil solution (sometimes with the assistance of microbes). If the plant doesn't get enough of any one of the elements, its growth will be compromised, even if all the others are plentiful. The 14 elements are categorized as primary and secondary macronutrients, and micronutrients, based on the quantity needed by the plant.

The primary macronutrients are needed in the largest quantities: nitrogen (N), phosphorus (P), and potassium (K). Each of these is about ½ to 2% of the dry matter in a plant. An acre of tomatoes yielding 2400 25-lb. cartons would take up about 180 lb. N, 21 lb. P, and 280 lb. K. Just the tomato fruit in that acre would have 100 lb. N, 10 lb. P and 180 lb. K. For 1000 sq. ft., the whole plant uptake would be 4.1 lb. N, 0.48 lb. P, and 6.4 lb. K and the tomato fruit would have 2.3 lb. N, 0.23 P and 4.1 lb. K. For an acre of green peppers yielding 804 boxes (225 cwt) the crop would take up 140 lb., 12 lb. P, and 140 lb. K. Just the pepper fruit would contain 45 lb. N, 6 lb. P and 50 lb. K. For 1000 sq. ft., the whole pepper plant uptake would be 3.2 lb. N, 0.28 lb. P and 3.2 lb. K, and the fruit would contain 1 lb. N, 0.14 lb. P and 1.2 lb. K.

Often it is necessary to replenish N, P and K in the soil every year to replace what is removed in the harvest or lost through leaching or to the atmosphere. The quantity of P and K removed in the harvested fruit can be a guide for how much should to be added to maintain soil fertility levels.

Nitrogen is an important part of proteins, DNA, and chlorophyll. When tomatoes or peppers have plenty of nitrogen they look vigorous and green, even lush. Nitrogen promotes 'vegetative' growth, that is, growth of stems and leaves. Too much nitrogen can lead to such strong vegetative growth that flowering is delayed, or plants flower but don't set fruit. This is a problem in tomatoes and peppers because delayed fruit set means delayed harvest, and possibly reduced yield over the whole season. When plants lack nitrogen, they are smaller, stems are thin and hard, leaves are lighter green, and older leaves yellow and die sooner than expected. The plant moves nitrogen out of the older leaves and into the younger leaves. Low nitrogen leads to reduced yield and makes plant more susceptible to some diseases.

Nitrogen taken up by crops comes from natural breakdown of soil organic matter and residues of legume and other previous crops; compost, seed meals, processed animal products used as organic fertilizers; urea; and inorganic fertilizers including calcium nitrate, potassium nitrate, ammonium nitrate, di- and monoammonium phosphate, and ammonium sulfate. For tomatoes and peppers, often just a portion of the required N fertilizer is applied before planting, and the remainder added in one or more sidedressings, topdressings, or through fertigation.

Phosphorus is an important part of membranes that surround each plant cell, DNA, and ATP, a compound that transfers energy in the plant. Without enough phosphorus plants are stunted, stems are thin and short, leaves look dark green or even purplish on the underside. Much of the phosphorus in soil is in forms unavailable to plants – this is especially true when pH is too high or too low. It is important for small plants to have a ready supply of phosphorus in their root zone to support early season growth, because unlike nitrogen or potassium, phosphorus does not move very much in the soil. This is why starter solutions for transplants often have higher levels of phosphorus, especially for early season plantings when the soil is still cool.

Phosphorus taken up by crops comes from natural breakdown of organic matter and minerals in the soil; compost and organic fertilizers; di- and monoammonium phosphate, monopotassium phosphate, superphosphate, and triple superphosphate. Phosphorus fertilizers are usually applied before planting, and/or in transplant water.

Potassium in plants is found dissolved as positively charged ions in the liquid solution in plant cells. It helps the plant maintain electric neutrality. Potassium is also critical for controlling the opening and closing of pores in the leaf (stomata) that regulate intake of carbon dioxide and loss of water from the leaf. It is also important in the regulation of enzymes. Without enough potassium, stems are weak, leaves yellow and die beginning at the edges. Older leaves are usually the first to show symptoms. Potassium is also important for fruit development. Tomato fruit contains a lot of potassium, and without enough potassium fruit color and flavor may not develop properly.

Potassium taken up by plants comes from compost and organic fertilizers; and inorganic materials including potassium chloride, potassium sulfate, potassium magnesium sulfate, potassium nitrate, and monopotassium phosphate. The full amount of K fertilizer may be applied before planting, or a portion applied before planting and the remainder through fertigation.

The secondary macronutrients, are needed in slightly smaller quantities: calcium, magnesium, and sulfur. Each of these is about 0.3 to 0.6% of the dry weight of the plant. Depending on the soil and crop, it may or may not be necessary to add these every year.

Calcium is an important part of plant cell walls and also regulates enzymes. Without enough calcium we see death of young growing points and fast-growing areas of fruits–what we call blossom-end rot on tomatoes and peppers. Blossom-end rot develops when poor management of water, nutrients, and/or soil pH leads to a shortage of calcium in rapidly developing areas of young tomato or pepper fruit. Just adding more calcium to the soil is not always the best response; it is important to look at each contributing factor.

Magnesium is part of the chlorophyll molecule, and also activates enzymes. Lack of magnesium usually shows up as yellowing between the veins of leaves, beginning with older leaves first.

Calcium and magnesium sources for plants include calcium and magnesium carbonates (lime), calcium sulfate (gypsum), magnesium sulfate (Epsom salts), and potassium-magnesium sulfate.

Sulfur is required for synthesizing chlorophyll, is found in some of the amino acids that form proteins, and is part of many ‘secondary’ compounds made by plants that contribute to flavor and plant self-defenses: just think of the strong smells and flavors of cabbage, mustard, onions, and garlic. With lack of sulfur we usually see pale green leaves, showing up on young leaves first, and stunted growth.

Sulfur sources include the sulfates mentioned above and elemental sulfur.

The last eight essential elements are called micronutrients because they are required in tiny quantities, each making up less than a few hundredths of a percent of the plant dry weight. Yet they are still essential for proper plant growth. The metals iron, zinc, and manganese are a few hundredths of a percent of the dry weight of the plant and copper is a thousandth of a percent of the dry weight. Chlorine is a few hundredths of a percent, boron a few thousandths of a percent, and molybdenum even a smaller fraction of dry weight. Finally, nickel is needed in such small amounts that there can be enough in the seed to supply the plant for its entire life.

Most of these elements are parts of enzymes or co-enzymes and without them the cell machinery does not run properly. Chlorine helps maintain electrochemical balance. Boron is important in flower development, pollination, and fruit formation, and plays a role in cell walls.

In many cases, the soil supplies sufficient amounts of micronutrients and it is not necessary to add more. Too much of a micronutrient can easily be toxic to the plant, or lead to a deficiency of one of the other micronutrients. At high soil pH micronutrients except molybdenum are less available, and a low soil pH the reverse is true. Because these nutrients are needed in such tiny quantities, and especially if soil conditions make them unavailable, it is sometimes easiest to correct deficiencies by spraying a solution containing the nutrients on the leaves.

Diagnosing nutrition problems usually involves a combination of observing symptoms, testing plant leaves for nutrient content, and reviewing soil tests and nutrient applications.

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To Shade or Not to Shade: Improving tomato/pepper fruit quality

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Dr. Drost is a Professor of Horticulture and Extension Vegetable Specialist in the Department of Plants, Soils and Climate at Utah State University. Dan has extension, research and teaching responsibilities that focus on small farms issues and addresses plant growth and crop production that impact Utah's commercial vegetable farms. Dr. Drost grew up on a diverse crop-livestock farm in Michigan and has a master's degree in horticulture from Michigan State University and a PhD in vegetable crops from Cornell University.

Session Description:

Addresses why growers should investigate shade to increase productivity and fruit quality.

To Shade or Not to Shade:
Improving Pepper/Tomato Fruit Quality

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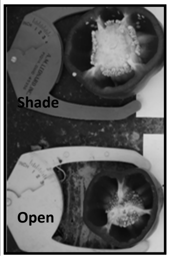
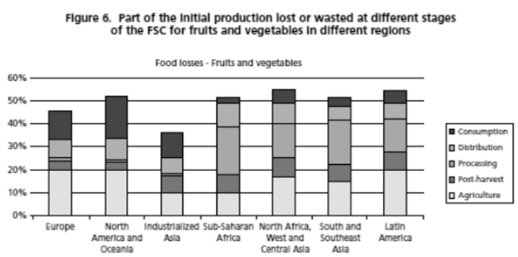


Fruit Losses & Farm Profits

- **The Field-to-Store losses for fruits-vegetables is estimated at 20-40% (NRDC, 2012)**
  - **Farm Production 20%** never harvested/damages/pricing
  - **Post-harvest 3%** quality/off-grade
  - **Processing 1%** trimming/
  - **Distribution 12%** temps/rejection/not sold/expired
  - **Consumer 28%** labeling/spoilage/etc.
- **Consumed vs. Loss 48% vs. 52%**
- **Cost to Households $1300-2300/yr.**

Crop Production Losses



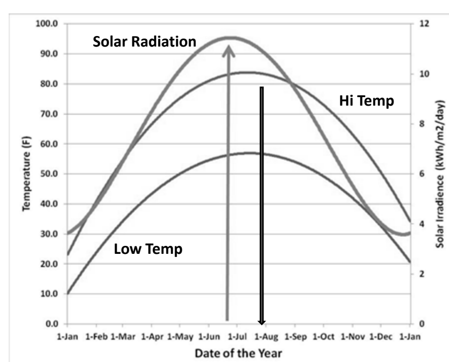
Global Food Losses, FAO - 2011

Vegetable Losses - Farm

- Over Planting
- Stress Related
  - Heat
  - Water
  - Pest
- Quality Issues
- Labor Issues
- Food Safety Scares


Climate Effects (stress issues)

Salt Lake City – Radiation & Temperatures

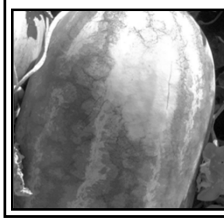


Sunburn & Fruit Surface Temperature

1. **Photo-oxidative Sunburn**: Bleaching, whitening, and/or wrinkling of fruit after shaded fruits become exposed to sun. FST - <u>90-100°F</u>
2. **Sunburn Browning**: Yellow, bronze, or brown spot on fruit. FST - <u>102-108°F</u>.
3. **Sunburn Necrosis**: Fruit surface temperature <u>110+°F</u>. Skin peels or fruit tissue dies.

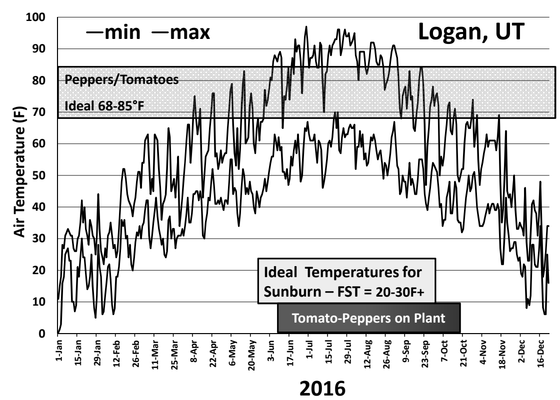






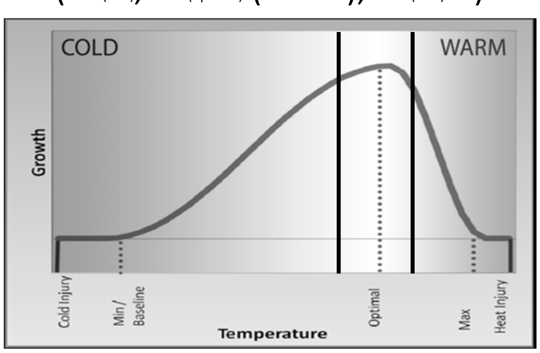

Other Vegetables



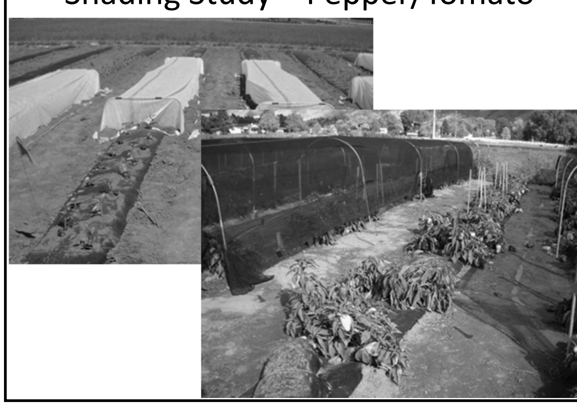


Pepper/Tomato & Temperature

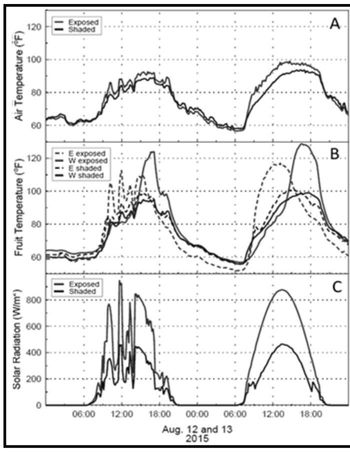
(50(min), 80(optimal) (68-85), 95(max)°F)

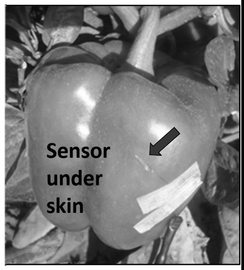


Shading Study – Pepper/Tomato

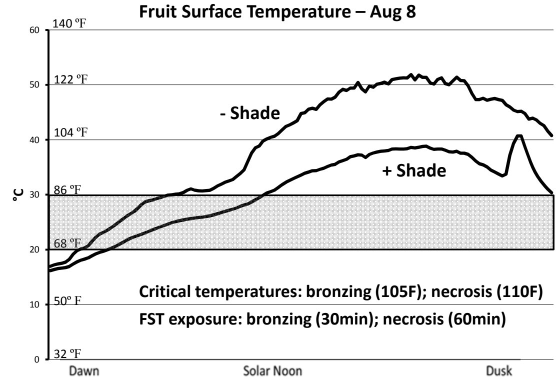


Temperature Responses – Air & Fruit





Fruit Surface Temperature – Aug 8



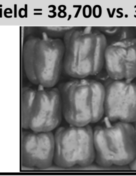
FST~25F warmer without shade; more damage

	Tomato Fruit Yield (lbs./Acre)			
	#1	**#2**	**Mkt**	**Culls**
– Shade	12,142	17,398	29,540	13,907
+ Shade	28,151	41,286	69,437	20,325
% change	131	137	135	46
	**	**	**	*
	Harvest window: 8/5 - 9/21			

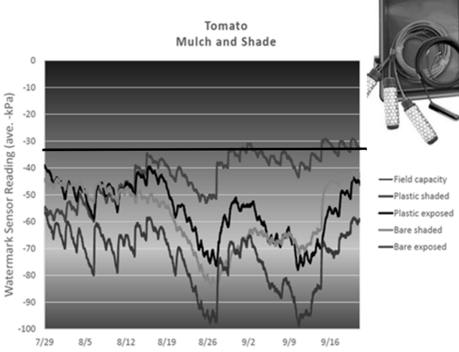
Tomatoes

Bell Pepper Yield & Quality

	Red Fruit Yield (lbs./Acre)			
	Fancy	**#1**	**#2**	**Culls**
– Shade	11,543	5,656	14,439	33,642
+ Shade	22,074	6,353	10,287	11,156
% change	91	12	-29	-67
	**	-	*	**
	8/23 - 9/29; red fruits only Marketable yield = 38,700 vs. 31,600 lb/A			



Soil Water & Shade



More Fancy & #1 red/Green with shade, therefore Significant increase in revenue to grower!

Table 3.4. Partial Budget for supplemental shade on 1 acre of 'Aristotle' red bell peppers.

Additional revenues with supplemental shade

Field Produced Red Bell Peppers + Supplemental Shade

	Units	Quantity	Price	Total
Red bell peppers				
Fancy	Carton	542	$23.50	$12,737.00
First Class	Carton	106	$21.25	$2,252.50
Second Class	Carton	120	$19.75	$2,370.00
Green bell peppers	Carton	71	$14.75	$1,047.25

Total additional revenue with supplemental shade

$18,400

See: Enterprise budget for peppers with shade on page 83
http://www.nass.usda.gov/Statistics_by_State/Utah/Publications/Annual_Statistical_Bulletin/Pdf/ab14/2014%20Agricultural%20Statistics.pdf

Additional costs with supplemental shade

Supplies					
	Cartons	Each	839	$1.18	$990.02
Labor					
	Hauling	Hours	36	$12.00	$432.00
	Grading and Packing	Hours	96	$12.00	$1,152.00
	Installation and Removal (structure and shade cloth)	Hours	100	$12.00	$1,200.00
Added Costs of Shade Structure					
	Annual Depreciation of Shade Structure*				$703.93
	Annual Maintenance of Shade Structure				$100.00
Added Costs of Shade Cloth					
	Annual Depreciation of Shade Cloth**				$1,210.75
	Annual Maintenance of Shade Cloth				$100.00
Total additional costs with supplemental shade					**$5,888.70**
Resulting Change in Net Income					**$12,520**

*Annual shade structure depreciation costs detailed in Table 3.2
**Annual shade cloth depreciation costs detailed in Table 3.3

Summary

- **Use tolerant varieties (heat, plant size)**
- **Increase plant size (water, nutrients)**
- **Minimize stress (weeds, pests)**
- **Consider shading**
  - **http://extension.usu.edu/productionhort/**
- **Evaluate economics & management**

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Biochar and Tomatoes – What we're learning

Background Information:

Britney Hunter
USU Extension Davis County
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Britney is a Horticulture Extension Assistant Professor (aka County Agent) for USU in Davis County. Britney organizes educational programs at the USU Botanical Center in Kaysville and provides expertise related to horticultural science to the community. Britney also has expertise is in out-of-season vegetable production using high tunnel greenhouses.

Session Description:

Study results of recent trial growing tomatoes with biochar soil amendment.

Biochar Soil Amendment to Enhance Tomato Production

Britney Hunter, Extension Assistant Professor
Utah State University

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Introduction to Biochar

Biochar is a charcoal product created through the pyrolysis process which also produces combustible gases and oils for energy generation and biochemical manufacturing

Plant Biomass

Mobile Pyrolysis Unit

~350-750°C

- **Heats biomass in closed system**
- **high temperatures >300°C**
- **limited supply of oxygen**

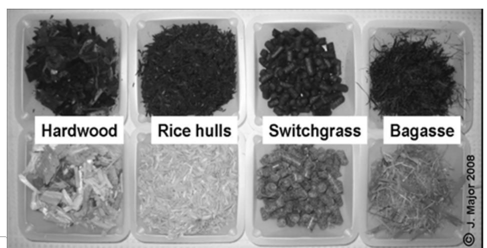
HEAT

ELECTRICITY

BIO FUELS

BIO CHAR

Uses of Biochar:
- Soil amendment
- Water treatment
- Environmental remediation
- Insulation
- Carbon sequestration



www.biochar-international.org

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2015-17 Farm Study Tomatoes and Melons

- 3 Vegetables Growers + USU Botanical Center
- Measure
  - Soil Improvement
  - Plant growth
  - Yield
  - Disease resistance

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Fruit Wood ⟶ Biochar

Robert McMullin

Biogreen pyrolysis® unit
Western Renewables Technology in Linden, UT

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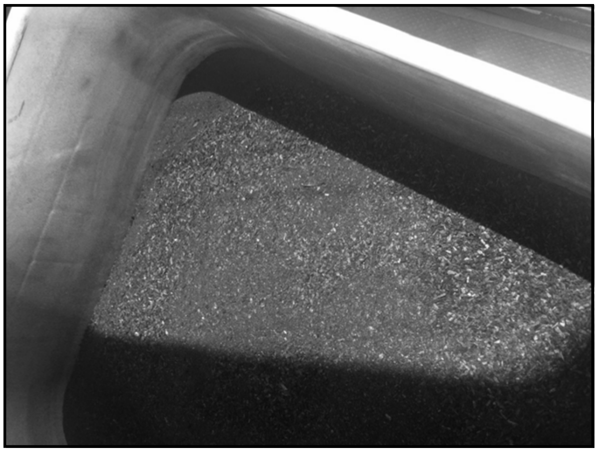
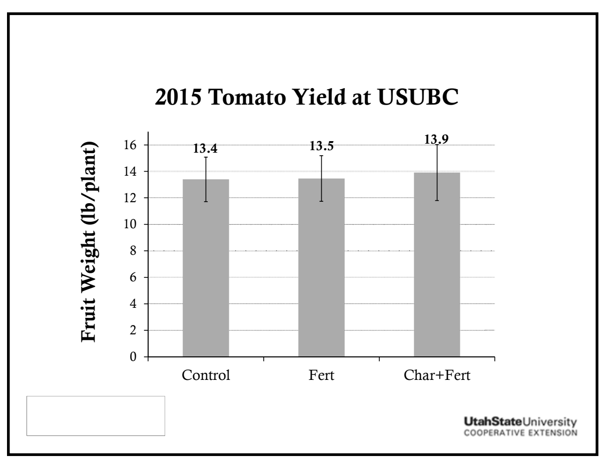
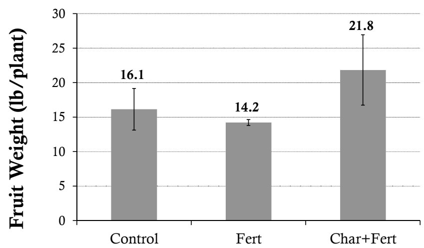



Resistance to Phytopthora with biochar
(Results pending)


2015 Tomato Yield at USUBC
Fruit Weight (lb/plant)
0
2
4
6
8
10
12
14
16
13.4
13.5
13.9
Control
Fert
Char+Fert
UtahStateUniversity
COOPERATIVE EXTENSION

2016 Tomato Yield at USUBC



50% plants died from Curly Top Virus

Both Control and Char+Fert treatment had a plot with one plant, which grew larger due to lack of competition

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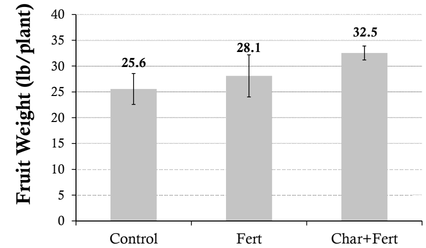
2015 Melon Yield at USUBC



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Specialty Biochar Products - $1.50+ per lb

Amazon	Home Depot	Whole Foods / Amazon
$19.99 - 1 Cubic foot	$24.99 - 1 Cubic foot	$47.95 - 1 Cubic foot

(Blue Sky Biochar)

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Bulk Pricing

- Varies highly depending on producer and "quality"
- $200 - $800 per ton
- 1% application = $2,000 - $8,000/acre

https://www.biochar-journal.org/en/ct/71

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Conclusion

- Worth experimenting with on small scale
- High product cost
- Weak evidence biochar promotes yield in tomato & melon

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Thank You – Stay Tuned

http://utahbiomassresources.org

WESTERN SARE Sustainable Agriculture Research & Education

Britney Hunter
Extension Assistant Professor
Utah State University

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Principles of Basic Soil Science

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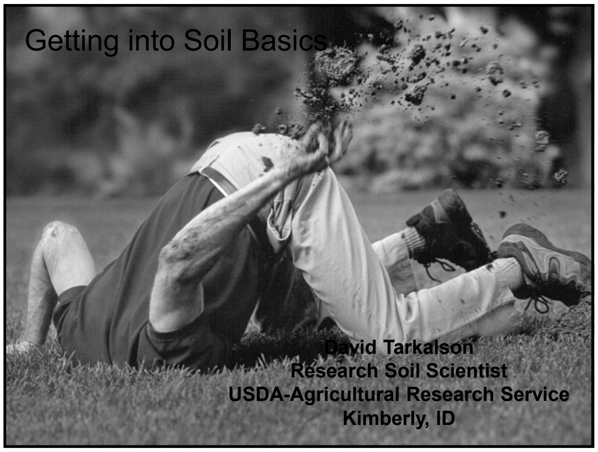
Systems Agronomist/Soil Scientist performing research in the areas of soil fertility, production management, and irrigation management.

Session Description:

Provide basic information on soil properties and formation.

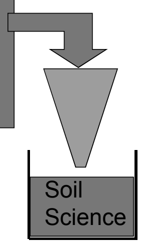


Soils

- Are necessary to sustain life
- Are the basis for the prosperity of most civilizations
- When mis-treated, causes civilization collapse
  - The Nation that destroys its soil destroys itself (Franklin D. Roosevelt)
- You don't need to know the science behind soils to be a good landowner but it helps

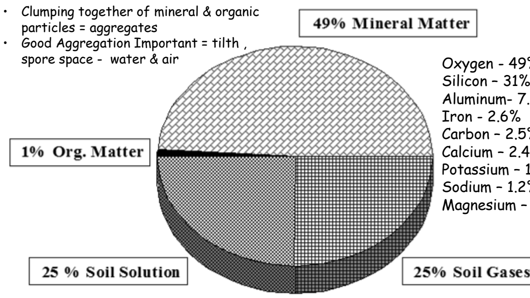
Soil Science

- Soil Classification
- Soil Microbiology
- Soil Physics
- Soil Fertility
- Soil Chemistry



What is soil?

- Clumping together of mineral & organic particles = aggregates
- Good Aggregation Important = tilth , spore space - water & air

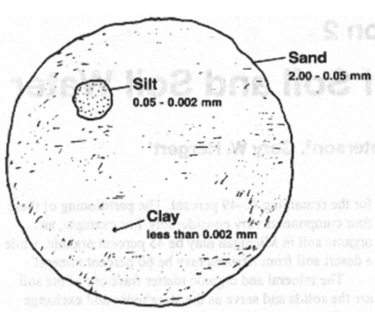


Oxygen - 49%
Silicon – 31%
Aluminum- 7.2%
Iron - 2.6%
Carbon – 2.5%
Calcium – 2.4%
Potassium – 1.5%
Sodium – 1.2%
Magnesium – 0.9%

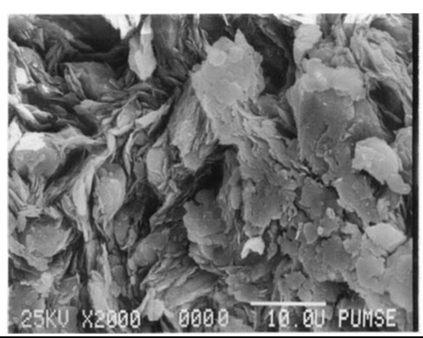
Dissolved Nutrients
Water for Plants

- In contact with above ground air/atmosphere
- Provides roots with oxygen
- Removes excess carbon dioxide from respiring root cells

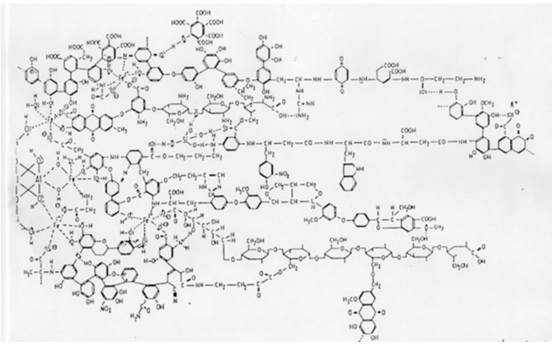
Relative Sizes of Soil Separates



Clay Electron Microscope Photo

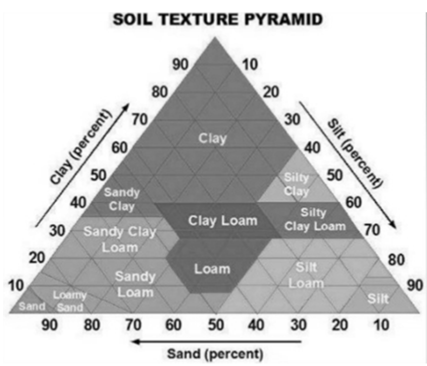


Organic Matter

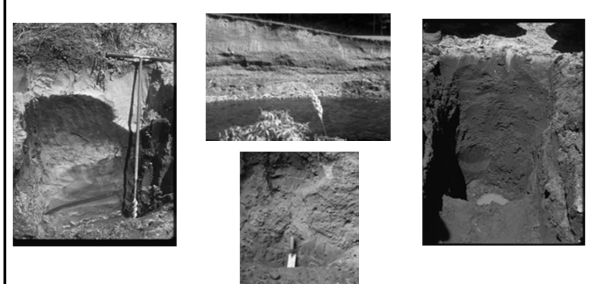


Demonstration Experiment

Soil Texture

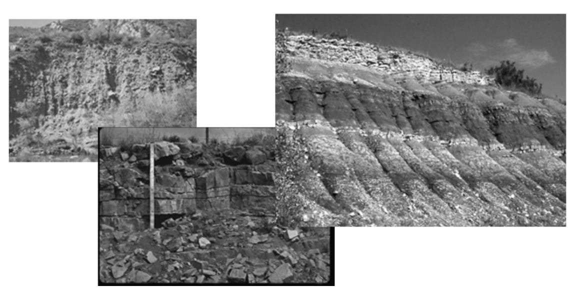


Soil Forming Factors

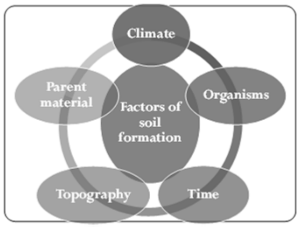


Why are these soils different?

So .... How do soils form?



Factors of soil formation



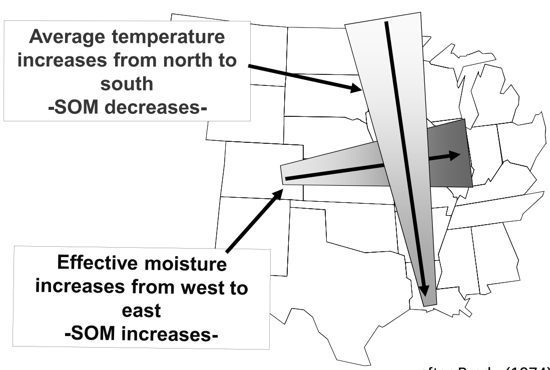
Climate
Organisms
Active factors

Parent Material
Topography
Time
Passive factors

Climate

- **Precipitation - water influences leaching of salts and other compounds in/out the soil.**
- **More chemicals removed -deeper the soil and more developed**
- **Native vegetation - OM content - W to E**
- **Temp - OM content**

Effect of climate on SOM



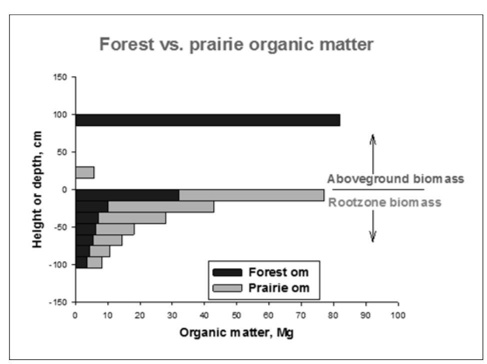
after Brady (1974)

Living Organisms

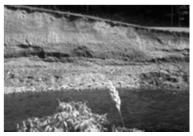
- **Organisms influenced by:**
  - **temperature**
  - **acidity**
  - **soil-water relations**
- **Contribute significantly to soil structure, nutrient transformations, fertility & aeration**
- **Microorganisms - most abundant organism**

Living Organisms

- **Vegetation - greatest mass - influences kind of soil developed - different root systems, size, above ground vegetative volume - nutrient content & life cycle**
- **i.e - forest vs. grassland**

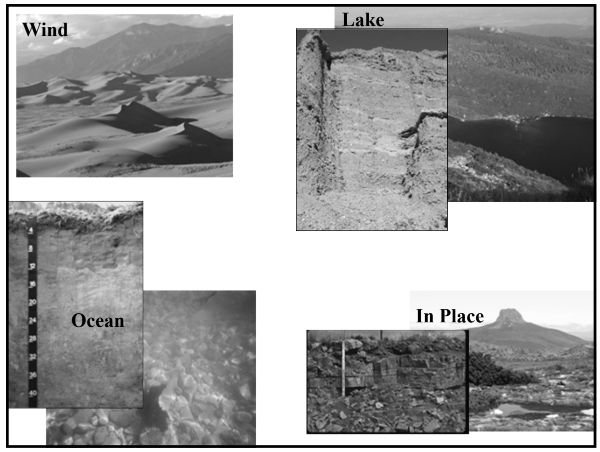


ICE



Flowing Water

Gravity

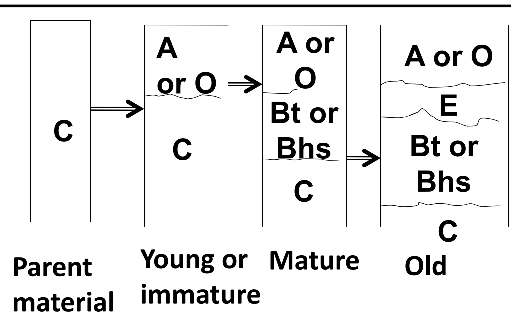


Topography

- **Topography variations - Affect moisture and temperature relations.**
  - **Valleys**
  - **Sandhills**
  - **Plains**
  - **Rolling hills**
  - **Dissected plains**
  - **Bluffs/Escarpments**
  - **Valley - side slopes**

Time

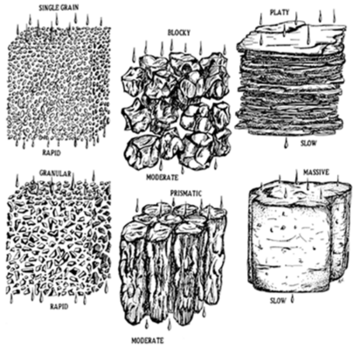
- **Soils - Young - Mature - Old**
- **Mature soil - equilibrium with its environment -full development of horizons**
- **Rate of weathering slows as soil approaches equilibrium**
- **Longer exposure > degree of weathering > more developed**



Soil Structure

- **Arrangement of soil particles ‘aggregates’**
  - **Microbial ‘gum’ formation**
  - **Weathering and pressure**
- **Various shapes and sizes**

Soil Structure



From Washington State University Extension

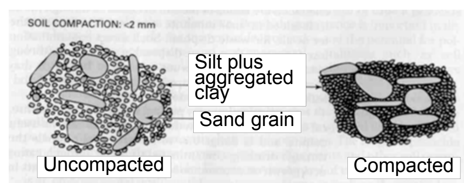
Soil Structure

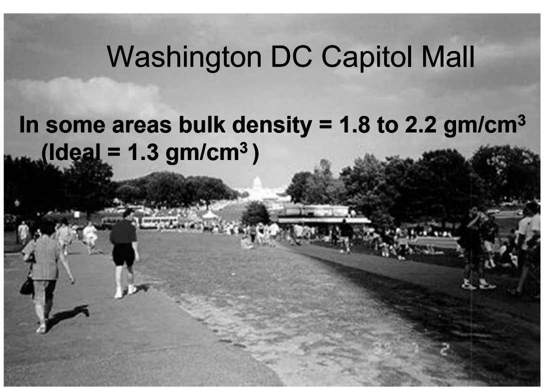
- **Good soil structure allows for favorable movement of air and water**
- **Structure can be destroyed through compaction and excessive tilling**
- **Low microbial populations in poorly structured soils**

Soil Structure

- **Poor soil structure inhibits water infiltration and root development**
- **Overall plant health declines in poorly structured soils**

What is Compaction?





Construction Site Study

On construction site
BD = 1.6 gm/cm^3

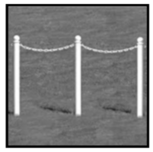
Off construction site
BD = 1.0 gm/cm^3

↑ BD by 30%
↓ Root growth by 45%
↓ Top growth by 40%

Best Cure is Prevention

- **Eliminate any activities that cause compaction.**
  - **Heavy equipment**
  - **Walking paths in lawns**
  - **Change areas of heavy activities**





Compaction

- **Possibly can deep rip soil then follow prevention practices.**

Compaction

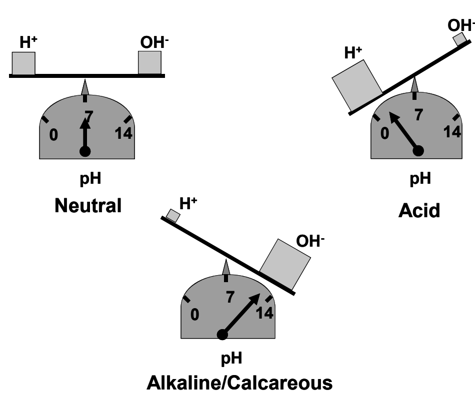
- **Organic matter additions may help some soils if you can work it into the soil then follow prevention ideas**

Soil pH

- **pH is defined as :**
  - **The negative logarithm of the hydrogen ion activity (concentration)**

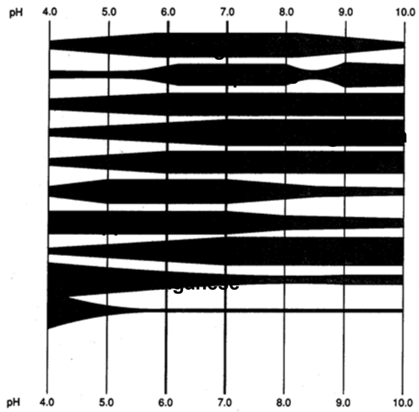
$pH = - \log [H^+]$

- **In other words, pH is a measure of the H+ concentration in the soil solution**



Soil pH

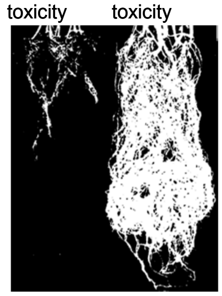
- **Importance of managing soil pH:**
  -Availability of plant nutrients



Al Toxicity

- **Roots**
  - **Interferes with cell functions**
  - **Inhibits nodulation**
  - **Interferes with uptake, transport, and use of nutrients and water.**

Barley roots **affected** by Al toxicity | Barley roots **not affected** by Al toxicity



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Soil Nutrients and Cycling: The big 3 and availability issues in calcareous soils

Biographical Information:
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Jim Ippolito is a soil scientist with 30 years of experience. He received his BS from the Univ. of Delaware, and MS and PhD from Colorado State University focusing on environmental soil quality/chemistry. He worked for Colorado State University from 1989-2007, for the USDA-Agricultural Research Service from 2007-2016, and currently again works for CSU. He has taught introductory soil science, soil fertility, and environmental sampling.

