Soil Management Strategies for

Improving Air Quality & Enhancing Energy Efficiency

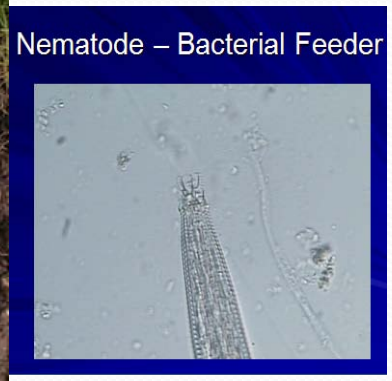
Clarence Chavez 4/2010

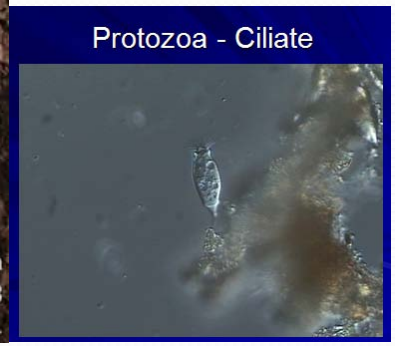
Quality Feed takes less Energy to Produce

Produce a high quality feed and the animal intake will be less!

Soils are not machines:

It's an ecosystem that needs to be Fed and Covered with Plants and residue at all times.





Soil's holds the sustenance of our lives!

A soil that filters, breathes and grows the food, but not without the interaction with water and air.

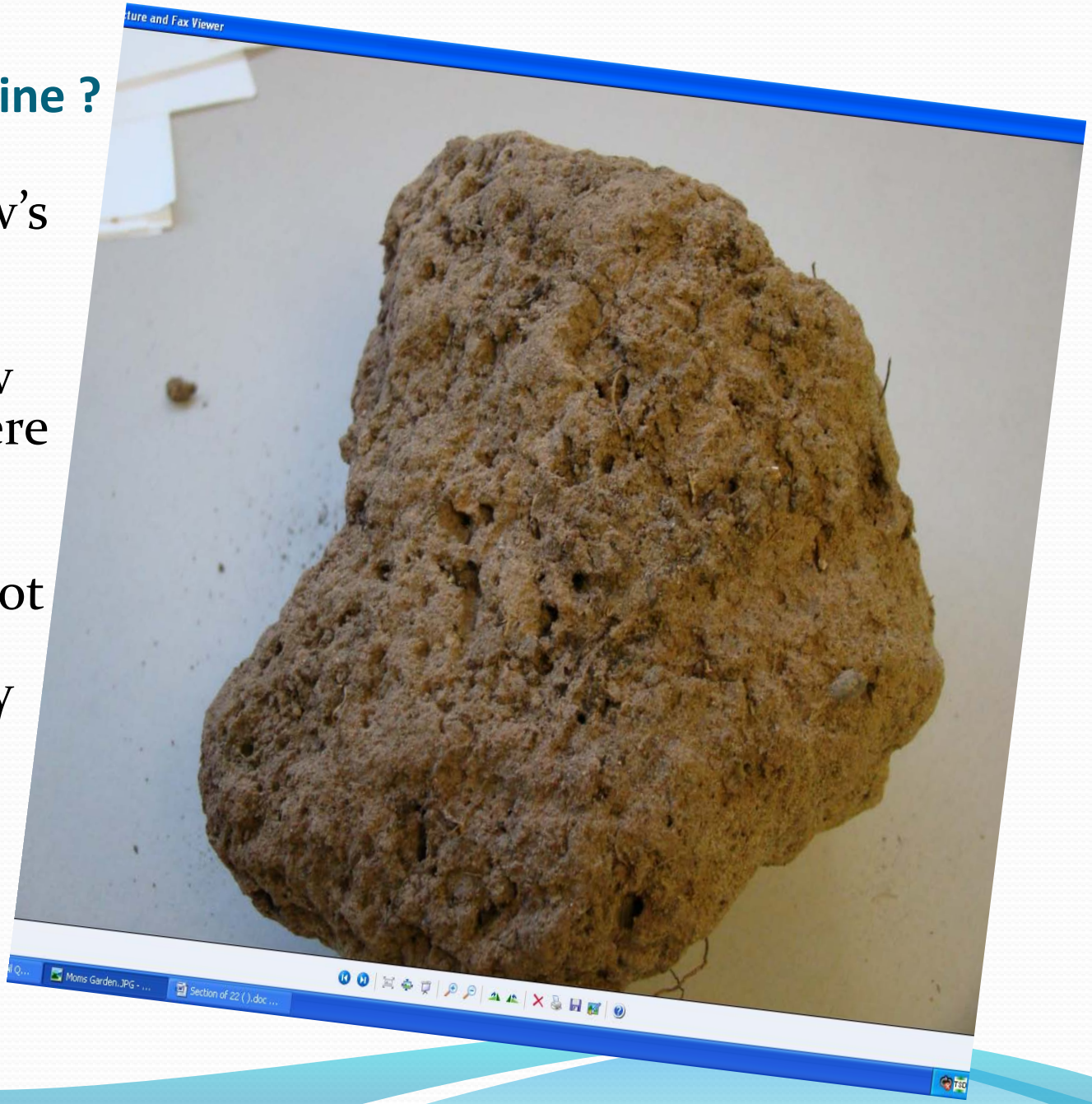
We as an agency have started to teach our field employees about soil quality and soil health as they relate to Water Quality, Plant Health, Air Quality, Energy Efficiency, etc…!

