

The background features abstract, overlapping geometric shapes in various shades of green, ranging from light lime to dark forest green. These shapes are primarily located on the left and right sides of the slide, framing the central text. The overall aesthetic is clean and modern, with a focus on natural, earthy tones.

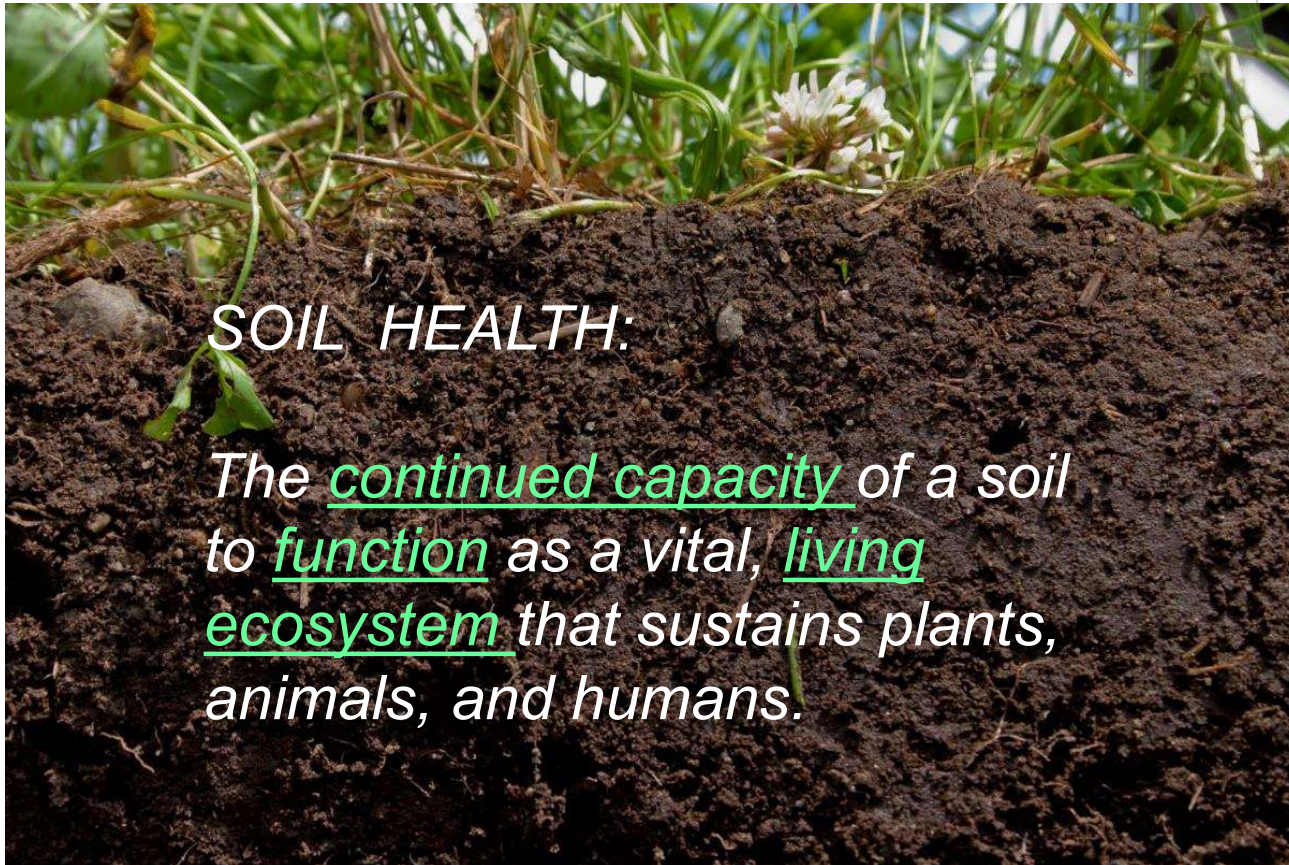
# Soil Health and Permanent Beds

# It all starts with the soil

- ▶ Your soil will make or break your vegetable production operation
- ▶ What does soil do??
- ▶ Functions of soil (as it pertains to vegetable production)
  - ▶ Medium for plant growth
  - ▶ Regulator of water supplies
  - ▶ Recycler of raw materials
  - ▶ Habitat for soil organisms
  - ▶ Stores and supplies nutrients to plants
- ▶ To be successful you must understand you are soil farmers