Session Description:

This presentation will focus on N, P, and K cycling and how they act/interact in calcareous soil systems.

Soil Nutrients and Cycling:

The Big 3 and Availability Issues in Calcareous Soils

Dr. Jim Ippolito
Associate Professor, Environmental Soil Quality
Dep. Soil and Crop Sciences
Colorado State University
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Soil Nutrients and Cycling

The Big 3 and Availability Issues in Calcareous Soils

A. What exactly are we talking about here?
   1. Nitrogen (N)
   2. Phosphorus (P)
   3. Potassium (K)
B. All are essential elements
   1. They are required by plants in relatively large quantities.
      a. We call these macronutrients

17 Essential Elements (i.e. nutrients)

Nutrient		*Concentration in Plants*		
Name	*Symbol*	*Relative*	*Average (%)*	*Classification*
Hydrogen	H	60,000,000	6 %	
Oxygen	O	40,000,000	45 %	**Non-mineral**
Carbon	C	30,000,000	45 %	
Nitrogen	N	1,000,000	1.5 %	
Potassium	K	250,000	1.0 %	**Primary**
Phosphorus	P	60,000	0.2 %	**Macro-Nutrients**
Calcium	Ca	125,000	0.5 %	
Magnesium	Mg	80,000	0.2 %	**Secondary**
Sulfur	S	30,000	0.3 %	**Macro-Nutrients**

Essential Elements (i.e. nutrients)

Nutrient		*Concentration in Plants*		
Name	*Symbol*	*Relative*	*Average (ppm)*	*Classification*
Chloride	Cl	3,000	100	
Iron	Fe	2,000	100	
Boron	B	2,000	20	
Manganese	Mn	1,000	50	**Micronutrients**
Zinc	Zn	300	20	
Copper	Cu	100	6	
Molybdenum	Mo	1	0.1	
Nickel	Ni	1	0.1	
Sodium	Na	--	--	Sugar beets
Cobalt	Co	--	--	Rhizobia in legume nodules
Vanadium	V	--	--	Green algae, replaces Mo
Silicon	Si	--	--	Rice, cereals

Nitrogen

I. Nitrogen Introduction

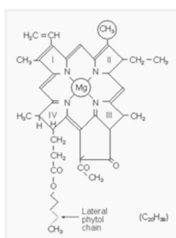
A. Most frequently limiting nutrient in cropping systems
B. Highest fertilizer use rates
C. Source of air and water quality degradation

Crop Response to N

N Deficient Turf

N Functions in the Plants

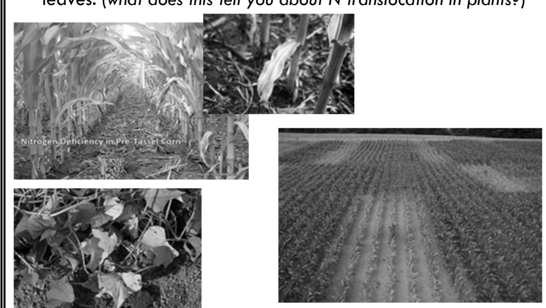
1. Amino acid and protein production
2. DNA/RNA
3. ATP/ADP
4. Chlorophyll



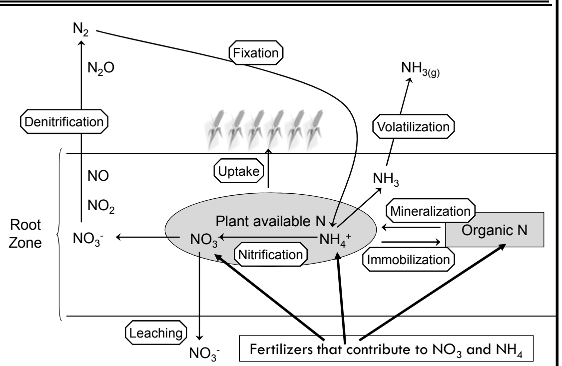
Chlorophyll

Visual Deficiency Symptoms

Yellowing, interveinal chlorosis, stunting, first appearing in <u>older</u> leaves. (*what does this tell you about N translocation in plants?*)



Soil N Cycle



N Forms in the Soil

INORGANIC N

- NH_4^+ (Ammonium) **form taken up by plants**
- NO_3^- (Nitrate) **form taken up by plants**
- NO_2^- (Nitrite)
- N_2O (Nitrous Oxide)
- NO (Nitric Oxide)
- N_2 (Nitrogen Gas) - Inert

ORGANIC N

- Amino Acids
- Proteins
- Amino-sugars (sugar molecule where –OH has been replaced with NH_2)
- Other Complex Unidentified Organic Compounds

So, how to plants obtain N in soils?

(lets focus on the relatively big players)

Soil N Cycle - Inputs

Symbiotic N_2 fixation

a. Occurs in nodules on legume roots
b. Symbiotic relationship with Rhizobia bacteria

Soil N Cycle - Inputs

Symbiotic N_2 fixation

a. Occurs in nodules on Legume roots
b. Symbiotic relationship with rhizobia bacteria
c. Fixation decreases with increasing soil N
    a. i.e., as from inorganic N fertilizer use.
d. Fixation ranges from 40 to 300 lbs/ac
    a. Perennial legumes (ie: alfalfa) 100-200 lbs/ac/yr
    b. Short season annual legumes (ie: peas) 50-100 lbs/ac/yr

Soil N Cycle - Inputs

Factors Affecting Symbiotic N_2 Fixation in calcareous soils:

1. pH (strain specific sensitivity)
    a. pH < 6.0 limits inoculation and N fixation
2. Soil fertility status
    a. Plants will use available NO_3^-/NH_4^+ before investing energy in N_2 fixation.
    b. Requires P, Mo, and Fe.
3. Legume health (pests, water status, light, etc)

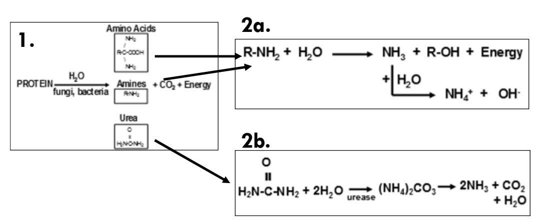
Soil N Cycle - Inputs

Industrial N_2 Fixation (Haber-Bosch)

$$3H_2 + N_2 \xrightarrow[\text{1200°C, 500 atm}]{\text{catalyst}} 2NH_3$$

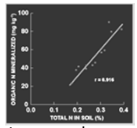
Organic Soil Inputs for N, must undergo:

Mineralization – 2 step process
organic → inorganic



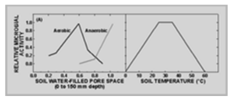
Organic Soil Inputs

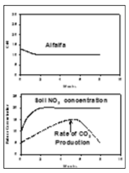
Mineralization & Immobilization

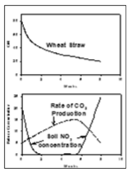


Factors affecting both:

i. total N content of the soil
ii. Microbial activity (affected by soil moisture and temperature)
iii. C:N ratio of the residue







iv. Soil pH > 8 can limit microbial activity, increase N gas losses

Nitrogen Cycle

Key points

1. solution N is controlled by:
   a. Inorganic N fertilizer inputs
   b. Organic fertilizer inputs (C:N ratio, pH, moisture, temp., etc.)
   c. Aerobic or anaerobic conditions
2. leaching losses dominate; atmospheric losses can be large. Runoff and erosion losses are typically lower.

Phosphorus

1. Plant and P Relationships

P functions in plants

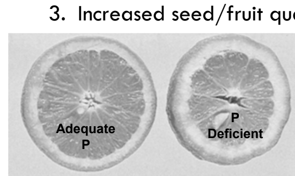
1. Primary function is in energy storage and transfer:
   i. Respiration
   ii. Photosynthesis
   iii. Membrane Transport
   iv. Synthesis of nucleic acids, lipids, and phospholipids
2. Growth and development (reproduction)
3. Disease and cold tolerance
4. Biological N fixation in legumes

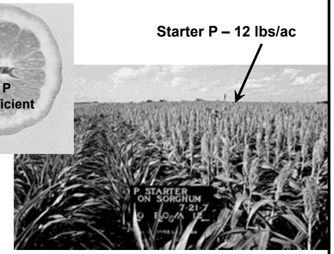
P Deficiency Symptoms

--Stunting
--Purple leaves
--older leaves
-- mobile/immobile in plants?

1. Plant and P Relationships

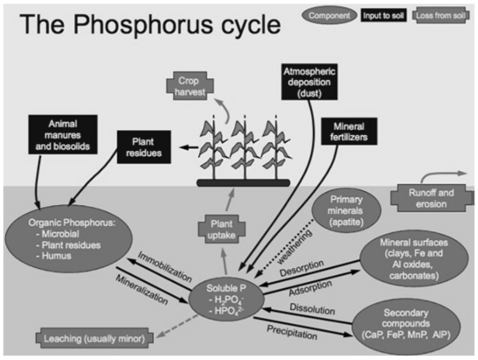
1. Increased plant and root growth
2. Increased speed to maturity
3. Increased seed/fruit quality





2. Phosphorus Cycle

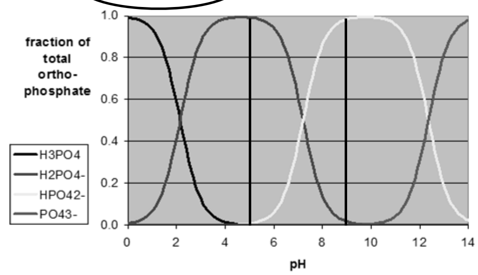
Plants take up $H_2PO_4^-$ and HPO_4^{2-} from the soil solution



P Availability Affected by soil pH

General Solution P Information:

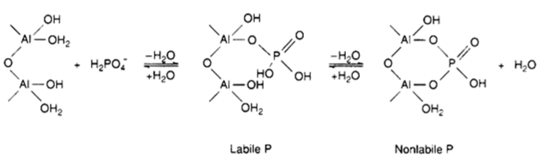
1. H_3PO_4, $H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-}



P Availability Affected by Al and Fe

Adsorption Process

1. Adsorption is a chemical reaction where P binds to the surface of soil minerals (Al/Fe oxides and 1:1 clay edges)
2. Adsorbed P is in equilibrium with solution P



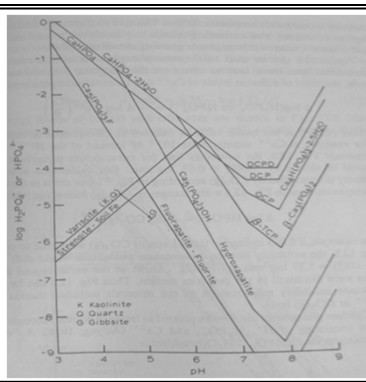
This can happen in calcareous soils, but it doesn't dominate

P Availability and Mineral Precipitation

Precipitation Process – formation of P minerals

1. Initially, highly soluble minerals form. Over time, these minerals react to form less soluble minerals.
2. Precipitation/dissolution reactions are pH dependent

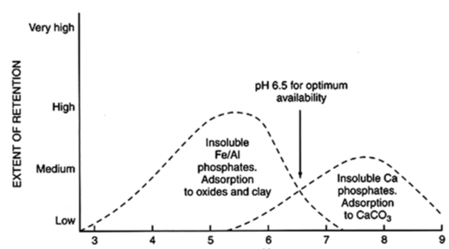
P Precipitation



P Availability

Combined effect of precipitation and adsorption

1. Both processes are highly pH dependent
2. Optimum availability around pH 6.5



P Cycle: Environmental Concerns, Phosphorus Cycle and Water Quality

Eutrophication

A. Nutrients stimulate algal productivity
B. Decay of algae depletes oxygen
C. Light penetration limited

Lake Ellesmere (NZ)

Phosphorus Cycle

Key points

1. solution P is controlled by inorganic solid phases
2. leaching losses are limited to extreme cases such as coarser textured soils; runoff and erosion losses are more common
3. organic P cycling is not fully understood
   a. Enzymes from plant roots and/or soil microorganisms work in tandem to cleave P from organic substances

Potassium

General K Information

Potassium uptake by some common crops on a per acre basis (IPNI Soil Fertility Manual, 2006).

Crop	Yield		K_2O taken up in total crop (lbs)
Alfalfa	8	tons	480
Coastal bermudagrass	8	tons	400
Corn	160	bu	213
Cotton	1000	lb linlbt	85
Grain sorghum	800	lb	240
Oranges	540	cwt	330
Peanuts	4000	lb	185
Rice	7000	lb	168
soybeans	60	bu	205
Tomatoes	40	tons	460
Wheat	60	bu	122

Forms and Function of K in Plants

Form:

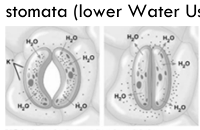
1. K is absorbed by roots as K^+.

Functions:

1. K^+ functions are particularly related to electrolyte concentration within plant cells.
2. Enzyme activation:
   > 80 enzymes are activated by K
3. K is essential for photosynthesis.
4. Translocation of sugars used for new growth requires energy (energy synthesis in plants requires K). Sugar translocation is greatly reduced in K deficient plants; this relates to fruit quality.

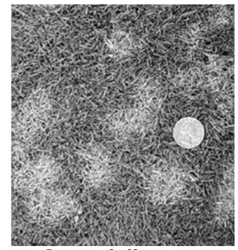
Functions of K in Plants

5. Water Relations: K^+ is essential for water balance and proper salt concentration in plant cells.
   a. K^+ maintains osmotic pressure that draws water into plant roots. K deficient plants are less tolerant of water stress.
   b. K^+ increases turgor pressure in guard cells surrounding each stoma causing stomates to open/close. Stomata malfunction under K deficiency causing lower rates of photosynthesis and higher transpiration or water loss through stomata (lower Water Use Efficiency).



Functions of K in Plants

Grass leaf spot

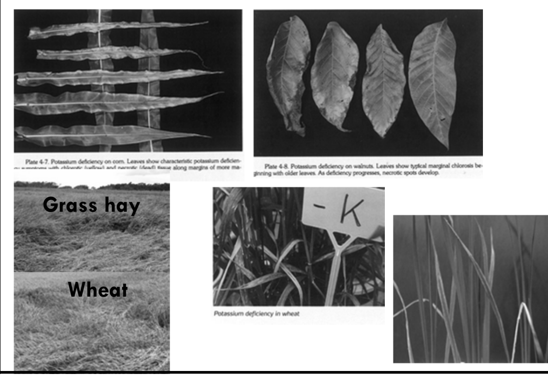

Grass dollar spot

Nutrients, such as K, don't control the disease, but they do strengthen the plant to be less susceptible.

K Deficiency Symptoms

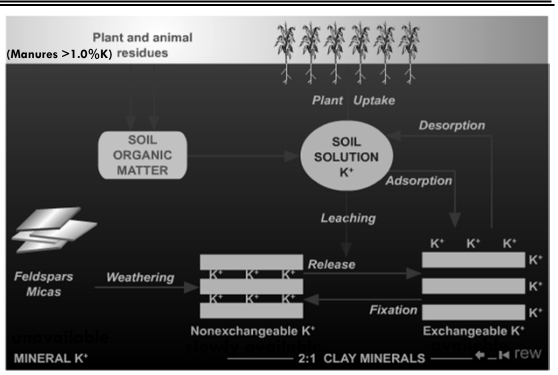
A. K is mobile in plants, so deficiency symptoms appear first in lower leaves.
   1. Symptoms progress toward the top leaves as severity increases.
B. Symptoms vary by species, but <u>usually appear on leaf margins.</u>
C. Deficiency can be triggered by dry soil conditions.
D. Weakening of straw leading to lodging.
E. Increased susceptibility to disease and pests.

Deficiency Symptoms



Potassium Cycle

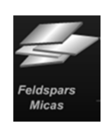
Unlike N, K (and P) are not lost as gases



Primary K Minerals (unavailable K)

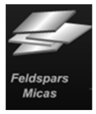
Comprise 90-98% total K, most of which is <u>unavailable</u> to crops during a growing season.

1. Mica - 2:1 minerals
   a. Muscovite - $H_2KAl_3(SiO_4)_3$
   b. Biotite - $(H,K)_2(Mg,Fe)_2Al_2(SiO_4)_3$
2. K Feldspars -- $KAlSi_3O_8$
3. Weathering – release of K
   a. very SLOW process



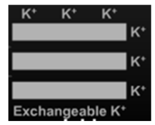
Primary K Minerals (unavailable K)

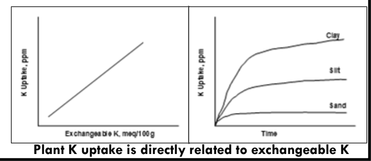
4. Soils with low K minerals in parent material and highly weathered soils may be K deficient.
5. Calcareous soils are relatively high in K.
   - >300 ppm exchangeable
   - Critical level is 120 ppm for most crops



Exchangeable and Solution K

1. K^+ is a cation so it is held on clay surfaces
2. Considered an "immobile" nutrient in soil
   BUT will leach from soils with low CEC, low pH
3. Readily available K represents 0.1-0.2% total K; of this, 90% is exch. K and 10% is solution K.
4. Soil testing labs measure Exchangeable K.

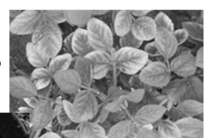




Plant K uptake is directly related to exchangeable K

The Big 3: N, P, and K

Questions?



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Soil and Plant Testing

Background Information:

Grant Cardon

Utah State University

4820 Old Main Hill

Logan UT, 8322-4820

grant.cardon@usu.edu

Professor and Extension Soils Specialist Utah State University Department of Plants, Soils and Climate, College of Ag Science **Education**: B.S., Agronomy and Soils, Utah State University (1986); Ph.D., Soil Science, University of California, Riverside (1990). **Extension Interests:** Grant's work at USU focuses on the training and assisting of county Extension agents on soil management issues, particularly soil fertility and salinity management. Grant serves as the chair of the USU Analytical Laboratory's (USUAL) oversight committee, and is the coordinator of the North American Proficiency Testing Program for the Soil Science Society of America. As the Extension Soils Specialist, Grant works to provide accurate interpretation of test results for soils, waters, plant tissues, manures and composts**. Research Interests:** Grant's research efforts include a project to inventory and map the extent and severity of soil and water salinity in the major river basins of Utah, and several projects around the state looking at the use and management of fertilizers and various non-traditional soil fertility amendments in horticultural and agricultural production. New projects include looking at cover crops and fertility management in dryland, conservation tillage systems, P and K rate and formulation effects on tart cherry tissue nutrient levels, fruit yield and quality components, and the N needs of rotational crops (esp. corn) following alfalfa.

Session Description:

We will look at the key features of proper and effective soil and plant tissue sampling as a means to obtaining accurate and complete soil and plant fertility management information.

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Agriculture

UtahState UNIVERSITY COOPERATIVE extension

May 2008 **AG/Soils/2008-01pr**

Understanding Your Soil Test Report

Grant E. Cardon, USU Extension Soil Specialist
Jan Kotuby-Amacher, Coordinator for North American Proficiency Testing Program
Pam Hole, Supervisor USU Analytical Labs
Rich Koenig, Washington State University

Regular soil testing helps to develop and maintain more productive soils for farming, gardening, and landscaping. The purpose of this guide is to help you understand and interpret the results from a Utah State University soil test report. Additional Utah State University Extension bulletins are available, which address solutions to specific soil problems and offer guidance on fertilizer selection and use. See "Where to obtain additional information" at the end of this guide.

General Information

A soil test report (Figure 1) lists the date the sample was received and when analyses were completed, as well as the lab number assigned to your sample. Use this number when contacting the lab with questions about your report. The sample identification is the name you assigned to your sample. The crop to be grown (or garden or lawn) is also listed, as well as any comments you provided on the information form submitted with your sample. The bulk of the report is composed of the results of tests you specified, test interpretations, and recommendations.

The utility of a soil test report depends largely on understanding the results in the context of the need for improvements or remedial measures in the soil physical (texture, structure, etc.) and chemical (pH, salinity, plant nutrient content, etc.) characteristics. To better understand the need for manipulation of these important soil conditions, this report offers two resources. First, each section of the soil test report is described along with a brief overview of the role of that soil condition on the soil's function and productivity. Secondly, a set of detailed tables of soil test interpretations and associated recommendations for amending soil is provided for the various settings or land uses under consideration for any given soil. As research continues, soil test interpretations can change as new information or technologies emerge. Therefore, the interpretations are subject to modification from time to time, and will be periodically updated within this publication.

A routine soil analysis includes an estimate of soil texture, and lab analysis of pH, soil salinity (ECe), and the levels of plant available phosphorus and potassium in the sample. This core of tests provides the minimum information needed to manage a soil for optimum physical conditioning and plant growth and performance. Additional tests are available to determine soil nitrogen levels, micronutrient levels (such as sulfur, iron, zinc, etc.), organic matter content, salt ion balances, and specific elemental analysis.

Figure 1. Example Soil Test Report

Soil Test Report
and
Fertilizer Recommendations

USU Analytical Labs
Utah State University
Logan, Utah 84322-4830
(435) 797-2217
(435) 797-2117 (FAX)
www.usual.usu.edu

Date Received: 4/20/2005
Date Completed: 4/27/2005

Name:
Address:

Phone:
County:

Lab Number: 501
Identification: GROSSL'S GARDEN
Crop to be Grown: Shrubs/Trees

Grower's Comments:
Acres in Field:

Soil Test Results			Interpretations	Recommendations
Texture		Clay Loam		
pH		7.5	Normal	
Salinity - ECe	dS/m	1.0	Normal	
Phosphorus - P	mg/kg	3	Very Low	2 lbs P2O5/1000 sq ft
Potassium - K	mg/kg	358	Adequate	0 lbs K2O/1000 sq ft
Nitrate-Nitrogen - N	mg/kg	7		2-4 lbs N/1000sq ft*
Zinc - Zn	mg/kg	1.8	Adequate	0 oz Zinc/1000 sq ft
Iron - Fe	mg/kg	1	Low	
Copper - Cu	mg/kg	1.4	Adequate	
Manganese - Mn	mg/kg	5.9	Adequate	
Sulfate-Sulfur - S	mg/kg	21.5	Adequate	0 lbs Sulfur/1000 sq ft
Organic Matter	%	2.1		
SAR				

Notes
*SEE GARDEN GUIDE.

For further assistance, please see your County Agent --
For further information and publications of interest, see the
USU Analytical Lab webpage or Utah State University Extension

A regular program of soil testing and evaluation of the results (particularly of routine analyses), coupled with the guidance provided by this document and Extension personnel at the county and state levels, will ensure that soil quality and productivity can be optimized and maintained at desirable levels.

In addition to this publication, please refer to the companion documents: "Selecting and Using Inorganic Fertilizers" and "Selecting and Using Organic Fertilizers" (HG509 and HG510, respectively. These publications provide detailed guidance on fertilizer sources, nutrient content determination, and calculation of application rates. These documents are available online at no charge at http://extension.usu.edu.

Texture

Texture refers to the texture class of the soil. Sandy soils (sand, loamy sand, sandy loam) have lower water and nutrient holding capacities, whereas high clay soils (clay, silty clay, clay loam, silty clay loam) tend to be poorly drained and are subject to compaction. Additions of organic matter will increase the ability of sandy soils to hold water and nutrients, and the ability of high clay soils to drain water and resist compaction.

Click here for a table of soil test interpretations and recommendations.

pH

pH indicates the acidity or alkalinity of soil. A pH of 7 is neutral. Values less than 7 are acidic and values greater than 7 are alkaline. Utah soils tend to be moderately alkaline (pH range 7.5 to 8.5). Most plants grow well in soils with pH values between 6.0 and 8.0. Trace element (e.g., iron) deficiencies can occur in soils with pH values greater than 8.0, and with some sensitive plants (e.g., berries, grapes, silver maple, pin oak) in soils with pH values greater than 7.5.

Salinity-ECe

Salinity indicates the amount of soluble salt in soil. High salinity levels inhibit seed germination and plant growth. Different plants have different salt tolerance levels. Generally, if ECe = 0 to 2, salinity effects are mostly negligible; if ECe = 2 to 4, salinity may affect sensitive plants; if ECe = 4 to 8, yields of many plants are restricted; if ECe = 8 to 16, only tolerant plants will grow; if ECe is above 16, only a few, very tolerant plants will grow.

A soil pH greater than 8.2 together with moderate to high salinity (ECe > 2 to 4) may indicate a problem with excess sodium. This can be verified by determining the sodium adsorption ratio (SAR) of soil (described below).

For more information on managing saline soils, please refer to: "Salinity and Plant Tolerance" (AG-SO-03) online at http://extension.usu.edu.

Phosphorus-P

The phosphorus soil test result is in units of parts per million (or ppm), which is equivalent to pounds of available phosphorus per million pounds of soil. The soil test value is a measure of the amount of phosphorus available to plants during the growing season. A very low or low phosphorus test value indicates that additional phosphorus must be applied to prevent a deficiency. An adequate to high soil test value indicates that sufficient phosphorus is available to grow the plants you identified. Very high amounts of phosphorus indicate excessive fertilizer or manure application, and may lead to nutrient imbalances in plants, or negative environmental impacts to nearby water sources..

Click here for a table of soil test interpretations and recommendations.

Potassium-K

The potassium soil test value is a measure of the amount of potassium available to plants during the growing season. A very low or low potassium test value indicates that additional potassium must be applied to prevent a deficiency. An adequate or higher soil test value indicates that sufficient potassium will be available for growing the plants you identified. There are no known negative impacts to plants for potassium levels testing high or very high.

Nitrate-Nitrogen-N

Nitrogen (N) is the most important, and generally the most limiting plant nutrient in the soil system. It is required for optimal growth and function for all living things, and hence is in very high demand in terrestrial systems. Annual additions of nitrogen are generally required for optimum growth and performance of any plant and so recommendations are based on annual plant needs rather than soil test levels. For this reason, nitrogen analysis is not included in the routine soil analysis package available through the lab. However, in many instances, especially where large, repeated applications of compost or manure are added to soils, nitrogen dynamics and management can be complex and knowledge of the soil test level is imperative to prevent over application, or loss of nitrogen from the system.

If requested, the amount of plant-available nitrogen is indicated by the nitrate-nitrogen value in the upper 2 or more feet of soil, normally the sum of 0 to 12 inch and 12 to 24 inch sample depths. The upper 2 feet of soil are used because nitrate-N is mobile and will move through soil with irrigation water or rainfall. Nitrogen recommendations depend on the nitrate-nitrogen soil test value, the crop to be grown or landscape setting (e.g., lawn or garden), yield, and site history (last crop grown, residue removal, and previous applications of nitrogen and/or manure). If a nitrate-nitrogen test was not requested, nitrogen recommendations will be based on the annual need of the crop to be grown, yield, and site history.

Zinc-Zn

Zinc is occasionally deficient in Utah soils, especially where topsoil has been removed during construction and land leveling activities. Plants such as corn, potatoes, onions, and beans are most susceptible to zinc deficiency. A low or marginal soil test zinc value indicates a need for zinc fertilization at rates indicated on your report.

Iron-Fe

Iron deficiency is a common problem with landscape plants in Utah. Iron sensitive trees, shrubs, and fruits growing in soils testing below 5 ppm iron may benefit from iron fertilization. Soil pH is an important factor in the optimum management of iron availability in soils, so consultation with extension personnel is helpful in understanding the dynamics and nuances of iron fertilization.

Copper-Cu and Manganese-Mn

Copper and manganese deficiencies are rarely observed in Utah. When indicated, copper and manganese applications should initially be made on a trial basis to determine if there is a response before treating large areas.

Sulfate-Sulfur-S

Sulfur deficiency is most likely to occur in higher elevation areas where irrigation waters are relatively pure or in urban settings where municipal water sources (which have been treated to have low levels of dissolved salts) are used for irrigation. A low or marginal sulfur test indicates a need for sulfur fertilization at rates recommended on the report.

Click here for a table of soil test interpretations and recommendations.

Sodium Adsorption Ratio-SAR

The SAR is the ratio of sodium (Na) to calcium (Ca) plus magnesium (Mg) in the soil solution. A high SAR can cause the deterioration of soil aggregates and often results in surface crusting and poor water infiltration and plant growth. Soils with a SAR greater than 10 to 15 are classified as sodic and will likely require the addition of gypsum (calcium sulfate) or other amendments (such as elemental sulfur and/or organic matter) at high rates to aid in the displacement of sodium, reformation and stabilization of soil aggregates, and improvement of infiltration. Contact your local county Extension agent for assistance in treating soils with a high SAR.

For more information on high sodium soils, refer to: “Managing Sodic Soils in Utah” (AG275) online at http://extension.usu.edu.

Organic Matter-O.M.

Organic matter provides nutrients such as nitrogen and sulfur for plant growth while improving soil tilth (physical condition). Generally, higher levels of organic matter are desirable. Soil organic matter content also influences the effectiveness and application rate of certain herbicides. Follow the instructions on your herbicide label or contact your local county Extension agent for assistance.

Recommendations

Nutrient recommendations are expressed in pounds per acre for agricultural soil samples, or pounds per 1000 square feet for turf, landscape, and garden soil samples. These recommendations are used as the basis for calculating the application rates of fertilizers you select to meet the nutrient needs.

Where to Obtain Additional Information

The Utah State University Analytical Laboratory has information on soil, plant, feed, and water analysis. Other Utah State University Extension bulletins are also available on a wide range of topics. For information and assistance in obtaining these guides, contact your local county Extension agent, the Utah State University Analytical Laboratory (Utah State University, Logan, Utah 84322-4830; 435-797-2217), or the Utah State University Extension Web site: http://extension.usu.edu.

This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Noelle E. Cockett, Vice President for Extension and Agriculture, Utah State University.

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August 2016 Horticulture/Fertilizers/2016-01

Calculating Fertilizer for Small Areas

Tiffany Maughan, Grant Cardon, and ***Dan Drost***

Introduction

Soil nutrients in the home landscape and garden may become depleted over time. Replacing these nutrients with fertilizers is often necessary. For some nutrients (phosphorus or potassium), a single yearly application is sufficient while with other nutrients (nitrogen) more frequent applications are warranted. Knowing exactly how much fertilizer to apply in your garden plot can be challenging as fertilizer recommendations are typically given for large areas (i.e., pounds per acre or per 1000 square feet). Gardeners and urban farmers often must convert these recommendations to much smaller areas, sometimes just a few square feet or even for a single container or pot. Guessing at amounts to apply often results in over or under fertilizing. Over fertilizing can lead to ground water contamination, negatively impact plant growth, and wastes money. Under fertilization results in decreased plant health and reduced yields. This fact sheet is meant to help gardeners convert fertilizer recommendations to fit their individual garden plot size.

Four Steps for Successful Fertilizer Application

1. **Soil test.** Start with having a soil test done on the area you will be growing in. This is particularly important when cultivating a new location, but should also be done once every few years in an established garden or if you are noticing decreased productivity. Utah State University Analytical Labs is open to the public and offers a wide variety of soil tests. Visit http://usual.usu.edu/ for a complete list of tests offered, pricing information and directions for collecting a soil sample. Once you get your soil test results, correct interpretation is important. If you are having difficulty interpreting your results, the fact sheet Understanding Your Soil Test Report provides a helpful explanation.

Table 1 shows a sample soil test report for the most basic test offered from the USU Analytical Lab, reporting soil texture, pH, salinity, phosphorous, and potassium. Soil nitrogen is not reported but a general recommendation is still given.

2. Deciding how much to apply. You will need to know the square footage of the area to be fertilized. Table 2 shows various formulas that can be used to calculate the square footage of your garden.

Once you know your garden's square footage and have the fertilizer recommendations from your soil test, calculate the number of pounds of each nutrient needed using the following equation.

Pounds recommended per 1000 sq ft X Square Footage/1000 sq ft = Pounds to apply in garden

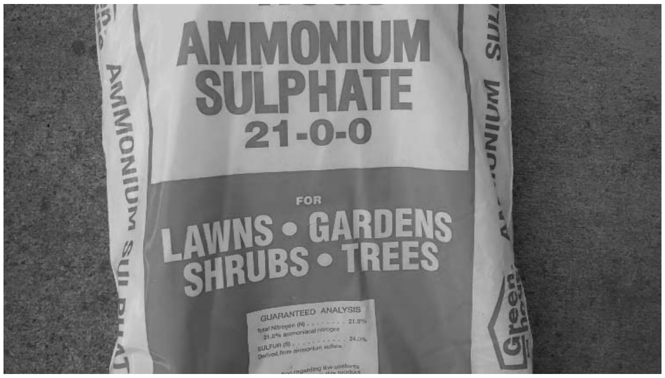
Based on your soil test results, determine which nutrients you need to apply. Usually, in vegetable gardens and lawns, nitrogen needs to be applied every year. If you do not have a soil test, a general recommendation for a vegetable garden is to apply 2 to 4 pounds of nitrogen per 1000 square feet.

3. Deciding which fertilizer to apply. There are many different fertilizer options that provide nutrients to the soil. All the different choices can be very overwhelming and leave homeowners confused about what they should actually apply. There are two main groups of fertilizers: organic and inorganic (sometimes referred to as chemical) fertilizers. Both types, if properly used, are a good option for homeowners. The fact sheets, Selecting and Using Organic Fertilizers and Selecting and Using Inorganic Fertilizers provide useful information on both types of fertilizer as well as lists of fertilizer nutrient content in each type.

Example: 10 by 20 foot garden and 2 pounds per 1000 square feet nitrogen recommendation

10 x 20 =200 square feet

2 lbs N x (200 sq ft/1000) = 0.4 pounds nitrogen applied over total garden area



All fertilizers sold commercially must be labeled with a standardized label. The label will have 3 numbers, separated by dashes, indicating the percentage of three major nutrients: nitrogen (N), phosphate (P_2O_5), and potash (K_20). As an example, a common starter fertilizer is 20-27-5. That means it contains 20% nitrogen, 27% phosphate, and 5% potash. To calculate how many pounds of each nutrient in your fertilizer bag, multiple the weight of the bag by the percentage of each nutrient.

Example: 5 pound bag of 20-27-5 fertilizer

Nitrogen: 5 lbs fertilizer x 20% (0.20) = 1 pound N

Phosphate: 5 lbs fertilizer x 27% (0.27) = 1.35 pounds Phosphate

Potash: 5 lbs fertilizer x 5% (0.05) = 0.25 pound Potash

Other nutrients, such as zinc, magnesium, iron or copper can also be purchased in a fertilizer but will be specified elsewhere on the label. Table 3 lists single nutrient fertilizers.

From our example above, the garden requires 0.4 lbs of nitrogen. If you are using the 20-27-5 fertilizer sources, you would apply 2 lbs (0.4 lbs. N / 0.20 (20% N) = 2) of that fertilizer over the 200 sq. ft. garden. Since the soil test (Table 1) indicated low P and high K applying a 20-27-5 fertilizer is an acceptable option. However, one without any K would be better.

When choosing a fertilizer material, application of only those nutrients needed (as dictated by soil test results) is advised to protect against unnecessary accumulation of excess nutrients in the soil. Excess amounts of P and K are not toxic to plants, but can have secondary environmental effects on surface water quality (e.g., P in runoff) and soil and water salinity (e.g., high K accumulation). Over-application of N is a serious issue that can have a detrimental effect on plant growth, and also presents potential undesirable environmental effects such as nitrate contamination of ground water. Additionally, N in surface water contributes to algal blooms that deplete oxygen for fish and other aquatic organisms. Furthermore, excess P in soils can present competitive uptake restriction over minor, but often limiting nutrients such as iron (Fe) and zinc (Zn). Finding one fertilizer that perfectly meets your soil test recommendation is not always possible; combining different single-nutrient fertilizers (Table 3) may be the best option for your situation.