What is your Base Line ?

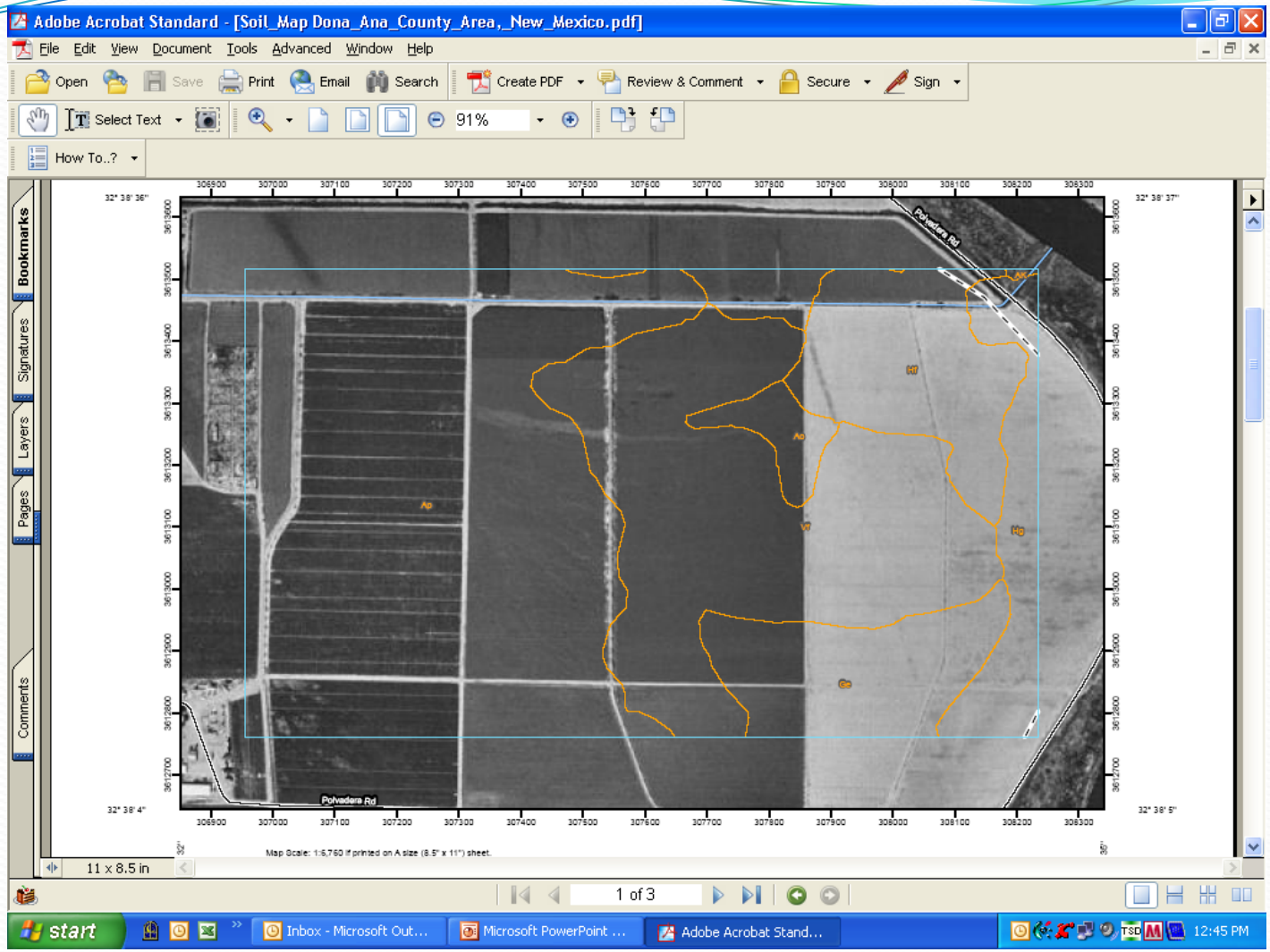
Soil Health & How's it Functions.

If you do not know your soils and where they are.

You probably do not know how to improve air quality or enhancing energy efficiency .



What do we assess and where?



Use it with wisdom...

The Soil Survey is a good start

Farmed soils have been Plowed, Land Leveled, Disked, Chiseling, Irrigated, Fertilized, Animal Hoof Action, Grazing, etc.

Testing for your Soil Baseline

Tissue, Water and Soil Lab Tests - $110

Active Carbon Tests

Soil Quality Test Kits in each office

Since the soils have been manipulated we must depend on field assessments.

Soil Health / Soil Function

To reduce energy and improve air and water quality

Taking care of the soil is where it is at!

CO^2

Soil Respiration

Soil Biota

O^2

Soil

Infiltration

Infiltration: Tilled vs Non-Tilled

Tilled soils use more energy than non-tilled soils – horse power, fuel, and create air quality and erosion problems.

