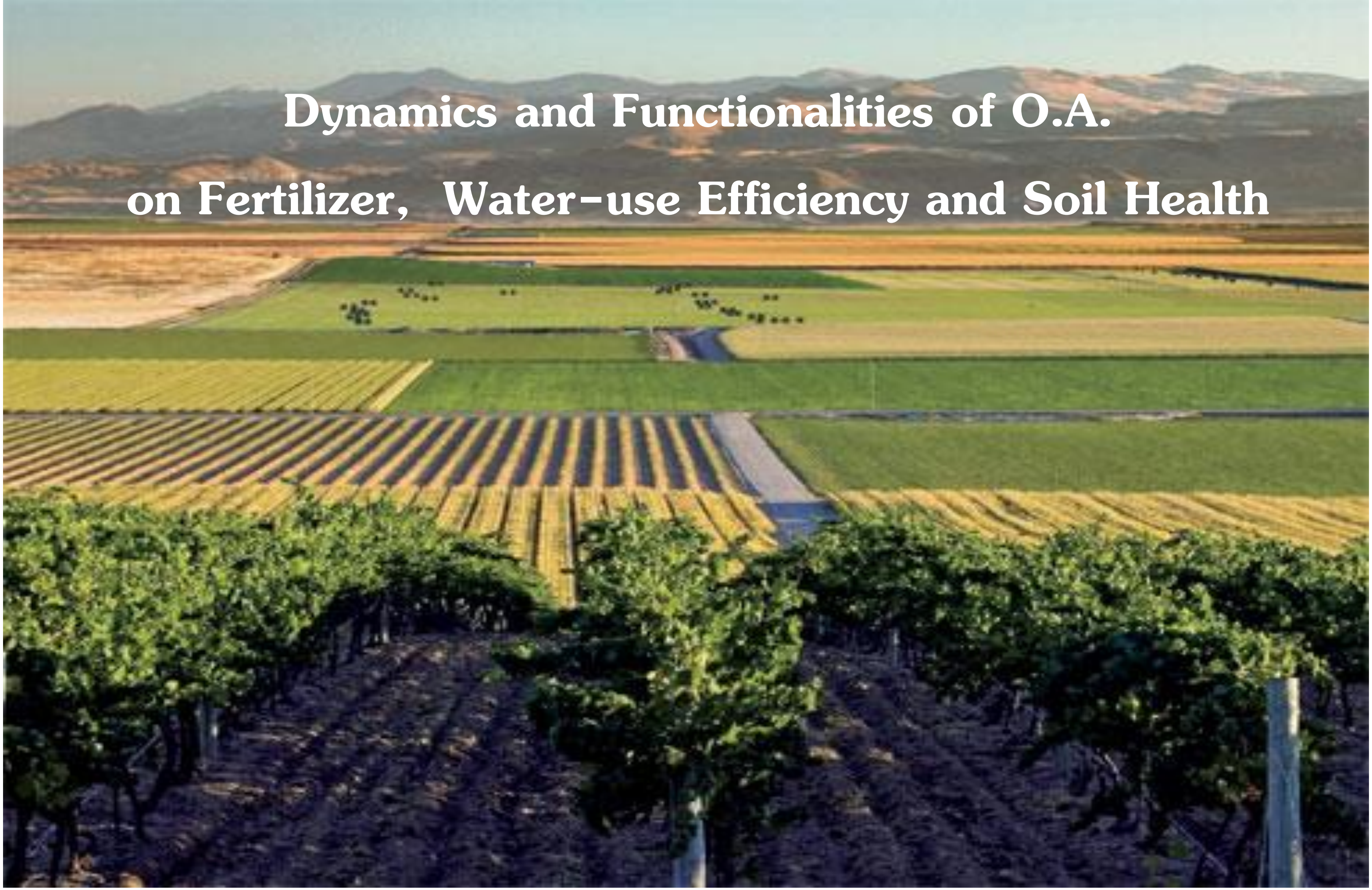
Dynamics and Functionalities of O.A. on Fertilizer, Water-use Efficiency and Soil Health



Mir M. Seyedbagheri

Professor/Soil Agronomist

Produced 2014

Future of Crop Production

Jacques Diouf
Director-General, FAO

1. By 2050 the world population will double
2. Crop production will need to double
3. Soil organic matter has declined drastically all around the world
4. We need to become smarter at maximising our resources
5. Water quantity and quality are declining
6. Soils are becoming salt affected and diseased
7. Cost of production is increasing
8. <u>We have to create an innovative soil and plant nutrient balance</u>

HOW H.S. ENHANCE CROP PRODUCTION

Humic Substances aren’t the only universal depot of carbon and energy but possess a big biological potential that makes them an analog of ATP for biosphere.