## How do We Define Soil Health?

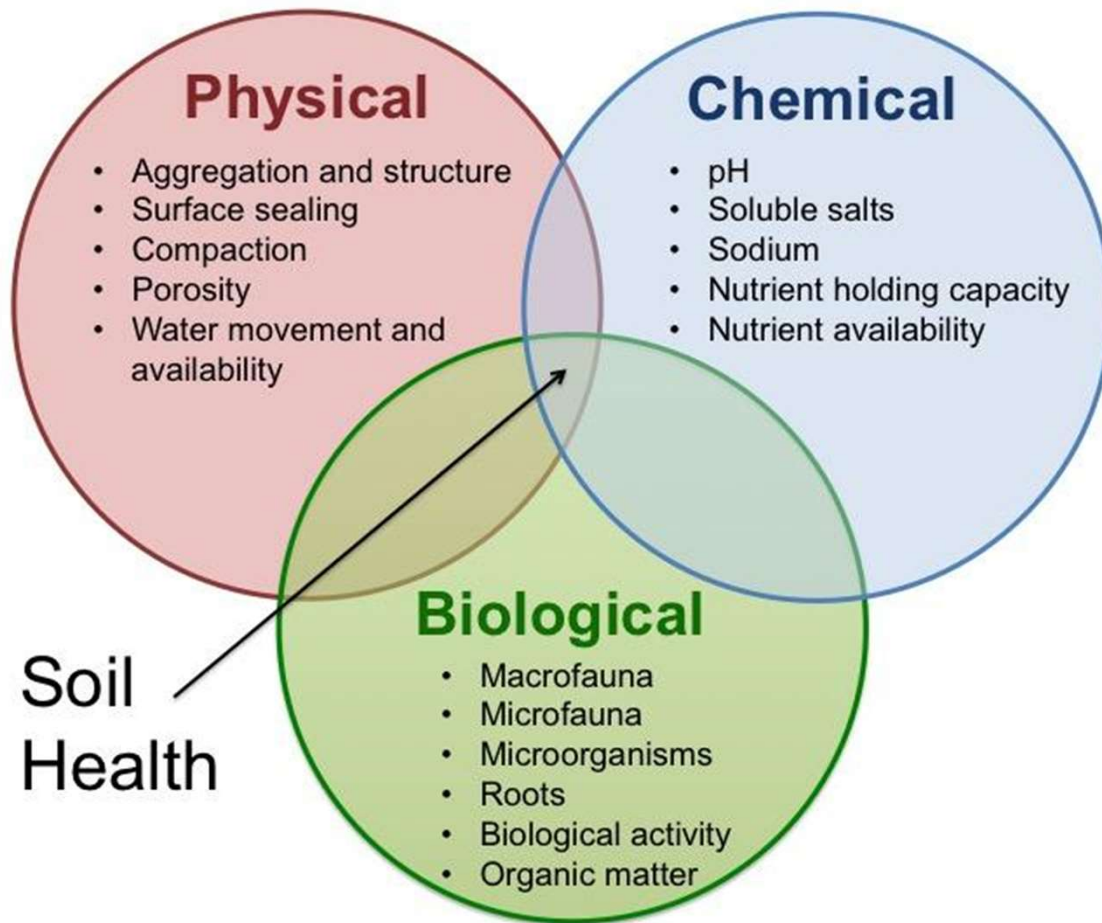


### *SOIL HEALTH:*