Respiration / Infiltration

Soil Respiration (lbs CO_2-C/a/d)	Class	Soil Condition (Table 1. pg. 53) (Class ratings & soil conditions at optimum soil temp. & moisture)
0	No soil activity	Soil has no biological activity and is virtually sterile
< 9.5	Very low soil activity	Soil is very depleted of available OM and has little biological activity.
9.5 - 16	Mod. low soil activity	Soil is somewhat depleted of available OM, and biological activity is low.
16 - 32	Medium soil activity	Soil is approaching or declining from an ideal state of biological activity.
32 – 64	Ideal soil activity	Soil is in an ideal state of biological Activity has adequate OM and active populations of microorganisms
> 64	Unusually high soil activity	Soil has a vary high level of microbial activity and has high levels of available OM, possibly from the additions of large quantities of fresh OM or manure.

Infiltration Rate (inches/hr)	Infiltration Class Table 3. pg. 56
> 20	Very rapid
6 – 20	Rapid
2 – 6	Mod. rapid
0.6 – 2	Moderate
0.2 – 0.6	Mod. slow
0.06 – 0.2	Slow
0.0015 - .06	Very slow
< 0.0015	Impermeable

Soil Respiration

Use of cover crops not only helps the soil biota and control erosion as well as improve:

- Soil tilth
- Increase organic matter levels
- Enhances water infiltration
- Lessens pests (weeds and bugs)
- Soil organic matter levels (up or down)
- Recycle Nutrients

Soil Infiltration

is sensitive to near surface conditions.

Indicator of compaction or soil pore clogging (degradation)

Which leads to **decreased yields** and increased erosion rates.

Soil Biota help create good infiltration

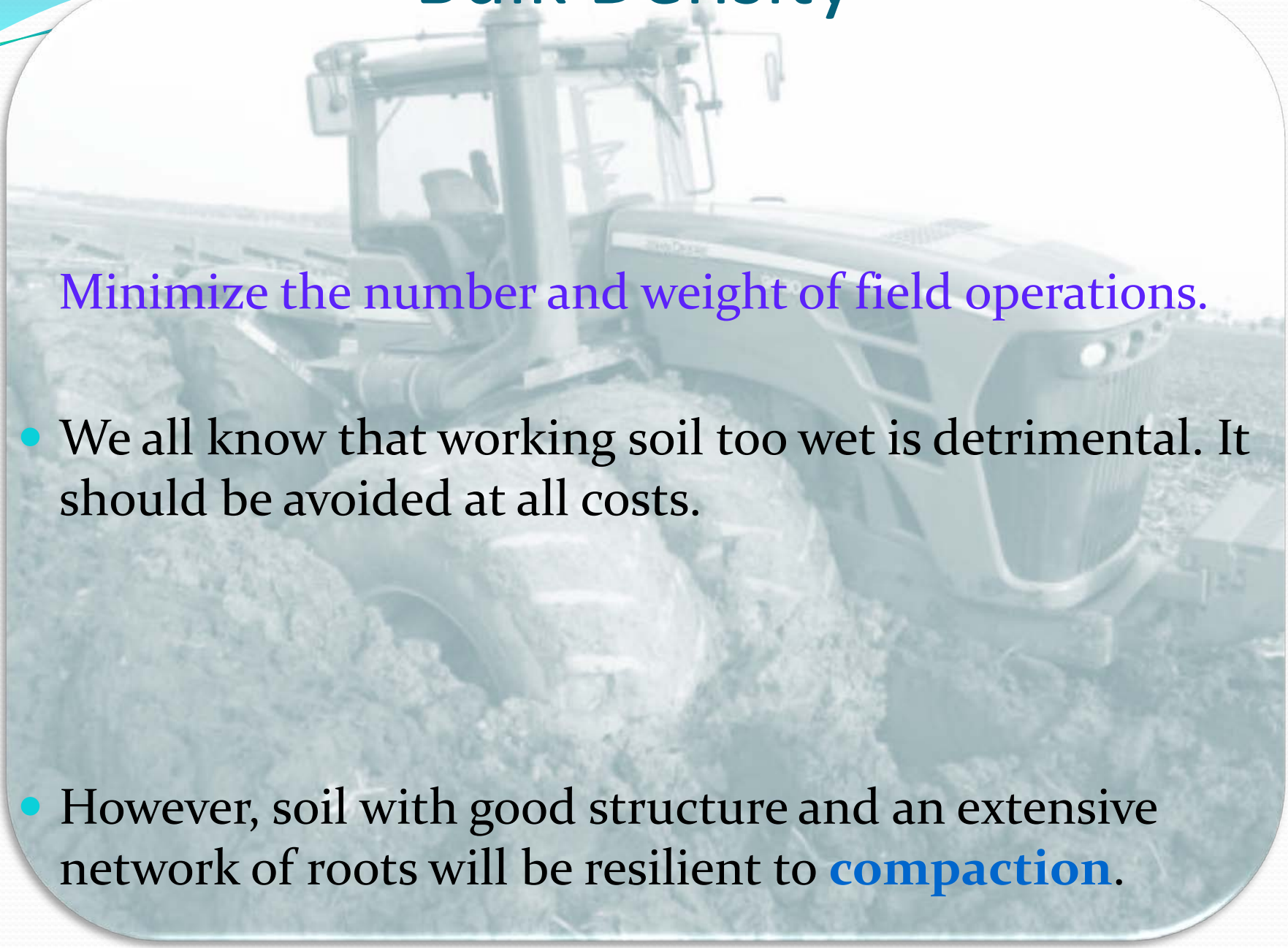
Bulk Density

Bulk Density (Soil Type Table 4. pg. 57)	Ideal Bulk Densities (g/cm^3)	Bulk Densities that restrict root growth
sands, loamy sands	< 1.6	> 1.80
sandy loams, loams	< 1.4	> 1.80
S. C. loams, loams, clay loams	< 1.4	> 1.75
silts, silt loams	< 1.3	> 1.75
silt loams, silty clay loams	< 1.4	> 1.65
S. clays, silty clays, some clay loams (35-45% clay)	< 1.10	> 1.58
clays (> 45% clay)	< 1.10	> 1.47

Bulk Density / Compaction

Ground Truth

Bulk Density



Minimize the number and weight of field operations.