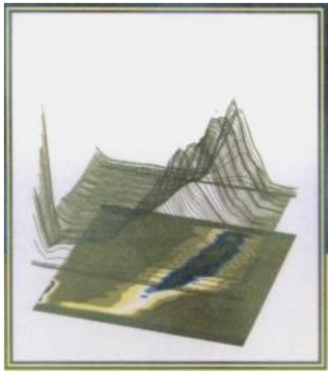
Chuko, 2008

H.A. Molecules/Puzzles

Humic Acids are "super-mixtures" Understanding the chemistry is very complex.

Functional Groups in Humates

Carboxyl	-CO2H
Phenol	-OHp
Hydroxyl	-OHa
Ketone	-C=O
Ester	O=C-O-R
Ether	-C-O-C-
Amine	-NH2,-NH, -N



Soil Composition

Reality check???

What percentage

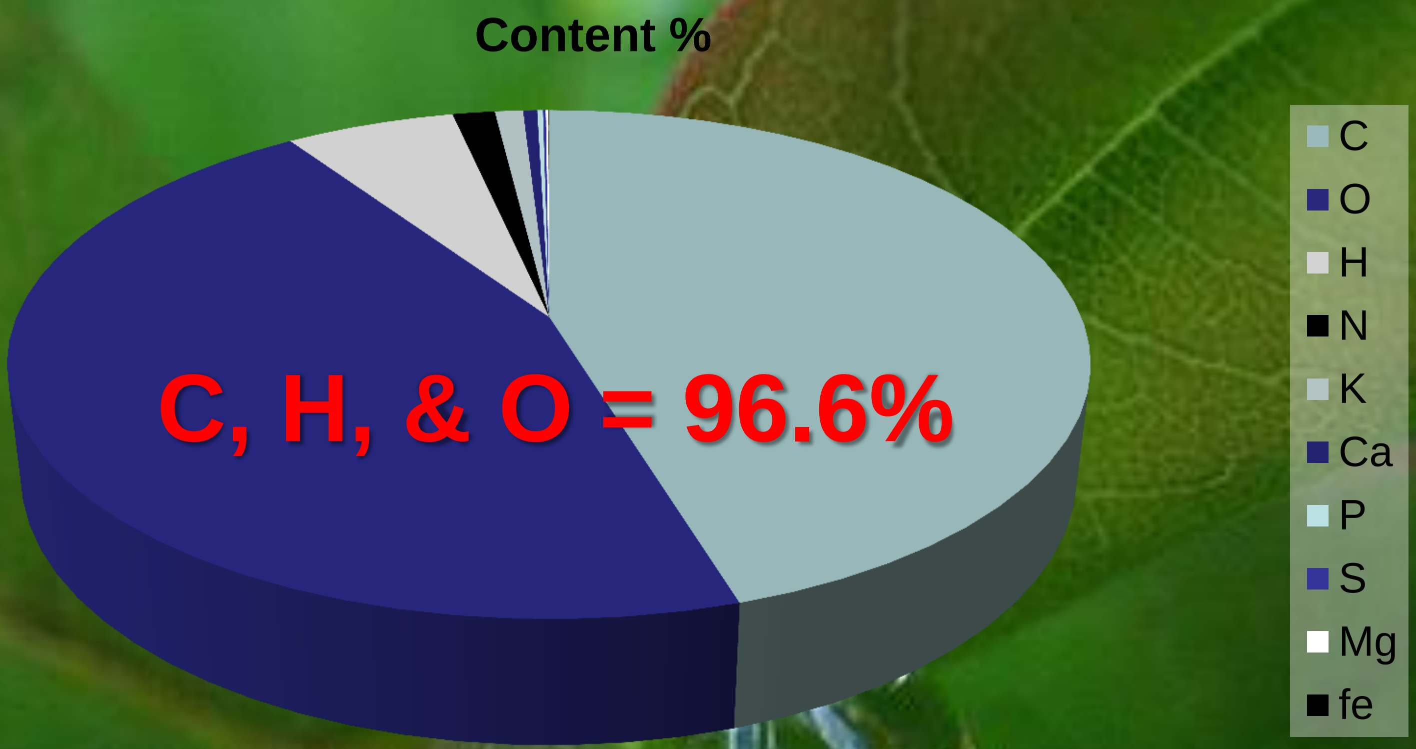
of harvested

crops, fruits, vegetables etc…

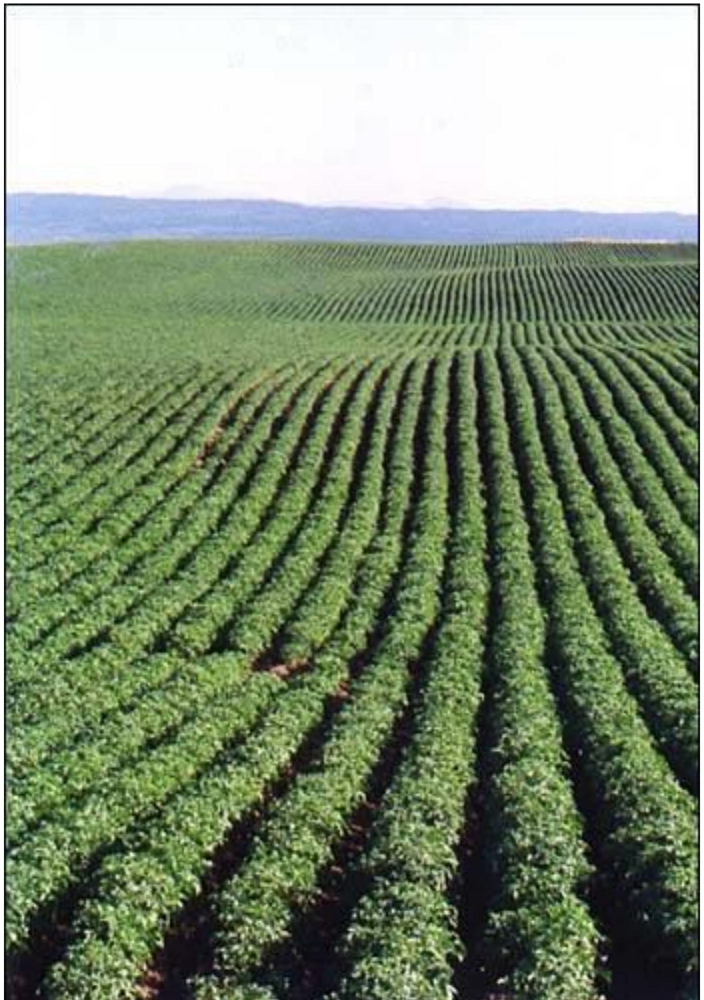
are made of

C – H – O ?