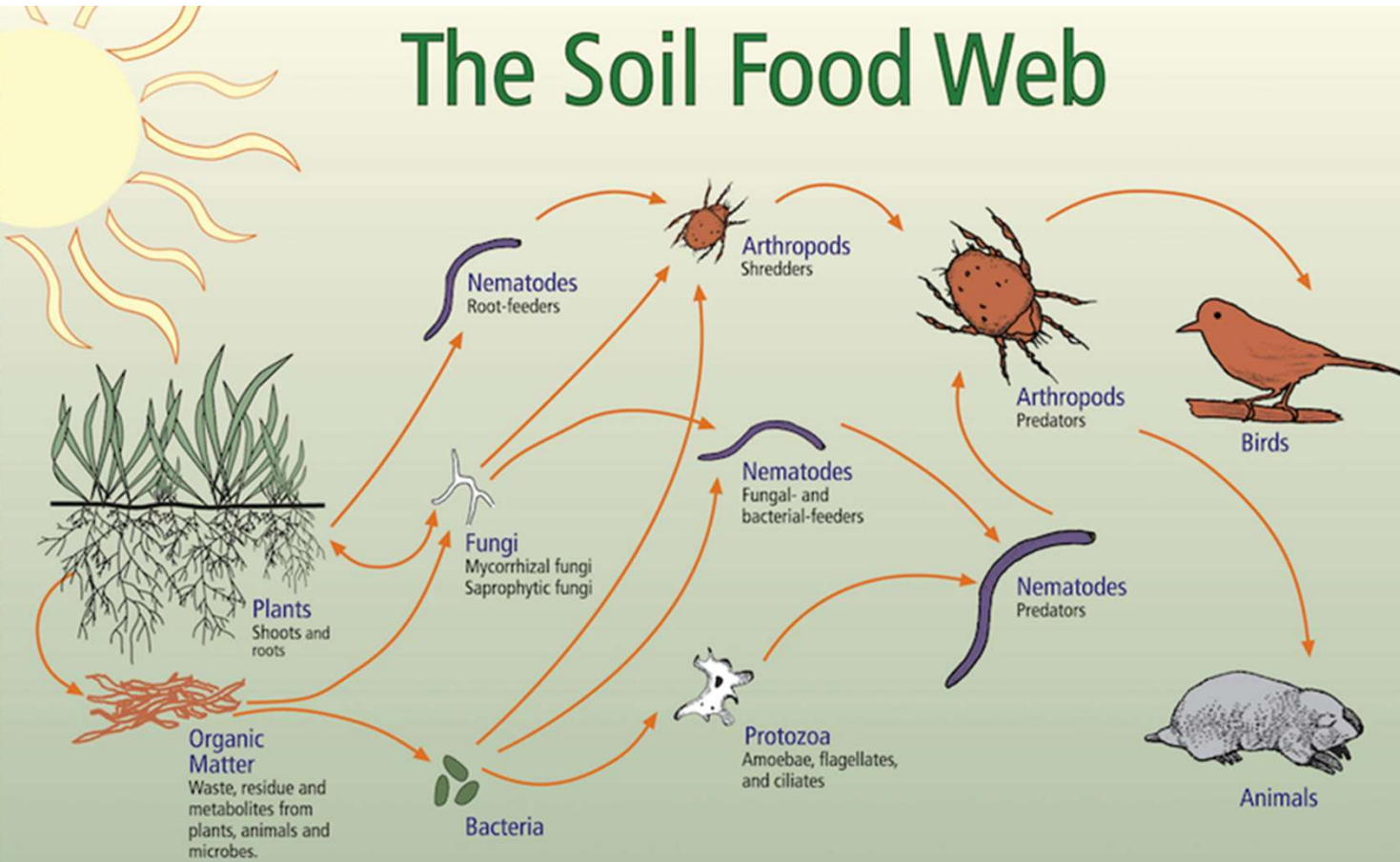
*The continued capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans.*