- We all know that working soil too wet is detrimental. It should be avoided at all costs.

- However, soil with good structure and an extensive network of roots will be resilient to **compaction**.

Irrigation Salinity (pg. 80)	EC	TDS
Classification - Table 11	(dS/m)	(mg/l)
No effects usually noticed	0.75	500
Can have detrimental effects on sensitive crops	0.75 – 1.50	500 – 1,000
Can have adverse effects on many crops	1.50 – 3.00	1,000 – 2,000
Can be used for tolerant plants (on permeable soils)	3.00 – 7.50	2,000 – 5,000

Salts in the soil Rating (Table 6. pg. 61)	EC range for 1:1 soil:water suspension for which yield reductions occur
S = Sensitive	> 0.90 dS/m
MS = Mod. Sensitive	> 1.40 dS/m
MT = Mod. Tolerant	> 2.50 dS/m
T = Tolerant	> 4.0 dS/m

Electrical Conductivity

Use a soil test and water test to be accurate then use the Crop Salt Tolerance Tables.

Indicates the amount of salts present in the soil. (K^+, Ca^+, Mg^+, Na^+, SO_4^{-2}, Cl^-, HCO_3^-, Co_3^{-2})

Excess salts will hinder plant growth i.e. salt affected irrigation water. Salt Crop Tolerance Table

Soil and Water EC

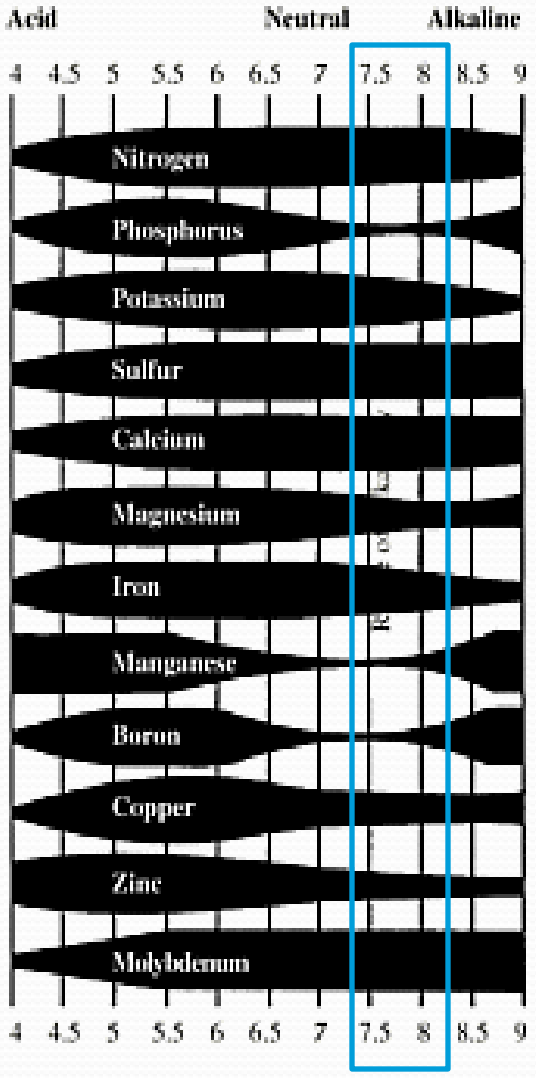
The bottom line

- Timing and amount of watering will help in the management of salts in any soil.

- Soil Health is very important – Infiltration, Leaching, Structure, Tilth, Plant Vigor.

pH -- is the measure of the acidity or alkalinity

of a soil or Water, which affects the availability of plant nutrients, activity of microorganisms, and the solubility of soil minerals



Soil and Water pH

The bottom line

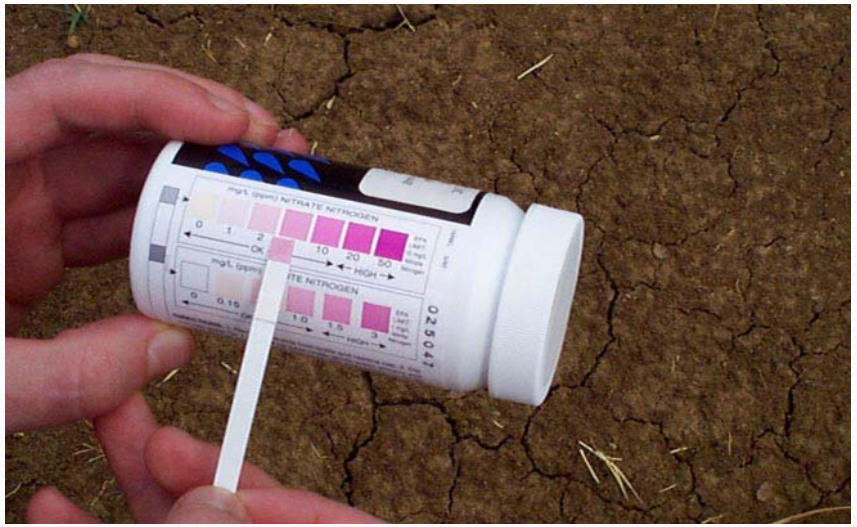
- Soil pH also affects the activity of beneficial microorganisms, which affects nutrient availability, uptake and stability.