Plant Composition



Mir's Theory: Farming is transforming sunlight into crop yield



- **Photosynthesis:**

capture C energy =Make it

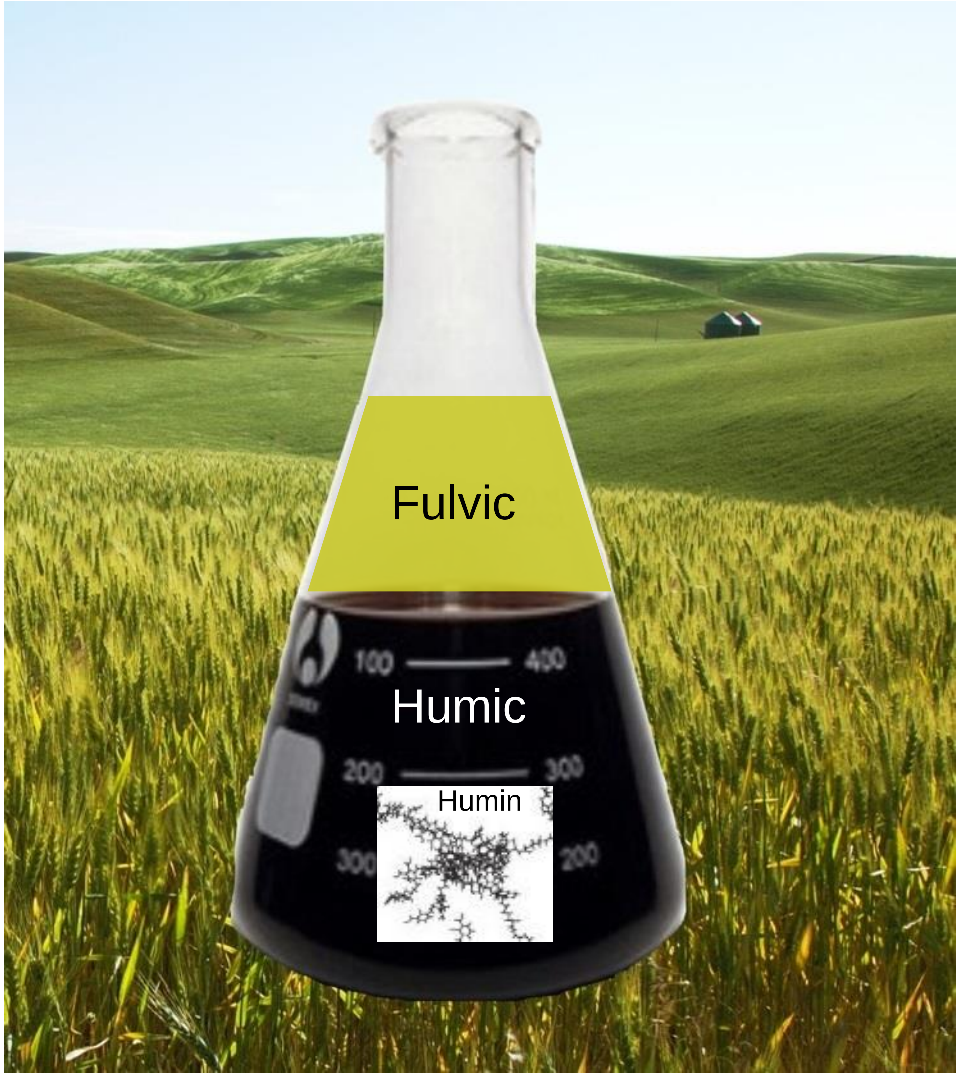