4. Measuring the correct amount. When working with backyard gardens, flower beds or patio boxes the amount of fertilizer needed is typically fairly small. Conversions to smaller measurements are often needed. Table 4 and 5 have useful conversions for various measurements. To take some of the guesswork out of measuring, consider investing in some simple tools that will improve accuracy. A small kitchen scale and a set of measuring cups and spoons that can be dedicated to fertilizer applications will prove useful.

Case Study

Table 1 is a sample garden report for the most basic test offered from the USU Analytical Lab. It recommends the gardener apply 2 to 4 pounds N per 1000 square feet, 1 to 2 pounds P_2O_5 per 1000 square feet, and 0 pounds K_2O per 1000 square feet and. The area to be fertilized is 200 square feet.

Calculations for each of the three nutrients follow.

Pounds recommended per 1000 sq ft X Square Footage/1000 sq ft = Pounds to apply in area

Nitrogen:

2 lbs N X (200 sq ft/1000 sq ft) = **0.4 lbs N**

to

4 lbs N X (200 sq ft/1000 sq ft) = **0.8 lbs N**

Phosphate:

1 lbs P_2O_5 X (200 sq ft/1000 sq ft) = **0.2 lbs P_2O_5**

to

2 lbs P_2O_5 X (200 sq ft/1000 sq ft) = **0.4 lbs P_2O_5**

Potash:

0 lbs K_2O X (200 sq ft/1000 sq ft) = **0 lbs K_2O**

> See companion Excel workbook at
>
> http://digitalcommons.usu.edu/extension_curall/1582/
>
> to enter in your exact specifications and get nutrient recommendations that fit your needs. The workbook will walk you through calculating fertilizer amounts.

Table 1. Sample soil test report from USUAL.

Soil Test Report

and

Fertilizer Recommendations

USU Analytical Labs
Utah State University
Logan, Utah 84322-9400
(435) 797-2217
(435) 797-2117 (FAX)
www.usual.usu.edu

Date Received: 3/31/2015
Date 4/9/2015
Name: Ima Gardener
Address: 120 Flower Lane
LOGAN UT 84321
Phone:
County: CACHE
Lab Number: 1501-0784
Grower's Comments:
Acres in Field:
Identification: 1
Crop to be Grown: Garden

Soil Test		Interpretations	Recommendations
Texture	Loam		
pH	7.6	Normal	
Salinity - ECe	0.7	Normal	
Phosphorus - P	12.1	Low	1-2 lbs P2O5/1000 sq ft
Potassium - K	580	High	0 lbs K2O/1000 sq ft
Nitrate-Nitrogen - N mg/kg			2-4 lbs N/1000 sq ft*
Zinc - Zn			
Iron - Fe mg/kg			
Copper - Cu			
Manganese - Mn			
Sulfate-Sulfur - S			
Organic Matter			
SAR			

Note
*SEE GARDEN GUIDE

Table 2. Formulas for calculating square footage of variously shaped areas.

Shape	Formula
Square or rectangle	Area = Length x Width
Triangle	Area = 1/2 x Base x Height
Circle	Area = 3.14 x radius2
Ovals (5% accuracy)	Area= Length x Width at midpoint x 0.8
Irregular shapes (5% accuracy)	Measure longest axis of area (length) At every 10 ft on the length line measure the width Total all widths and multiply by 10 Area = (A + B + C + D + E) x 10

Table3. Single source fertilizers.

Fertilizer	N-P-K
Urea	46-0-0
Ammonium nitrate	34-0-0
Ammonium sulfate	21-0-0
Triple superphosphate	0-45-0
Potassium chloride	0-0-60

Table 4. Equivalents for volume measurements

Gallons	Quarts	Pints	Fluid Ounces	Cups	Tablespoons	Teaspoon	Milliliters	Liters
1	4	8	128	16	256	768	3785	3.785
-	1	2	32	4	64	192	946	0.946
-	-	1	16	2	32	96	473	0.473
-	-	-	1	1/8	2	6	30	0.03
-	-	-	-	1	16	48	236	0.236
-	-	-	-	-	1	3	15	0.015
-	-	-	-	-	-	1	5	0.005
-	-	-	-	-	-	-	1	0.001

Table 5. Rate of application equivalent table (dry materials)

Per Acre	Per 1,000 sq ft	Per 100 sq ft	Per 10 sq ft
1 lb	2.5 tsp	0.25 tsp	0.025 tsp
3 lbs	2.25 tbs	0.75 tsp	0.075 tsp
4 lbs	3 tbs	1 tsp	0.10 tsp
5lbs	4 tbs	1.25 tsp	0.13 tsp
10 lbs	0.4 cup	2 tsp	0.2 tsp
100 lbs	2.25 lbs	0.25 lb	2.4 tsp
200 lbs	4.66 lbs	0.5 lb	1.6 tbs
300 lbs	7 lbs	0.75 lb	2.4 tbs
400 lbs	9.25 lbs	1 lb	3.2 tbs
500 lbs	11.5 lbs	1.15 lbs	4 tbs

This project is funded in part by USDA-Risk Management Agency under a cooperative agreement. The information reflects the views of the author(s) and not USDA-RMA.

EXTENSION UtahStateUniversity

USDA

PLANT ANALYSIS
INFORMATION SHEET

USU Analytical Labs
1541 N 800 E / 9400 Old Main Hill
Logan, UT 84322-9400
(435) 797-2217 or Fax (435) 797-2117
www.usual.usu.edu

USU ANALYTICAL LABORATORIES

Grower's name: ____________________

Mailing Address: ____________________

City, State, Zip: ____________________

County: ____________________

Phone : ____________________

Email: ____________________

Sample no. ____________________

Collection date: ____________________

Sample collected by: ____________________

Field identification: ____________________

Plant or crop type: ____________________

Variety: ____________________

Plant age or growth stage:* ____________________

FIELD HISTORY (Place an X by appropriate response).

General vigor of plants:	☐ Vigorous	☐ Moderately vigorous	☐ Weak	
Irrigation system:	☐ Flood	☐ Furrow	☐ Sprinkler	☐ Drip
Soil texture:	☐ Sandy loam	☐ Loam	☐ Clay loam	☐ Other (specify)
Soil depth:	☐ Shallow	☐ Deep	☐ Soil series __________ (name)	
Soil drainage:	☐ Rapid	☐ Moderate	☐ Slow	
Cover crop:	☐ None	☐ Sod	☐ Legume	☐ Weeds

Last year's crop: ____________________ (name & vigor)

FERTILIZER USED (Enter amount in lbs/acre)

	TYPE	THIS SPRING	1YEAR AGO
Nitrogen			
Phosphorus			
Potassium			
Other(s)			
Nutrient Sprays			
Other sprays used			
Weed control			

Does this sample represent an average of planting? ☐ Yes ☐ No   Problem area? ☐ Yes ☐ No

If there is a problem, do you think it is nutritional? ☐ Yes ☐ No

Describe: ____________________

*Contact the lab or your County Agent concerning proper sampling.

ANALYSIS REQUESTED

	Price/sample
__ Plant Tissue Test (N, P, K, Ca, Mg, Mo, S, B, Fe, Zn, Mn, Cu)	$48.00

Total cost of analysis: $ __________

☐ Check # __________ ☐ Cash

■ Credit Card

__________ **CALL FOR CC #** __________

☐ Visa ☐ Master card ☐ Discover ☐ AmEx

UtahState UNIVERSITY extension

USU Analytical Laboratories
1541 N 800 E / 9400 Old Main Hill
Utah State University
Logan, UT 84322-9400
Telephone (435) 797-2217, Fax (435) 797-2117
www.usual.usu.edu

PLEASE INCLUDE PAYMENT WITH SAMPLE TO PREVENT DELAY ON SAMPLE PROCESSING.

Rev. 2/01/2017

FRUIT TREE LEAF SAMPLING PROCEDURES

1. Leaf samples should be collected between approximately July 15 and August 15.

2. Select five (5) fruit trees of the same variety. A single sample should not represent an area of more than five (5) acres. Mark or map plants sampled for future reference. In diagnosing poor growth areas, take a composite sample from affected plants and a separate sample from nonaffected plants.

3. Collect 10-20 leaves per plant at random from around the tree at shoulder height and combine them into one sample. Collect those leaves in the center of the current season's growth (see diagram below).

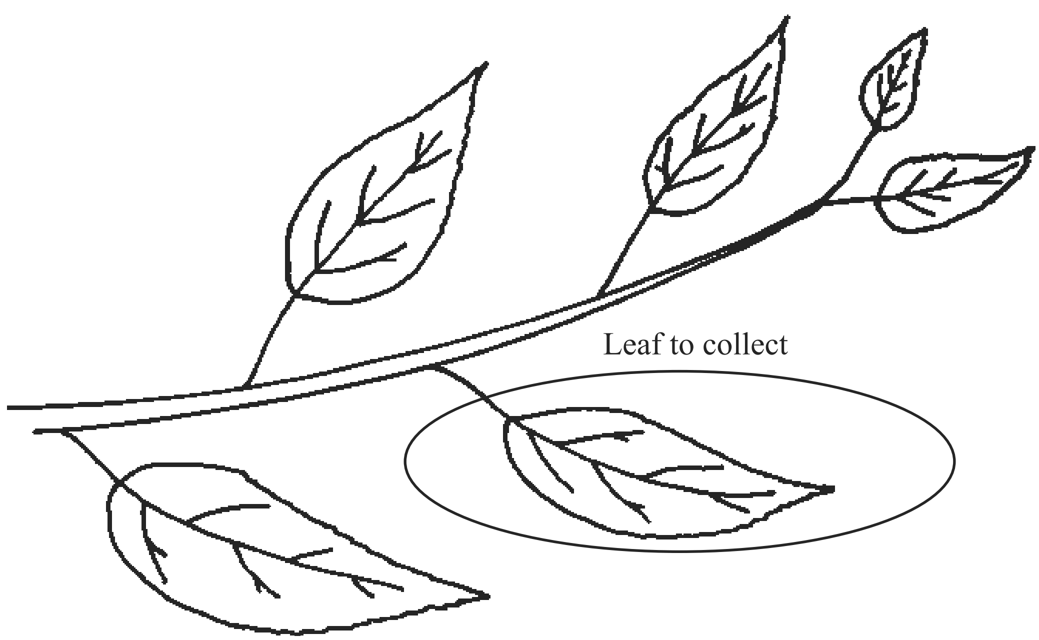
4. The leaves should be briefly rinsed (less than 30 seconds) in clear, soft water. Allow the leaves to dry before sending to the lab.

5. Repeat steps 1-4 for each fruit variety to be tested.

6. Place the leaves in a suitable paper bag.

7. Fill out the Plant Analysis Information Sheet (on reverse side) and enclose it, the leaves, and check in a suitable mailer. Be sure to send a check payable to the USU Analytical Labs so that analysis can be completed. Mail to:

USU Analytical Laboratories
Skaggs Research Lab
Utah State Univeristy
1541 N 800 E / 9400 Old Main Hill
Logan, UT 84322-9400



Utah State University extension

SOIL ANALYSIS INFORMATION SHEET

USU Analytical Labs
1541 N 800 E / 9400 Old Main Hill
Logan UT 84322-9400
(435) 797-2217 or Fax (435) 797-2117
www.usual.usu.edu

USU ANALYTICAL LABORATORIES

Date: ______________________________

Name: ______________________________

Mailing Address: ______________________________

City, State, Zip: ______________________________

County: ______________________________

Phone : ______________________________

Email : ______________________________

	Sample Numbers 1	2	3	4
Sample I.D.	______	______	______	______
Sample Depth	______	______	______	______
Tests Desired*	______	______	______	______

*TESTS OFFERED
Price is per sample

1. Basic (Phosphorus (P) + Potassium (K) only) 14.00
2. Routine (pH, salinity, texture, Phosphorus (P), Potassium (K), recommendations-indicate crop!)...................................... 25.00
3. Manure application - (Routine + Nitrate-N**) 35.00
4. Micro Plus (Routine + micronutrients (Zn, Fe, Cu, Mn)).... 35.00
5. Complete (pH, salinity, texture, P, K, Nitrate-N**, micronutrients, sulfate, organic matter) 67.00
6. UDOT Required (pH, salinity, SAR, organic matter, particle size, >2mm)... 61.00
7. Landscaper (UDOT plus P, K, NO3-N**, micronutrients).. 90.00

Please contact the lab for individual analyses/additional analyses

**Nitrate-N analysis requires special sampling/handling. See procedures on reverse side.

TESTS REQUIRE 2 CUPS OF SOIL PER SAMPLE

Providing too much soil may cause delays, while too little soil may not be enough for all tests requested.

COMMENTS or special problems: ______________________________

____

____

Total cost of analysis: $ __________________

☐ Check # ______________________ ☐ Cash

☐ #________**CALL FOR CC #**______________

☐ Visa ☐ Master card ☐ Discover ☐ AmEx

PLEASE INCLUDE PAYMENT WITH SAMPLE TO PREVENT DELAY ON SAMPLE PROCESSING.

LAWN • GARDEN • ORCHARD

Crops to be Grown	Sample Numbers 1	2	3	4
1. Garden/flowers/veg.	☐	☐	☐	☐
2. Lawn	☐	☐	☐	☐
3. Shrubs/trees	☐	☐	☐	☐
4. Fruit trees/canes	☐	☐	☐	☐
5.______________	☐	☐	☐	☐

MATERIALS APPLIED DURING PAST YEAR

	1	2	3	4
1. Manure	☐	☐	☐	☐
2. Leaves/ grass/residues	☐	☐	☐	☐
3. Commercial fertilizer	☐	☐	☐	☐
4. ______________	☐	☐	☐	☐

FIELD CROPS

Crops to be Grown IRRIGATED	Sample Numbers 1	2	3	4
1. Alfalfa 100%	☐	☐	☐	☐
2. Grass Hay 100%	☐	☐	☐	☐
3. Legume /Grass Hay	☐	☐	☐	☐
% Legume(25% increments)	____	____	____	____
4. Grass Pasture	☐	☐	☐	☐
5. Legume/Grass Pasture	☐	☐	☐	☐
% Legume(25% increments)	____	____	____	____
6. Corn (silage)	☐	☐	☐	☐
7. Corn for grain	☐	☐	☐	☐
8. Wheat	☐	☐	☐	☐
9. Barley/Oats for Grain	☐	☐	☐	☐
10. Potatoes	☐	☐	☐	☐
11. Turf (golf/sports)	☐	☐	☐	☐
12. ______________	☐	☐	☐	☐
NON-IRRIGATED				
13. Grain	☐	☐	☐	☐
14. Alfalfa	☐	☐	☐	☐
15. Grass Pasture	☐	☐	☐	☐
16. Reclamation	☐	☐	☐	☐
17.______________	☐	☐	☐	☐
YIELD GOAL**	____	____	____	____
Acres in field	____	____	____	____
CROP LAST YEAR	____	____	____	____
Yield per acre	____	____	____	____
Was straw/stover removed? __Yes	☐	☐	☐	☐
__No	☐	☐	☐	☐

MANURE FOR THIS CROP:

Tons per acre	____	____	____	____

**use realistic goals for your conditions

Rev. 2/01/2017

SOIL SAMPLING PROCEDURE

Good samples are required to derive useful information from soil tests.

WHEN: Any time of the year; early fall is often preferred. Allow two weeks to get results before buying fertilizer. For special nitrate tests, sample in the spring (see instructions below).

TOOLS: (a) A clean plastic container for each depth to be sampled. (b) Sampling auger or tube (USU Extension Office) or a shovel will serve for plow-layer samples.

AREA: Select an area having uniform color, texture, drainage, and the same cropping and fertilizer treatment last year. Leave out non-typical spots or sample them separately. For each area to be sampled, take separate samples from 8 to 10 locations in a pattern that will represent the entire area.

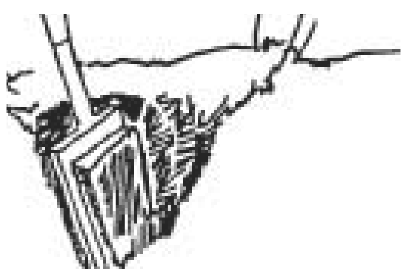
DEPTH: (a) Standard topsoil sample: from surface down to 12 inches; (b) Turf samples: surface down to 6 inches (4 inches for golf greens); (c) For special nitrate tests, see instructions below.

TAKING THE SAMPLE: Scrape away surface litter. Avoid manure spots. If previous fertilizer was banded, take special care to get a representative sample.

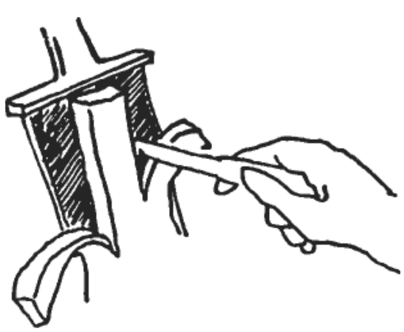
(a) Using a soil tube or auger: follow the instructions given with the tool.

(b) Using shovel:

1. Dig a V-shaped hole to plow depth. Remove a 1-inch slice of soil from one side.



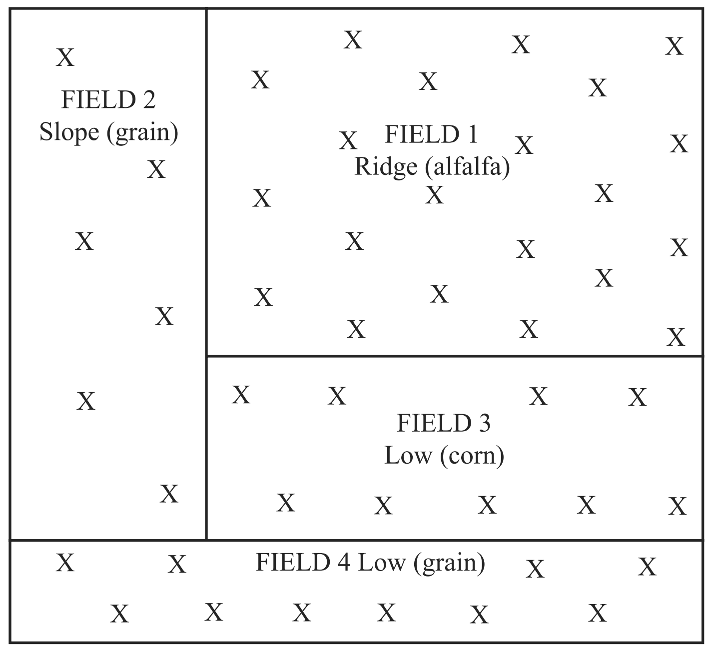
2. Discard the edges of the slice until your sample is about 1 or 2 inches wide. Put it in a clean bucket.



3. Repeat 1 and 2 for other samples for the sampling areas.

SAMPLE HANDLING: Combine the samples from the field in a clean container. Mix them well, then take about 1 pint (to fill the bag provided, or a heavy-duty, resealable plastic bag) to send for analysis. Assign it an identification (please keep it brief, and it should match both the form and the sample container sent to the lab) and record details in your files.

SHIPPING:Send samples prepaid by mail or express, accompanied by this description form and a check payable to USU Analytical Laboratories, Logan, UT 84322-9400. Retain a copy for your files.



SPECIAL SAMPLING for nitrate-N when applying manure.

b. Take samples 0 to 12 inches deep as described above. Put these in one container.

c. Starting at the bottom of the hole in (b), sample the 12 to 24-inch (or 12 to 36-inch) depth. Put these subsoil samples into a separate container. Mix and label the combined subsoil sample as above. This sample will be analyzed for Nitrate-N only, and is not included in the cost of the analysis for the 0-12 inch deep sample.

d. Spread samples out on a clean surface and air-dry them before mailing (or deliver them to the lab within 24 hours).

Nutrient Sources: How to choose them to meet plant nutrient need in traditional, organic, or mixed management settings

Biographical Information:
Bryan Hopkins, Ph.D.
Brigham Young University
5115 LSB
Provo, UT 84602
hopkins@byu.edu

Bryan G. Hopkins is a Professor at Brigham Young University with a Ph.D. in Agronomy and a Certified Professional Soil Scientist. He specializes in teaching and research in the areas of plant nutrition and soil fertility.

Session Description:

Importance of plant nutrition and soil fertility. Legitimate practices to build and maintain a healthy soil. Sources of nutrients and pros and cons of each. How to determine rates of application for various nutrient sources.

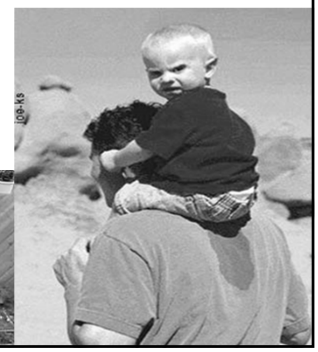
NUTRIENT SOURCES

How to choose them to meet plant nutrient need in traditional, organic, or mixed management settings?

Bryan G. Hopkins
Professor, Ph.D., CPSSc
Brigham Young University

4 R's of fertilizer stewardship

- The Right
  - Source
  - Rate
  - Timing
  - Placement



The basis of this presentation is built upon facts.

- We have conducted hundreds of evaluations of traditional, new, and even "miracle" fertilizer products over the past two decades.
- We've reviewed hundreds of evaluations of other scientists.

The basis of this presentation is built upon facts.

- "In God we trust; all others bring data."
  - *W. Edwards Deming*

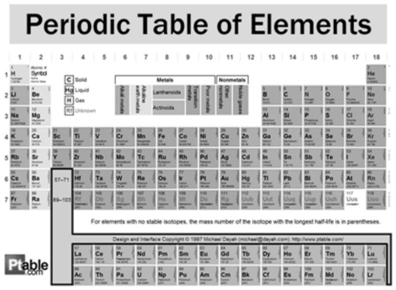
The basis of this presentation is built upon facts.

- The fact is that >90% of the time, we find that the claims by the fertilizer manufacturer are not completely true based on our studies.
- Therefore, we are "pessimistically optimistic".
- We have come across some fertilizer sources that do, in fact, represent an improvement over what we have used in the past.

The universe is made of two things

- Matter
- Energy

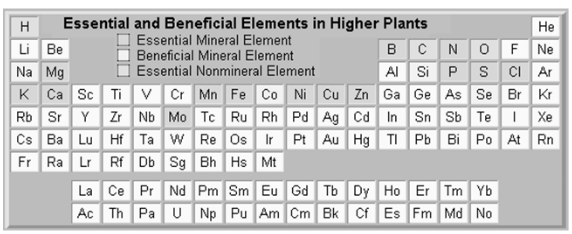
Matter is made up of various elements



All living organisms, including plants, are made up of these elements.

Element	Amount in Whole Plant %
Oxygen	45
Carbon	44
Hydrogen	6
Nitrogen	2
Phosphorus	0.5
Potassium	1.0
Calcium	0.6
Sulfur	0.4
Magnesium	0.3
Boron	0.005
Chlorine	0.015
Copper	0.001
Iron	0.020
Manganese	0.050
Molybdenum	0.0001
Zinc	0.0100
Total	99.9011

Essential and Beneficial Elements (Nutrients)



Growing healthy plants is a dependent upon have adequate amounts of these elements available for uptake.

Avoid

- Deficiencies of essential nutrients
- Excesses of essential nutrients
- Excesses of toxic elements

Element	Amount in Whole Plant %
Oxygen	45
Carbon	44
Hydrogen	6
Nitrogen	2
Phosphorus	0.5
Potassium	1.0
Calcium	0.6
Sulfur	0.4
Magnesium	0.3
Boron	0.005
Chlorine	0.015
Copper	0.001
Iron	0.020
Manganese	0.050
Molybdenum	0.0001
Zinc	0.0100
Total	99.9011

The top three (oxygen, carbon, and hydrogen) come from the air and water. Fertilizing with these is not needed.

It is important that roots have ample oxygen, thus, vital to have good soil structure.

Element	Amount in Whole Plant %
Oxygen	45
Carbon	44
Hydrogen	6
Nitrogen	2
Phosphorus	0.5
Potassium	1.0
Calcium	0.6
Sulfur	0.4
Magnesium	0.3
Boron	0.005
Chlorine	0.015
Copper	0.001
Iron	0.020
Manganese	0.050
Molybdenum	0.0001
Zinc	0.0100
Total	99.9011

Element	Amount in Whole Plant %
Oxygen	45
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Phosphorus	0.5
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Calcium	0.6
Sulfur	0.4
Magnesium	0.3
Boron	0.005
Chlorine	0.015
Copper	0.001
Iron	0.020
Manganese	0.050
Molybdenum	0.0001
Zinc	0.0100
Total	99.9011

Some greenhouse operations do supplement the carbon (via carbon dioxide) used for photosynthesis.

Soil minerals and organic matter supply the rest, which we call “mineral nutrients”.

Element	Abbrev-iation	µmol/g dry wt	mg/kg (ppm)	%	Relative number of atoms
Molybdenum	Mo	0.001	0.1	---	1
Copper	Cu	0.10	6.0	---	100
Zinc	Zn	0.30	20.0	---	300
Manganese	Mn	1.0	50.0	---	1,000
Iron	Fe	2.0	100.0	---	2,000
Boron	B	2.0	20.0	---	2,000
Chlorine	Cl	3.0	100.0	---	3,000
Sulfur	S	30	---	0.1	30,000
Phosphorus	P	60	---	0.2	60,000
Magnesium	Mg	80	---	0.2	80,000
Calcium	Ca	125	---	0.5	125,000
Potassium	K	250	---	1.0	250,000
Nitrogen	N	1000	---	1.5	1,000,000

Average Concentrations of Mineral Nutrients in Plant Shoot Dry Matter that are Sufficient for Adequate Growth

Element	Abbrev-iation	µmol/g dry wt	mg/kg (ppm)	%	Relative number of atoms
Molybdenum	Mo	0.001	0.1	---	1
Copper	Cu	0.10	6.0	---	100
Zinc	Zn	0.30	20.0	---	300
Manganese	Mn	1.0	50.0	---	1,000
Iron	Fe	2.0	100.0	---	2,000
Boron	B	2.0	20.0	---	2,000
Chlorine	Cl	3.0	100.0	---	3,000
Sulfur	S	30	---	0.1	30,000
Phosphorus	P	60	---	0.2	60,000
Magnesium	Mg	80	---	0.2	80,000
Calcium	Ca	125	---	0.5	125,000
Potassium	K	250	---	1.0	250,000
Nitrogen	N	1000	---	1.5	1,000,000

Average Concentrations of Mineral Nutrients in Plant Shoot Dry Matter that are Sufficient for Adequate Growth

Notice that plants need very small amounts of some nutrients, such as molybdenum (Mo). As such, Mo is rarely deficient because of the low amount needed and the ample amount in most soils.

Other nutrients are needed in high quantities. For example, nitrogen (N) is needed at high levels. Because of demand (and soil chemistry issues), N is commonly deficient.

Element	Abbrev-iation	µmol/g dry wt	mg/kg (ppm)	%	Relative number of atoms
Molybdenum	Mo	0.001	0.1	---	1
Copper	Cu	0.10	6.0	---	100
Zinc	Zn	0.30	20.0	---	300
Manganese	Mn	1.0	50.0	---	1,000
Iron	Fe	2.0	100.0	---	2,000
Boron	B	2.0	20.0	---	2,000
Chlorine	Cl	3.0	100.0	---	3,000
Sulfur	S	30	---	0.1	30,000
Phosphorus	P	60	---	0.2	60,000
Magnesium	Mg	80	---	0.2	80,000
Calcium	Ca	125	---	0.5	125,000
Potassium	K	250	---	1.0	250,000
Nitrogen	N	1000	---	1.5	1,000,000

Average Concentrations of Mineral Nutrients in Plant Shoot Dry Matter that are Sufficient for Adequate Growth

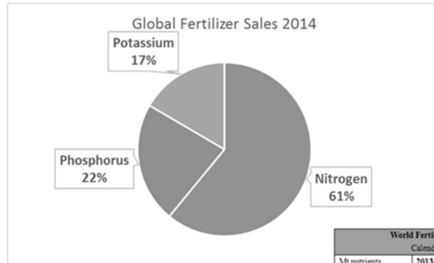
Knowing plant composition isn’t the whole story. The amount found in the soil and the chemistry of soil impact the likelihood of having a deficiency.

Element	Abbrev-iation	µmol/g dry wt	mg/kg (ppm)	%	Relative number of atoms
Molybdenum	Mo	0.001	0.1	---	1
Copper	Cu	0.10	6.0	---	100
Zinc	Zn	0.30	20.0	---	300
Manganese	Mn	1.0	50.0	---	1,000
Iron	Fe	2.0	100.0	---	2,000
Boron	B	2.0	20.0	---	2,000
Chlorine	Cl	3.0	100.0	---	3,000
Sulfur	S	30	---	0.1	30,000
Phosphorus	P	60	---	0.2	60,000
Magnesium	Mg	80	---	0.2	80,000
Calcium	Ca	125	---	0.5	125,000
Potassium	K	250	---	1.0	250,000
Nitrogen	N	1000	---	1.5	1,000,000

Average Concentrations of Mineral Nutrients in Plant Shoot Dry Matter that are Sufficient for Adequate Growth

For example, calcium (Ca) is the nutrient with the third highest amount in plants, but it is rarely deficient (especially in Western US soils) because our soil and irrigation water has very high levels of this element.

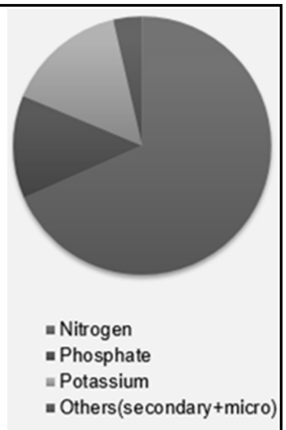
The "Primary Macronutrients" are nitrogen, phosphorus, and potassium because they are the most commonly deficient.



World Fertilizer Consumption Calendar Year Basis			
Mt nutrients	2013	2014(e)	2018(f)
Nitrogen N	111.3	113.7	119.5
Phosphorus P2O5	41.8	42.2	45.9
Potassium K2O	29.7	30.8	34.0
Total	**182.8**	**186.7**	**199.4**

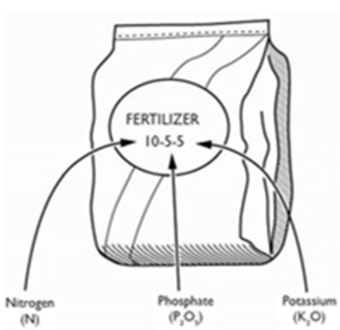
Source: P. Heffer, IFA, June 2014

The secondary macronutrients (calcium, magnesium, & sulfur) and the micronutrients are only a fraction of global sales, which is a good indication that they are not as commonly deficient as NPK.



However, the "other" nutrients can be important too, as seen here with iron deficiency in this leaf.

By law, fertilizer bags have to list the guaranteed analysis of the primary macronutrients. The other nutrients are required to be listed, but they generally are included.



How to read a fertilizer label

The numbers on a fertilizer bag indicate the percentage of nitrogen (N), phosphate (P_2O_5), and potash (K_2O), written as N-P-K.

Source Considerations

- Release - "Quick" vs. Slow vs. Controlled
- Traditional vs. Biosolids/liquids vs. Certified Organic
- Dry vs. Liquid

Source Considerations: Water Solubility

- Plants have to drink their nutrients.
- As such, in general, it is important that dry fertilizer sources are highly water soluble or it will become soluble over the course of the season.
- For example, rock phosphate (apatite) is completely insoluble in most soils and, thus, is not an effective fertilizer.
- However, some water insoluble nitrogen sources can be effective slow release fertilizers.

Source Considerations: Organic

- Growers selling produce as Certified Organic have to use OMRI certified fertilizers that have gone through the approval process.
- Realize that from a plant/human health standpoint that an atom of nitrogen is an atom of nitrogen—indistinguishable whether it came from a OMRI Certified Compost or from a bag of non-certified urea fertilizer.
  - There are other differences to consider (other beneficial properties, source of manufacturer, philosophical differences, etc.)

Source Considerations: Rate of Release

Slow Release – Controlled Release

- Reduces environmental loss (especially for nitrogen)
- More efficient:
  - Money savings: reduced applications
  - More to crop
  - Reduce total output

"Controlled Release"

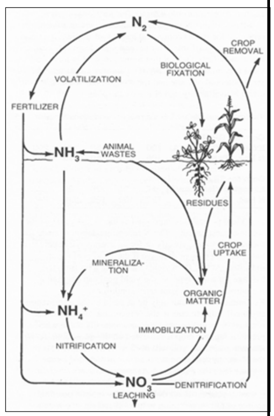
1. Uncoated: (Slow-Release)
   - IBDU – relies on decomposition by chemical and biological processes.
2. Coated: (Controlled-Release)
   - PSC (Poly Sulfur Coated) – relies on water to move through coating.
3. Bio-Inhibited: (Delayed-Release)
   - Urease inhibitors
   - Organics

Source Considerations

- $$$
- convenience
- added nutrients (P, S, etc.)
- urea vs. ammonium vs. nitrate
  - N loss mechanisms
- Timing
  - Plant need
  - Release patterns

Nitrogen (N) in soil

- N ends up as nitrate (NO_3^-)
  - Microbial/Plant uptake
  - Denitrification
    - conversion to N_2O(g)
  - Lateral flow to surface water
  - Vertical flow to groundwater - very mobile



>10% of "Quick release" N is lost

- Apply when cool and immediately water it in with ¼ inch water.

However, important considerations

- Timing of N release isn't always what it is claimed.
  - Temperature at soil surface can be very hot at times and result in rapid release of N from polymer coating.
  - Spring vs. Summer vs. Fall

Polymer Coated Urea

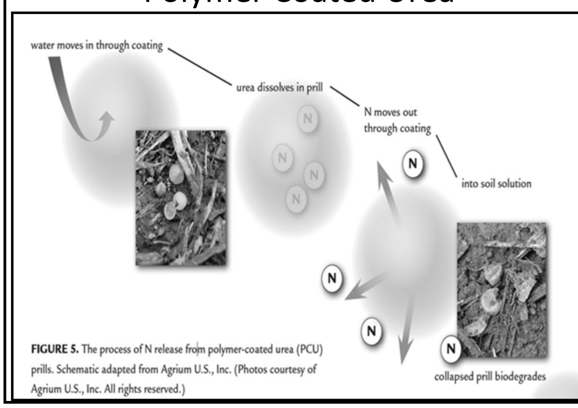
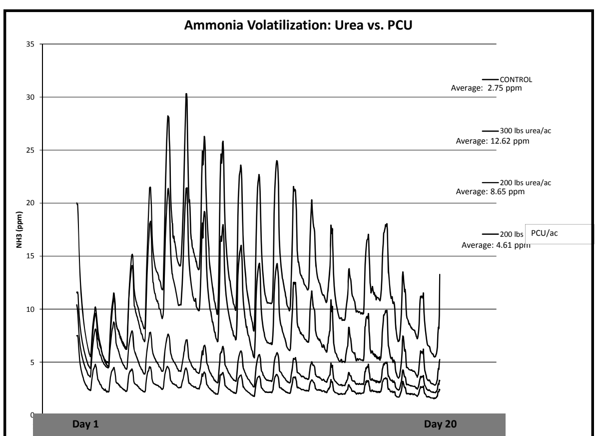
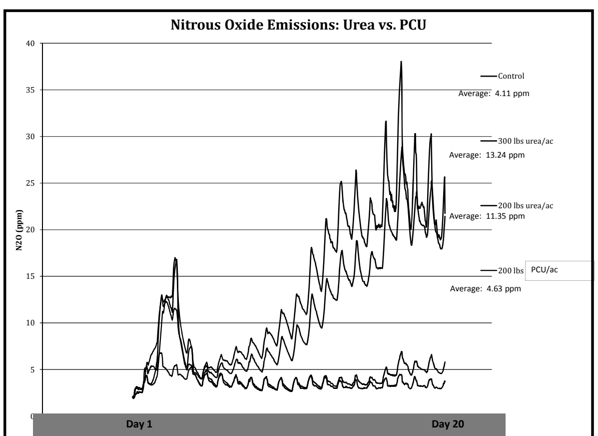


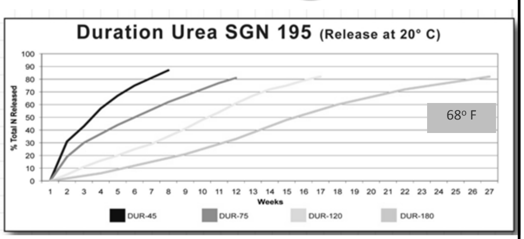
FIGURE 5. The process of N release from polymer-coated urea (PCU) prills. Schematic adapted from Agrium U.S., Inc. (Photos courtesy of Agrium U.S., Inc. All rights reserved.)