# Soil Properties



# The Soil Food Web



**First trophic level:**  
Photosynthesizers

**Second trophic level:**  
Decomposers  
Mutualists  
Pathogens, Parasites  
Root-feeders

**Third trophic level:**  
Shredders  
Predators  
Grazers

**Fourth trophic level:**  
Higher level predators

**Fifth and higher trophic levels:**  
Higher level predators



what's underneath

One teaspoon of *healthy* soil contains

**100 million-  
1 billion** individual  
bacteria

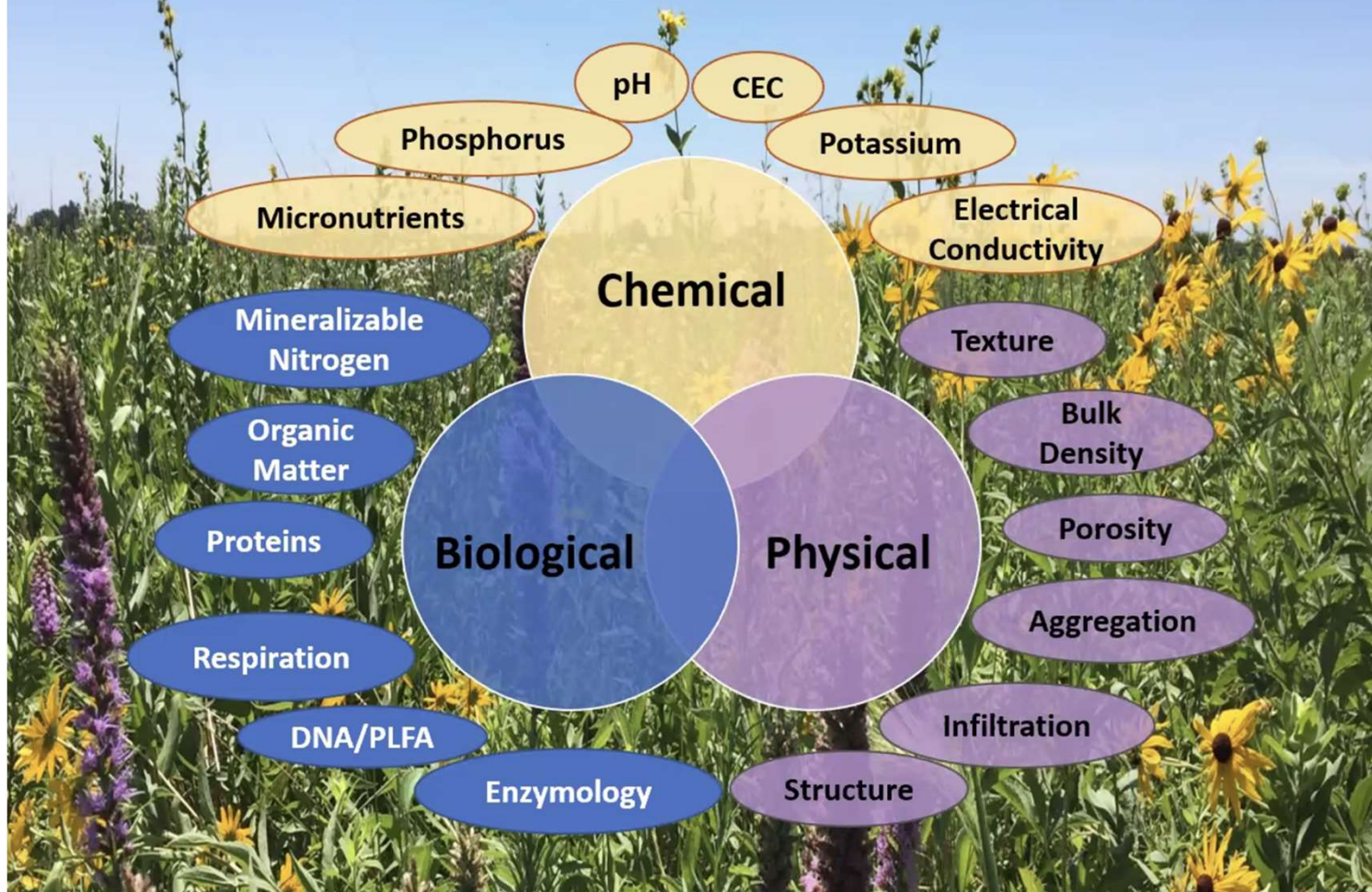
Source: *Soil Biology Primer* page c-1 (Elaine Ingham, Andrew R. Moldenke, Clive Edwards)