- **Translocation:**

moves C energy =Move it

- **Respiration:**

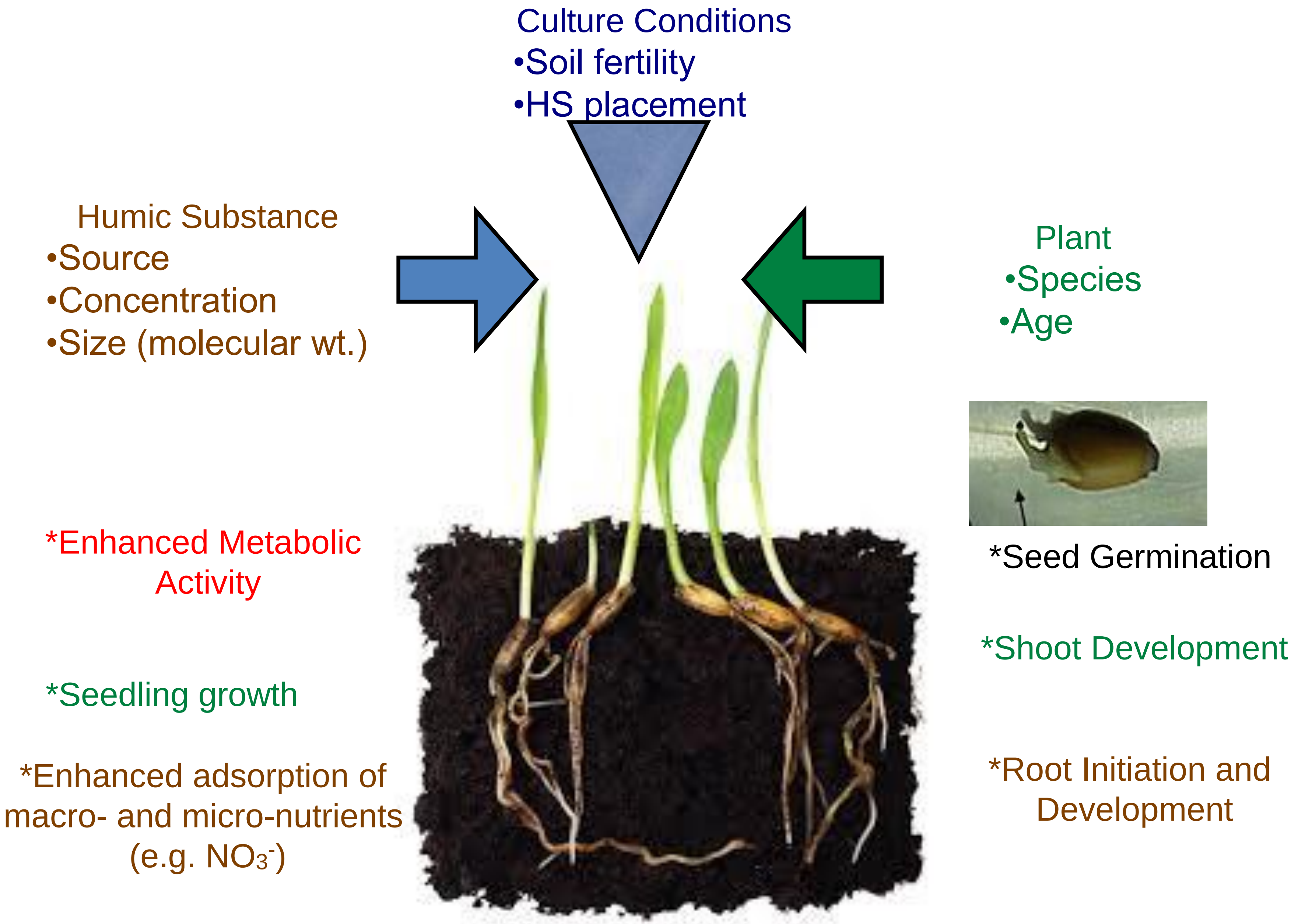
re-manufacture C energy = Use it (yield)