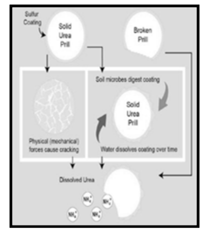


Polymer Coated Urea

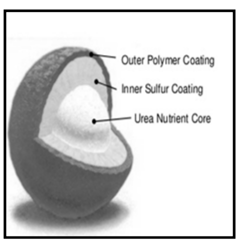
- Duration CR®

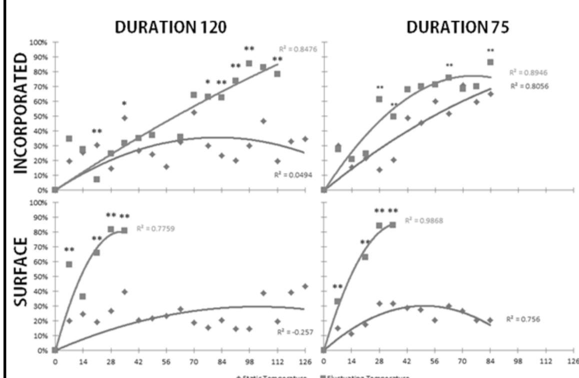


Sulfur Coated Urea

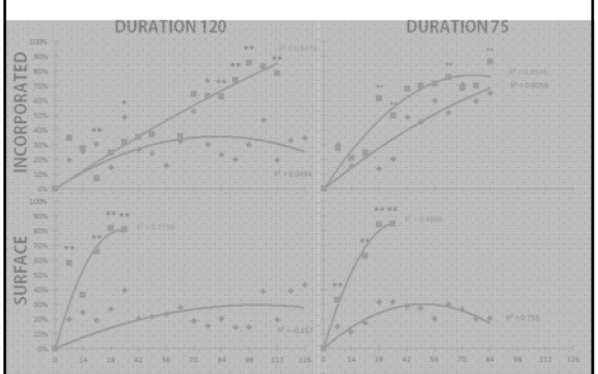


Polymer-Sulfur Coated Urea

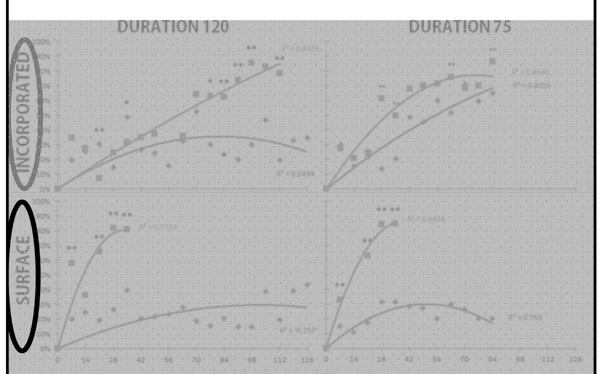


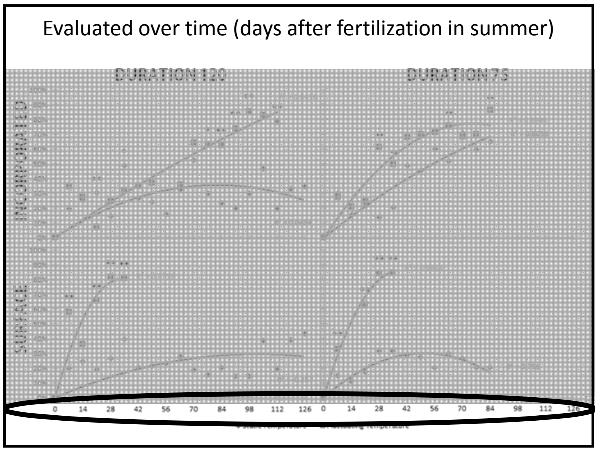


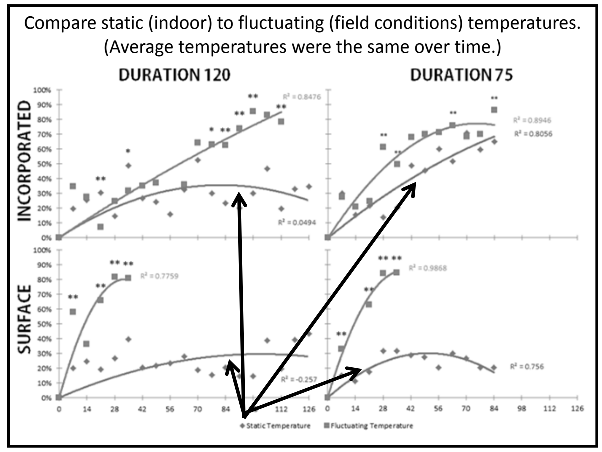
Compare several fertilizer sources

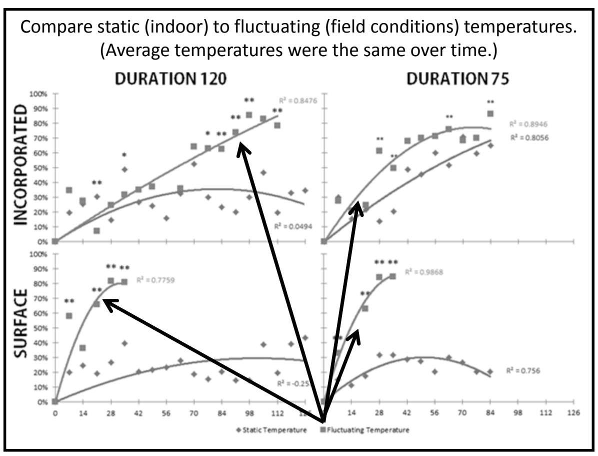


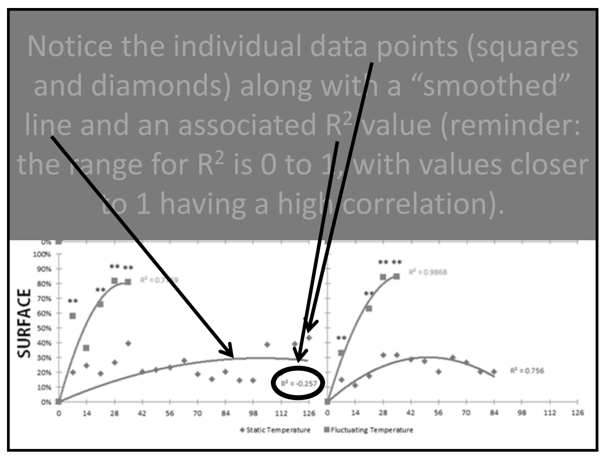
Compare incorporated into the soil to surface application.

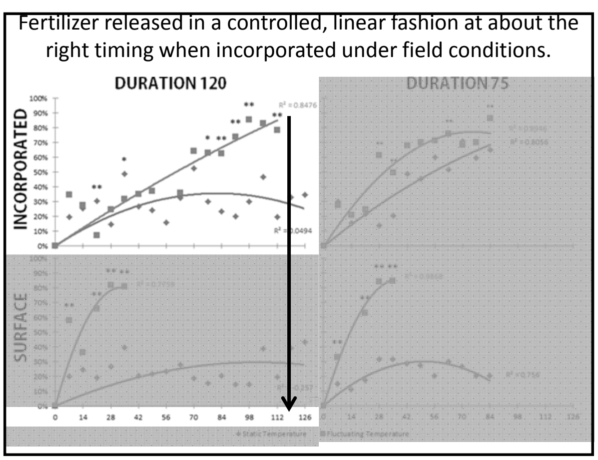


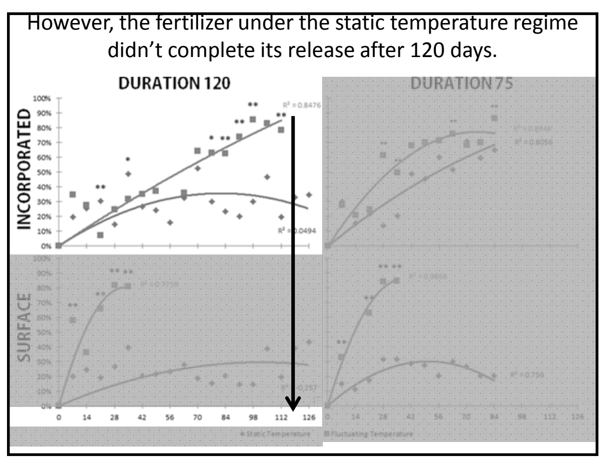

Evaluated over time (days after fertilization in summer)
DURATION 120
DURATION 75
INCORPORATED
SURFACE


Compare static (indoor) to fluctuating (field conditions) temperatures. (Average temperatures were the same over time.)
DURATION 120
DURATION 75
INCORPORATED
SURFACE
Static Temperature
Fluctuating Temperature

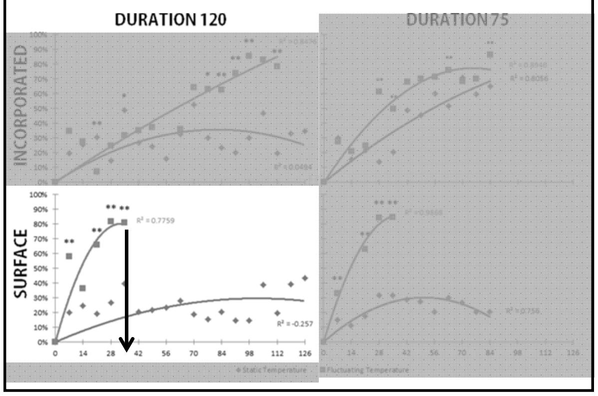

Compare static (indoor) to fluctuating (field conditions) temperatures. (Average temperatures were the same over time.)
DURATION 120
DURATION 75
INCORPORATED
SURFACE
Static Temperature
Fluctuating Temperature


Notice the individual data points (squares and diamonds) along with a "smoothed" line and an associated R2 value (reminder: the range for R2 is 0 to 1, with values closer to 1 having a high correlation).
SURFACE
Static Temperature
Fluctuating Temperature

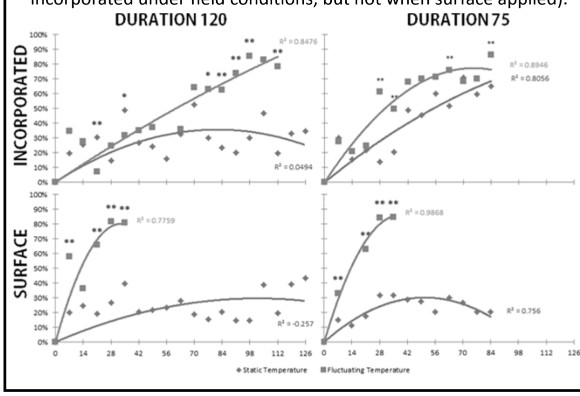

Fertilizer released in a controlled, linear fashion at about the right timing when incorporated under field conditions.
DURATION 120
DURATION 75
INCORPORATED
SURFACE


However, the fertilizer under the static temperature regime didn't complete its release after 120 days.
DURATION 120
DURATION 75
INCORPORATED
SURFACE

And, more importantly, when surface applied the fertilizer under field conditions released much faster than when incorporated (achieving near completion after about 35 days).

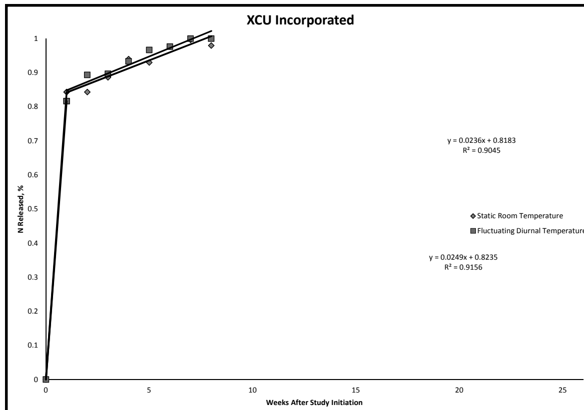


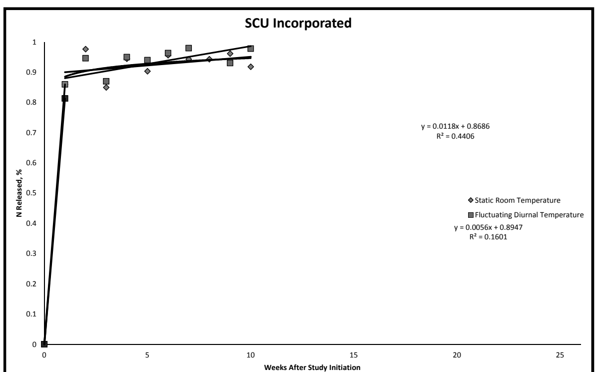
Similar results for Duration 75 (releasing fertilizer at ~75 days when incorporated under field conditions, but not when surface applied).



Quality of Coatings

- Not all "slow" or "controlled" release work





Compost, Manure, Biosolids, etc.

- These can be very effective fertilizers.
  - Slow release source of nutrients.
  - Add organic matter to soil (increases water & nutrient holding capacity of soil, can help improve soil structure and oxygen content).
- However, there can be problems.
  - Pathogens, Weed Seeds, Insects, Nematodes, and other pests (these can be controlled if the composting or other treatment processes are complete)
  - Often result in environmental contamination as the release of nutrients continues after the growing season.

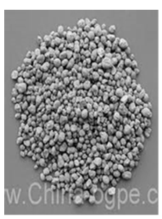
fertilizers

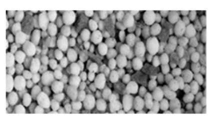
They are **not** all created equal

Questions:

- **Homogenous** Pellets vs Granular **Blends**? Pros and Cons.
- Can you put out **micro-nutrients** using a **'Blend'?!**
- **Uniformity** of pellet?
  - How does this impact distribution?
- Does '**Size'** of the pellet make a difference?! What in the world is **'SGN'**
- Difference between **'SLOW'** release vs **'CONTROLLED'** release.

- Homogenous Pellets
  Blends



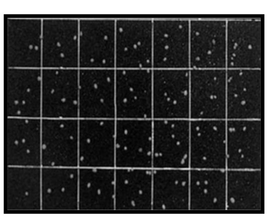


Particle Size:

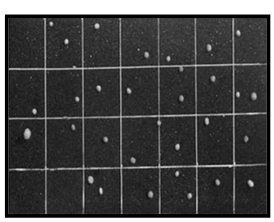
- Referred to as **<u>size guide number</u>** or **SGN.**
- The larger the SGN number the larger the size of the particle.
- SGN is the average particle diameter of the product expressed in millimeters multiplied by 100.
  - Particle size of 1.5 will have an SGN of 150
- The more particles applied per sq. inch the better the performance.

Particle size impacts distribution!

150 SGN applied at 200 lbs/acre



240 SGN applied at 200 lbs/acre



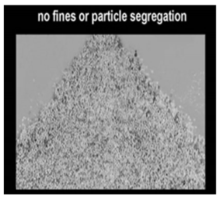
Particle Uniformity:

- Impacts spreadability of product
  - Dense, heavy material will be thrown greater distances
  - Fine material will stay close to the spreader
- Impacts product performance
  - Urea (light) will not travel as far. Can impact color (striping).
- Spreaders are built to apply 'Tire track to tire track'.
  - If you spread wider than that striping a very good possibility.

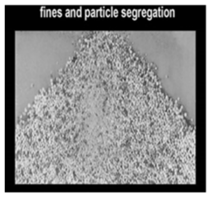
Particle Uniformity:

"Varying particle size and density cause irregular ballistic behavior resulting in inconsistent delivery of product"

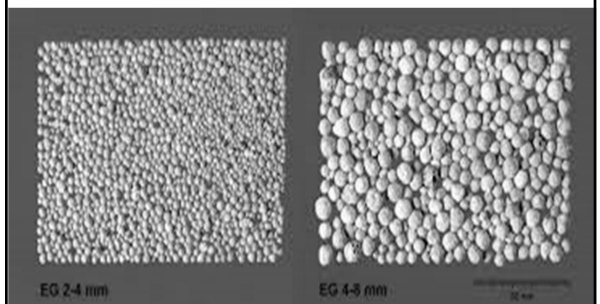
Good Quality



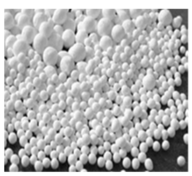
Poor Quality



Uniformity vs Varying Sizes



How will these particles travel differently?



Common Scenarios

- The vast majority of soil samples from urban landscapes have been grossly over fertilized and only need nitrogen and sulfur for at least the next 3-5 years.
- Farms generally need nitrogen, phosphorus, potassium, and sulfur. Sometimes micronutrients.
- Don't guess . . . SOIL TEST!

Avoid over fertilization that can result in toxicities and nutrient imbalances.

If I need a complete or nearly complete fertilizer, I have two basic approaches.

- Compost, etc.
  - This generally has a complete amount of all of the nutrients.
  - Nitrogen is what I almost always use to calculate how much I need. If you get the correct amount of nitrogen, you are likely applying ample of the other nutrients.
- Traditional sources
  - These are generally less costly.
  - These are easier to handle because you need less.

Good, Most Common Traditional Sources (there are literally hundreds of sources, but most are blends which include these)

- Nitrogen
  - Urea (46-0-0)
  - Ammonium Sulfate (20-0-0-24; benefit because also includes sulfur in addition to the nitrogen)
- Phosphorus
  - Triple or Treble Super Phosphate (0-46-0)
  - Monoammonium phosphate (11-52-0)
- Potassium
  - Potash or potassium chloride (0-0-60)
  - Sulfate of potash (0-0-50; benefit because also includes sulfur)

A word about iron

Iron chlorosis is very common in alkaline soils

- Best approach—choose species/varieties that are adapted to the alkaline soils of the west.
- However, if you have plants that are showing symptoms, you can treat for this deficiency.

In general,

- Iron fertilizers are not effective when applied to the soil because they turn solid and generally won't resolubilize.
  - Exception is Iron EDDHA, but you have to apply it at high rates
- Foliar sprays can be effective, but you have to apply frequently (every time there is new growth).
- Trunk injections can also be effective.
- Lower soil pH is also a possibility, but very difficult and expensive. See this link.

https://pubs.wsu.edu/ItemDetail.aspx?ProductID=15017

A word about humates, etc.

- These are known to be effective in certain conditions (especially when the soil organic matter is low and with new plantings).
- We have had positive results with some (not all) products, especially when blended with phosphorus fertilizers.

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Berry Session: Spider Mite Management in Berries and Update on Spotted Wing Drosophila

Biographical Information:

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I am an extension and research entomologist at Utah State University, as well as the Utah Extension Integrated Pest Management Coordinator. I develop, test and demonstrate novel pest management technologies for horticultural crops, including fruits and vegetables, and I provide outreach teaching on insect pest management.

Session Description:

Basics on IPM options to suppress spider mites in berry plantings, and an update on the latest survey and research on spotted wing drosophila, an invasive insect pest of fruit and vegetable crops in Utah.

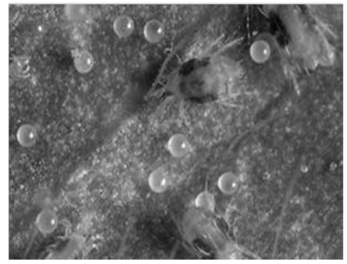
Mite Management and Spotted Wing Drosophila Update

Diane Alston and Lori Spears, Entomologists, Utah State University

Urban & Small Farms Conference
February 22, 2017
Viridian Center, West Jordan, UT

UtahState University

Spider Mites: How Do They Make a Living?



Twospotted Spider Mite, *Tetranychus urticae*

- Prefer undersides of leaves
- Form colonies, webbing: eggs, nymphs & adults
- Very small (1/10 inch length)
- Overwinter as dormant females (orange color) at base of canes & on weeds/ground cover
- 10-14 day life cycle in summer
- Suck plant sap: fine, gray stippling on leaves

Spider Mites: Caneberry Symptoms

"Mite Burn"

- Hot, dry conditions promote mites
- "Mite burn": yellow, brown bronzing, begins on lower leaves first
- Mites move up from (broadleaf) weeds on the ground
- Raspberry leaves are highly sensitive to mite feeding
- Fruiting canes: reduces vigor & berry yield
- Primocanes: weakens, predisposes to winter injury

Spider Mite Management: Cultural Control

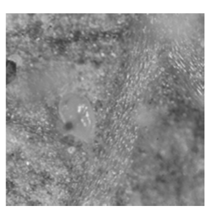
- Plant vegetation in alleyways (grass)
  - Minimize broadleaf weeds
    - field bindweed, common mallow, knotweed
- Overhead sprinklers (cool & wet)
- Avoid disturbing ground cover (avoid dust)
- Avoid plant stress – water!
- Macro-tunnels:
  - Good venting, temperature mgmt.
  - Avoid hot, dry conditions
- Cultivar resistance:
  - Heavily pubescent leaves reduce mites

Grass alleyways & overhead sprinklers

Spider mite-induced defoliation

Spider Mite Management: Biological Control

- Predatory mite
  - *Galendromus* (*Typhlodromus*) *occidentalis*
  - western predatory mite
- Other predators:
  - thrips, pirate & big-eyed bugs, ladybeetles, lacewings
- Naturally occurring
  - Supplemental releases – predatory mite
- Avoid insecticides & miticides toxic to beneficial insects & mites

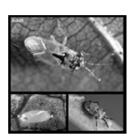


Western predatory mite, note tear-drop-shaped body

Common Natural Enemies of Mites

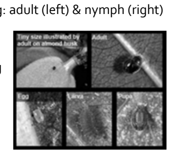
Western flower thrips (omnivore)

Minute pirate bug: adult (left) & nymph (right)



Big-eyed bug

Lacewing larva



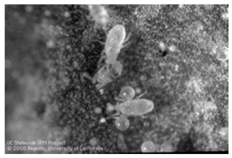
Mite destroyer lady beetle

Mite Sampling

Look for early leaf bronzing

Shake leaves over light-colored sheet or tray; look for 'moving Specks'

Use 10-30 x magnification hand lens to closely observe mites & natural enemies



Western predatory mites eating spider mites & mite eggs

Spider Mite Management: Chemical Control

Least Disruptive & Organic Miticides*

- insecticidal soap (M-Pede, others) – physical
- horticultural oil (JMS Stylet Oil, others) - physical
- azadirachtin / neem oil (Trilogy, others) – Unkn^
- cottonseed+clove+garlic oil (GC-Mite) – physical
- sulfur (do not use above 90°F or within 1 month of an oil spray)

Commercial Miticides

- etoxazole (Zeal) – 10B^
  - eggs, early nymphs; 1 day PHI
- hexythiazox (Savey) – 10A^
  - Eggs, nymphs; 3 d PHI
- acequinocyl (Kanemite) – 20B^
  - adults, eggs, nymphs; 1 day PHI
- bifenazate (Acramite 50WS) – Unkn^
  - adults, eggs, nymphs; 1 day PHI
- fenbutatin-oxide (Vendex 50WP) – 12B^
  - adults, nymphs; 3 day PHI (raspberry only)

*Some formulations are OMRI-listed; ^IRAC MoA groups

Rotate Chemical Groups to Manage Resistance

- Rotate Modes of Action (MoA)
- Rotate MoA between mite generations (≥ 2 wk)
- Check label for # applications allowed per season

Savey → Mite Growth Inhibitor (10^) ← Zeal

Not a rescue treatment

Apply at first sign of adults laying eggs

Kanemite → METI III (energy) 20^

Vendex → Mit ATP (energy) 12^

Acramite → Unkn MoA

^IRAC MoA groups

Rotate Chemical Groups to Manage Resistance

- Rotate Modes of Action (MoA)
- Rotate MoA between mite generations (≥ 2 wk)
- Check label for # applications allowed per season

Savey → Mite Growth Inhibitor (10^) ← Zeal

Kanemite → METI III (energy) 20^

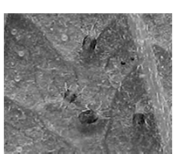
Vendex → Mit ATP (energy) 12^

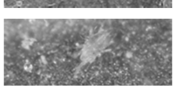
Effective for suppression of a building mite population

Acramite → Unkn MoA

^IRAC MoA groups

Berry Spider Mite IPM





Scout leaves on lower canes for mite injury when temperatures rise

Avoid plant stress

Adequate water! Including ground cover

Good plant nutrition

Scout for early signs of mite feeding

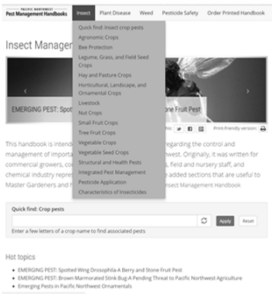
Intervene early:
1. irrigate & cooling, prevent mite dispersal & dust
2. apply less disruptive miticide early in mite population increase
   e.g., horticultural oil or Savey
3. Apply stronger miticide, if needed
   e.g., Acramite

Observe Pre-Harvest Intervals

Fruit IPM Advisory – Free Newsletter

Only requirement is e-mail address

Pacific Northwest Insect Management Handbook



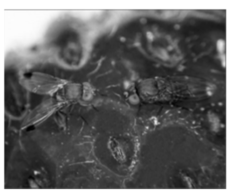
pnwhandbooks.org/insect

Utah Pests Fact Sheets: utahpests.usu.edu

Invasive Insect: Spotted Wing Drosophila

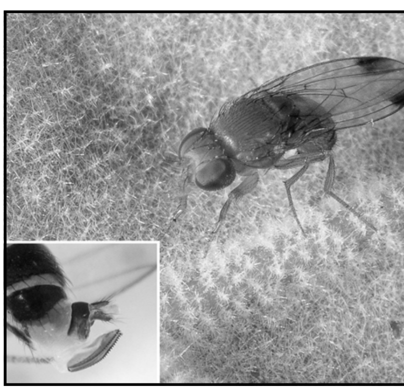
Drosophila suzukii

- First detected in Utah in 2010
- Established in Utah, Davis, Weber, Box Elder, Cache & Rich Counties
- Found in commercial orchards, backyard gardens, and wild habitats
- Overwintering, reproducing, and completing full generations in Utah
- No reports of damage!



D. suzukii is related to common drosophilid flies

Fruit Damage



Identification

Production of high-quality fruit now requires aggressive management programs: estimated costs of managing SWD

- Increases in pesticide costs of $100 to $300 per acre
- Insecticide applications are typically made on a 5-10 day schedule
- Growers of late season sweet cherry report as many as 11 additional pesticide applications
- Late season berries may require up to 16 additional applications

Recent surveys have revealed higher numbers of adults in traps situated near commercial, feral, and wild fruits

Year	# of SWD	First trap catch
2010	73	Aug 18
2011	61	Sep 8
2012	16	Sep 17
2013	23	Sep 25
★ 2014	3,582	Jun 2 / Aug 12
2015	6,967	Jul 20
2016	11,073	Aug 8

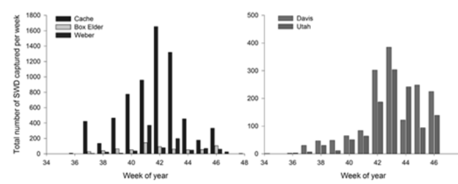
SWD was captured at all field sites: 2016

County	# of traps	# of SWD	First trap catch
Utah	32	1,133	Aug 22
Davis	20	1,559	Sep 5
Weber	6	897	Aug 8
Box Elder	10	687	Sep 12
Cache	19	6,728	Sep 5
Rich	8	69	Sep 12

Trap captures were relatively low in most commercial fields

County	# of traps	# of SWD	First trap catch
Utah	32 (22)	1,133 (417)	Aug 22
Davis	20 (6)	1,559 (80)	Sep 5
Weber	6	897	Aug 8
Box Elder	10	687	Sep 12
Cache	19 (6)	6,728 (658)	Sep 5
Rich	8	69	Sep 12

SWD adults are not detected in traps until late summer or early fall: activity peaks in late September to October.



Sep

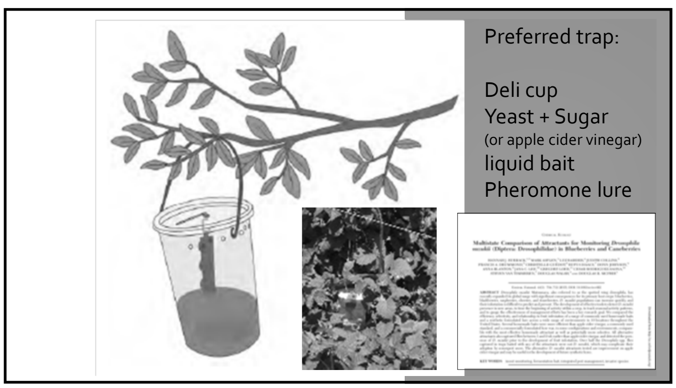
Sep Oct

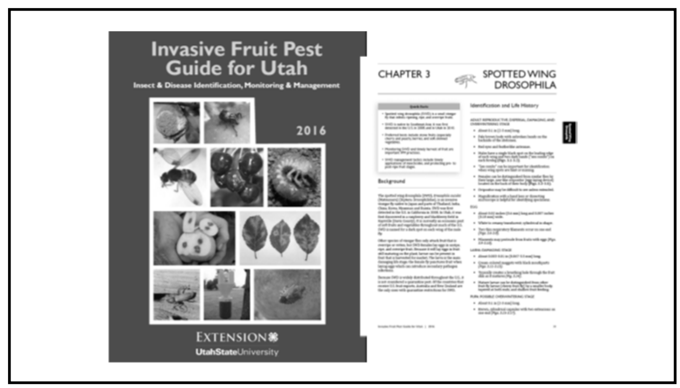
Logan River Canyon
- wild fruit site

Home gardens, especially those with late, soft fruits


Noncrop Host Plants of Spotted Wing Drosophila in North America
Earlier activity of Drosophila suzukii in high woodland landscapes but relative abundance is unaffected
Invasion biology of spotted wing Drosophila (Drosophila suzukii): a global perspective and future priorities


JOURNAL OF APPLIED ENTOMOLOGY
Humidity affects populations of Drosophila suzukii (Diptera: Drosophilidae) in blueberry
Temperature-Related Development and Population Parameters for Drosophila suzukii (Diptera: Drosophilidae) on Cherry and Blueberry


Preferred trap:
Deli cup
Yeast + Sugar
(or apple cider vinegar)
liquid bait
Pheromone lure
Multisite Comparison of Attractants for Monitoring Drosophila suzukii (Diptera: Drosophilidae) in Blueberries and Caneberries


Invasive Fruit Pest Guide for Utah
Insect & Disease Identification, Monitoring & Management
2016
EXTENSION
UtahStateUniversity
CHAPTER 3
SPOTTED WING DROSOPHILA
Identification and Life History


Questions?

Bees and Pollination

Background Information:
Corey Andrikopoulous
Utah State University
5305 Old Main Hill
Logan, Utah 84322

I am a California native and received my Bachelor's degree in Biology and Zoology from Humboldt State University in 2013. It was there that I first developed my interest in pollination biology, in particular the role of wild pollinators on small farms. This interest brought me to Utah in the fall of 2014 to work with Dr. Jim Cane at the USDA-ARS Pollinating Insect Research Unit. I am currently pursuing a Master's degree in biology at Utah State University. My research focuses on the use of native bees for raspberry pollination, with an emphasis on mason bee management strategies

Session Description:

I will be talking about how bee pollination can improve fruit yield and quality, the best options for raspberry pollination in Utah, guidelines for appropriate stocking density of honey bees, mitigating the impact of pesticides on pollinators, and the potential benefits of cross pollination between cultivars.

Bees and Pollination

Corey Andrikopoulos
Jim Cane
Diane Alston
Utah State University
USDA-ARS Pollinating Insect Research Unit
Logan, Utah

Vocabulary

Anther: Pollen donor

Stigma: Pollen receiver

Ovule: “Egg”

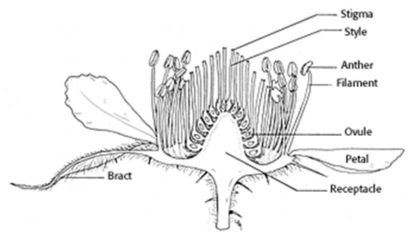


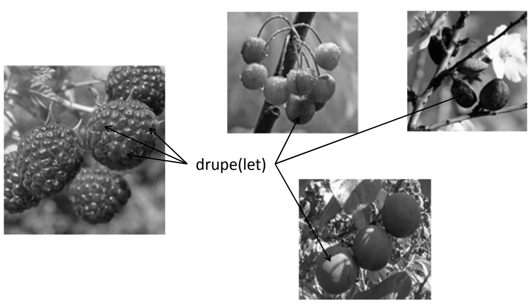
Figure 167. - Longitudinal section of 'Willamett' raspberry flower, x10.

Stigma + Style + Ovary = Pistil

~70-100 pistils/ flower

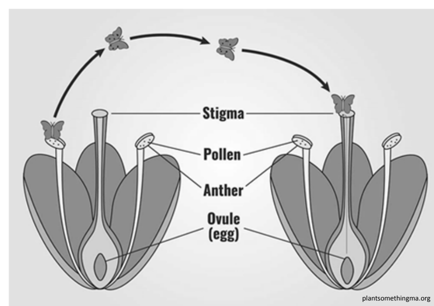
Vocabulary

Drupelets: Small drupes forming aggregate berry



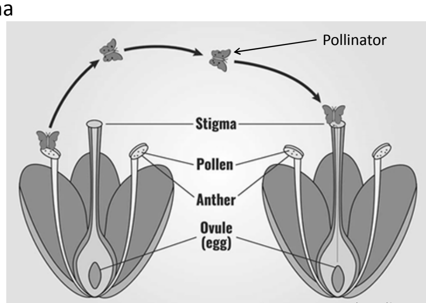
Vocabulary

Pollination: Transfer of pollen from anther to stigma



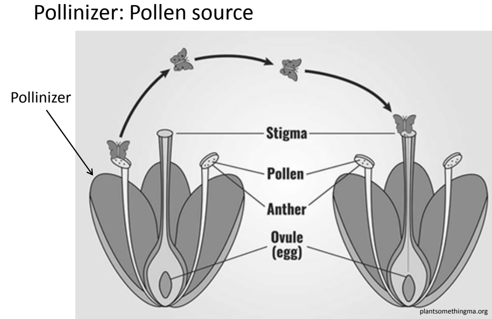
Vocabulary

Pollinator: Organism tranferring pollen from anther to stigma



Vocabulary

Pollinizer: Pollen source



Vocabulary

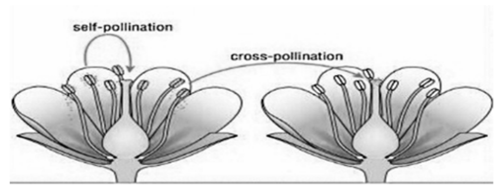
Fertilization: Fusion of gametes resulting in seeds/fruit

cedars.inverclyde.sch.uk

Vocabulary

Self-pollination: Placing own pollen upon stigma

Cross-pollination: Transfer of pollen between flowers



chicoseedlendinglibrary.org

Vocabulary

Self-fruitful: Producing fruit from self pollen

Self-incompatible: Not producing fruit from self pollen

Self-fruitful

Self-incompatible

Raspberry pollination

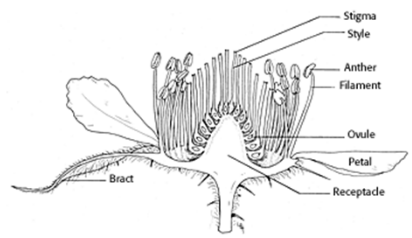
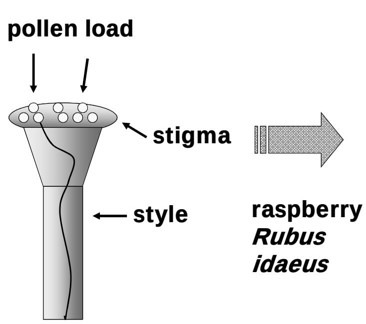
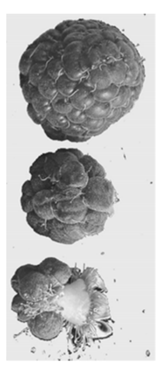


Figure 167. - Longitudinal section of 'Willamett' raspberry flower, x10.

Raspberry Pollination



raspberry
Rubus idaeus

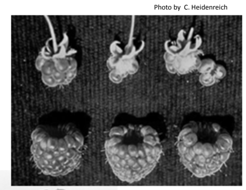


Slide from Jim Cane

Incomplete Pollination

Photo by Jim Cane

Photo by C. Heidenreich



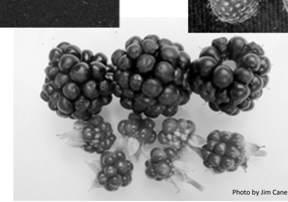
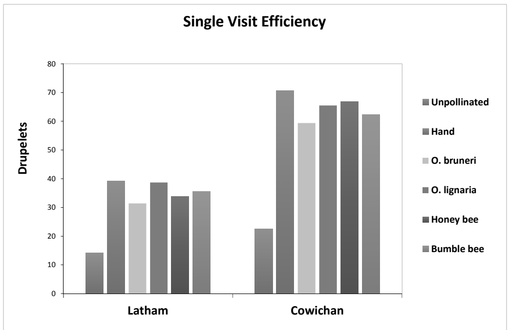


Photo by Jim Cane

Pollination and Drupelet Set

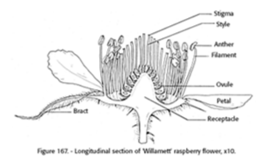


Raspberry flowers

- Flowers viable 2-3 days
  - Weather dependent
  - Stigmas become receptive at different times
  - Best yield when visited consecutive days

Not viable

Viable



Raspberry flowers

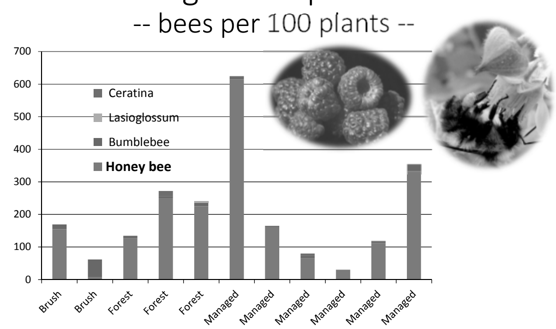
- Produce large amounts of nectar and pollen
  - Abundant nectar in morning, peak first two days
  - Presentation schedule varies
  - Pollen not highly attractive

Raspberry flowers

- Petals can have strong influence on visitation

Bees visiting red raspberries- - Ore.