**USDA** United States  
Department of  
Agriculture

Want more soil secrets?  
Check out [www.nrcs.usda.gov](http://www.nrcs.usda.gov)

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# Soil Health Indicators





## 4 Principles that Conserve the Soil Ecosystem



1. Minimize Disturbance
2. Maximize Soil Cover
3. Maximize Biodiversity
4. Maximize Continuous Living Roots

*Care for your belowground livestock as you would your aboveground livestock*

Natural  
Resources  
Conservation  
Service

[nrcs.usda.gov](https://nrcs.usda.gov)



## MAXIMIZE CONTINUOUS LIVING ROOTS

- Crop Rotation
- Relay Crops
- Forage and Biomass Planting
- Perennial Crops
- Cover Crops

## MINIMIZE DISTURBANCE

- No-till
- Reduced Tillage
- Controlled Traffic
- Avoid Tillage When Wet
- IPM

## MAXIMIZE BIODIVERSITY

- Crop Rotation
- Rotational Grazing
- IPM
- Pollinator Plantings
- Organic Fertilizers
- Legumes in Mix
- Agroforestry
- Cover Crops
- Crop/ Livestock Integration

## MAXIMIZE SOIL COVER

- Mulching
- Reduced Tillage
- Forage and Biomass Planting
- Residue Retention
- Cover Crops
- Green Manures

4

### SOIL HEALTH PRINCIPLES

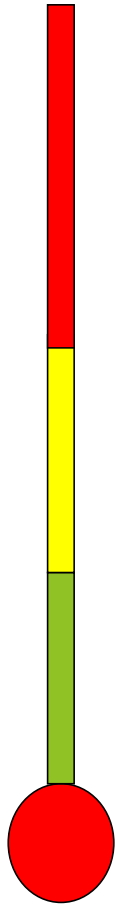
Nutrient/  
H<sub>2</sub>O Mgt



# Soil Health Principles to Support High Functioning Soils



# When soil temperature reaches...



**140 F** Soil bacteria die

**130 F** 100% moisture is lost through evaporation and transpiration

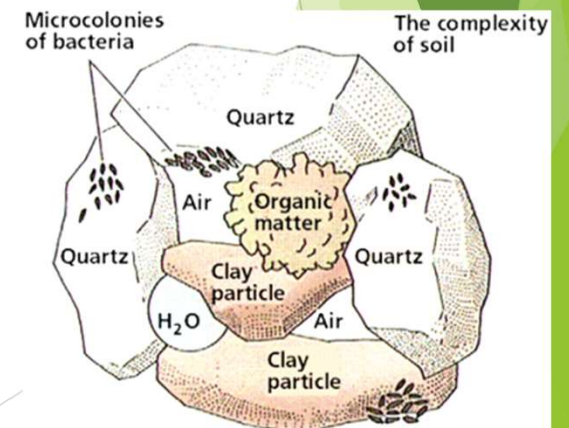
**100 F** 15% of moisture is used for growth  
85% moisture lost through evaporation and transpiration

**70 F** 100% moisture is used for growth



## Soil Health

- organic matter
- aggregate stability
- water infiltration
- water-holding capacity
- nutrient use efficiency
- diverse soil biology
- **soil function**



Slide by Kris Nichols: USDA ARS Lab ND.



➤ Soil organic matter (SOM) is <6% of soil by weight but controls >90% of the function

Slide by Kris Nichols: USDA ARS Lab ND.