The 5-R's of Nutrient Stewardship



1. Right Fertilizer
2. Right Rate
3. Right Time
4. Right Place

5. Right Humate



Organic Acids Influences Plant Growth and Soil Health

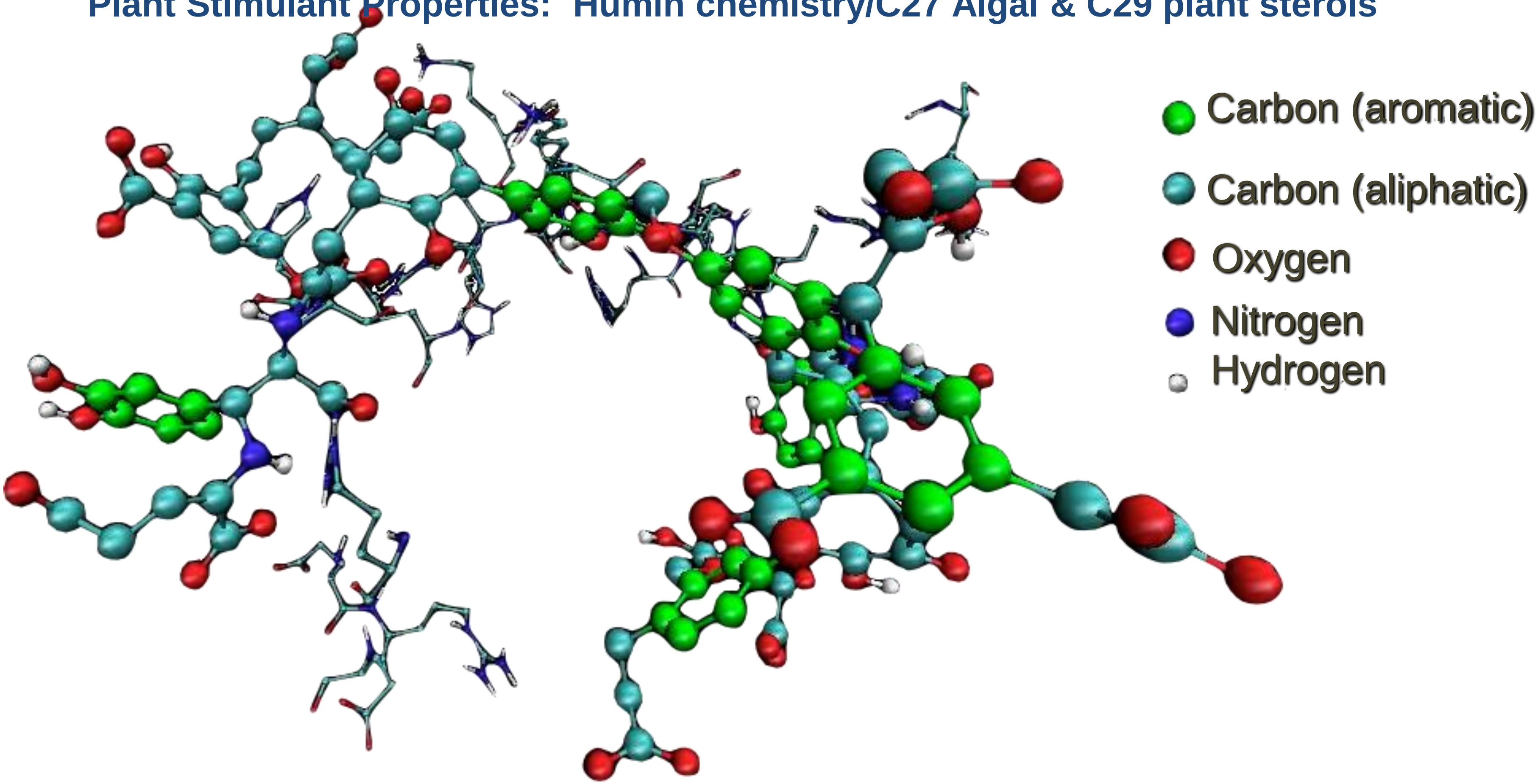
Interactions of soil minerals, humic and microbes