-- bees per 100 plants --



Slide from Jim Cane

Pollinators

Ceratina picture here

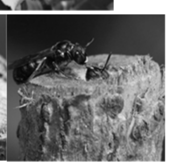
Honey Bee
(*Apis mellifera*)

- Most commonly used pollinator
- Can be managed or rented
- > 10,000 foragers per strong hive
- Distribute well across a field
- Highly attracted to raspberry
- Non-native, declining

Bumblebee
(*Bombus spp.*)

- Wild native bees
- Frequent visitors of raspberry
- Several species
- Active in poor weather conditions
- Will work in confined spaces
- Excellent for high tunnel and greenhouse production
- Commercially available?

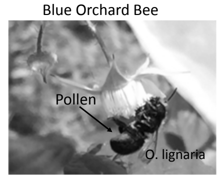
Small Carpenter Bee
(*Ceratina spp.*)



- Small black solitary bee
- Overwinter in pithy twigs and stems, including cut raspberry canes
- Potential to build up a wild population on farms
- Small but effective pollinators
- Active during both spring and fall bloom

Mason bees
(*Osmia spp.*)

Blue Orchard Bee



- Infrequent raspberry visitor
- Several western species experimentally managed for raspberry
- Excellent pollinators under caged conditions
- Potential for greenhouse or high tunnel production in early spring

Stocking Density

- 1-2 honey bee colonies per acre

Stocking Density

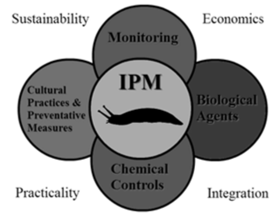
- In field evaluation
  - Walk slowly down row
  - Count # bees per foot row
  - Conducted away from apiaries, fair weather
  - >1 bees per 3-6' = ideal
  - <1 bee per 12' row = insufficient

Stocking Density

- Avoid drastically overstocking

Mitigating Pesticide Risk

- Use Integrated Pest Management (IPM) to make targeted pest management decisions



Mitigating Pesticide Risk

- Pyrethroids highl
- Pesticides can have sub-lethal affects

Mitigating Pesticide Risk

- Avoid spraying at bloom
- Apply at dusk or night so formulation dries by morning
- Avoid windy or dewy nights

Mitigating Pesticide Risk

- Granular formulations usually safer for bees
- Dust or microencapsulated formulation = much longer residual, bees pick it up as though pollen

Cross-pollination

- Cross-pollination by other cultivars has potential to increase yields
- Increased drupelet set for controlled crosses of numerous cultivars

Cultivars crossed	Flowers	Fruits	Seeds	Seeds/fruit	Increase in Seeds (Self = 100%)
Glen Ample x G. Ample	34	26	710	27.3	100.0
x Laszka	23	23	814	35.4	129.7
x Polana	30	23	1 301	56.6	207.3
x Polka	23	16	759	47.4	173.6
x Radziejowa	27	18	743	41.3	151.3
x Schönemann	30	30	1 220	40.7	149.1
x Sokolica	21	18	1 047	58.2	213.2
x Veten	24	17	746	43.9	160.8
x Willamette	26	21	1 386	66.0	241.8
Mean for cross-pollination		166	8 016	48.3	

Adapted from Zurawicz, 2015.

Cross-pollination

- Yet to be demonstrated in the field

Resources

- USU extension (http://extension.usu.edu/agriculture)
- Project ICP (http://icpbees.org/)

Acknowledgements

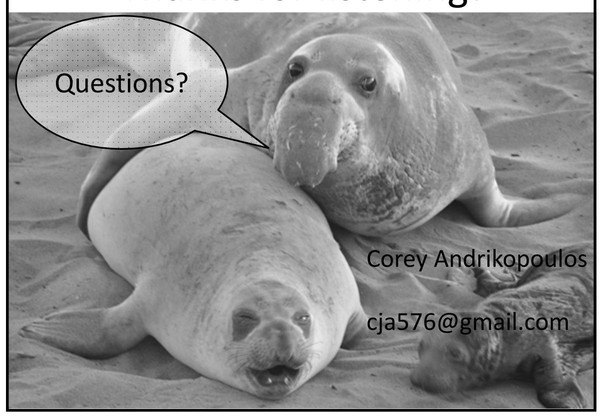
Jim Cane
Diane Alston
Brent Black
Byron Love
Andi Kopit
Shannon Heiner
Logan Bee Lab

UtahStateUniversity

USDA ARS

PROJECT ICP

Thanks for listening!



Raspberry Varieties for the South

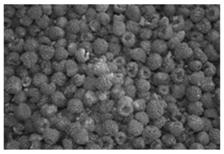
Background Information:

Rick Heflebower
Utah State University
475 S.Donlee Drive
St. George, Utah
rick.h@usu.edu

Horticulture Extension Agent for Utah State University in Washington County

Session Description:

Brief slide presentation on varieties and cultural practices for southern Utah.



Raspberry Production

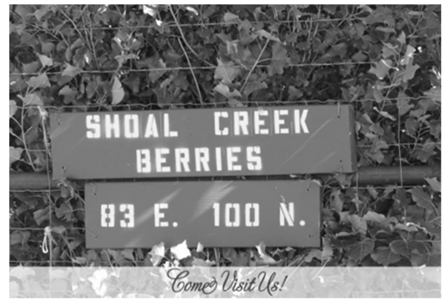
in Southern Utah

Rick Heflebower

Horticulture Extension Agent

UtahStateUniversity
COOPERATIVE EXTENSION

Darrell and Karen Humphries



Shoal Creek Berry Farm

- Location is 40 miles west of Cedar City
- Elevation 5,200 feet
- Frost Free Season about 100 days
- Below winter lows of 0 is normal
- Snow cover is variable
- Average last freeze June 8
- Average first freeze September 14

Greatest Challenge

- Dealing with the short growing season
- Extremes and variable temperatures
- Cold temperatures in winter with no snow can destroy fruit buds
- Earliest freeze September 6
- Latest Freeze October 21
- September frost can take 50 % of your crop

Variety Selection, Pruning are Critical

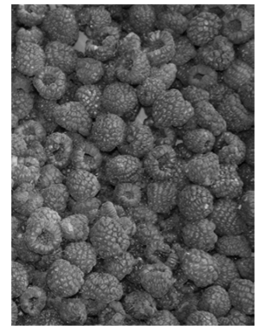
Bearing habit can make a difference

This type of injury is common

Summer Bearing **Fall Bearing**

Varieties

- Anne
- Autumn Bliss
- Caroline
- Heritage
- Himbo Top
- Jaclyn
- Joan J
- Polana
- Polka
- Prelude



Can we shift the growing season?

- With such as short season
- Extreme temperature swings
- Row covers?

Value added and diversifying

Questions?

Back to Top

Freeze Protection Strategies

Background Information:

Brent Black
Utah State University
4820 Old Main
Logan, UT 84322
brent.black@usu.edu

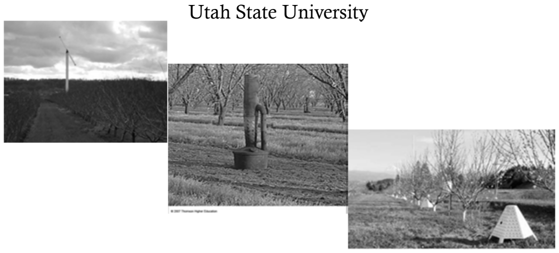
Extension Fruit Specialist at Utah State University since 2005. Focus on commercial tree fruit crops and small acreage berry production.

Session Description:

An overview of field heaters, wind machines and other strategies to mitigate spring frost risk, and the environmental conditions where each of these are appropriate.

Freeze Protection Strategies for Berry Production

Dr. Brent Black
Utah State University

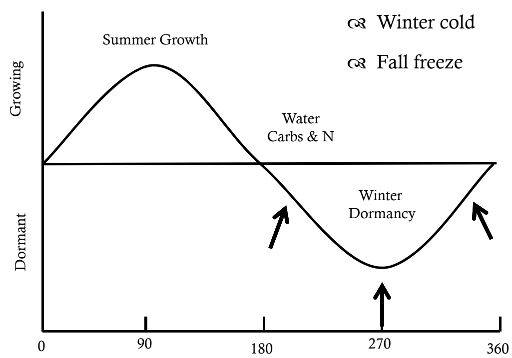


Winter freeze

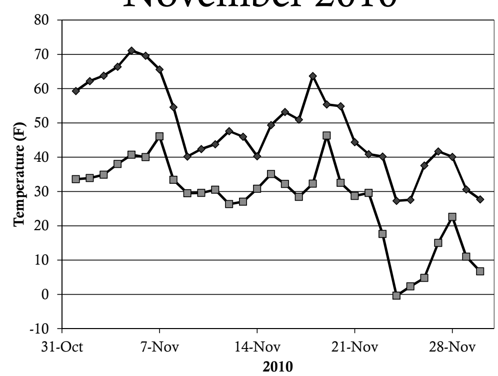
- Winter cold hardiness?

Cultivar	2007	2008	2009	2010	2011
	Spring survival				
	(% survival)				
Cascade Bounty	93	100	100	96	90
Cowichan	97	100	100	99	74
Canby	53	100	94	97	75
Tulameen	88	100	87	82	16
Lauren	49	100	81	42	20
Mean	75	100	94	89	59
Coldest temperature (F)	-1.5	1.6	0.0	-0.2	3.4

- Spring freeze
- Winter cold
- Fall freeze



November 2010



Spring Critical Temperatures

	Stage			
	Tight Green	Balloon	Full Bloom	Fruit
Strawberry	22	28	31	28
Red Raspberry	25	27	29	27
Black Raspberry	26	28	30	28

MSU Extension

UtahState University

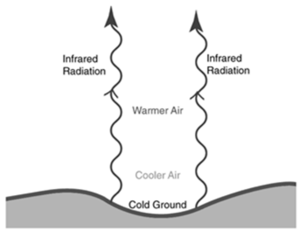
Desiccation

- Raspberry and Blackberry
- Desiccating winds increase winter injury

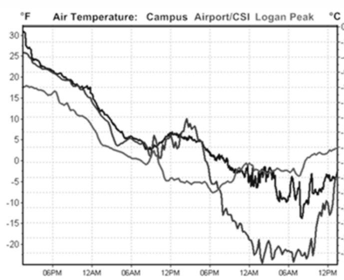
UtahState University

Radiative Freeze

- Heat loss pathways
  - Radiation
  - Conduction



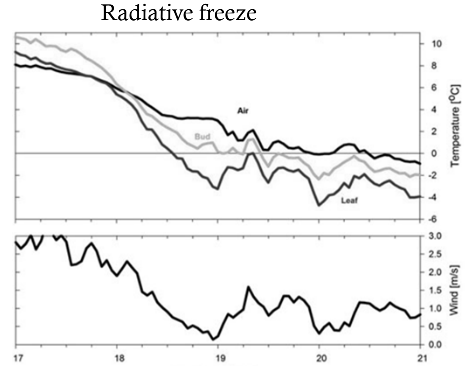
Radiative Freeze	Advective Freeze
Calm winds <5 mph	Wind >5 mph
Clear Skies	Clouds may exist
Cold air mass 30 – 200 ft deep	Cold air 500-5,000 ft deep
Inversion develops	No inversion exists
Frost forms	No frost forms
Cold air drainage	No cold air drainage



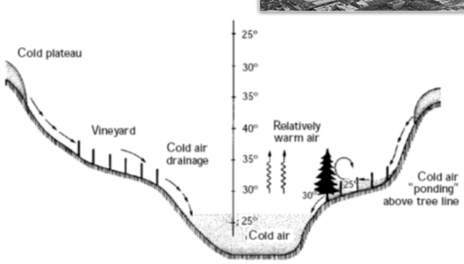
Elevations
Airport: 4464’
Campus: 4794
Logan Peak: 9724

UtahState University

Radiative freeze



Inversion



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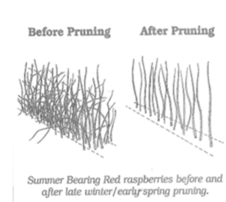
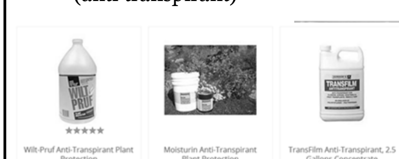
Mitigation - desiccation

- Fall pruning
- Wind breaks
- Anti-desiccant coatings (anti transpirant)





Radiative Freeze

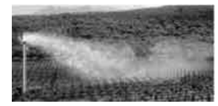
- Calm winds <5 mph
- Clear Skies
- Cold air mass 30 – 200 ft deep
- Inversion develops
- Frost forms
- Cold air drainage
- **Mitigation - YES**

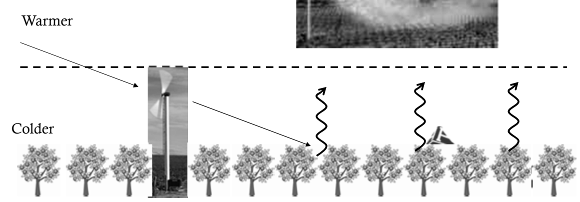
Advective Freeze

- Wind >5 mph
- Clouds may exist
- Cold air 500-5,000 ft deep
- No inversion exists
- No frost forms
- No cold air drainage
- **Mitigation – NOT LIKELY**

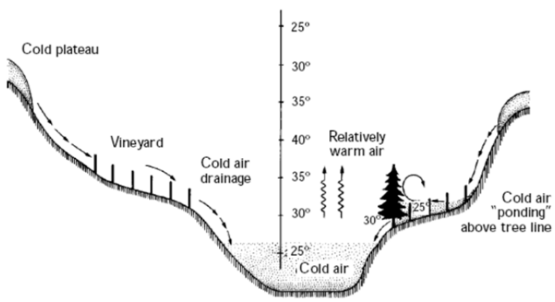
Mitigation

- Wind Machines
  - Mix inversion layer
  - Decreases boundary layers
  - $30,000 per 10 acres



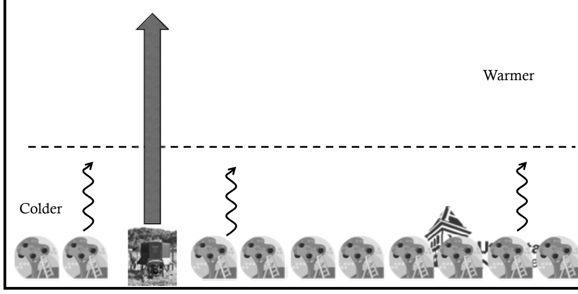


Location, Location, Location



Mitigation

- Vertical fan
  - Lifts out cold air
  - May still have bud/air temperature difference



Mitigation

- Water
- Wind
- Flames
- Fumes

Flames and Fumes

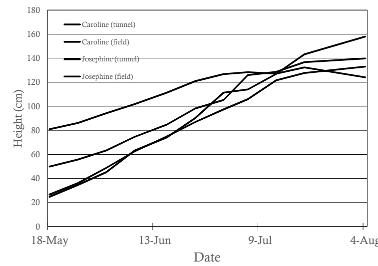
- Heaters
  - Heating oil
  - Propane
- Smoke?

Mitigation

- Floating Row Covers or Crop Blankets
  - Place in late afternoon when canopy temp >32
  - Insulate to keep heat on canopy
  - Better for low-growing plants - Strawberries
  - Not effective under windy conditions

Results

- Cane growth

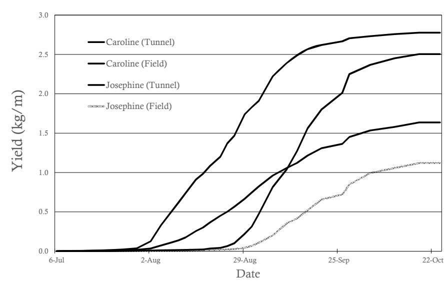


Mitigation

- Tunnels?
- Management time
- Not good for winter protection

Results

- Yield
- Fruiting season



Avoidance

Tunnels with fall bearers

- Caroline and Josephine
- Cut back to ground level
- Tunnels and row covers in early spring
- Shade cloth during fruiting
- Compared to outside planting

Summary – Freeze issues

- Site selection (avoid frost pockets)
- Know when the damage is occurring (fall, winter, spring)
- Keep plants healthy (Carbs)
- Reduce desiccation stress
- Consider fans, heaters or covers:
  - Radiative freeze
  - Damage from temperatures a few degrees below critical
  - Labor available
- Fall bearers

Horticulture

UtahStateUniversity
COOPERATIVE EXTENSION

extension.usu.edu

April 2010 Horticulture/HighTunnels/2010-04

Temperature Management in High Tunnels

Brent Black, Extension Fruit Specialist, and ***Dan Drost***, Extension Vegetable Specialist

Introduction

High tunnels have proven to be an effective method for extending the growing season for a number of high-value crops in a diverse range of climates. High tunnels are large plastic covered structures that are used to modify the growing conditions of the covered area. High tunnels are similar to greenhouses, except that warming and cooling of high tunnel is usually entirely passive, where expensive cooling fans and heaters are often used in greenhouses.

High tunnels are used for cold protection, and to provide optimal growing conditions for longer periods of time. The key to tunnel management is to understand the temperature requirements of the crop. This fact sheet spells out temperature considerations and how these are best addressed using high tunnels and other season-extending technologies.

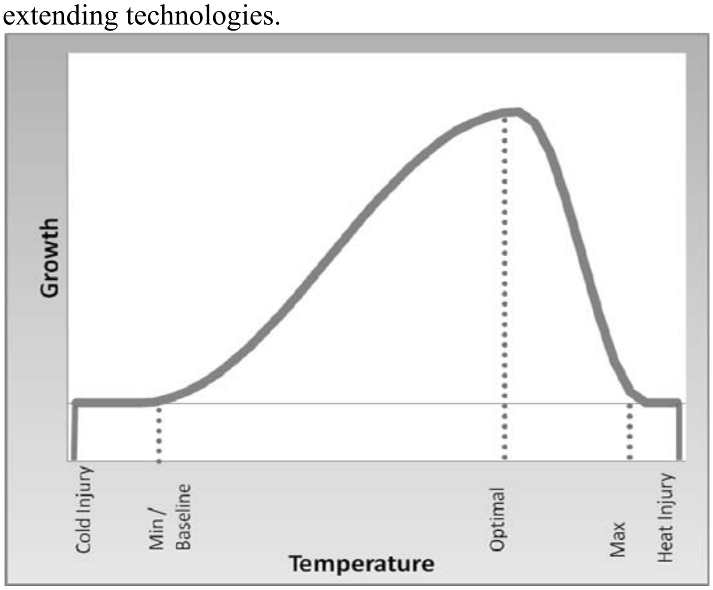


Figure 1. Typical relationship between temperature and plant growth rate.

Temperatures and Growth

Figure 1 shows the typical relationship between temperature and plant growth. At the left side of the graph is a point where temperatures are cold enough to cause plant injury. When temperatures are above that point, the plant may survive un-injured, but may not grow until temperatures exceed the minimum or base temperature for growth. As temperatures increase above the base, the plant growth rate also increases up to the point where temperature is optimal and plant growth is maximized. As temperatures exceed the optimum, then plant growth slows until the point where heat injury begins to take place.

The "critical" or "cardinal" temperatures are the minimum, optimum and maximum temperatures that define this growth curve, and these temperatures differ from crop to crop. A cool season crop like lettuce can withstand colder temperatures than a warm season plant like watermelon. Cool season plants also have a lower optimum temperature than do warm season crops. Therefore, they tend to undergo heat stress symptoms at lower temperatures. The cardinal temperature for seed germination and plant growth of some common fruit and vegetable crops is shown in Tables 1-3.

Table 1. Cardinal temperature for fruit crop growth.

Crop	Minimum (°F)	Optimum (°F)	Maximum (°F)
Strawberry	40	65-75	85
Raspberry	40	65-75	90
Blackberry	40	75-85	95

Temperatures Management

High tunnels are heated when sunlight warms the plants and soil. The warmed plants and soil reradiate the heat, warming the air within the tunnel. Temperatures within a closed tunnel can increase rapidly on sunny days even when outside air temperatures are relatively cold. Even in late winter, it is often necessary to ventilate tunnels on sunny days to prevent the temperatures from exceeding the crop's growth optimum. One of the key management tools is to situate

Table 2. Cardinal temperature for seed germination of select vegetables.

Crop	Minimum (°F)	Optimum (°F)	Maximum (°F)	Ideal range (°F)
Asparagus	50	75	95	60-85
Bean	60	80	95	60-85
Bean, lima	40	85	85	65-85
Beet	40	85	95	50-85
Cabbage	40	85	100	45-95
Carrot	40	80	95	45-85
Cauliflower	40	80	100	45-85
Celery	40	70	85	60-70
Chard, Swiss	40	85	95	50-85
Corn	50	95	105	60-95
Cucumber	60	95	105	60-95
Eggplant	60	85	95	75-90
Lettuce	35	75	85	40-80
Muskmelon	60	90	100	75-95
Okra	60	95	105	70-95
Onion	35	75	95	50-95
Parsley	40	75	90	50-85
Parsnip	35	65	85	50-70
Pea	40	75	85	40-75
Pepper	60	85	95	65-95
Pumpkin	60	90	100	70-90
Radish	40	85	95	45-90
Spinach	35	70	85	45-75
Squash	60	95	100	70-95
Tomato	50	85	95	60-85
Turnip	40	85	105	60-105
Watermelon	60	95	105	70-95

From Knott's Handbook for Vegetable Growers (4th Edition).

an accurate minimum-maximum thermometer in the house and use it to track daily low and high temperatures. Carefully following tunnel temperatures is essential to developing management strategies for maintaining optimum plant growth conditions.

Opening the end doors or vents is the first step in ventilation and temperature regulation. If this does not sufficiently reduce the temperature then the side walls can also be opened (Figure 2). Doors should be closed in the late afternoon to retain heat through the night time. Low tunnels placed over individual rows of crops within the high tunnel can add an additional "temperature lift" to prevent cold damage at night (Figure 3). Low tunnels also require careful ventilation to prevent extreme high temperatures. Without proper ventilation of both high and low tunnels, temperatures in a Northern Utah high tunnel have exceeded 120°F on a sunny day in early March.

Figure 2. Side ventilation of a tomato high tunnel.

Figure 3. Low tunnels within a high tunnel.

Later in the spring, as the day and night temperatures remain above the minimum for the crop, the plastic can be removed from the tunnel and replaced with shade cloth to reduce the risk of sunburn or other heat stress.

Table 3. Cardinal temperature for growth of selected vegetables.

Crop	Min. (°F)	Opt. (°F)	Max. (°F)
Chive, Garlic, Leek, Onion	45	55-75	85
Beet, Broad Bean, Broccoli, Cabbage Chard, Collards, Kale, Parsnips Radish, Spinach, Turnip	40	60-65	75
Artichoke, Carrot, Cauliflower, Celery Endive, Lettuce, Mustard, Parsley, Pea, Potato	45	60-65	75
Lima Bean, Snap Bean	50	60-70	80
Sweet corn	50	60-75	95
Pumpkin, Squash	50	65-75	90
Cucumber, Muskmelon	60	65-75	90
Sweet Pepper, Tomato	65	70-75	80
Eggplant, Hot Pepper, Okra, Sweet Potato, Watermelon	65	70-85	95

From Knott's Handbook for Vegetable Growers (4th Edition).

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Alternative Crops

Background Information:
Brandon Willis
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brandoncwillis@gmail.com

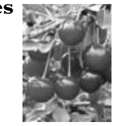
From 2013 through 2016 Brandon Willis served as the Administrator for the Risk Management Agency at the United States Department of Agriculture. Prior to this appointment, Willis served as Senior Advisor to Agriculture Secretary Tom Vilsack. In August 2009 he was appointed as Deputy Administrator of Farm Programs for USDA's Farm Service Agency (FSA). Before joining USDA Willis served as the Agriculture Legislative Assistant for U.S. Senator Max Baucus (2006-2009). Willis earned his bachelor's degree in crop and soil science from Utah State University in Logan, Utah, and his law degree from the University of Wyoming in Laramie, Wyo. In 2009, he completed his master's degree in agricultural law from the University of Arkansas. He grew up on a fourth generation sheep ranch in northern Utah.

Session Description:
I will cover my experience experimenting with honey berries, Canadian sour cherries, and elder berries.

Willis Experiment Station

Crops Grown

- **University of Saskatchewan Cherries**
  - Carmine Jewel
  - Crimson Passion



- **Honeyberries a.k.a Haskaps**
  - Svetlana
  - Blue Belle
  - Berry Blue

- **Elderberries**
  - Native blue elderberries
  - European and American black elderberries

Crops Grown

- **Currants**
  - Black
  - Red

- **Chokecherries**

Sour Cherries – Background

- Developed by the University of Saskatchewan
- Very cold hardy – Zones 2-8
- Bush cherries 6-12’
- Darker red than Montmorency
- 3.5 to 6.0 grams per fruit

My Experience – Cherries

My Experience – Sour Cherries

- Planted 150 Carmine Jewel in 2007
- Planted in plastic row cover
- Began production in 3rd year. Full production by 5th year
- Yield – At least 12,000 pounds per acre
- No insect or disease problems
- Bird problems

Height – 4 to 7"

7

Production 12,000 lb/ac

8

Machine Harvesting

9

Machine Harvesting

10

Uses– Darker red, tarter and smaller than Montmorency

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Honeyberries –Background

- **Uses** – Same as blueberry except fresh eating
- **Cold Hardy** – Zones 2-8
- **Yields** – 5,000-11,000 lb/acre
- **Soil** – No special needs
- **Harvest–** First fruit of season

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My Experience – Honeyberries

- Purchased in 2007
- Varieties – Berry Blue, Blue belle, Svetlana
- ¾ acre
- 4 years to production

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My Experience – Honeyberries

- **Hardy** – Never winterkilled. Even when raspberries were wiped out
- **Early Harvest** – End of June in Bear Lake. Berries drop fast
- **Handpicking** – Yes, if you do not like who is picking
- **Bird and Wind** – Combine to cause problems with harvest
- **Flavor** – Great in jam and jelly. Not good fresh
- **Watering** – Require a bit more than raspberries to grow
- **Yields** – Poor yields, varied by variety

14

Height – 4-5”

15

16

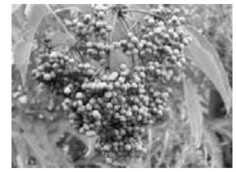
17

18

19

Elderberries

- European
- American
- Native Blue Elderberries



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Elderberries – My experience

- Too short of a growing season for American and European varieties
- Easy to grow, wildlife and pollinators like them
- Juice from native blue elderberries is superior
- Invest in high yielding varieties

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Red and Black Currants – My experience

- Planted 2 acres in 2007
- 90 percent black currants 10 percent red currants
- Shorter than both bush cherries and honeyberries
- Struggled to get picker low enough to grab all the fruit
- Low maintenance
- Hardy, full crop each year
- No value unless you have a marketing plan
- Same production window as summer bearing raspberries

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Chokecherries

- Planted 2/3 acre in 2010
- Replicated real world conditions

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Conclusions

- **Sour Cherries**
  - Easy to grow
  - PYO potential
- **Honeyberries** –
  - Potential for alternative crop in cold areas
  - Harvest costs could be an issue
  - Marketing completely new crop
  - New varieties are key for productivity
- **Elderberries**
  - Easy to grow
  - Marketing and returns could pose challenge
- **Currants**
  - Marketing challenges
- **Chokecherries**
  - Too early to tell

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Berry Production in Pennsylvania

Biographical Information:
Kathy Demchak
Penn State University
102 Tyson Building, University Park, PA 16802
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Kathy Demchak has been a Sr. Extension Associate in the Dept. of Plant Science at Penn State University since 1999. She has worked with berry crops since 1992, and has conducted research and demonstration work on high tunnel berry production since the year 2000. She is part of a Specialty Crops Research Initiative project entitled "Optimizing Protected Culture Environments for Berry Crops", headed by Eric Hanson at Michigan State University.

Session Description:

According to the last Ag Census, berries were produced on over 1900 farms in Pennsylvania. Most of these farms are highly diversified operations that grow a wide range of crops. This talk will provide an overview of some of the approaches growers use in their operations as they adjust to changes in consumer demand for different berry crops, changes in pest complexes, the availability of new berry production methods, and changes in consumer purchasing behaviors.

BERRY PRODUCTION IN PENNSYLVANIA

Kathy Demchak, Dept. of Plant Science, Penn State Univ.

PA Berry Industry

- Berries produced on over 1900 farms in Pennsylvania!
- Average berry acreage per farm (as of 2012)
  - Strawberries: 1.0
  - Blueberries: 1.3
  - Raspberries: 0.5
  - Blackberries: 0.5
  - Hardy kiwi: 5 (no, not a typo… just a few farms)
  - Currants and gooseberries: Don't know…

How Do PA Growers Market Their Berries?

- On-farm
  - PYO
  - Ready-picked on-farm market
    - Diverse offerings
  - Adding value, diverse offerings
    - "Customers pick $3 worth of strawberries and buy another $20 of stuff before they leave"
  - Value-added products

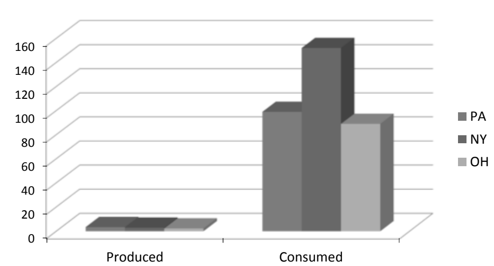
How Do PA Growers Market Their Berries?

- Off-farm
  - Farmers markets
  - Produce auctions
  - Restaurants
  - Some to regional or local grocery stores

Kicking off the season

- PYO Strawberries – the crop that kicks off the season
  - More strawberry growers than any other state!
  - Average a whopping 1.0 acre
    - Usually sell as a combo of PYO and ready-picked at farm stand
  - Has decreased over time – changes in amounts people pick

Strawberry Production vs. Consumption (million pounds) in PA, NY, and OH



Calculated from data from USDA-NASS Noncitrus Fruits and Nuts 2015 Summary, U.S. Census Bureau (www.census.gov), and USDA-ERS Fruit Yearbook Supply and Utilization tables

What are the Options in PA?

- Many production systems available
- June-bearers and Day-Neutrals

- Most use June-bearers to kick off the season, draw customers in to buy other things
- Day-neutrals if taking to farmer's markets
  - Buy if they are already there
  - Looking for other crops
  - Remarkably successful in some instances

Lots of Possibilities




Matted row

Dormant plants planted in spring
Harvested in following year
Renovated, carried over for 2-4 harvest years

Field Plasticulture

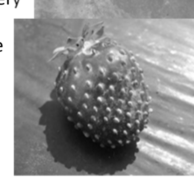
Plug plants used
Planted in late summer/early fall
Harvested for 1 or 2 years
Better for warmer areas of state

Day-neutrals

- Usually grown in a plasticulture system

Seascape

- Had been standard for several years
- Sweet
- Does well if carefully managed
  - V. susceptible to powdery mildew
  - Splits when it hears the word "rain"

San Andreas

- Good flavor and firmness, but slow to begin fruiting
- Hot humid conditions in PA
  - Susceptible to fruit anthracnose

Albion

- Individual plants tend not to yield consistently during season
  - Not all plants produce at once
- Nice flavor, color, and firmness if fully ripe
- But still susceptible to fruit anthracnose
- Top DN cultivar these days

Low Tunnels?

- Used with strawberries in the plasticulture system
- Help with disease management
- Extend season
- Cheaper alternative to high tunnels?

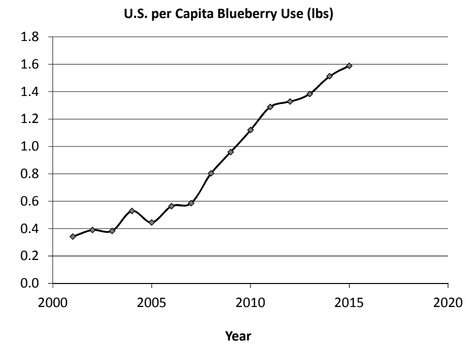
Dubois Agrinovation System used for Plastic Cover Comparison 2016

TunnelBerries
Sponsored by USDA-SCRI

Tunnel components

What about Blueberries?

- Fastest growing small fruit crop in PA
  - Both in acreage and number of farms



Source: Fruit Yearbook, USDA-ERS

Soil pH – A big issue in PA

- Even bigger problem here?
- But…
- California production?

- Water acidification
- Mulch acidification and organic matter addition
- Soluble fertilizers, constant feed

Raspberries and Blackberries

- Where high tunnels come in…

Level of Experience with Berries/Tunnels

- Potential, current and former high tunnel berry growers: 261, 80, and 12 growers, respectively. Not all answered all questions.
- Potential high tunnel berry growers were experienced
  - 80% grew berries in the field
  - 32% had other crops in tunnels
- Most responses were from NE and Upper Midwest – but some from Utah!!

Tunnel Types

B. Strik

	Potential		Current	
Tunnel Type:	Single-bay	Multi-bay	Single-bay	Multi-bay
Strawberries, SD	85	26	17	8
Strawberries, DN	90	21	16	15
Black rasp.	*83*	*19*	*5*	*3*
Red rasp., summer	*92*	*30*	*12*	*13*
Red rasp., fall (PF)	*110*	*30*	*21*	*18*
Blackberry, summer	*68*	*17*	*11*	*8*
Blackberry, fall (PF)	*70*	*16*	*8*	*6*
Blueberry	51	16	2	4

Current Growers (of 73 responses)	Currently Grow -- (no.)--	Dis- cont.	Future Plans ↑ acreage	↓
Strawberries, SD	22	7*	9	2
Strawberries, DN	29	2	19	3
Black rasp.	*9*	*0*	*5*	*0*
Red rasp., summer	*22*	*1*	*8*	*2*
Red rasp., fall (PF)	*36*	*1*	*21*	*1*
Blackberry, summer	*19*	*2*	*9*	*2*
Blackberry, fall (PF)	*15*	*0*	*12*	*1*
Blueberry	7	1	12	1

**SWD wasn't present yet!!

Why Are Growers Using Tunnels for Raspberries?

- Same reasons for both types
  - Protect crop from rain (~65%)
  - Improve fruit appearance
  - Extend harvest later (PF only)
  - Promote increased yields
  - Allow harvest during rain
  - Lengthen shelf-life
  - Promote larger berries (~40%)

Usually Used for Everbearing Raspberries

Polka

Josephine

SWD Observations in Tunnels

- Relatively low SWD populations in tunnels
  - But plenty of larvae in fruit – turned out to be mainly other species
- One H. T. raspberry grower reported no SWD issues with daily picking combined with tunnels
  - But probably eggs and tiny larvae…?
- Combine with refrigeration
- Quite a bit of other research going on…

Raspberry and Blackberry Varieties

Summer-Bearers

- Nova
  - Also produces a light fall crop in field, more substantial crop in tunnel
  - Good size and flavor
  - Must be fully ripe to release from receptacle

Prelude

Primocane-Fruiters

Polka

Josephine

Nantahala

- Late season
- Wonderful flavor
- Yields “medium” due to not harvesting entire crop even in tunnels
- Large berries

Niwot

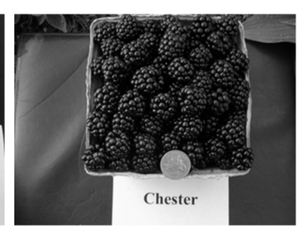
- Primocane fruiting black raspberry
- From Pete Tallman, Colorado
- Fruited as summer-bearer in 2014 – lots of cane left from 2013
- Tipped at a foot in 2013 due to frost
- Trellised long laterals (5-6’) that resulted from this

Photo: Retha Sellmer

Apache

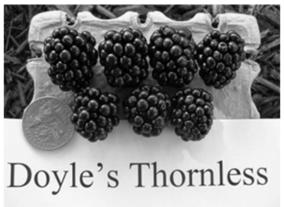
Yield concentrated in early part of harvest season,
Sweet berries, vigorous plants, stem canker probs?