- A healthy soil, high in Organic Matter will regulate its own pH, appropriate to the plant root.

- pH values between 6 and 7.5 are optimum for general crop growth, NM soils range from 7.5 to 8.2

Nitrogen requirements from fertilizers, irrigation water and the decompositions of crop residue by microbes must be checked for excess

Soil Nitrate / Nitrite



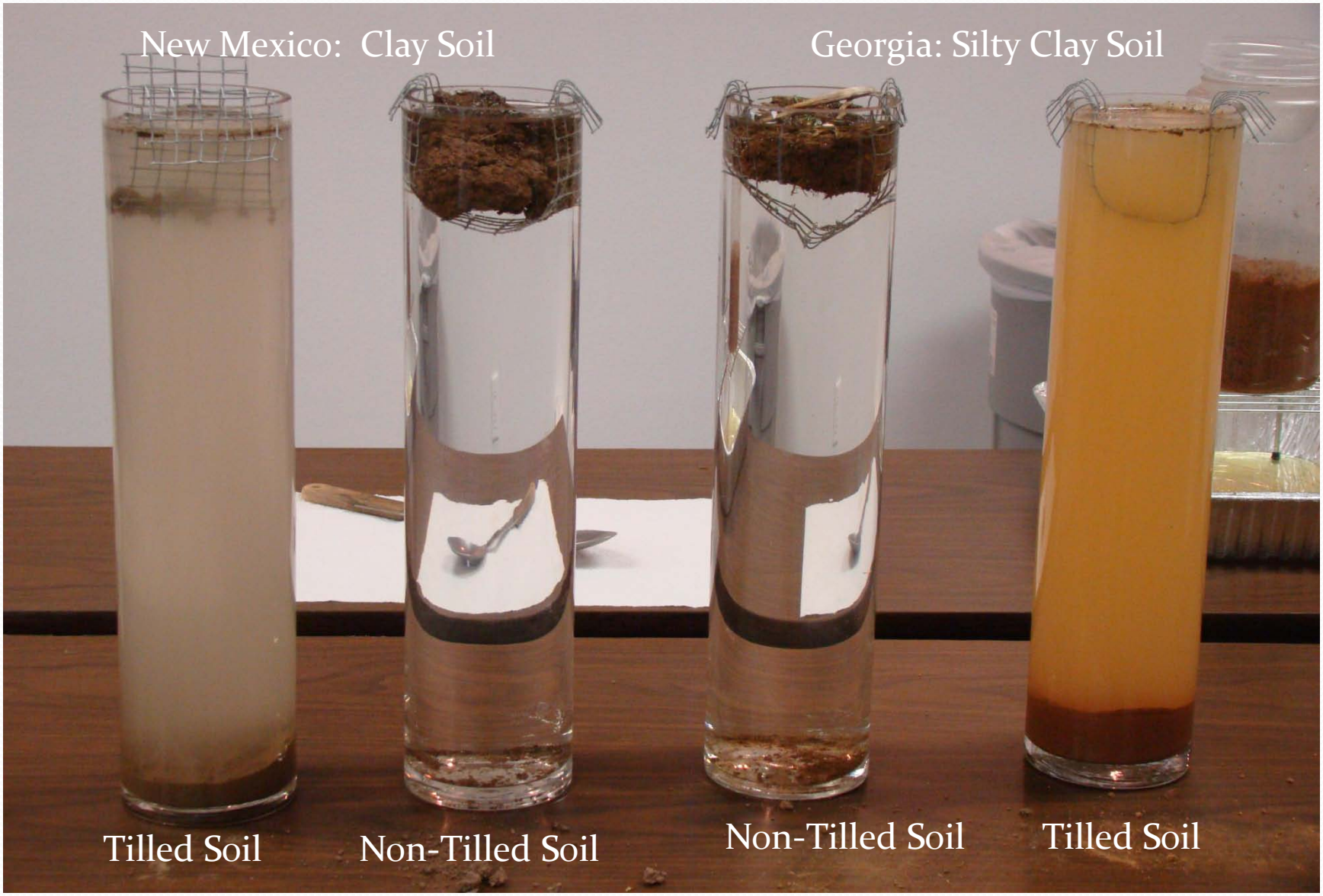
Nitrate (NO_3) / Nitrite (NO_2)

Proper fertilizer use.

- Fertilizers (in crop residue, manure, etc…) that enhance the soil. The best approach is to feed the soil biota, which will in turn feed the plant.

- A good soil will grow healthy crops. Don't over do it with fertilizer amendments (follow a nutrient management plan) as that is a waste and can be a pollutant.