Physical: organo-mineral complexes and water infiltration

Chemical: soil solution chemistry, complexation-chelation and buffering

Biological: microbial activation, soil foodweb

Plant Stimulant Properties: Humin chemistry/C27 Algal & C29 plant sterols



HUMIN AND ITS FUNCTIONALITY

Theoretically, humin is the non-soluble fraction of soil humus which breaks down slowly by soil microbial activity, and affects the soil by regulating its water holding capacity, ion exchange rate, EC, pH and soil crumble (micro aggregates).

Biomarkers

- Gas chromatography-mass spectrometric analysis of the humin pyrolysate revealed the occurrence of **hopanoid** and **steroid** biomarkers.
- Biomarkers have been widely used to assess the biological sources of dead matter. These are pristene, sterenes, and hopenes in the humin pyrolysate.

Pristene Biomarker

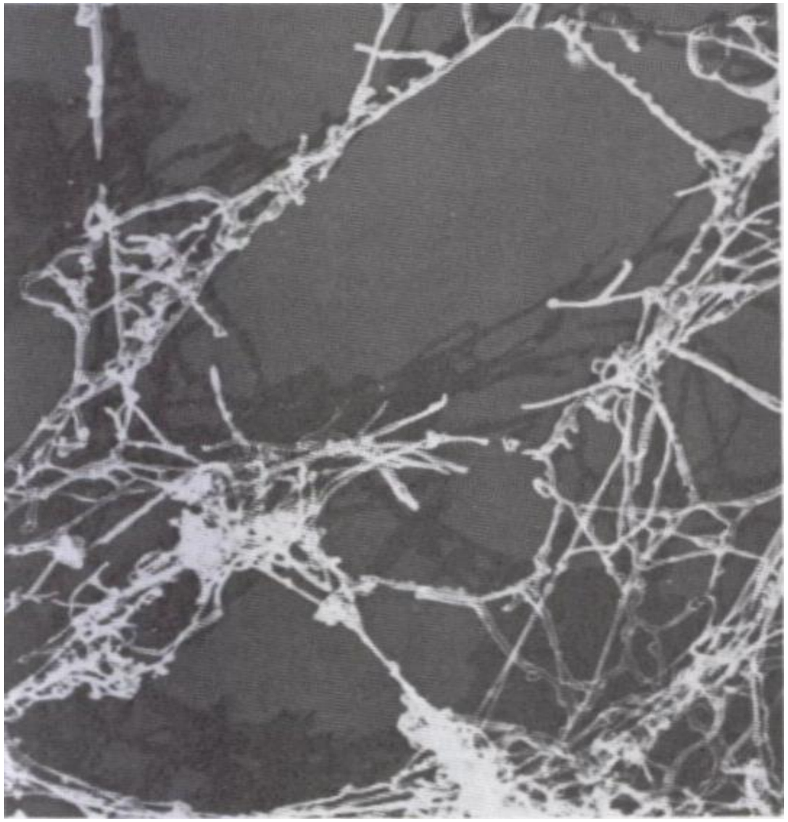
- Pristene is most likely derived from the phytol side chain of chlorophyll.
- Pristene is thus a marker of photosynthetic activity.
- Precursors of sterenes include C27 algal and C29 plant sterols.