# Conservation Cropping Practices




# Conservation Practices

- Cover crops
- Mulching
- Crop rotation
- No-till / Low-till





## Soil Health Management Systems

What is it?		What does it do?	How does it help?
<p><b>Crop Rotation</b></p> <p>Growing a diverse number of crops in a planned sequence to increase soil organic matter and biodiversity in the soil.</p>		<ul style="list-style-type: none"> <li>• Increases nutrient cycling</li> <li>• Manages plant pests (weeds, insects, and diseases)</li> <li>• Reduces sheet, rill and wind erosion</li> <li>• Holds soil moisture</li> <li>• Adds diversity so soil microbes can thrive</li> </ul>	<ul style="list-style-type: none"> <li>• Improves nutrient use efficiency</li> <li>• Decreases pests</li> <li>• Improves water quality</li> <li>• Conserves water</li> <li>• Improves plant production</li> <li>• Increases yields</li> </ul>
<p><b>Cover Crop</b></p> <p>An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.</p>		<ul style="list-style-type: none"> <li>• Increases soil organic matter</li> <li>• Prevents soil erosion</li> <li>• Conserves soil moisture</li> <li>• Increases nutrients cycling</li> <li>• Suppresses weeds</li> <li>• Reduces tillage / compaction</li> </ul>	<ul style="list-style-type: none"> <li>• Improves crop production</li> <li>• Improves water quality</li> <li>• Conserves water</li> <li>• Improves nutrient use efficiency</li> <li>• Decreases use of pesticides</li> <li>• Improves water efficiency to crops</li> </ul>
<p><b>No Till* / Reduced Till</b></p> <p>A way of growing crops without minimal soil disturbance.</p> <p><i>*No till is optimal, and is possible when good soil health is achieved through a conservation cropping system.</i></p>		<ul style="list-style-type: none"> <li>• Improves water holding capacity of soil</li> <li>• Increases organic matter</li> <li>• Reduces soil erosion</li> <li>• Reduces energy use</li> <li>• Decreases compaction</li> <li>• Increases soil moisture for plants</li> </ul>	<ul style="list-style-type: none"> <li>• Improves water efficiency</li> <li>• Conserves water</li> <li>• Improves crop production</li> <li>• Improves water and air quality</li> <li>• Improves crop production</li> <li>• Saves renewable resources</li> </ul>



# What are salts?

- ▶ Dissolved inorganic solutes
- ▶ Common soluble salts are
  - ▶ Calcium, magnesium, sodium, chloride, sulfate and bicarbonate
- ▶ Sources include
  - ▶ Commercial fertilizer
  - ▶ Animal manure
  - ▶ Compost
- ▶ Manure have a higher level of salts than commercial fertilizers



# The challenge

- ▶ Rain leaches a field of salts
- ▶ No access to rain/snow in greenhouse
- ▶ Results in build up of salts in soil



# The impact

- ▶ High salts cause
  - ▶ Difficulty for crops to obtain water
  - ▶ Reduced plant growth
- ▶ Exposure to above average levels results in:
  - ▶ Root injury
  - ▶ Leaf Chlorosis
  - ▶ Marginal burn of leaves
  - ▶ Wilting
- ▶ Different vegetables have different sensitivity to salts
- ▶ Seed germination and seedlings most susceptible



# Salinity levels

## mmhos/cm at 25° C\*

less than 0.40

0.40 – 0.80

0.81 – 1.20

1.21 – 1.60

1.61 – 3.20

More than 3.20

## Effects\*\*

Salinity effects mostly negligible.

Very slightly saline; but yields of very salt sensitive crops may be restricted.

Moderately saline. Yields of salt sensitive crops are restricted. Seedlings may be injured. Satisfactory for well-drained greenhouse soils.

Saline condition. Yields of most crops restricted. Salinity higher than desirable for greenhouse soils.

Strongly saline. Only salt tolerant crops yield satisfactorily. Bare spots due to germination injury. Greenhouse soils should be leached.

Very strongly saline. Only a few very salt tolerant crops yield satisfactorily.