Water Stable Aggregate:
See the difference: what Tillage would do to a healthy soil.



Aggregate Stability / Soil Slaking - Classes

- ✓ Class 0 to 3 are relatively unstable.
- ✓ Class 4 indicates some stability, but very little strength.
- ✓ Classes 5 and 6 represent relatively stable soil fragments or aggregates.

strength relates to the ability of the soil to resist loss of its structure

Aggregate Stability

- Table 8:

Organic Matter (%)	Water Stable Aggregates (%)	Clay (%)	Water Stable Aggregates (%)
0.4	53	5	60
0.8	66	10	65
1.2	70	20	70
2	75	30	74
4	77	40	78
8	81	60	82
12	85	80	86

- For example: for a soil with 2% organic matter and 10% clay, the suitable aggregate stability range (taken from Table 8) would be 65 to 75% water stable aggregates.

Aggregate Stability

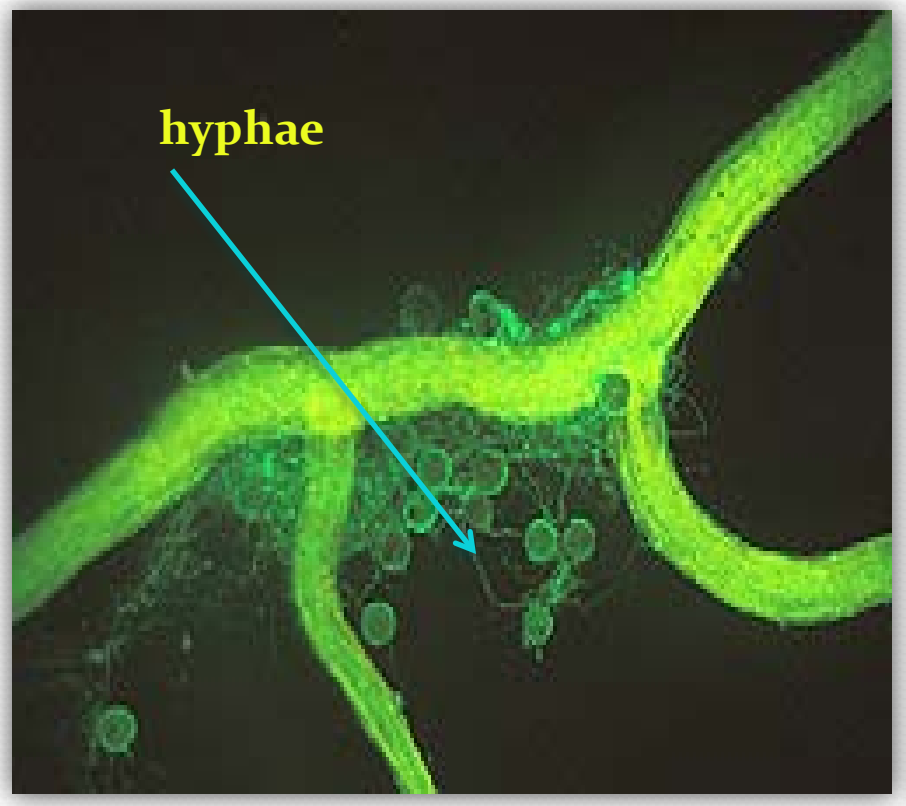
- **Assist in Water Holding Capacity / Increase Soil Organic Matter.**
- **Protects organic matter from rapid breakdown from soil biota.**
- **Minimize tillage practices such as: "Plow – Disk – Floating etc…"**

Note: Tillage systems that maximize surface residues are preferred.
Use tillage sparingly to solve specific soil problems.

Major practices – cover crop or cocktail mixture cover crops (2 to 12 seeds),
no till or minimum till
crop rotation, mulching, composting,
IWM, IPM, nutrient management, etc.

Fungal Hyphae – produce humic compounds and organic "glues" (extra-cellular polysaccharides, proteins, lipids, etc…)

Glues bind soil particals into aggregates which improves soil porosity, nutrient cycling, respiration, reduce erosion.