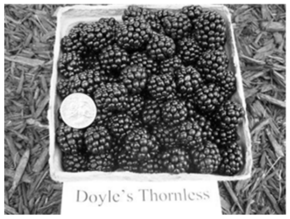
Chester



Standard for cold-hardiness, yields mostly
In first 2/3 of harvest season, not great flavor

Doyle's Thornless





Sparse canes, long laterals,
most prostrate of the varieties, productive

Illini Hardy

Reliable, consistent, but small fruit,
Very thorny

Kiowa

Won the prize for biggest fruit and
nastiest thorns

Primocane-Fruiters

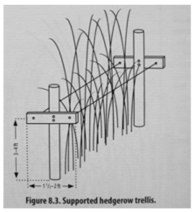
Low yield issues in PA – early fall frosts

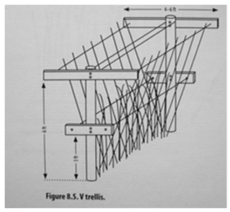
Prime-Ark® 45
- Very sweet
- Large (10 g) fruit
- Downside:
  - Very late
  - Combine with tunnels?

- 'Black Magic'

Trellising – Raspberries or Blackberries

- Simple supported hedgerow or narrow "V"commonly used





Trellised

Tip 6" above highest trellis wire

Rotating Cross-Arm Trellis

- For use with winter-tender trailing blackberry varieties
- Rotate canes to ground in winter, cover with row covers
- At least two 20+ acre plantings in PA

3-4 canes tied to horizontal wire close to ground

Tip when they reach next plant

USDA-ARS Appalachian Fruit Research Station

Causes laterals to break

USDA-ARS Appalachian Fruit Research Station

For winter, will be covered

Note: row cover does not work if canes are upright

For harvest

In High Tunnels?

- Red raspberries: Very similar to field
- Black raspberries: Tip high (~6'), leave laterals up to 4' long
- Blackberries: Tip high (6'), may need to tip laterals, leave 3/8" wood or heavier

Irrigation - Trickle

- 1x/week during early spring and late fall, increasing to 3x/week during summer
- About 2 hours each time if 0.45gal/100'/min trickle tape - unless uncovered (may get rain)
- Water quality an issue at Rock Springs and elsewhere
  - pH 7.6 - 8.6
  - High in calcium and magnesium

Irrigation

- Issues with water source?
  - If hard water from wells – test
  - Need to treat?
  - Better off with surface or rainwater?

Nutrition

- Are the same N fertilizer rates as for field production best?
  - Less leaching of nutrients
  - More growth and crop removal
  - Do these balance out? Seem to…
- Deficiencies observed only in raspberries so far
- Do tissue tests each year

Fertilization: Potassium

- Typically recommended only N yearly after planting for field production – other nutrients based on tissue tests
- Large amounts of potassium removed with crop
  - 17-35 lb/a just in fruit in tunnel
  - Wood (1962) 52 lb K/acre all plant parts

Potassium Issues

At research farm and in grower plantings

0.85% here

1.0 to 1.45% is considered deficient in PA

The explanation?

- Soil was high in potassium
- Real issue was water source – not something we normally worry in the field
  - Source was well water
  - No rainfall - Bigger impact of water source in tunnel

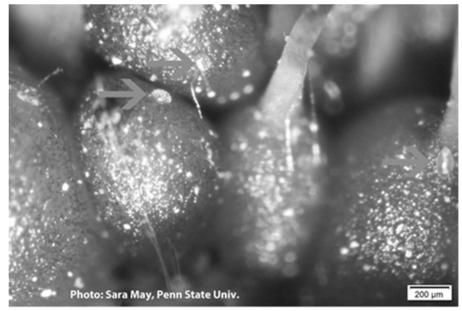
New problem? – Broad mites

- Looks like fire blight
- Can hitch a ride on whiteflies (yes, we're serious…), or workers' hands

Broad mites – PF blackberries

Broad mites - blackberries

Broad mites - blackberries



What to do?

- Watch for symptoms
- Rogue plants if suspicious, plus a few on each side of it
- Miticides?
  - Depends on state

Speaking of problems… NOT a borer

- This hole is made by a solitary bee (pollinator!)
- Very common in tunnels (and field) in PA

Labor Sources?

- That's were pick-your-own comes in…
- Or large families
- More looking into H2A guest worker program
- Labor that can be employed year-round with diverse crops

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Weed Management Basics

Biographical Information:
Matt Palmer
USU Extension
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Ephraim, UT 84627
matt.palmer@usu.edu

Extension Faculty in Sanpete County

Session Description:

A basic knowledge about weeds and their control will save time and expense by learning and applying proper management techniques. The main points that I am going to discuss are weed types, weed identification resources, basic steps and techniques of weed control for farms and gardens.

Weed Management Basics

Matt Palmer
USU Extension

Weeds (Farm Enemies)

- Plant in the wrong place
- Plants with a competitive advantage
  - Seed viability
  - Reproduce rapidly
  - Easily dispersed
  - No enemies

You Are Now the Army General Of Your Farm

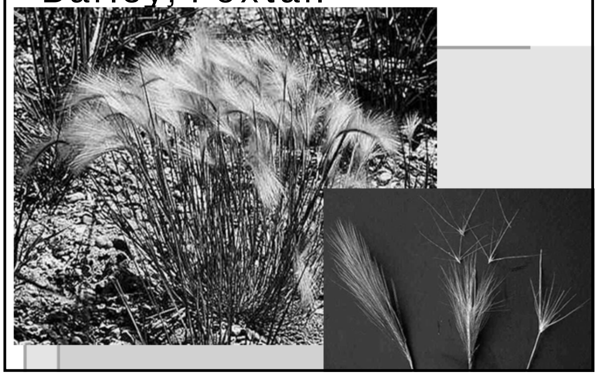
Gather Intelligence (Know Your Enemy)

- Weed Identification
  - Herbaceous or Woody
  - Shape and color of flower and leaf
  - Annual, Perennial, or Biennial
  - Grass, or Broadleaf
  - Mode of Reproduction
    - Seed
    - Roots/Rhizomes
    - Vegetative

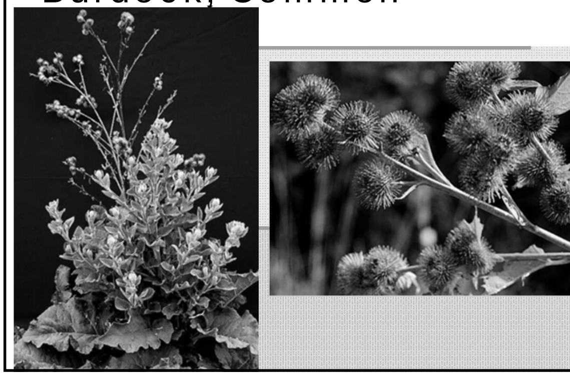
Bur Buttercup

Puncture Vine

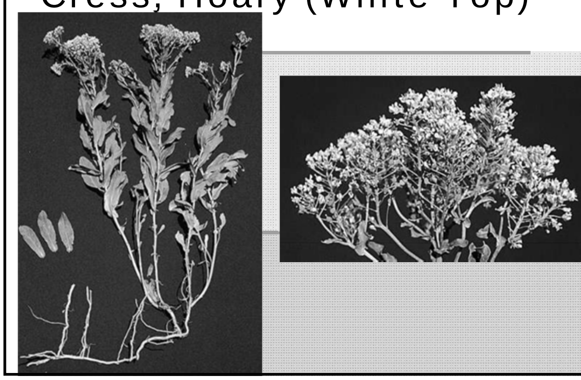
Barley, Foxtail



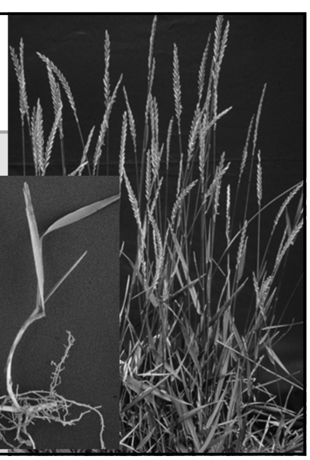
Burdock, Common

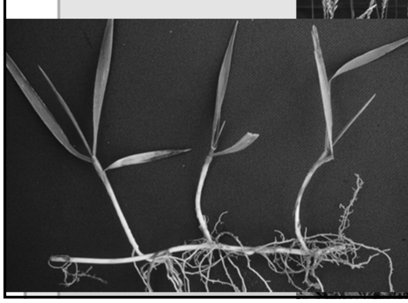


Cress, Hoary (White Top)

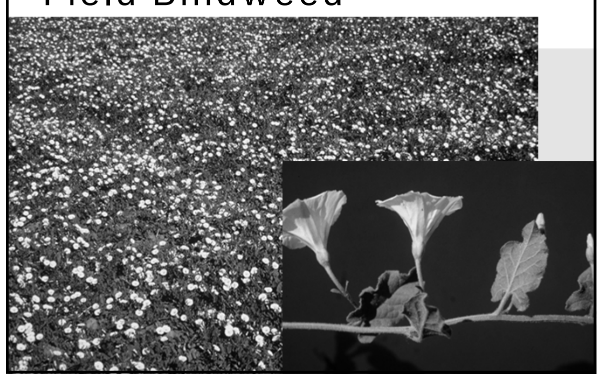


Quackgrass





Field Bindweed



Knapweed, Russian


Thistle, Canada, Scotch, Musk



Kochia

Pigweed, Redroot


Weed Control Phase 1

- Prevention
  - Clean equipment
  - Plant certified weed free seeds
  - Keep weeds and weed seeds out
    - Hay, Straw, Top Soil, Compost, Manure
  - Prevent weeds going to seed

Phase 2

- Cultural Practices
  - Healthy Crops
    - Soil fertility
    - Crop varieties
    - Plant density
    - Irrigation
    - Crop rotation
    - Insect pests and disease control
  - Cover Crops

Phase 3

- Mechanical or Physical Techniques
  - Hand pulling, hoeing
  - Cultivating (plow, disk, mow, dig)
  - Mulching (straw, wood chips, gravel, plastic)
  - Weed Barriers
  - Flame Weeding

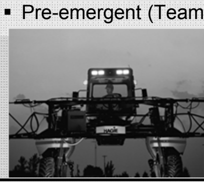
Phase 4

- Biological Control Agents
  - Insects
  - Diseases
  - Chickens
  - Goats/Sheep

Phase 5 (Chemical)

- Organic
  - Vinegar
  - Clove extracts
  - Citric acid
  - Acetic acid
- Not very effective on mature weeds and perennial weeds

- Non-Organic
  - Restricted and Non-restricted
  - Non-selective (Round Up)
  - Broad Leaf (2,4-D)
  - Pre-emergent (Team)








Resources

- Common Weeds of the Yard and Garden
- Weeds of the West
- Biological Control of Invasive Plants in the U.S.
- A Guide to Common Organic Gardening Questions
- extension.usu.edu/weeds/

Insect and Mite Pest Management of Cole Crops & Tomatoes

Background Information:

Cami Cannon
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Cami Cannon is the Vegetable IPM Associate and conducts outreach activities for the Utah Vegetable Integrated Pest Management Program. These activities include seasonal pest monitoring, seasonal pest advisories, editing publications and fact sheets, developing web content, and graphic design.

Session Information:

Insect and mite pest biology, identification, host plants, symptoms, and management for Utah cole crops and tomatoes.

COMMON INSECT & MITE PESTS OF COLE CROPS & TOMATOES

Cami Cannon, Vegetable IPM Associate, Utah IPM Program

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Beating tray and loupe

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Common Tomato Insect Pests

- Beet leafhopper
- Aphids
- Tomato hornworm
- Tomato russet mite

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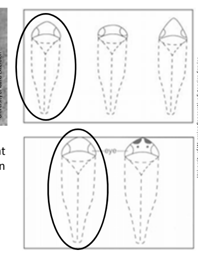
Beet Leafhopper (BLH)



- Vary in color from one insect to the next and from time of year, spring: light brown to lemon green, summer: tan to variably mottled, overwintering: tan and mottled
- Wedge-shaped, slightly roof-shaped face (as opposed to well-rounded or sharply pointed) absent of clearly defined spots
- 0.12 in. long
- Direct feeding damage is not economically important
- Vector of Beet Curly Top Virus (BCTV)

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Beet Leafhopper: BCTV hosts

<u>Vegetables</u>: sugar and table beet, tomato, pepper, potato, bean, Swiss chard, spinach, flax, and cucurbits (melons, squash, gourds, cucumber)

<u>Weeds</u>: mustards, kochia, Russian thistle, lambsquarters, filaree, plantain, pigweed, borage, shepherd's purse, several others

<u>Major weed hosts of BLH</u>: Russian thistle and weedy mustards

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Beet Leafhopper: BCTV in Utah

- BCTV severe in 2016 vegetable crops
- Chronic in southern Utah, but more variable in the north
- Overwinters in southern Utah migrates or is blown to other parts of the state in early summer
- The leafhopper picks up the virus while feeding on infected weeds in spring

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Beet Leafhopper: BCTV symptoms

- Small leaves: twist, curl, purple veins
- Thickened, stiff, crisp leaves
- Blister-like swellings on veins on underside of leaves
- Yellowing & death of mature leaves
- Enlarged and deformed calyx structure
- Small fruits that ripen prematurely
- Reduced fruit quality & yield
- Stunted growth
- Phloem necrosis of taproot (dark concentric rings in cross section or linear streaks in longitudinal section)

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Beet Leafhopper: BCTV symptoms

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Beet Leafhopper: BCTV symptoms

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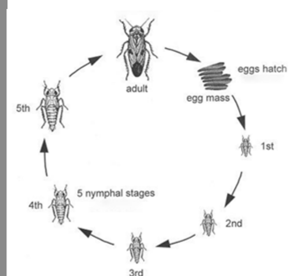
Beet Leafhopper: life cycle



- Overwinters as mated females on weed hosts in uncultivated areas in southern Utah and southern US
- Migrate or are blown north in early summer
- Adults move in to cultivated fields when weeds begin to dry up, where they feed and reproduce on suitable host plants
- Most BCTV is seen within the first 6-8 weeks of planting, and BLH move back into uncultivated areas, however, in 2016 BCTV symptoms & BLH were detected later in the season than normal
- Development from egg hatch to adult can take about 2-3 months
- Multiple generations occur each year

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Beet Leafhopper: BCTV infection

- BLH feeds on weeds as it migrates northward from overwintering sites in the south
- Sugar beet is preferred host, but BLH does not distinguish host type until 45 min. after trial feeding
- Infection can occur within as little as 1 minute of feeding
- Random movement and sampling to find preferred host

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Beet Leafhopper: management

- BCTV is challenging to manage: sporadic and unpredictable
- Insecticide applications directed at leafhoppers are ineffective
- Primary strategies are prevention and rapid response by removing infected plants
- Even primary strategies may be inadequate in years with high pest pressure
- Infected plants cannot be treated and should be removed
- Management options:
  - Remove infected plants immediately upon detection
  - Exclude leafhoppers with floating row cover (first 6-8 weeks or throughout the season)
  - Destroy and remove plant debris
  - For tomatoes, plant resistant varieties: 'Rowpac', 'Roza', 'Salad Master', 'Colombian'
  - Use dense plant spacing
  - Shade plants

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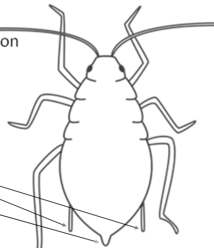
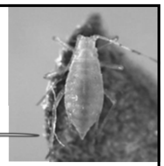
Aphids

- ~1/8 in. long, pear-shaped body
- Wingless and winged forms
- Often found in dense groups on leaves or stems, but may be found singly
- Don't move rapidly when disturbed
- Cornicles
- Cauda





Common but not very harmful unless vectoring a virus

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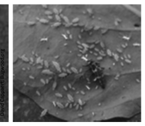
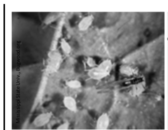
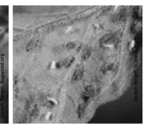
Aphids



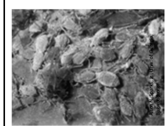
Green peach aphid

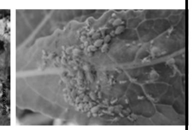


Melon/Cotton aphid



Potato aphid





Cabbage aphid

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Aphids: hosts

<u>Green peach aphid</u>
Extensive host range
fall/ spring: peach, apricot, nectarine
summer: tomato, potato, pepper, eggplant, squash, pumpkin, cucumber, spinach, mustard greens, cabbage, broccoli, legumes, celery, okra, corn. Many other crops and weeds

<u>Melon/Cotton aphid</u>
Extensive host range, many cucurbits
fall/ spring: catalpa, rose of Sharon
summer: cantaloupe, honeydew, casaba, Persian melon, watermelon, cucumber, squash, pepper, asparagus, eggplant, okra, and several weeds

<u>Potato aphid</u>
Many same hosts as green peach aphid
fall/ spring: wild rose plants, ornamental rose plants
summer: tom, potato, pepper, eggplant, squash, pumpkin, cucumber, spinach, mustard greens, cabbage, broccoli, legumes, celery, okra, corn. Many other crops and weeds

<u>Cabbage aphid</u>
Can only survive on cole crops, other mustard family plants, and related weeds
fall/ spring: cole crop residue, weeds
summer: broccoli, cauliflower, cabbage, Brussels sprouts, kale, collards, kohlrabi, oilseed rape, Chinese broccoli, Chinese cabbage, radish, kale, and related weeds

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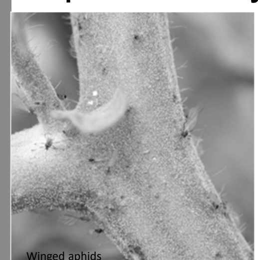
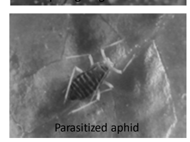
Aphids: identifying pictures



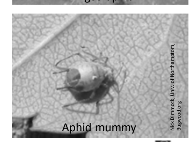
Winged aphids

Aphid giving live birth

Winged aphid



Parasitized aphid



Aphid mummy

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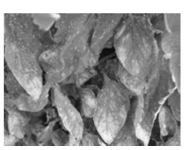
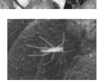
Aphids: symptoms





- Tend to feed on newer tissue
- Aphid feeding causes:
  - stunted, yellowed distorted and curled leaf tissue
  - loss of plant vigor
  - honeydew, sooty mold fungus, and cast skins found on leaves and fruits
  - virus transmission

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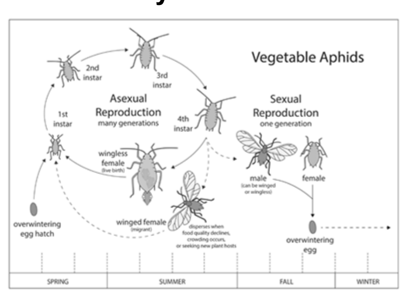
Aphids: life cycle



Generalized aphid life cycle in Utah. Many species of aphids live on a woody host from fall to spring, and migrate to vegetables or weeds for the growing season.

Aphids are common, but not very harmful unless vectoring a virus

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Aphid Vectored Viruses




- Alfalfa mosaic Virus
  - Seen in Utah to date on: tomato, pepper, potato, pea, bean
- Potato Virus Y
  - Seen in Utah to date on: potato
  - Other potential veggie hosts: tomato, pepper
- Watermelon mosaic virus
  - Seen in Utah to date on: cucurbits
  - Other potential hosts: pea
- Occasionally others may show up but these are most common

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Aphids: management

- *Avoid excess fertilization* - aphid densities higher on plants with excess N
- *Use mulches or row covers* – row covers and metallic or reflective mulches interfere with winged aphid ability to find new plants
- *Remove/destroy plant debris* - disk fields immediately after harvest to destroy alternate host plants and reduce available aphid and virus sources
- *Maintain healthy, vigorous plants* - more tolerant to attack
- *Plant susceptible crops upwind* - decreases aphid migration to crop, aphids are blown downwind
- Numerous predators and parasitoids, but usually doesn't reduce aphid populations quickly enough to prevent virus infection

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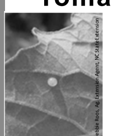
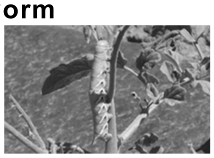
Tomato Hornworm






Eggs

spherical, greenish-yellow eggs found singly on undersides of leaves

Larvae

green with distinct black "horn" on the top of the tail end, 7 white "v" shapes along side of body, up to 4 in. long and ½ in. wide

Adult

gray to gray-brown moth with light markings, referred to as sphinx, hawk, or hummingbird moths, with up to 5 in. wingspan

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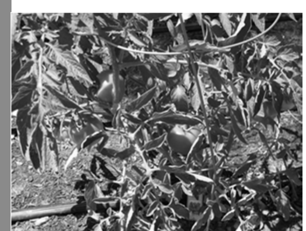
Tomato Hornworm: hosts



- Peppers, tomatoes, eggplant, potatoes, and related solanaceous weeds
- Primarily eats leaves but also eats blossoms, stems, and fruits

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Tomato Hornworm: symptoms



- Larvae are harmful while adults are harmless or beneficial as pollinators
- Larvae feed in the upper part of plants
- Dark green or black droppings
- Defoliate plants (leaves consumed by larvae)
- Decreased production due to loss of foliage
- Increased sunscald due to loss of foliage
- Scars or large deep cavities on fruit

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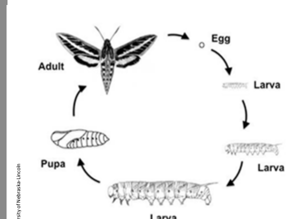
Tomato Hornworm: life cycle



- Adults emerge in late spring or early summer
- Eggs deposited singly on undersides of leaves, hatch in about 1 week
- Larvae begin feeding on foliage
- Larvae feed for 3-4 weeks, molting 5 times
- Fully grown larvae burrow 3-4 in. into soil where 2 in. long pupa is formed
- Adult moths emerge from pupae
- Adult moths are seen at dusk, hovering (like hummingbirds) over beds of petunias and other flowers with long corollas

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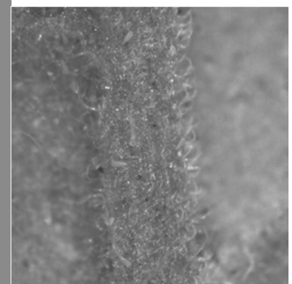
Tomato Hornworm: management

- Monitor for hornworm damage
- Spot treat infected plants
- Plow field after harvest
- Rotate crops
- Hornworm pops. often do not exceed economic thresholds due to predation from natural enemies. Only treat when they are causing extensive defoliation or are feeding on fruit. Target young larvae and eggs.

Tomato Russet Mite



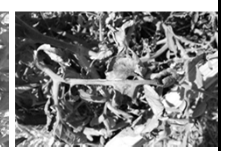
- Cigar-shaped bodies
- Yellowish-tan or pink
- Microscopic (0.01 in. long) need a 14x hand lens to see
- Feeding usually in lower part of plant
- When infestations are severe, mites will disperse to upper leaves (heavily damaged plants)
- Abundant during hot, dry weather in mid- and late summer

Tomato Russet Mite: hosts

- Tomato, eggplant, pepper, potato, other solanaceous plants
- Alternate hosts: nightshades and morningglory

Tomato Russet Mite: symptoms





- Piercing-sucking mouthparts
- Feeding usually in lower part of plant
- Greasy bronzing or "russeting" of the surface of stems, leaves, and fruits
- Yellow, curled, withered, and fallen leaves
- Fruits with longitudinal cracks and bronze colorization

Tomato Russet Mite: life cycle

© NSW Department of Primary Industries

- Abundant during hot, dry weather in mid- and late summer
- Highly reproductive – 53 eggs per female, complete life cycle in a week at warm temps
- Live for about 22 days
- Eggs laid on undersides of leaves, leaf petioles, and stems
- Move between closely spaced plants that are touching
- Can be carried by the wind

Tomato Russet Mite: management

- *Use clean transplants* – inspect to ensure free of russet mites
- *Avoid planting during hot, dry periods* – stressed seedlings more vulnerable to attack
- *Avoid transplanting seedlings near infested crops or weeds*
- *Promptly remove or destroy infested plant debris*
- *Sanitize equipment* – make sure tools & equipment used on infested plants are properly cleaned before using on healthy plants
- Several predatory mites that feed on tomato russet mite but often a lag time between increase pops. of TRM and predatory mites

Common Cole Crop Insect Pests

- Cabbage Maggot & Seedcorn Maggot
- Flea beetles
- Cabbage aphid
- Diamondback moth, cabbage looper, imported cabbageworm

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Cabbage Maggot & Seedcorn Maggot: symptoms

Cabbage maggot damage

Seedcorn maggot damage

Cabbage maggot damage

- CM: larvae feed on roots of cole crops, can tunnel through tap roots, providing entry for decay, fungi, bacteria, plants show wilting, reduced growth, lighter green plant parts, seedlings are most vulnerable while healthy plants can tolerate moderate infestations
- SM: prefer soils rich in organic and decaying matter (e.g. manure) burrow/feed in seeds and roots/taproots of veggies, destroy seed germ, may cause rot in plant tissue, damaged seeds unable to provide adequate food resources to support initial plant growth, seeds and plants may not emerge causing reduced stands, lower leaves of infested plants often become chlorotic (yellow) and severe damage results in halted plant growth

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Cabbage Maggot & Seedcorn Maggot: hosts

Damage to a young bean plant caused by the seedcorn maggot

- CM: prefer cauliflower, Brussels sprouts, radish, cabbage, broccoli, collards, kohlrabi, turnip, cress, beet, celery, and cauliflower and Brussels sprouts can be more susceptible than hybrid cultivars of broccoli
- SM: polyphagous (feed on several veggie host plants) prefer soybeans and corn, other susceptible hosts are brassicas, beans, peas, cucumber, melon, onion, potato, and others

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Cabbage Maggot & Seedcorn Maggot: life cycle

Seedcorn maggot

- Pupae overwinter in crop debris or in the soil
- Adult flies emerge in April and May
- Mated females lay eggs in soil, base of host plants, or on seeds
- CM larvae burrow into stems and feed on roots of host plant
- SM larvae burrow into seeds and feed on emerging cotyledons and plant roots
- About 2-3 generations per year

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Cabbage Maggot & Seedcorn Maggot: management

- Common in wet springs; well-drained soil beds are critical to reduce infestation
- *Rotate crops* – plant susceptible hosts as far away as possible from where they were planted the previous year
- *Plant seeds in raised soil beds* to promote soil drying and warming and discourage egg-laying by maggots
- *Destroy or disc under crop residue* immediately after harvest
- *Direct seed when conditions are ideal* for rapid seed germination

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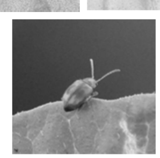
Flea Beetles



- Numerous species in Utah
- 1/8 in. long with small dark metallic bodies, enlarged hind legs, jump quickly when disturbed
- Overwinter as adults under plant debris & soil clods

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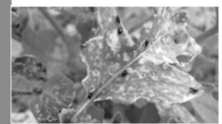
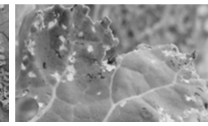
Flea Beetle: hosts

- Tomato, pepper, eggplant, potato, radish & relatives, cabbage & relatives, beans, herbs
- Less tolerant crops: cole crops such as cabbage, edible greens, and seedlings
- Also many weeds

Flea Beetles: symptoms





- Larvae can feed on roots, not usually a problem except for tuber flea beetles
- Most damage caused by adult flea beetles
- Adults chew small “shotholes” & shallow pits in leaves, cotyledons, and stems – seedlings are most at risk for damage
- Holes and frass reduce marketability

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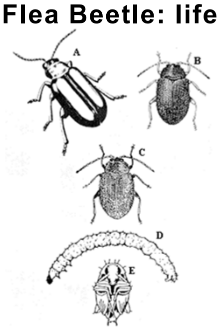
Flea Beetle: life cycle



- Overwinter as adults in soil, plant debris, weeds
- Emerge mid- to late-spring
- Mated females lay eggs in soil at base of host plant
- Larvae feed on below-ground plant parts
- Pupation in the soil
- Adults emerge to feed on above-ground plant parts
- 1-2 generations possible depending on species and temperatures

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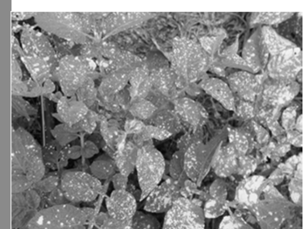
Flea Beetle: management



Kaolin clay (e.g. Surround[OB]) registered for flea beetle control

- Avoid planting susceptible crops after potatoes
- Control weeds around planting sites
- Use row covers during seedling establishment
- Eliminate old crop debris and other surface trash
- Plant crops as late as possible when feasible
- Plant trap crops
- Use companion crops and living or non-living mulches to obscure host plants

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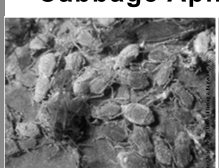
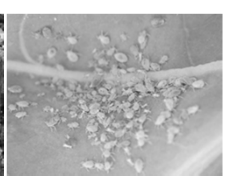
Cabbage Aphid


- Thoroughly destroy winter egg hosts like Brussels sprouts, cabbage, and kale by tilling or roguing
- Avoid excess fertilization
- Use row covers or reflective mulches
- Maintain healthy, vigorous plants

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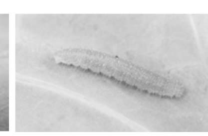
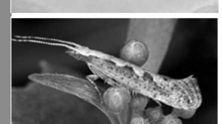
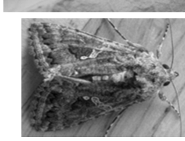
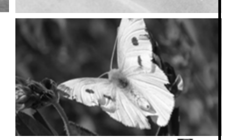
Diamondback Moth, Cabbage Looper, & Imported Cabbageworm



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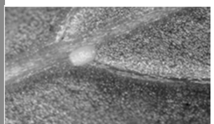
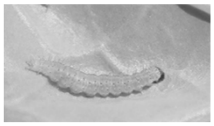
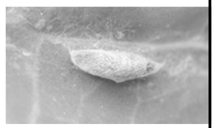
Diamondback Moth (DBM)


- Egg: round, yellow, 0.02 in. wide, laid singly and in clusters
- Larva: green-gray, no stripes, 0.5 in. long, wiggles vigorously when disturbed or rapidly attach a silken line to a leaf and drop over the edge
- Pupa: loose mesh cocoon, 0.3 in. long, pupates on leaves
- Adult: moth, 0.75 in. wingspan, grayish brown with white-cream markings, active at dusk and dawn
- Migratory in the north and resident in the south, overwinters as adult in trash and debris around crop fields, 4-6 gens/yr

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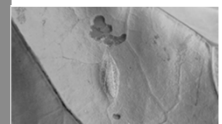
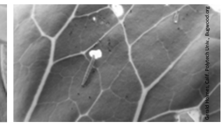
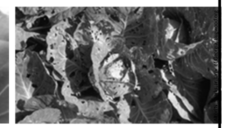
Diamondback Moth (DBM): hosts & symptoms

- Hosts: Attacks plants exclusively in the Brassica family preferring cabbage and broccoli, but will also feed on Brussels sprouts, cabbage, cauliflower, Chinese cabbage, collards, kale, kohlrabi, mustard, radish, rutabaga, turnip, watercress, and cruciferous weeds
- Symptoms: mine through leaves creating "window panes", primary damage on outer or older leaves of older plants, larvae also feed on flower buds and floral stalks, larvae present in heads and stems at harvest reduce marketability of the crop

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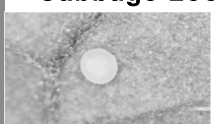
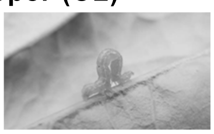
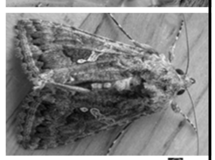
Cabbage Looper (CL)



- Egg: dome, yellowish-white, 0.02 in. high, laid singly or in clusters, ridged
- Larva: pale to dark green, smooth, few sparse hairs, 1.5 in. long, arches body into a loop
- Pupa: fuzzy cocoon, 1.2 in. long, pupates on leaves, plant debris, and soil
- Adult: moth, grayish brown, silver '8', 1.5 in. wingspan, mostly active at night
- Migratory (some resident), overwinters as pupa on leaves, plant debris, and soil, 1-3 gens/yr

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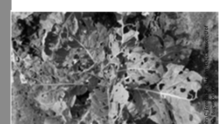
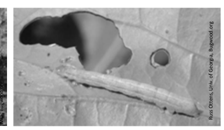
Cabbage Looper (CL): hosts & symptoms


- Hosts: Brassicas, beet, celery, cucumber, lettuce, lima bean, parsnip, pea, pepper, potato, snap bean, spinach, squash, sweet potato, tomato, and weeds such as wild lettuce, dandelion, lambsquarters, curly dock
- Symptoms: typically after head formation begins in cole crops but sometimes caterpillars attack seedlings, ragged holes in leaves, bore into heads, contaminate leaves and heads with larval bodies and frass

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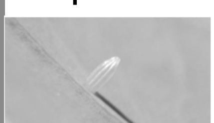
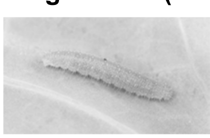
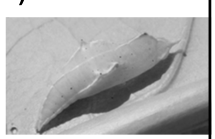
Imported Cabbageworm (ICW)


- AKA cabbage white butterfly
- Egg: rocket/bullet, yellow, 0.04 in. long, laid singly
- Larva: green, fuzzy, thin yellow stripe on back and sides, 1.2 in. long, sluggish
- Pupa: naked chrysalis, 0.75 in. long, pupates on leaves and occasionally debris
- Adult: butterfly, white, 2 (female) or 1 (male) dark spot(s), 2 in. wingspan, active during day
- Resident, overwinters as pupa on leaves and sometimes debris, 3-4 gens/yr

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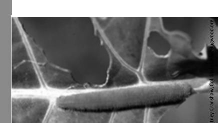
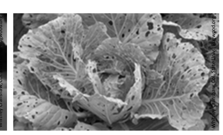
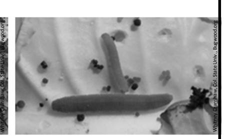
Imported Cabbageworm (ICW): hosts & symptoms

- Hosts: Attacks plants exclusively in the Brassica family including many related weeds, prefer broccoli, cabbage, and cauliflower
- Symptoms: larvae feed on outer leaves, round holes, frass in broccoli or cauliflower heads, bore into heads reducing marketability

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Characteristic	Diamondback Moth	Cabbage Looper	Imported Cabbageworm
Utah status	migratory in the north and resident in south	migratory (some resident)	resident
overwintering stage and site	adult, in trash and debris in and around crop fields	pupa, (see pupation site below)	pupa, (see pupation site below)
# generations per year	4 to 6	1 to 3	3 to 4
ADULT			
type	moth	moth	butterfly
activity period	dusk and dawn (crepuscular)	mostly night (semi-nocturnal)	day
color	grayish brown	grayish brown	white
wing marks	white/cream diamonds	silver "8"	females: 2 dark spots males: 1 dark spot
wingspan	0.75 inch (18 mm)	1.5 inches (38 mm)	2 inches (50mm)
EGG			
shape	round	dome	rocket/bullet
color	yellow	yellowish-white	yellow
size	0.02 inch (0.4 mm) wide	0.02 inch (0.4 mm) high	0.04 inch (1.0 mm) long
distribution	laid singly and in clusters	laid singly and in clusters	laid singly
LARVA			
color	greenish gray	pale to dark green	green
texture	smooth, few sparse hairs	smooth, few sparse hairs	fuzzy/velvety due to dense short hairs
marks	no stripes	thin, white or light yellow stripes	thin, yellow stripe
shape	tapered at both ends	tapered at head	blunt ends
size	0.5 inch (12 mm)	1.5 inches (38 mm)	1.2 inch (31 mm)
behavior	wiggles (vigorously)	arches body into a loop	sluggish
# of instars (molts)	4	5	5
PUPA			
type	loose mesh cocoon	fuzzy cocoon	naked chrysalis
size	0.3 inch (8 mm)	1.2 inches (30 mm)	0.75 inch (19 mm)
pupation site	on leaves	on leaves, plant debris, and soil	on leaves, and occasionally on debris

Diamondback Moth, Cabbage Looper, & Imported Cabbageworm: management

- Interplant w/ unrelated plants
- Start with clean transplants
- Row covers prevent adults from laying eggs. Remove row covers at harvest
- Handpick and destroy larvae
- Plant early or use early maturing varieties
- Remove plant debris
- Plant tolerant varieties
- Biological insecticides, such as Bt and spinosad, are highly effective against cabbage caterpillars.
- Many natural predators (pictured: ground beetle, paper wasp, lacewing larva, ambush bug

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vegetableguide.usu.edu

- Specific to Utah
- Production and pest management
- Soil, nutrient, and water management
- Vegetable IPM practices
- Vegetable crop chapters
  - Brassica
  - Cucumber, pumpkin, squash
  - Melon
  - Onion
  - Potato
  - Tomato, pepper, Eggplant
  - Sweet corn
- Pesticide information
- Spray tables
- PDF: https://utahpests.usu.edu/IPM/files/uploads/Publications/UT-veg-guide-2016.pdf

UTAHPESTS.USU.EDU/IPM

utahpests.usu.edu

- Fact sheets
- Video fact sheets
- Image gallery
- Slideshows
- Utah Pest News
- UPPDL
- IPM
- IPM Pest Advisories
  - Tree fruit
  - Vegetable
  - Landscape ornamental
  - Turf
- Bee resources

- Google
"[pest of interest] usu" or
"[pest of interest] extension"
e.g. "corn earworm usu"
"corn earworm extension"

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utahpests.usu.edu/uppdl/

- Utah Plant Pest Diagnostic Lab (UPPDL)
- Identification of arthropod (insect, spider, mite, etc.) or disease affecting your plants
- Instructions on sample preparation
- How to submit forms, specimens, and images

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THANK YOU

Please fill out the vegetable guide survey in your binder if you haven't done an I-clicker version of that survey

Please also remember to fill out the surveys in the guide books that you receive

email: cami.cannon@usu.edu

Back to Top

Vegetable Pest Management 101: Common Insect and Mite Pests of Corn and Squash

Biographical Information:
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I am an extension and research entomologist at Utah State University, as well as the Utah Extension Integrated Pest Management Coordinator. I develop, test and demonstrate novel pest management technologies for horticultural crops, including fruits and vegetables, and I provide outreach teaching on insect pest management.