# Vegetables and their sensitivity

## \*Rating Interpretation:

S = Sensitive  
MS = Moderately sensitive  
MT = Moderately tolerant  
T = Tolerant

## 1:2 Soil/Water Ratio

0.0 - 0.8 mmhos/cm  
0.9 - 1.6 mmhos/cm  
1.7 - 2.4 mmhos/cm  
2.5 - 3.2 mmhos/cm

## Vegetable Crops


Artichokes  
Asparagus  
Beans  
Beets, red  
Broccoli  
Cabbage  
Carrots  
Cauliflower  
Celery  
Cucumbers  
Kale  
Kohlrabi  
Lettuce  
Onions  
Peas  
Peppers  
Potatoes  
Pumpkins  
Radishes  
Spinach  
Squash  
Tomatoes

## Tolerance Rating

MT  
T  
S  
MT  
MS  
MS  
S  
MS  
MS  
MS  
MS  
MS  
MS  
MS  
S  
S  
MS  
MS  
MS  
MS  
MS  
MS  
MS  
MS

# Potential solutions

- ▶ Annual testing for salts in soil
- ▶ Place high tunnel in areas with good drainage
- ▶ Match fertilizer application with plants growth
- ▶ Expose to rain/snow during winter
- ▶ Use irrigation water to leach out salts
  - ▶ 6 inches- leach 50% of salts
  - ▶ 12 inches- leach 80% salts

Report Number F22302-0885			3505 Conestoga Dr. Fort Wayne, IN 46808 360.983.4719 algreatlakes.com									
Account Number 42185												
Soil Test Report												
Reported To	Customer Information		Sample Information									
IASWCD	Name	BROXONBERRY FARM	Lab Number	23440								
225 S EAST ST STE 142	Farm		Date Received	10/28/2022								
INDIANAPOLIS, IN 46202-4002	Field		Date Reported	11/1/2022								
	Sample ID	1										
Analysis Results												
Analysis	Result	Soil Test Rating										
		Very Low	Low	Medium	High	Very High						
Organic Matter, %	15.5	[Progress bar]										
pH	7.8	[Progress bar]										
Buffer pH		[Progress bar]										
Phosphorus, Bray-1 Equiv ppm P	456	[Progress bar]										
Potassium, ppm K	357	[Progress bar]										
Magnesium, ppm Mg	1145	[Progress bar]										
Calcium, ppm Ca	4350	[Progress bar]										
Sodium, ppm Na	94	[Progress bar]										
Cation Exchange Capacity, meq/100g	32.6	[Progress bar]										
Potassium, % Cation Saturation	2.8	[Progress bar]										
Magnesium, % Cation Saturation	29.3	[Progress bar]										
Calcium, % Cation Saturation	66.7	[Progress bar]										
Hydrogen, % Cation Saturation		[Progress bar]										
Sodium, % Cation Saturation	1.3	[Progress bar]										
Soluble Salts (1:2), mmho/cm	0.4	[Progress bar]										
Sulfur, ppm S	33	[Progress bar]										
Zinc, ppm Zn	17.8	[Progress bar]										
Iron, ppm Fe	81	[Progress bar]										
Manganese, ppm Mn	34	[Progress bar]										
Copper, ppm Cu	2.2	[Progress bar]										
Boron, ppm B	5.1	[Progress bar]										
Soil Fertility Recommendations - Pounds per 1,000 Square Feet												
Intended Crop	Yield Goal (acre basis)	Lime	Nitrogen (N)	Phosphorus (P <sub>2</sub> O <sub>5</sub> )	Potash (K <sub>2</sub> O)	Magnesium (Mg)	Sulfur (S)	Zinc (Zn)	Manganese (Mn)	Iron (Fe)	Copper (Cu)	Boron (B)
Market Garden		0	2	0	2	0	0.00	0.00	0.05	0.00	0.02	0.00
												0.00
Comments												
Report reviewed and approved by our professional agronomy staff.												