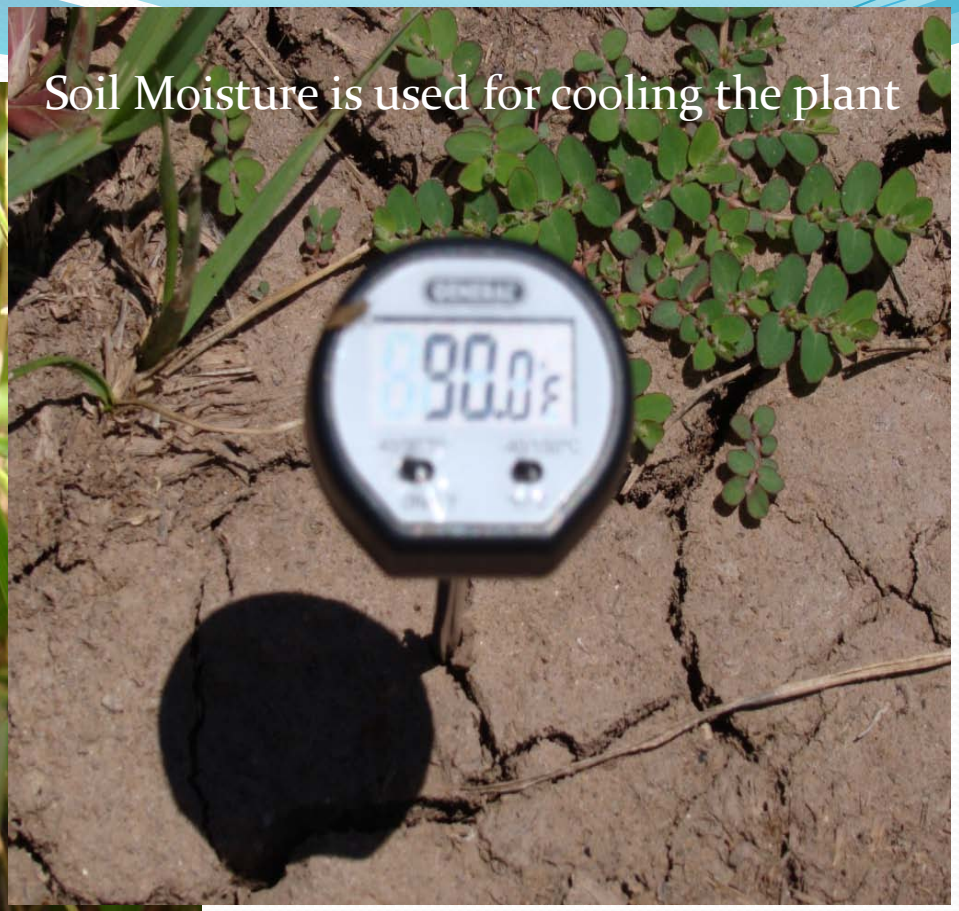
Symbiosis of the Mycorrhizal fungi and other members of the fungi family are
-- soil structure builders

Increasing Nutrients Availability: "Available plant nutrients (N, P, & K) tend to be higher in fresh earthworm casts than in the bulk soil." [Edwards et al., 1995]

10 Earthworms per cubic food is a good indicator of soil health

65 -90 Degrees F

Soil Moisture is used for growing the plant

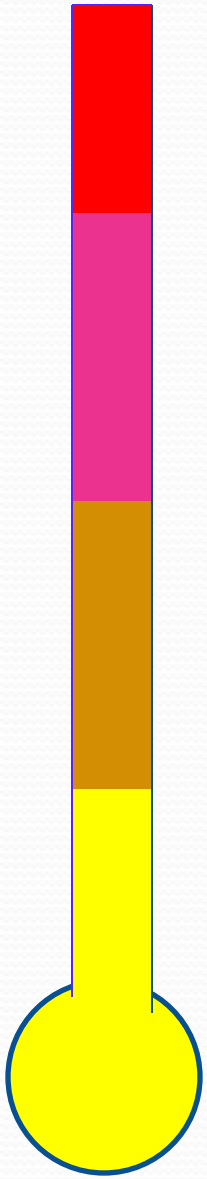


Soil Moisture is used for cooling the plant

ENVIRONMENT FOR SOIL BIOTA AND CROP ROOTS (I.E., INCREASED NUTRIENT CYCLING AND WATER USE EFFICIENCY)

Soil Temperatures

- 140 degrees, soil bacteria die.
- 101-130 degrees, 100% moisture lost through evaporation and transpiration. Some species of bacteria, arthropods, start dying
- 95 -100 degrees, 15% moisture used for growth, 85% moisture lost through evaporation and transpiration.
- 65 - 95 degrees, 100% moisture used for growth. Soil Biota is active and doing their job.



Soil physical observations and estimations of: depth, roots, structure, texture, and aggregate stability

- Measuring the depth of topsoil
- Observe plant roots
- Examine soil structure, texture, color, fragments, pore space, depth etc...

Hidden Message : Root Diversity and Keep Roots Growing

Active Carbon

What is Active Carbon?

The active carbon component in soil consists of:

1. Microbial biomass carbon
2. Particulate organic matter
3. Soil carbohydrates
4. Amino acids
5. Fine and very fine roots

Active C

- Many soil properties impact soil quality, but organic matter deserves special attention.

- It affects several critical soil functions, can be manipulated by land management practices, and is important in most agricultural settings across the country.

The Active C in the Field

1) Organic matter enhances nutrient and water holding capacity
2) Improves soil tilth
3) Improves soil structure (Glomalin, Soil Biota)
4) Enhances crop productivity and quality
5) Environmental quality (Air and Water)
6) Reduce the severity and costs of natural atmospheric CO_2, levels that contribute to climate change.
7) Reduces soil /wind erosion.

The NRCS Active C Field Kit
Does 10 samples at a time (5 gr each)

Critical solutions made up for analysis (permanganate solution)

Taking the color density reading

What does Active C – do in soil?

- ✓ Small amounts of Active Carbon makes a huge difference in aggregate stability (Soil Structure).
- ✓ Bulk Density of a soil will decrease with higher amounts of organic carbon (no matter how small the increase).
- ✓ Increased infiltration. (Microbes/OM)
- ✓ Reduced soil crusting. (Glomalin/Soil Glues)
- ✓ Higher water holding capacity.
- ✓ Improved nutrient cycling.