Session Description:

Review of identification, monitoring and management of common insect and mite pests of corn and squash crops in Utah.

Vegetable Insect Management:
Insect and Mite Pests of Corn & Squash

Diane Alston, Entomologist, Utah State University
Urban & Small Farms Conference


February 22, 2017
Viridian Center, West Jordan, UT

EXTENSION
UtahStateUniversity

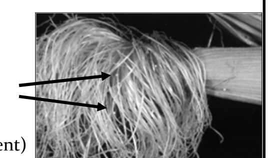
utahpests.usu.edu/ipm

Corn Earworm

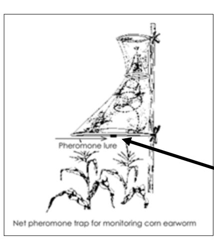
- Key pest of sweet corn in Utah
- CEW will also attack field corn, pepper & tomato fruits
- Tan-brown moth (1.5 inch wingspan), active at dusk
  - Carried on wind currents up to 300 miles
- Effective pheromone trap to monitor moth populations
  - Thresholds for timing sprays


Corn Earworm

- Eggs laid on fresh, green silks
  - Up to 1,000 eggs per female
  - Silks grow ~1/2 inch per day
- Eggs hatch in 2 to 10 days (temp. dependent)
- 1st instar larva crawls into ear tip
  - Chews developing kernels, silks & sometimes leaves
  - Tom/Pep fruits: tunnels into fruit, chews leaves
- Mature larva (1.5 inch long caterpillar) feeds in ear 10-14 days
- Pupate in the soil



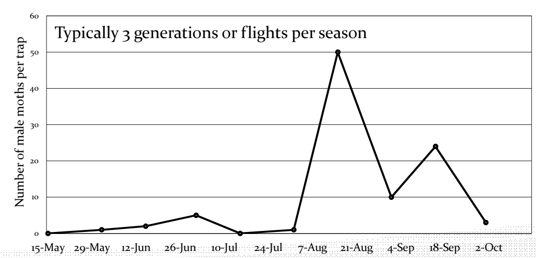

Corn Earworm Trap



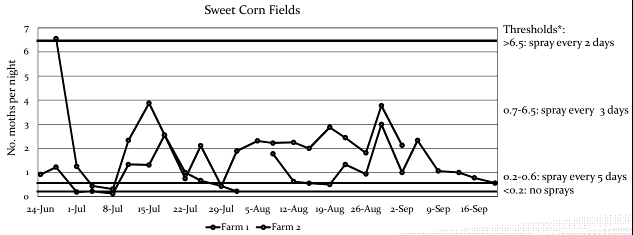
Hercon Pheromone Lure

Hartstack Trap

Typical Corn Earworm Moth Flight Without Insecticides – Cache County



CEW Moth Trap Data for 2 Davis Co. Farms - 2013



*Reapply insecticides to keep an active residue on new silks

CEW Management: Insecticides

- Protect silks when present
- Reapply based on trap threshold & insecticide residual
- Follow insecticide label
- Rotate among classes
- Follow pre-harvest interval

Insecticide class	Common name	Brand name
Pyrethroid	bifenthrin cyfluthrin esfenvalerate lambda-cyhalothrin permethrin zeta-cypermethrin pyrethrin	Brigade Baythroid Asana Warrior Ambush Mustang Pyganic (Org)
Carbamate	carbaryl methomyl thiodicarb	Sevin Lannate Larvin
Organo-phosphate	malathion	Malathion
Spinosyn	spinosad spinetoram	Success, Entrust(Org) Radiant

CEW Management: Cultural & Biological

- Plant early for silking before major moth flight
- Varietal tolerance or resistance
- Fall tillage to destroy overwintering pupae
- Biological control
  - Trichogramma wasp releases
    - Limited success in Utah
  - Natural enemies
    - Predatory & parasitic insects

Trichogramma wasp

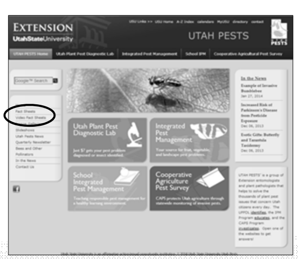
Minute pirate bug

Sources of Traps & Pheromone Lures

Hartstack Trap & Hercon CEW Lure

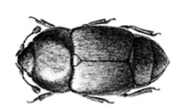
- Great Lakes IPM, Inc., Vestaburg, MI
  - www.greatlakesipm.com
- Scentry Biologicals, Inc., Billings, MT
  - www.scentry.com
- Trece, Inc., Adair, OK
  - www.trece.com

Online Fact Sheet – www.utahpests.usu.edu



Interactions with other pests

- Secondary pest problems
- Earworm injury opens up eartip to other pests (molds, insects)
- Dusky sap beetle (Coleoptera: Nitidulidae) attracted to decay; larger problem on super sweet corn hybrids
- European earwig (Dermaptera) – feed on silks, pollen in tassels & enter ear tips

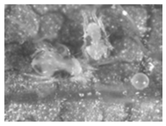


Dusky sap beetle

European earwig

Spider Mites

- Twospotted spider mite
- Bank's grass mite
- Pierce leaf cells with mouthparts
  - Suck out cell contents
  - Gray stippling damage
  - 'Mite burn'
- More prominent along field borders
  - Weeds alternate plant hosts
- Yield loss most severe if corn infested from tasseling to soft dough stage


TSSM

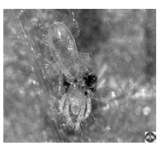

BGM

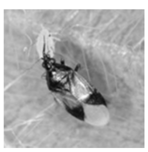

Spider mite injury

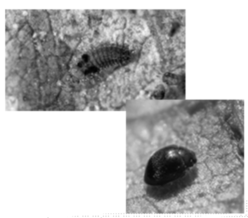
Spider Mite Management

- Adequate irrigation
  - Mites like it hot & dry!
- Scout to detect mites early
  - 10 – 30 x magnification hand lens
  - Look for webbing, dirty leaves
  - Shake leaves over white paper
- Control weeds
  - Field edges
- Avoid creating dust

Mite Biological Control: Natural Enemies


Predatory mites


Predatory true bugs:
Minute pirate bug


Spider mite destroyer:
Small, black lady beetle


Lacewing larvae

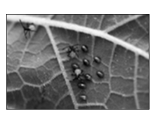
Miticides

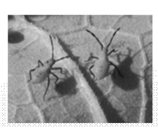
- Onager (hexythiazox)
- Zeal (etoxazole)
- Comite (propargite)
- Oberon (spriomesifen)
- Sulfur
- Insecticidal soap
- Horticultural oil


Spider mites move from weeds onto corn when conditions change to hot & dry

Squash Bug

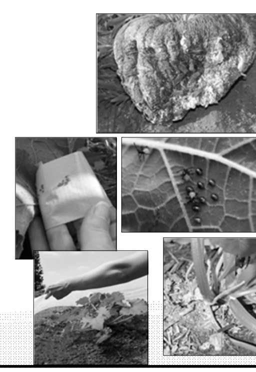
- Squash & pumpkin
- Adults & nymphs suck fluids from plant leaves, stems & fruit
- "Sudden wilt" – disruption of xylem vessels
- Congregate in plant debris under plants

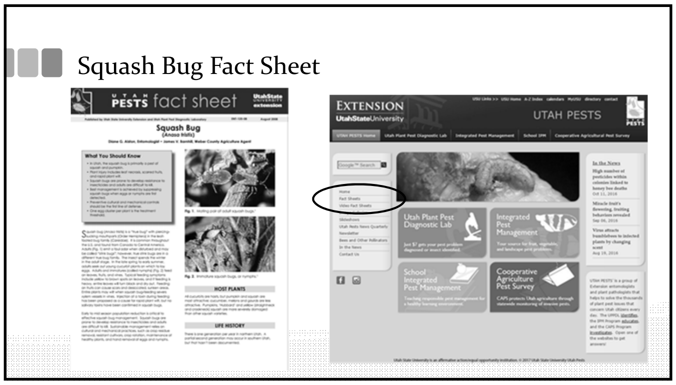


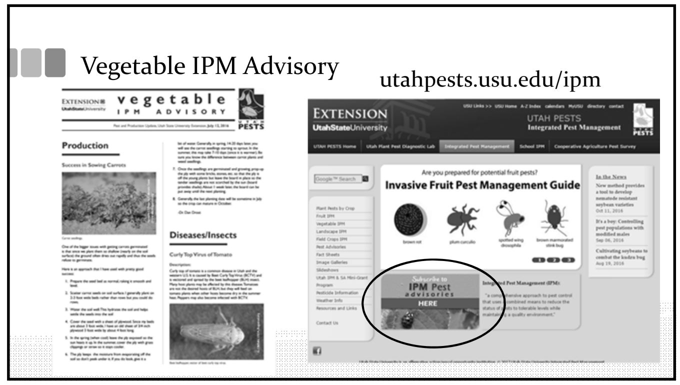


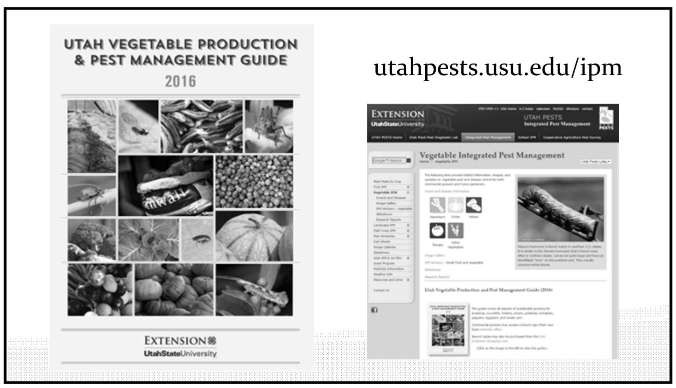
Squash Bug

- Sanitation: Remove garden debris in fall, nearby woodpiles or other protected sites (adults over winter)
- Hand pick or destroy eggs & nymphs
  - Duct tape removal method
- Floating row cover over transplants
- Chemicals: spray when first detect nymphs, drench undersides of leaves & stems
- kaolin clay (Surround), malathion, carbaryl, neem oil, pyrethroids, pyrethrins, novaluron (Rimon)
- Rotate chemical modes of action to avoid resistance

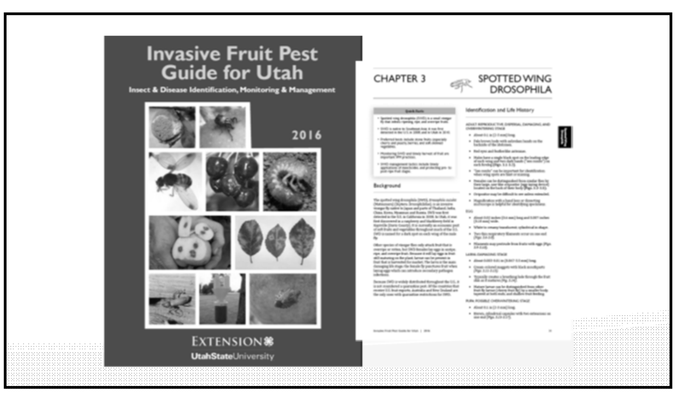



Squash Bug Fact Sheet
UTAH PESTS fact sheet
Squash Bug
EXTENSION UtahStateUniversity
UTAH PESTS


Vegetable IPM Advisory
utahpests.usu.edu/ipm
vegetable IPM ADVISORY
Production
Diseases/Insects
EXTENSION UtahStateUniversity
UTAH PESTS Integrated Pest Management
Invasive Fruit Pest Management Guide
IPM Pest advisories HERE


UTAH VEGETABLE PRODUCTION & PEST MANAGEMENT GUIDE
2016
EXTENSION
UtahStateUniversity
utahpests.usu.edu/ipm
Vegetable Integrated Pest Management


Pacific Northwest Insect Management Handbook
pnwhandbooks.org/insect
Insect Management


Invasive Fruit Pest Guide for Utah
Insect & Disease Identification, Monitoring & Management
2016
EXTENSION
UtahStateUniversity
CHAPTER 3
SPOTTED WING DROSOPHILA


Questions?

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Diseases of Onions and Cucurbits Plus Curly Top Update

Background information:
Claudia Nischwitz
Utah State University
5305 Old Main Hill
claudia.nischwitz@usu.edu

I am the extension plant pathologist at USU. I work mostly on management and identification of vegetable diseases and do diagnostics.

Session Description:

Presentation on onion and cucurbits diseases that occur in Utah

Diseases of Onions and Cucurbits plus Curly Top Update

Claudia Nischwitz

Associate Professor and Extension Specialist

Email: claudia.nischwitz@usu.edu

UtahStateUniversity COOPERATIVE EXTENSION

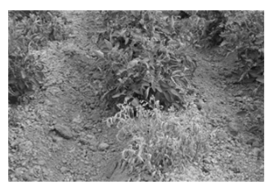
Curly top

Curly top

- Tomatoes and peppers
- Other hosts: Beans, pumpkins, gourds, beets and spinach
- Causal agent: Curtoviruses
- Transmitted by beet leafhopper

Curly top

- Symptoms (tomato):
  - Leaf margins turn upwards
  - Leaves turn yellow with purple veins
  - Premature fruit ripening
  - Stunted plants



http://wrir4.ucdavis.edu/Photos/FRCs/drec/pages/Tomato%20Curly%20Top%20Virus.htm

http://www.growingproduce.com/vegetables/virus-slams-california-tomatoes/

Curly top

- Symptoms (pepper):
  - Plants are yellow and stunted
  - No marketable fruit

http://wrir4.ucdavis.edu/PHOTOS/pest/pages/Beet%20Curly%20Top%20Virus%20on%20Bell%20Peppers%20NM.htm

http://www.growingmagazine.com/fruits/new-approaches-in-virus-resistance-development/

Curly top

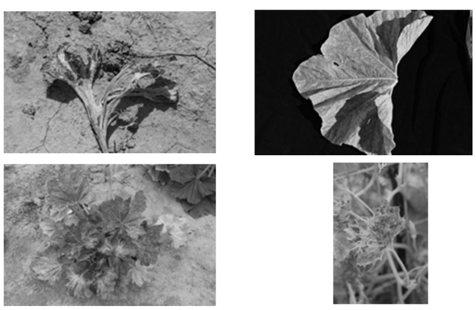
- Management:
  - Floating row covers for young transplants
  - Shade cloth
  - Good weed control

Watermelon mosaic virus

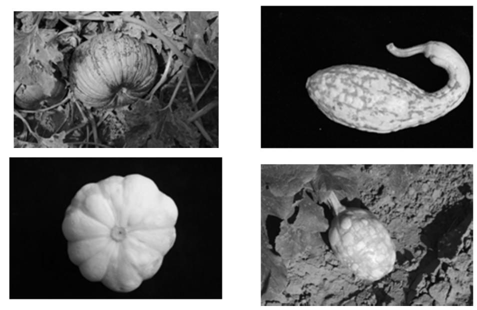
Watermelon mosaic virus

- Affects summer squash, winter squash, pumpkin and zucchini
- Causes color breaking and warts on fruit
- Mosaic and distortion of leaves
- Transmitted by aphids in non-persistant manner (aphids have to feed on infected plant every time before being able to transmit it)

Symptoms



Symptoms



Watermelon mosaic virus

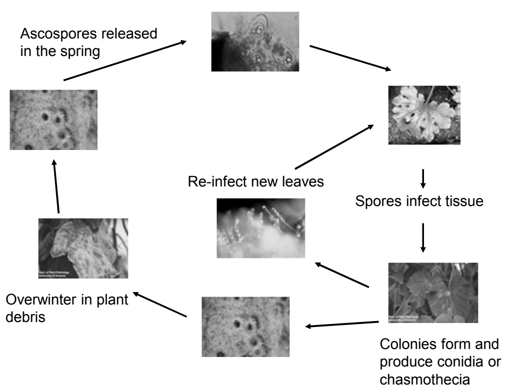
- Management:
  - resistant summer squash varieties (some are GMO)
  - No resistant pumpkin or winter squash varieties
  - Good weed control (clover, common mallow etc)
  - Avoid planting close to alfalfa

Powdery mildew

Powdery mildew

- Many hosts: Utah vegetables: mostly cucurbits
- Damage in vegetables is caused by the reduced ability of the plant to photosynthesize due to the leaves being covered with fungal mycelium (reduced fruit quality, yield)
- In some cases when leaves get necrotic and fall off fruits can become sunburned

Powdery mildew



Powdery mildew

- Management:
- Cultural
  - Resistant varieties if available
  - Remove infected plant material at the end of the growing season to prevent overwintering
  - Plant spacing
- Chemical control
  - Sulfur products work well for most powdery mildews; Read the label if the product is registered for the crop
    Do NOT apply sulfur above 90 F – plants can get burned
  - Chlorothalonil

Powdery mildew

- Management:
- Cultural
  - Resistant varieties if available
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  - Chlorothalonil

Rhizopus and Choanephora rot

Rhizopus rot

- Common fungus (bread mold)
- Occurs in storage
- Enters squash through tiny wounds (insect, sand etc)
- Temperatures of 59-86F and moisture are ideal growing conditions

Choanephora rot

- Affects blossoms and fruit
- Warm temperatures (above 75F) and moist conditions
- Short lived disease, as soon as conditions change the disease will stop
- No control measures

Iris yellow spot virus

Iris yellow spot virus

- Affects onions, occasionally garlic
- Yield loss when plants infected early in season
- Symptoms:
  - Lense shaped lesions
  - When lesions merge leaf dies
- Transmitted by onion thrips
- Management:
  - Good thrips control
  - Good weed control

Iris yellow spot virus

Iris yellow spot virus

https://www.plantmanagementnetwork.org/pub/php/brief/2007/iris/

Botrytis neck rot

Botrytis neck rot

- Symptoms:
  - No symptoms in the field
  - In storage:
    - Top of onion gets soft
    - Brown discoloration when bulb is cut from the top down

Botrytis neck rot

Botrytis neck rot

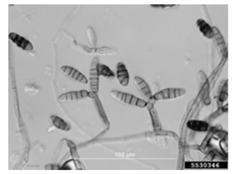
- Management:
  - Do not cut leaves off until they are dried down

Embellissia skin blotch

Embellisia skin blotch

- Host: Garlic
- Fungus (*Embellisia allii*) survives in soil, plant debris or infected bulbs
- Symptoms:
  - Dark gray – black spots on outer skin layer of garlic bulb
  - Most of the time symptoms are only superficial, not affecting market value

Embellisia skin blotch on garlic



Bruce Watt, University of Maine, Bugwood.org

Embellisia skin blotch

- Prefers temperatures of 78-84F
- Moist soils with manure applications increase disease development
- Management:
  - Red garlic cultivars less susceptible than white ones
  - Remove outer skin of bulb
  - Keep garlic dry in storage

TMV/ToMV - Management

Thank you for listening!
Questions?

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Understanding and Promoting Soil Health: Facts vs. Myths

Background Information:

Meredith Albers
USDA-Natural Resources Conservation Service
125 S. State Street, Room 4010
Salt Lake City, UT 84138
meredith.albers@ut.usda.gov

The NRCS dates back to the days of the Dust Bowl era in the 1930s with a continued purpose to assist landowners and operators with natural resource conservation. Soil Scientists with NRCS create and updated soil maps for general land use planning. Resource Soil Scientists provide project-specific soils information and help users interpret our soil maps and data to get the information they need and improve the public's understanding of soil as a resource. I graduated from the University of Missouri where I studied nutrient cycling in forest soils. I worked on soil surveys in Iowa and Minnesota before moving west to help users apply our soil maps in Montana and now Utah as a Resource Soil Scientist.

Michael Domeier
Natural Resources Conservation Service
Wallace Bennett Federal Building
125 South State Room 4010
Salt Lake City, Utah
mike.domeier@ut.usda.gov

The Natural Resources Conservation Service provides technical information to private landowners on conserving soil, maintaining water quality, and enhancing wildlife on private lands. My position as the State Soil Scientist is to provide the soil maps and interpretations that are a critical component of successful conservation planning. We also provide soils information to external customers involved in agriculture, housing, land appraisals and other land uses. I graduated from the University of Minnesota and have worked in field soil survey in Minnesota, Florida, and Utah.

Session Description:

Mike Domeier and I will be presenting on the importance of soil health for water and nutrient management will be discussed. There will be a mention of the additional environmental benefits. The basic principles of how to improve and maintain the soil health will be covered. Finally there will be a discussion of implementing soil health principles in a garden or small farm operation.

Understanding and Promoting Soil Health: Fact vs. Myths

Mike Domeier,
State Soil Scientist
Meredith Albers,
Resource Soil Scientist
USDA-Natural Resources Conservation Service, Salt Lake City

2011 Missouri River Floods

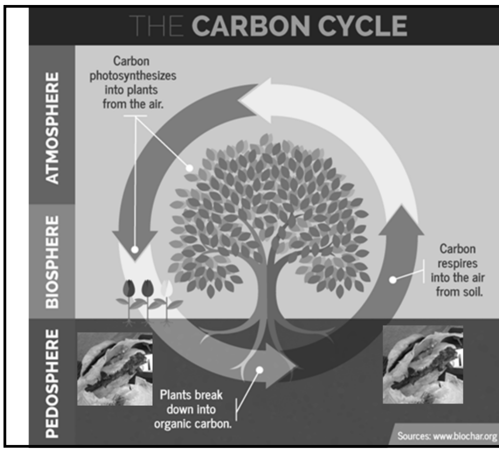
What is Soil?

1. Physical Stability and Support
2. Water (Infiltration & Availability)
3. Provide Nutrients to Plants

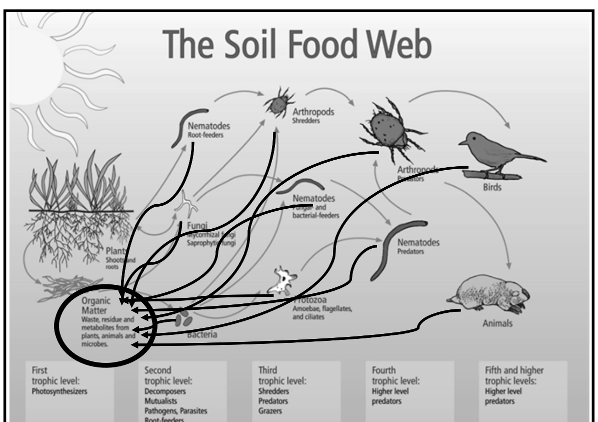
What is Soil Health?

The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans.

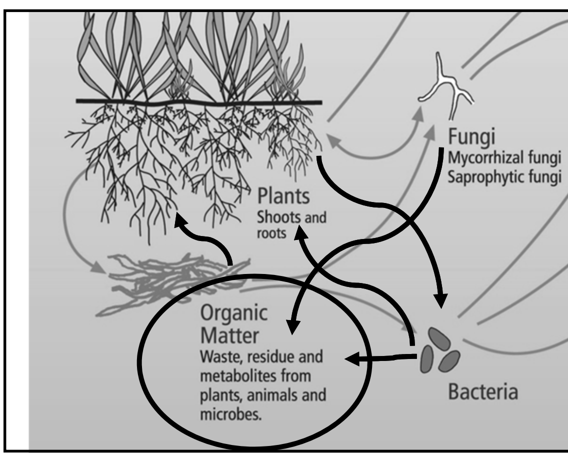
4. Filtering and Buffering
5. Biodiversity and Habitat

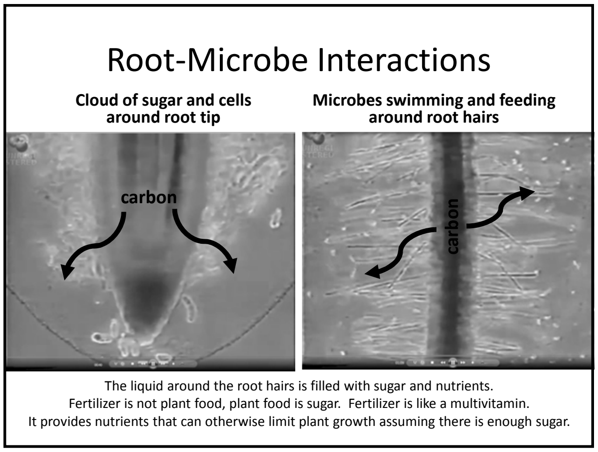


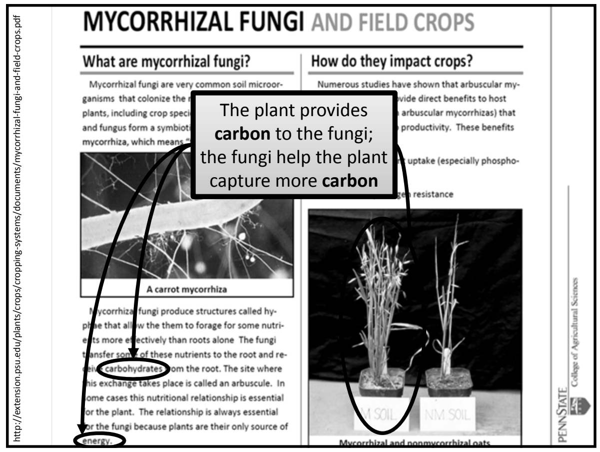
https://commons.wikimedia.org/wiki/File:The-carbon-cycle_biosphere.png#metadata

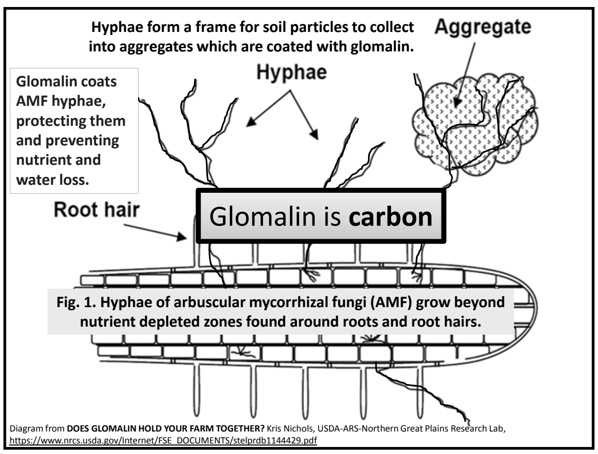


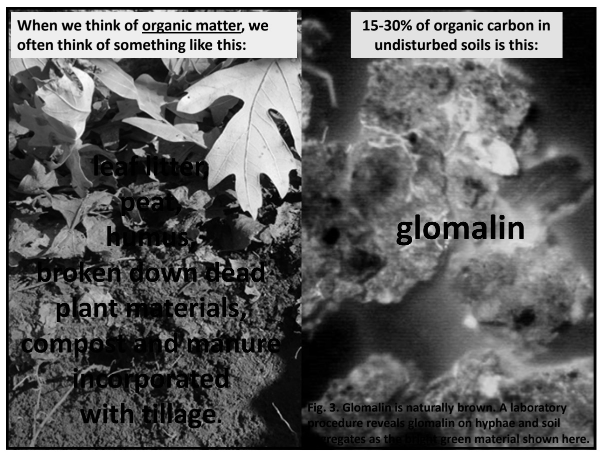
Soil Biology Primer - https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/

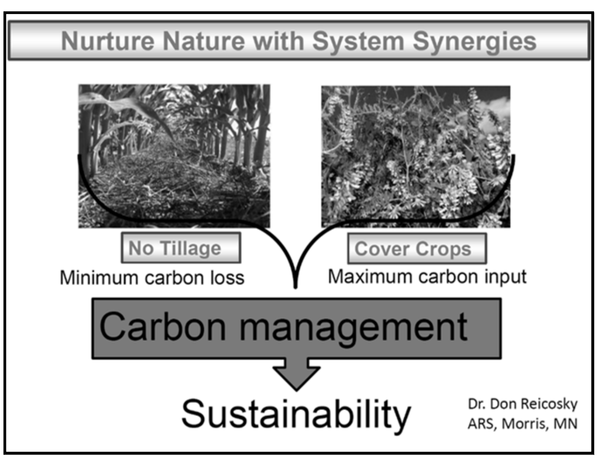












Soil Health Principle 1

Manage More by Disturbing Soil Less

Three Types of Agricultural Disturbance

1. Physical (tillage)
   - Rapid breakdown of organic matter after tillage
   - Destroys soil structure, pores, and hypae
     - Impedes water infiltration and root growth
     - Reduced habitat for microorganisms
2. Chemical (fertilizer and herb/pesticides)
   - Hijacks soil food web
3. Biological (overgrazing, long-term haying)
   - Removes carbon (food!) from the system

Soil Health Principle 2

Use Diversity of Plants to add Diversity to Soil Organisms

Plants interact with particular microbes
→ trade sugar (**carbon**) for other nutrients

- Require a diversity of plant carbohydrates to support the variety of microbes
- Increase soil organic matter
- Improve nutrient utilization and availability
- Break pest cycles
- Lack of plant diversity will drive system to favor some microbes more than others

Soil Health Principle 3

Grow Living Roots Throughout the Year

Living Plants Support Living Microbes

- Increase biodiversity and biomass of soil organisms
- Increase microbial activity influences the N mineralization and immobilization
- Increase plant nutrient/vitamin uptake/concentrations with mycorrhizal and bacteria associations
- Sequester and redeposit nutrients
- Increase organic matter
- Improve physical, chemical and biological soil properties

Soil Health Principle 4

Keep it Covered as Much as Possible

Benefits:

- Provide Habitat and Food for Soil Organisms
  - ✓ Control Erosion, Protect Soil Aggregates
  - ✓ Moderate Soil Temperature
  - ✓ Conserve Moisture
- Suppress Weeds

Soil Health Principle 5

Incorporate Livestock

Benefits:

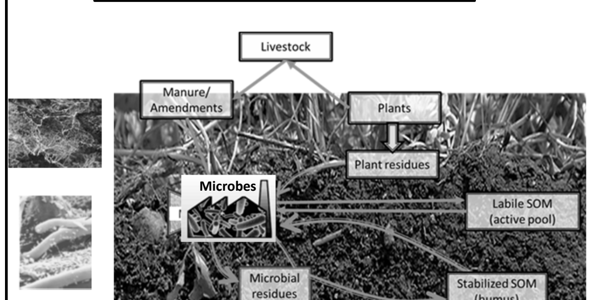
- Keep carbon (and other nutrients) on the soil
  - ✓ Haying removes carbon
  - ✓ Manure has to be disposed
- Includes more levels of the food web, mimicking natural systems
  - ✓ Manure for dung beetles
  - ✓ Chickens control insects

Soil Health Planning Principles

1. Disturb the soil as *little* as possible
2. Crop rotations and cover crop *diversity*
3. Keep a *living root* in the soil
4. Keep the soil *covered*
5. Incorporate *livestock* where practical

Goal: To create the most favorable habitat for the **soil food web** to build **organic matter.**

Microbes are the factories that make organic matter



Importance of soil organic matter
Learning how soil functions

Improves the soils ability to store and transport water
Stores and supplies plant nutrients
Provides a carbon and energy source for soil microbes
Improves aggregate stability
Reduces erosion hazard
Provides cation exchange sites
Lowers the bulk density of soils
Retains carbon from the atmosphere
Makes soils more friable
Improves water infiltration
Reduces crusting

Soil Organic Matter & Available Water Capacity

Percent SOM	Sand	Silt Loam	Silty Clay Loam
1	1.0	1.9	1.4
2	1.4	2.4	1.8
3	1.7	2.9	2.2
4	2.1	3.5	2.6
5	2.5	4.0	3.0

Inches of Water/One Foot of Soil
1 acre inch = 27,150 gallons of water

Berman Hudson
Journal Soil and Water Conservation 49(2) 189 194 189-
March April 1994 –
Summarized by:
Dr. Mark Liebig, ARS, Mandan, ND
Hal Weiser, Soil Scientist, NRCS, Bismarck, ND

Value of Soil Organic Matter

Assumptions: 2,000,000 pounds soil in top 6 inches
1% organic matter = 20,000#
Nutrients:
Nitrogen: 1000# * $0.50/#N = $500
Phosphorous: 100# * $0.70/#P = $ 70
Potassium: 100# * $0.50/#K = $ 50
Sulfur: 100# * $0.50/#S = $ 50
Carbon: 10,000# or 5 ton * $?/Ton = $ 0

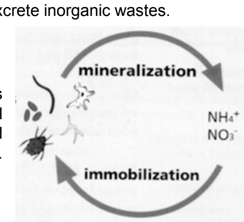
Value of 1% SOM Nutrients/Acre = $670

Original Jim Kinsella/Terry Taylor(2006)/revised Jim Hoorman (2011)

Mineralization and Immobilization

Organisms consume other organisms and excrete inorganic wastes.

Organic nutrients are stored in soil organisms and organic matter.



Inorganic nutrients are usable by plants, and are mobile in soil.

Organisms take up and retain nutrients as they grow.

Annual Decisions and Planning

- Establishing a cover crop
- Terminating the cover crop – chemical, frost, mechanical
- Planting the cash crop – planting into CC
- Growing the cash crop – weed control
- Harvest and yield of the cash crop

Crop Classification Warm Season

Grasses
- Corn
- Millet
- Sudan
- Sudex
- Sorghum

Broadleaf
- Alfalfa
- Soybean
- Buckwheat
- Chick pea
- Cow pea
- Sunflower

Crop Classification Cool Season

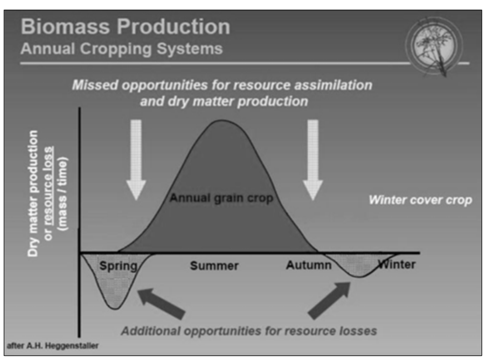
Grasses
- Barley
- Rye
- Triticale
- Wheat
- Oats

Broadleaf
- Canola
- Clovers
- Mustards
- Pea
- Radish
- Turnips
- Vetch
- Lentil

Just try something. Start small and build from there.

Cover Crop	Seeding Rate (#/ac)
Turnip	1
Radish	2
Austrian Pea	15
Hairy Vetch	5
Small grain	20
Total	**43**

Oats, Vetch, Peas



A. H. Heggenstaller, University of Alberta

Thank you! Any Questions?

References:
- USDA NRCS Soil Health http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/
- Utah Soil Health in Utah http://www.nrcs.usda.gov/wps/portal/nrcs/main/ut/soils/health/
- Idaho NRCS Soil Health Website http://www.id.nrcs.usda.gov/technical/soil_health.html
- "Soil Health To-Go" Podcasts http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/soils/health/?cid=nrcseprd370020
- Does glomalin hold your farm together? Kris Nichols, USDA-ARS-Northern Great Plains Research Lab, https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1144429.pdf
- Jay Fuhrer presentations on Soil Health and the Carbon Cycle: http://www.forestrywebinars.net/webinars/understanding-the-carbon-cycle-in-agricultural-fields-a-case-study-with-hayland/ (1:01 hr) and presentation for Utah Workshop: https://youtu.be/umdFJ9mzjug (1:22 hr)
- Soil Biology Primer - https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/
- Penn State College of Agricultural Sciences pamphlet - http://extension.psu.edu/plants/crops/cropping-systems/documents/mycorrhizal-fungi-and-field-crops.pdf

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Worker Protection Standards-WPS Law

Background Information:

Drew S. Matthews
Utah Department of agriculture and Food-Pesticide Program
128 17th Street
Ogden, UT 84404
dmatthews@utah.gov

I have been a bureaucrat for the last 30 years. B.S. in Agriculture from Southern Utah University, Certified Public Manager from the State of Utah, 6 children, 4 grandchildren. I have worked in the Pesticide Program for over 9 years.