# Permanent Beds



# Choosing a growing site

- ▶ Determine last spring and first fall frost date
- ▶ Determine frost free days
- ▶ Is site large enough to meet your needs
- ▶ Soil type
- ▶ Orientation of site (slope vs direction)
- ▶ Are there depressions if so can they be corrected
- ▶ Seasonal water table height
- ▶ Is there access to water
- ▶ Does the soil have contaminants



# Permanent beds

- ▶ Permanent beds will have
  - ▶ Low weed pressure
  - ▶ Soil fertility will increase over time
  - ▶ Soil microbial diversity will increase as well
  - ▶ Soil compaction will be eliminated
  - ▶ Water and nutrient holding capacity will improve



# Once you have chosen your sight

- ▶ To decide what approach you take next will be determined by the following:
  - ▶ When you start your land prep
  - ▶ How much time you have
  - ▶ What equipment you have



# Mark your beds

- ▶ Identify and stake out the corners of bed
- ▶ Your rows will be 30” wide
  - ▶ Industry standard
  - ▶ Most market garden tools are 30”
- ▶ Walkways will be 14” wide
  - ▶ Allows for room to squat and harvesting totes
- ▶ Length is based on your operation but needs to be consistent
- ▶ Consistent size allows for easier
  - ▶ Production evaluation
  - ▶ Row covers and landscape fabric can be one size only



# Set up beds

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# If you are preparing your soil.....

- ▶ Slow way
- ▶ In summer and plant in the spring
- ▶ Utilize a silage tarp
  - ▶ Identify the area you want to start working
  - ▶ Mow as close to the soil as possible
  - ▶ Add compost to surface
  - ▶ Law down silage tarp
  - ▶ Provide adequate weight along the edges (sand bags)
  - ▶ Leave it in place until the following spring



# Silage Tarp





# Slow way

- ▶ Tarp, Cardboard, Compost (no tillage)
  - ▶ Let that sit over the winter
- ▶ Till, Tarp, Spread compost (6”), Cover Crop for several months
  - ▶ Low weed pressure
  - ▶ Great Soil Tilth
  - ▶ Can be done in fall
  - ▶ Cover crops work compost into ground (improved microbial numbers)
  - ▶ Keeps weeds at bay
- ▶ Till, Tarp, Cover crop for several months
  - ▶ Works great as well
  - ▶ Keeping living roots in the ground



## Slow way (cont.).....

- ▶ Lasagna gardening
  - ▶ Layers of compost, Layer of carbonaceous material, repeat
  - ▶ Allow it to break down for some time



# Fast Way.....

- ▶ Fast Way
- ▶ Will always come with some issue
- ▶ Plow, Till, Plant
  - ▶ Mulch with 4 inches of compost and cover with straw
- ▶ Till, light compost, plant
- ▶ Mow, 8 inches of compost over layer of cardboard / mulch paper
  - ▶ Takes a lot of compost
  - ▶ Works best as a slow method



## Another Option

- ▶ Constructed raised beds
- ▶ Minimum 6” deep
- ▶ Filled with equal parts
  - ▶ Compost
  - ▶ Peat moss
- ▶ Other recipes are out there



# Bed Maintenance

- ▶ Maintenance
  - ▶ Weekly - Weed bed, Look / respond to insect pressure / plant disease
  - ▶ Monthly- If necessary apply supplemental nutrients
- ▶ Bed Turn Over
  - ▶ Remove all plant debris (some root mass is ok)
  - ▶ Remove any rocks
  - ▶ Broadfork
  - ▶ 2 inches Compost
  - ▶ Amendments
  - ▶ Form beds



# Broadfork

- ▶ A tool used to aerate the soil
  - ▶ Used every 12 inches
  - ▶ Prevents compacted soil
  - ▶ Compacted soil - Inhibits soil biology



# Tilther

- ▶ Power tool driven tiller
  - ▶ Tills only 2 inches into the soil
  - ▶ Creates a seed bed



# BCS

- ▶ Walk behind tractor (not a tiller)
- ▶ Over 20 attachments





## Bed preparation rake

- ▶ Used to remove rocks and roots from soil
- ▶ 30" wide



# Landscape fabric

- Use keep to keep week pressure to a minimum
- Fabric cab be purchased with holes burnt in or you can DIY



# Stirrup hoe

- ▶ Great for weeding beds



# Flame weeder

- ▶ Used to weed garden
- ▶ Used on small weeds only





Questions

?