Lab Testing

Is a **means of estimating the nutrient supplying power of the**

Soil, Water, Tissue

Tissue

Water

Soil

(PW-2) Irrigation Water, Soil and Plant Tissue Analysis Interpretation GUIDE (Example))

PW 2 - Cropping System Guide - Sante Fe-Nambe at Loomis Farm.pdf - Adobe Acrobat

File Edit View Document Comments Forms Tools GeoPDF Advanced Window Help

(PW-2) Irrigation Water, Soil and Plant Tissue Analysis Interpretation GUIDE (Example)

Producer: Nambe, NM **Crop:** Peas **Yield:** 2,379 lb/ac **Irrigation Water:** 13 ac-in (No. of irrigations =)

Tillage Operations: minimum tillage with incorporated cover crops (rye)

Soil Texture: Clay **Soil Structure:** Granular **Aggregate Stability:** Good (high Organic Matter)

Nutrients	Irrigation Water Analysis (ppm x 0.23 x 13" = lb./ac.)		Soil Analysis 0-6" depth (ppm x 1.7 = lb./ac.)		Nutrient Inputs	Plant Tissue Analysis Note: N is kjeldahl nitrogen & Sulfur is total Sulfur		Should I Apply Nutrients? - Yes (Y) No (N) - Maintenance (M) - Not Sure (?) - Other (O)	Conservation Practices to consider for achieving sustainability
ON = Organic Nitrogen mineralized	ppm or mg/l	Pounds per Acre	ppm or mg/Kg	Pounds per Acre (VL, L, M, H, &VH)	Pounds per Acre	% or ppm & Rating (low - high)	Sufficiency Range (bud to full bloom)		
Organic Matter			1.51%	25,670				O: cover crops	♥ Cover Crops
N mineralized			ON	32.0	≈ 90 -150			O: legume	
Nitrate-Nitrogen	Not	Analyzed	25.9	44.0 H	N	4.1% H	3.1-3.6%	N: don't apply	
Phosphorus			7.5	12.8 VL	P_2O_5	0.34% H	0.3-0.35%	M: Manure	♥ Crop Rotations
Potassium	0.9	2.7	78	133.0 H	K_2O	2.4% M	2.2-2.8 %	N: don't apply	
Sulfate-Sulfur	5.0	15.0	Not	Analyzed	none	0.22% L	0.2 – 0.4%	O: Gypsum	
Calcium	26.7	79.8	200	340 M	none	0.56% L	1.2-1.5%	M: Gypsum	♥ Manure or Compost
Magnesium	2.7	8.1	21	36.0 L	none	0.21% L	0.27-0.35%	M: Epsom Salt	
Zinc			0.33	0.56 L	none	32 L	25-100 ppm	M: compost	
Iron	Not	Analyzed	1.85	3.2 L	none	128 M	50-300 ppm	M: compost	♥ Minimum-Till (No-Till); Residue mgt.
Manganese	Not	Analyzed	1.51	2.6 M	none	23 L	30-400 ppm	M: compost	
Copper			0.62	1.1 M	none	10 H	5-10 ppm	N: not needed	
Boron	Not	Analyzed	Not	Analyzed	none	18 L	20-60 ppm	M: compost	♥ IWM
Molybdenum					none	Not	Analyzed	O: not analyzed	
Sodium	8.5	25.4	49	use SAR		0.01 %	Range needed	N: don't apply	♥ Soil Amendments (e.g. gypsum)
Chloride	2.9	8.7				not analyzed	Range needed	N: don't apply	
Bicarbonate	96.4	288.2							
Carbonate	0	0							♥ IPM

Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC)

- Electrical Conductivity of Irrigation Water (ECiw) = 0.182 mmhos/cm
- Sodium Adsorption Ratio (SAR) from water test = 0.42 & pH = 7.45
- Refer to Irrigation Water Quality Guidelines (WQ-8) for infiltration assessment. Total Dissolved Solids = 119 mg/l (soluble salts applied = 428 lb./ac./yr.)
- ECe (EC of Soil Saturation extract) = 1.41 mmhos/cm & pH = 7.8 Sodium Adsorption Ratio (SAR) from soil test = 0.89
- Refer to Crop Salt Tolerance Table (WQ-6) to evaluate for potential yield reduction and salinity management considerations/options

Refer to the NRCS Nutrient Uptake Tool: http://npk.nrcs.usda.gov/ for calculating NPK removal by crop

rudy garcia 2009

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Soil Management Strategies

Fossil Fuels in the form of fertilizers

The best approach is to feed the soil biota, which will in turn feed the plant.

Soil Management Strategies

Cover Crops

IWM

IPM

Crop Rotations,

Soil Temperature

Plant/Root Diversity

No-Till or Minimum Till

Soil Management Strategies

Green
Manure

Roller
Chopping

Crop Residue

Manure Mgt.

Soil Management Strategies

Pasture Management and Grazing

Mob Grazing only take 50% of forage

Mob Grazing ;
Frequent Rotation

Over Grazing;
No - Rotation

Soil Management Strategies

Soil Management Strategies

Water Inefficiency

Soil Management Strategies

Water Efficiency

Soil Management Strategies

I W M

2.5 – 3% Organic Mater in New Mexico

Soil Moisture Monitoring and Irrigation Record keeping

Air Quality

Only comes after building Soil Quality and Good Soil Health

Sustainability is our future!!!!!

Clarence Chavez
Soil Scientist
NM - NRCS

Any QUESTIONS ?