Session Description:

If you use pesticides, you are subject to the WPS

WPS Update

- EPA's WPS outreach and implementation effort
  - Activities
  - Cooperative agreements & contracts
  - Timing of materials
- Inspection guidance
- Ongoing implementation issues

1

Implementation Timeline

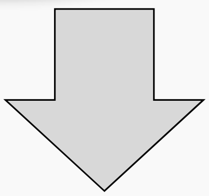
9/28/2015 Revised WPS final rule signed

11/2/2015 Revised WPS final rule published in the Federal Register.

1/2/2017 Compliance Required with Most Revised WPS Requirements Except:
- New content in Worker and Hander Training
- New content in Pesticide Safety Information Display
- Responsibility for Handlers related to the Application Exclusion Zone

1/2/2018 Compliance Required with All WPS Requirements

2




3

EPA's Outreach and Implementation

Educate Regulators	• Develop broad understanding of WPS revisions among OPP & regional staff and state/tribal inspectors & program leads
Stakeholder Outreach	• Ensure stakeholders understand the WPS revisions, impacts and the timeline for implementation: regulated community, farmworker advocates and other NGOs; coordinate with other federal agencies
Materials Development	• Ensure that regulators, the regulated community and other stakeholders have the information they need to implement the WPS revisions: presentations, webinars, FAQs, fact sheets, How to Comply Manual, Inspector Guidance
Implement Pesticide Safety Training	• Ensure that updated pesticide safety training materials are available by June 2017 and that we have processes in place to approve train-the-trainer programs and pesticide safety training material

4

Who is missing in the previous slide?



5

Existing Protections During Applications

WPS Label statement:

- Requirement: "Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application."
  - Who is responsible for compliance: Applicator (handler)
  - Who is protected: Workers & other persons (besides protected handlers)
  - Is the protection limited to the boundaries of the ag establishment? No, it extends beyond boundaries

6

New Protections During Applications in Outdoor Production

Application Exclusion Zone (AEZ):

- Requirement (170.405(a)(1))
  - Effective January 2, 2017, the agricultural employer must ensure NO application is allowed to take place if workers or other persons are in the treated area or AEZ that is WITHIN the boundary of the establishment owner's property
  - The WPS establishes AEZ distances in outdoor production of 25 or 100 feet around the application equipment based on application method

7

A = Application
E = Exclusion
Z = Zone

8

AEZs in Outdoor Production (170.405(a)(1))

- 100 foot AEZ
  - Applied aerially, by air blast or with a spray quality smaller than medium (volume median diameter < 294 microns)
  - Applied as a fumigant, smoke, mist or fog
- 25 foot AEZ
  - Applied other than above & sprayed from a height of >12 inches from planting medium with spray quality of medium or larger
- No AEZ
  - Applied otherwise

9

Droplet Size and Relation to AEZ Pesticidestewardship.org

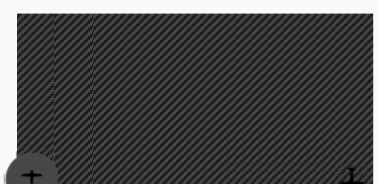
Color Codes for Droplet Size

AEZ	Category	Symbol	Color Code	Approximate VMD Range
100 foot AEZ	Very Fine	VF	Red	< 150
100 foot AEZ	Fine	F	Orange	150 – 250
25 foot AEZ	Medium	M	Yellow	250 – 350
25 foot AEZ	Coarse	C	Blue	350 – 450
25 foot AEZ	Very Coarse	VC	Green	450 – 550
25 foot AEZ	Extremely Coarse	XC	White	> 550

NC Cooperative Extension — Empowering People • Providing Solutions

10

Application Exclusion Zone in Outdoor Production



When the application is concluded, the AEZ no longer exists.

Field — AEZ — Treated Area

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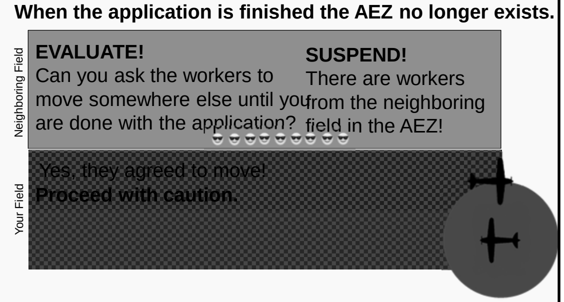
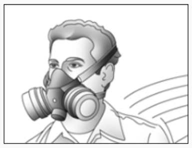
AEZs on Field Borders

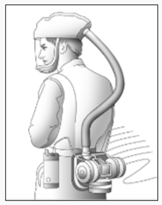
When the application is finished the AEZ no longer exists.



OSHA Requirements Adopted by WPS



Tight-fitting half mask elastomeric respirator



Loose-fitting Powered Air-Purifying Respirator (PAPR)

OSHA Small Entity Compliance Guide, 2011

13

Respirator Requirements in Revised Rule: 170.507(b)(10)

- When a respirator is required by the labeling, handler employer must provide handlers with the following before the handler performs any activity requiring the respirator:
  - Medical evaluation
  - Fit test
  - Respirator training
- Handler employer must maintain records for 2 years documenting completion of these.

14

Owner and Immediate Family Exemption

170.601(a)

- Key points about exemption:
  - There is no exemption for “family farms”
  - The “agricultural establishment” is NOT exempt
  - Exemption only covers the owner and immediate family members
  - ***Owners and immediate family must still comply with some WPS provisions and all labeling requirements***

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Owner and Immediate Family Exemption

170.601(a)

- **Owners and immediate family must still comply with the following WPS requirements:**
  - When respirators are required on the pesticide labeling, following WPS requirements for training, medical evaluation, fit testing, and recordkeeping (170.507(b)(10))
  - Providing and using the PPE and other work attire listed on pesticide labeling; but they are eligible for the allowable exceptions to PPE, such as for using a closed system (170.507(a), 170.507(b) and 170.607

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Owner and Immediate Family Exemption

170.601(a)

- **Owners and immediate family must still comply with the following WPS requirements:**
  - Keeping everyone, including members of the immediate family, out of the application exclusion zone during the application (170.405)
  - Ensuring that any pesticide applied is used in a manner consistent with the product’s labeling (170.309(a))

17

WPS Definition of Handler

Handler means any person, including a self-employed person, who is employed by an agricultural employer or commercial pesticide handler employer and performs any of the following activities:

1. Mixing, loading, or applying pesticides.
2. Disposing of pesticides.

…

9. Performing tasks as a crop advisor *during any pesticide application or restricted-entry interval, or before the inhalation exposure level listed in the pesticide product labeling has been reached*…

WPS Definition of Worker

Worker means any person, Including a self-employed person, who is employed and performs activities directly relating to the production of agricultural plants on an agricultural establishment.

Additional WPS Resources

- www2.epa.gov/pesticide-worker-safety
- www.pesticideresources.org
- **Ag Center,** http:www.epa.gov/agriculture

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So, doesn't this sound like fun?

This may be a bood time to explain "Train Wreck Insurance"

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Train Wreck Insurance is?

- Not actually property insurance.
- It is having enough knowledge to know when you have a problem and how to keep it from becoming a bigger concern.

UDAF WILL GIVE YOU TRAIN WRECK INSURANCE

- Inspection on how to comply
- Answer questions and give out information.
- Citations and fines ??????

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Other Employer Responsibilities

- **General responsibilities**
- **Minimum age (18)**
- **Pesticide safety training**

WPS PIRT
May 4, 2016

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Who Must Comply

All types of employers must comply with the requirements discussed in this session:

- Agricultural employers of workers
- Agricultural employers of handlers
- Commercial pesticide handler employers

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An employer must:

- Provide to each supervisor of workers or handlers (including labor contractors) information & directions sufficient to ensure the workers/handlers receive the WPS protections
  - Must specify the tasks for which the supervisor is responsible in order to comply
- Require each supervisor of workers or handlers (including labor contractors) to provide sufficient info & directions to the workers/handlers to ensure they can comply

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Employer

- Verify that all employed handlers and early-entry workers are at least 18 years old
  - In employment records
  - Focus on employees who seem close to 18

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Pesticide Safety Training
Workers 170.401(a) and Handlers 170.501(a)

- Key Changes
  - Annual training for workers and handlers
  - No grace period
- Implementation timing
  - January 2017 all new training requirements will be fully enforceable – EXCEPT new content.
  - January 2018 new content required.

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Trainer Qualifications for workers 170.401(c)4 and handlers 170.501(c)4

- Trainers of workers or handlers must either:
  - **be certified** as an applicator of RUPs, or
  - **have completed** an EPA-approved pesticide safety train-the-trainer program for handlers or workers, or
  - **be designated** as a qualified trainer by EPA or the agency responsible for pesticide enforcement.
    - Certified applicator or handler designation also qualifies them to train workers.
    - If only training workers, trainer only needs worker designation.

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Train-the-Trainer Implementation

- EPA will issue process for **approving train-the-trainer programs**
  - We will maintain a list of approved TTT programs
  - Recommend that TTT programs provide documentation (certificate) to "graduates"
  - TTT programs should keep a list of "graduates"
- PERC (cooperative agreement) is developing a **national train-the-trainer program**
  - Manual, online modules, hands-on curriculum

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What is UDAF going to do?

- All train the trainer programs – Utah Farm Bureau (UTFB) (1 Person) and Futures Through Training (FTT)(5 People) have obtained Private Pesticide Applicator Licenses
- The 1 UTFB person has taken the national online course
- UDAF is leaning towards each and every employer having a Private Applicator License so they can train their own employees
- The goal is to have all employers be able to train their employees.
- Note the family exemption no longer applies to training. You have to train your family and keep records for two years.

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Questions?

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- dmatthews@utah.gov
- 801-386-6510

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Honey and Chickens

Biographical Information:
James Barnhill
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Agriculture Extension Agent for 30 years. Area of expertise include crop production, pasture management, pest and disease control in crops. Recently retired from the Morgan and Weber County extension offices.

Session Description:
A hands on approach to raising chickens, and an introduction to producing honey.

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Season Extension

Biographical Information:

Daniel Drost
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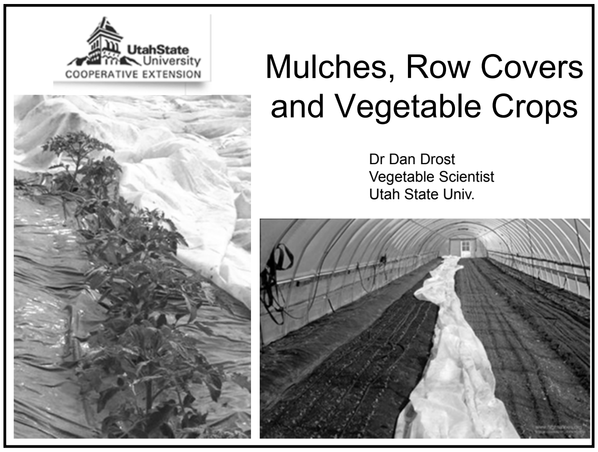
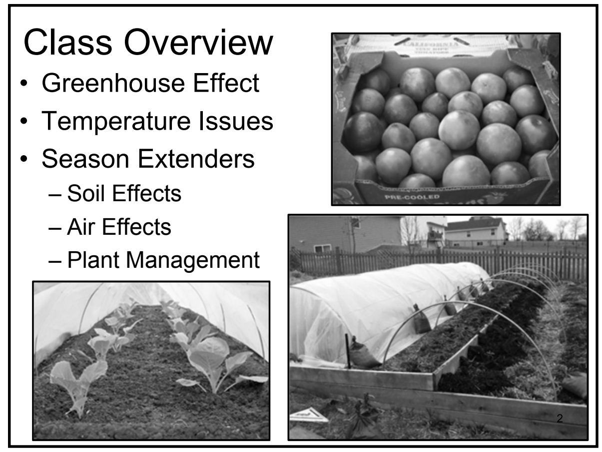
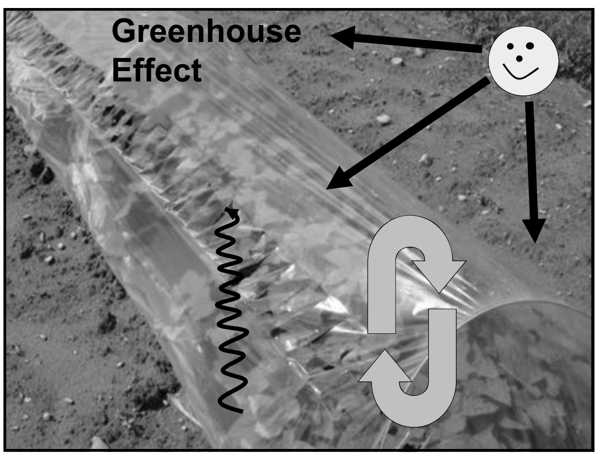
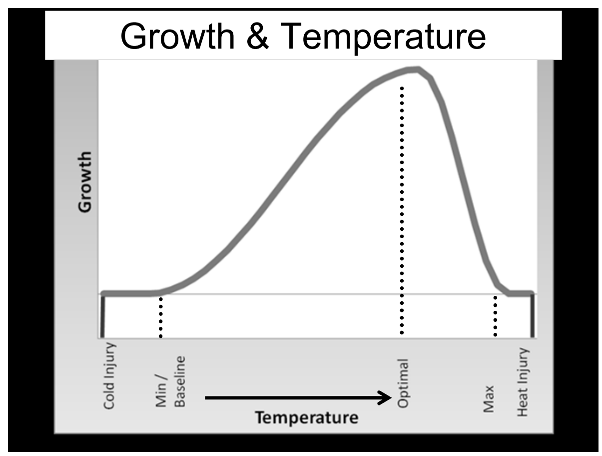
Dr. Drost is a Professor of Horticulture and Extension Vegetable Specialist in the Department of Plants, Soils and Climate at Utah State University. Dan has extension, research and teaching responsibilities that focus on small farms issues and addresses plant growth and crop production that impact Utah's commercial vegetable farms. Dr. Drost grew up on a diverse crop-livestock farm in Michigan and has a master's degree in horticulture from Michigan State University and a PhD in vegetable crops from Cornell University.

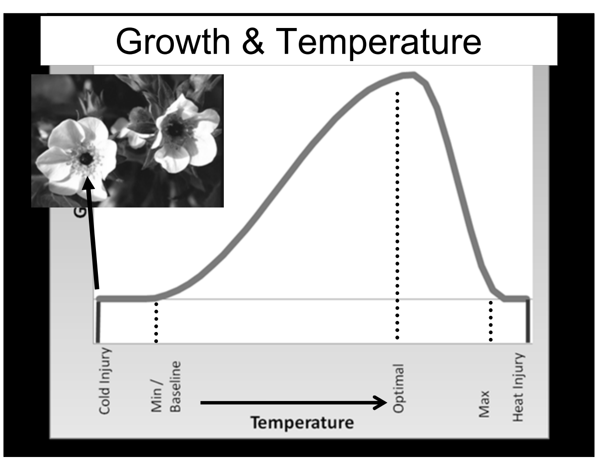
Session Description:
Introduction to green house effects, temperature issues, and season extenders.

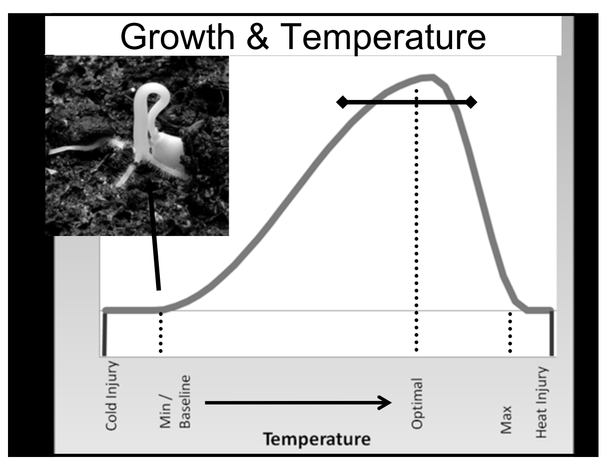

UtahState University
COOPERATIVE EXTENSION
Mulches, Row Covers and Vegetable Crops
Dr Dan Drost
Vegetable Scientist
Utah State Univ.

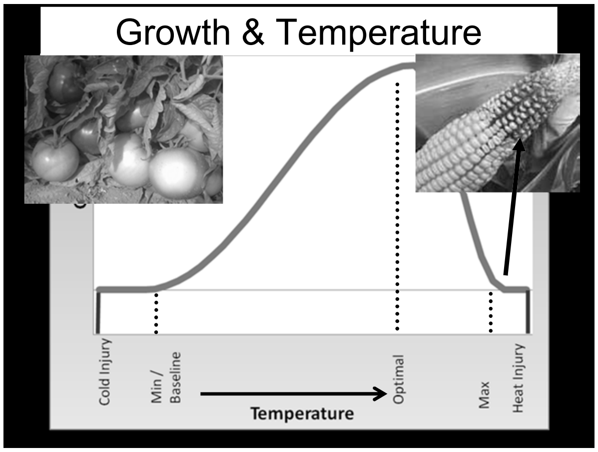

Class Overview
• Greenhouse Effect
• Temperature Issues
• Season Extenders
– Soil Effects
– Air Effects
– Plant Management
2


Greenhouse Effect


Growth & Temperature
Growth
Cold Injury
Min / Baseline
Temperature
Optimal
Max
Heat Injury


Growth & Temperature
Cold Injury
Min / Baseline
Temperature
Optimal
Max
Heat Injury


Growth & Temperature
Cold Injury
Min / Baseline
Temperature
Optimal
Max
Heat Injury



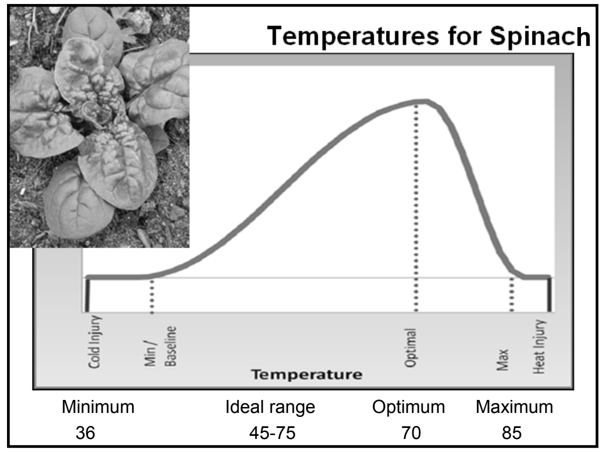


Table 2. Cardinal temperature for seed germination of select vegetables.

Crop	Minimum (°F)	Optimum (°F)	Maximum (°F)	Ideal range (°F)
Asparagus	50	75	95	60-85
Bean	60	80	95	60-85
Bean, lima	40	85	85	65-85
Beet	40	85	95	50-85
Cabbage	40	85	100	45-95
Carrot	40	80	95	45-85
Cauliflower	40	80	100	45-85
Celery	40	70	85	60-70
Chard, Swiss	40	85	95	50-85
Corn	50	95	105	60-95
Cucumber	60	95	105	60-95
Eggplant	60	85	95	75-90
Lettuce	35	75	85	40-80
Muskmelon	60	90	100	75-95
Okra	60	95	105	70-95
Onion	35	75	95	50-95
Parsley	40	75	90	50-85
Parsnip	35	65	85	50-70
Pea	40	75	85	40-75
Pepper	60	85	95	65-95
Pumpkin	60	90	100	70-90
Radish	40	85	95	45-90
Spinach	35	70	85	45-75
Squash	60	95	100	70-95
Tomato	50	85	95	60-85
Turnip	40	85	105	60-105
Watermelon	60	95	105	70-95

From Knott's Handbook for Vegetable Growers (4th Edition).

Table 3. Cardinal temperature for growth of selected vegetables.

Crop	Min. (°F)	Opt. (°F)	Max. (°F)
Chive, Garlic, Leek, Onion	45	55-75	85
Beet, Broad Bean, Broccoli, Cabbage Chard, Collards, Kale, Parsnips Radish, Spinach, Turnip	40	60-65	75
Artichoke, Carrot, Cauliflower, Celery Endive, Lettuce, Mustard, Parsley, Pea, Potato	45	60-65	75
Lima Bean, Snap Bean	50	60-70	80
Sweet corn	50	60-75	95
Pumpkin, Squash	50	65-75	90
Cucumber, Muskmelon	60	65-75	90
Sweet Pepper, Tomato	65	70-75	80
Eggplant, Hot Pepper, Okra, Sweet Potato, Watermelon	65	70-85	95

From Knott's Handbook for Vegetable Growers (4th Edition).

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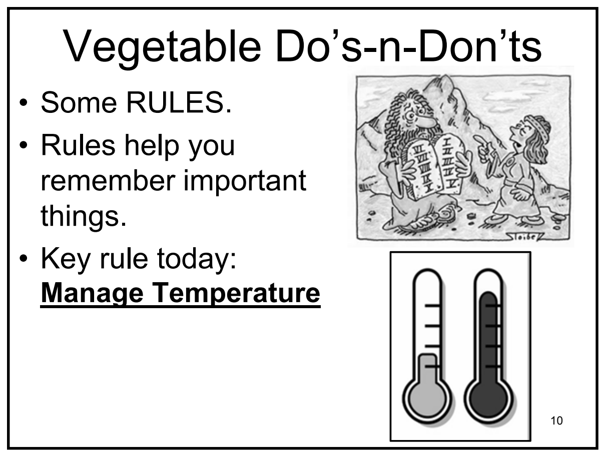
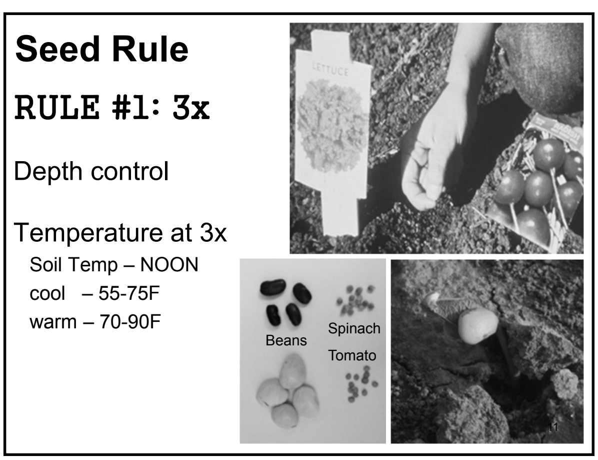
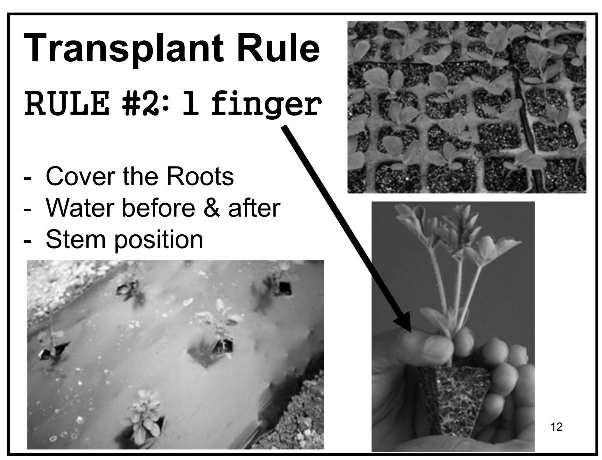
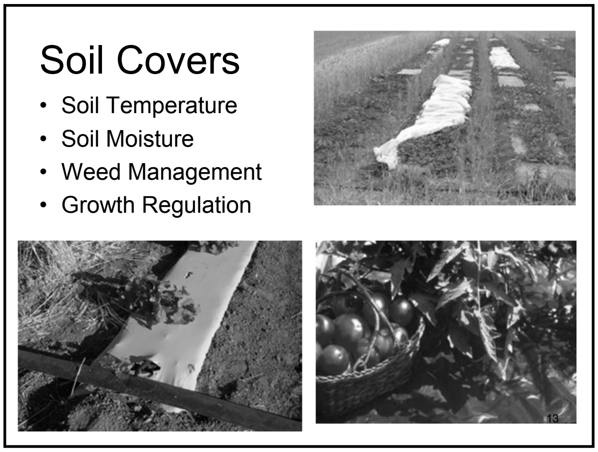
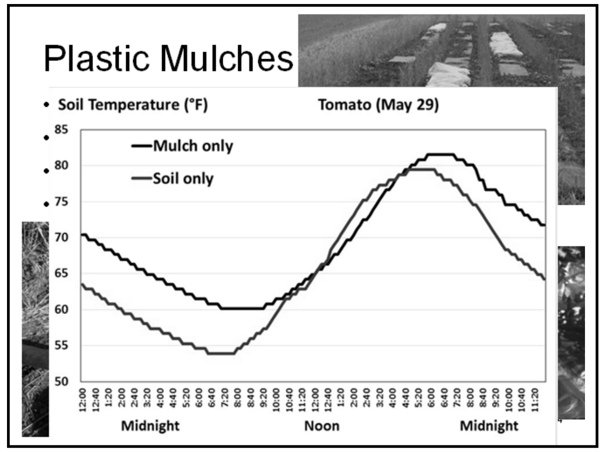
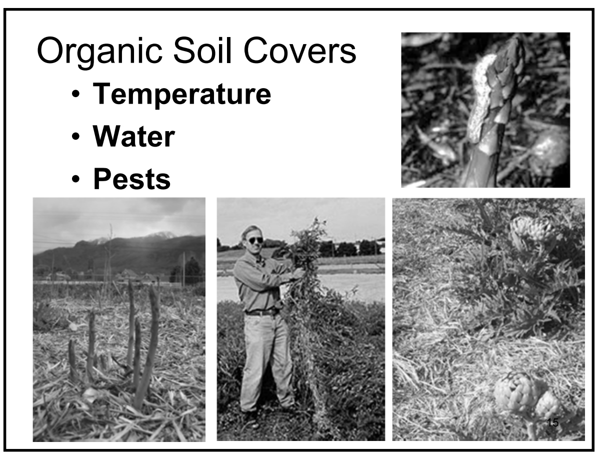


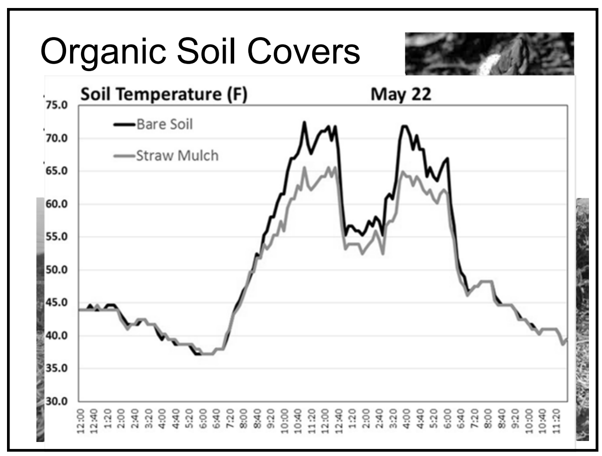


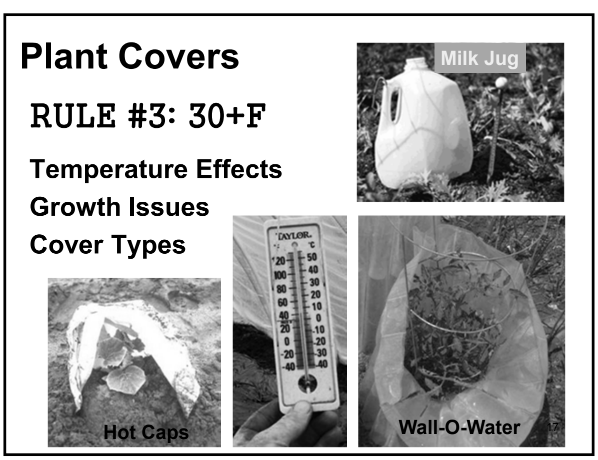



Soil Covers
• Soil Temperature
• Soil Moisture
• Weed Management
• Growth Regulation
13


Plastic Mulches
Soil Temperature (°F)
Tomato (May 29)
Mulch only
Soil only
Midnight
Noon
Midnight


Organic Soil Covers
• Temperature
• Water
• Pests
15

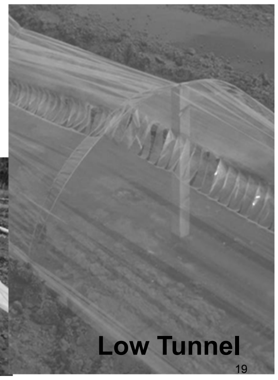

Organic Soil Covers
Soil Temperature (F)
May 22
Bare Soil
Straw Mulch


Plant Covers
RULE #3: 30+F
Temperature Effects
Growth Issues
Cover Types
Milk Jug
Hot Caps
Wall-O-Water
17


Purpose:
➢ Creating better growing conditions for plants.
➢ Earlier/Later production
➢ Grow more vegetables
Why Covers?

Row Covers

Temperature (+10-30F)
Insect Issues
Growth Changes



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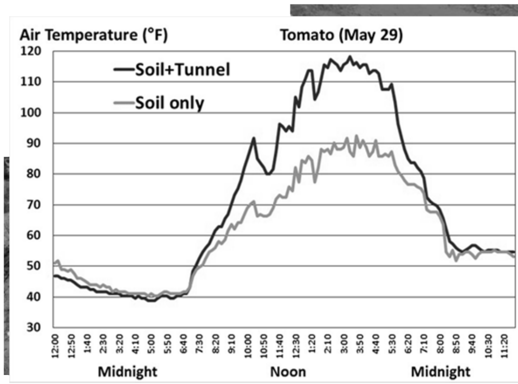
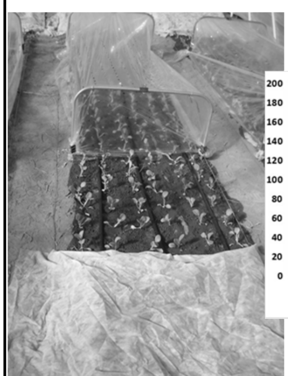
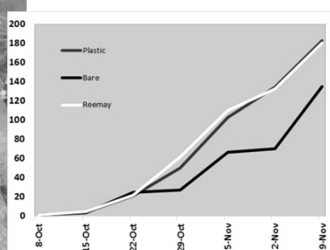
Row Covers

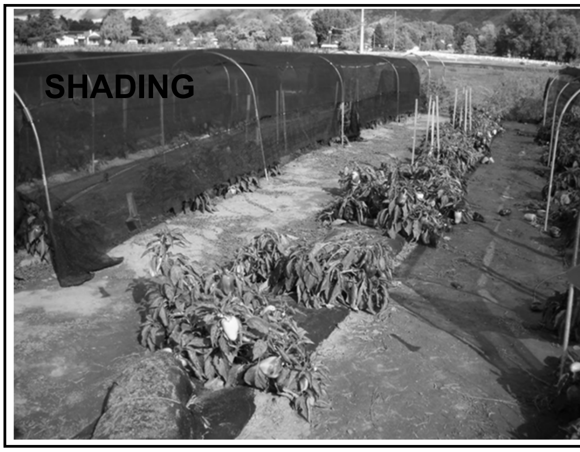


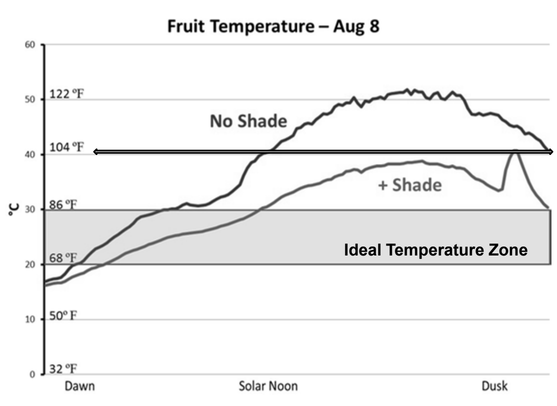
Spinach Growth





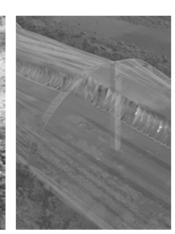
21





Things to remember

1) Managing Temperature….
   - Soil and Air
2) Other Benefits: Fewer Weeds; Better Water
3) Change When you Grow



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Farm Food Safety

Background Information:

Karin Allen
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8700 Old Main Hill
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Karin Allen is an Associate Professor in the Department of Nutrition, Dietetics and Food Sciences at Utah State University and serves as the Food Quality and Entrepreneurship Specialist for Cooperative Extension. Dr. Allen works with small food producers (both on and off the farm) to address food processing issues including labeling, safety, and regulatory compliance, as well as issues specific to agritourism and community supported agriculture operations.

Session Description:

An introduction to farm food safety, including safe growing, harvesting, and post-harvesting conditions. A general introduction to the government programs that address food safety like FSMA and GAP.

Farm Food Safety

Karin Allen, PhD

EXTENSION
UtahStateUniversity
EXTENSION.USU.EDU

Why should I worry about food safety?

- Centers for Disease Control (CDC) estimates that each year in the US:
  - 48 million people get sick from a foodborne illness
  - 128,000 people are hospitalized because of foodborne illness
  - 3000 people die because of foodborne illness
- The USDA estimates that these illnesses cost $15.6 billion per year

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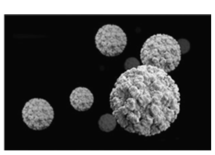
Most Foodborne Illness is Caused by Viruses and Bacteria

- Some cause illness more frequently, but the symptoms are mild
- Norovirus and *Salmonella* cause the most illness in the US
- *Salmonella* has been responsible for many produce recalls



Source: Centers for Disease Control

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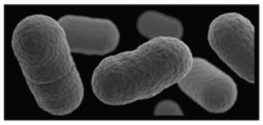
Most Foodborne Illness is Caused by Viruses and Bacteria

- Some types occur less frequently, but the illness is more likely to be severe or fatal
- *Listeria* and *E. coli* O157:H7 can cause severe symptoms or death
- Both of these bacteria have been responsible for produce recalls



Source: Centers for Disease Control

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Where are the Contaminants From?

- Bacteria and viruses can come from many places
  - Environmental sources
  - Harvesting or processing equipment
  - Workers who are ill
- Most bacteria is destroyed when food is cooked
  - Produce is often eaten raw, so bacteria is still alive
  - Contaminated produce can spread bacteria to other foods and equipment

Food Safety is everyone's responsibility.

But it begins on the farm!

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Safe Growing Practices

- Clean shoes or boots before working in the field to prevent outside contaminants from being brought in
- Do not eat, drink, smoke or chew gum when working in the field
- Watch for evidence of wild animals in the field, and do not bring pets
- Follow all requirements for using natural fertilizers

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Safe Harvesting Practices

- Use cleaned, sanitized containers whenever possible
- Do not harvest dropped produce (fruits or vegetables that have fallen off of a vine or tree)
- Do not harvest produce that has obvious animal damage
- Follow all Safe Growing Practices during harvest as well

Safe Post-Harvest Practices

- Wash hands before handling harvested produce
- Clean and sanitize food-contact surfaces before starting
- Some types of produce should be triple rinsed
  - This removes dirt that can contain additional bacteria
- NEVER handle harvested produce when you are ill

What is wrong with this picture?

Programs that Address Food Safety

- There are laws that require food safety standards are met
  - Food Safety Modernization Act (FSMA)
- There are inspections and audits that require food safety standards are met
  - Good Agricultural Practices (GAP)
- There are other programs that do not focus on food safety, but include some standards
  - National Organic Program (NOP)

FSMA – Food Safety Modernization Act

- FDA regulations that must be followed by produce growers
  - Some exemptions based the size of the farm and the crops they grow
- "Produce Safety Rule" published in 2015
  - Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption
- Mandatory inspections conducted by the FDA or the State Department of Agriculture
- Specific regulations focused on microbial safety of food
  - Five major sources of contamination are addressed
- Emphasis is on evaluating/preventing risks and recordkeeping

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Produce Safety Rule Focus Areas

- Worker Training and Health and Hygiene
- Agriculture Water (includes irrigation and postharvest water sources)
- Biological Soil Amendments
- Domesticated and Wild Animals
- Equipment, Tools, and Buildings

FSMA compliance does not guarantee you will pass a GAP audit!

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GAPs – Good Agricultural Practices

- USDA program based on FDA's Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables
- Implemented in 2002
- Voluntary audits performed by USDA, State Departments of Agriculture, or other private companies
  - Many buyers may require GAP audits
- Overall food and worker safety requirements

GAP audits do not guarantee you are in compliance with FSMA!

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Where to Find Information

- Utah State University Extension
  - extension.usu.edu
- Utah Department of Agriculture and Food (UDAF)
  - ag.Utah.gov
- Food and Drug Administration (FDA)
  - www.fda.gov
- United States Department of Agriculture (USDA)
  - National Organic Program: www.ams.usda.gov
  - Good Agricultural Practices: www.ams.usda.gov/services/auditing/gap-ghp

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