Soil Particles & HS in Perspective

Particle type	Diameter (mm)	Number of Particles/g	Surface Area Sq.cm/g
Very course sand	2.00-1.00	90	11
Course sand	1.00-0.50	720	23
Medium sand	0.50-0.25	5,700	45
Fine sand	0.25-0.10	46,000	91
Very fine sand	0.10-0.05	722,000	227
Silt	0.05-0.002	5,780,000	454
Clay	<0.002	90,300,000,000	8,000,000

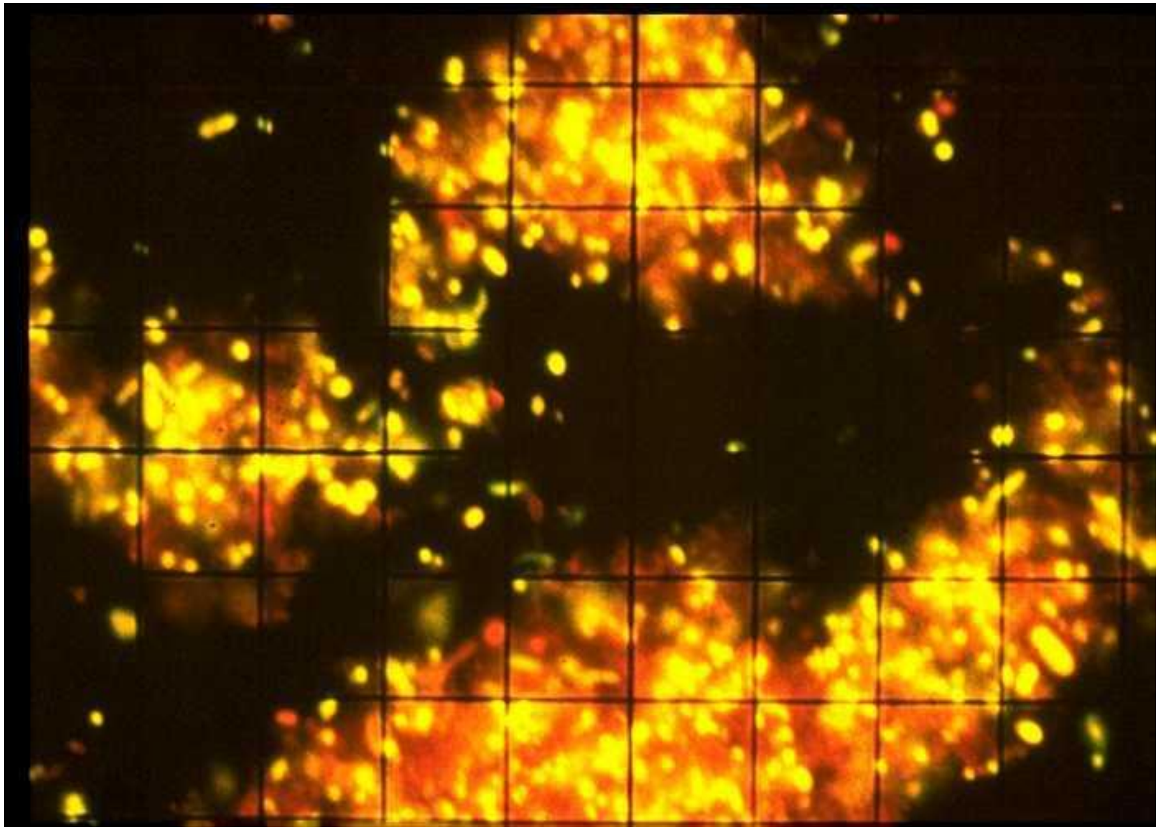
Relative comparison .005 mm = 5,000 nanometers

Particle size dynamics of H.S. and how they create organo-mineral complexes



Transmission electron micrograph of a 0.01% (w/v) HA solution. The scale: 0.4 cm = 1 μm. HAs and FAs form flat elongated multi-branched filaments of 20 to 100 nm in width. Smallest particles are spheroids of 9-12 nm in diameter.

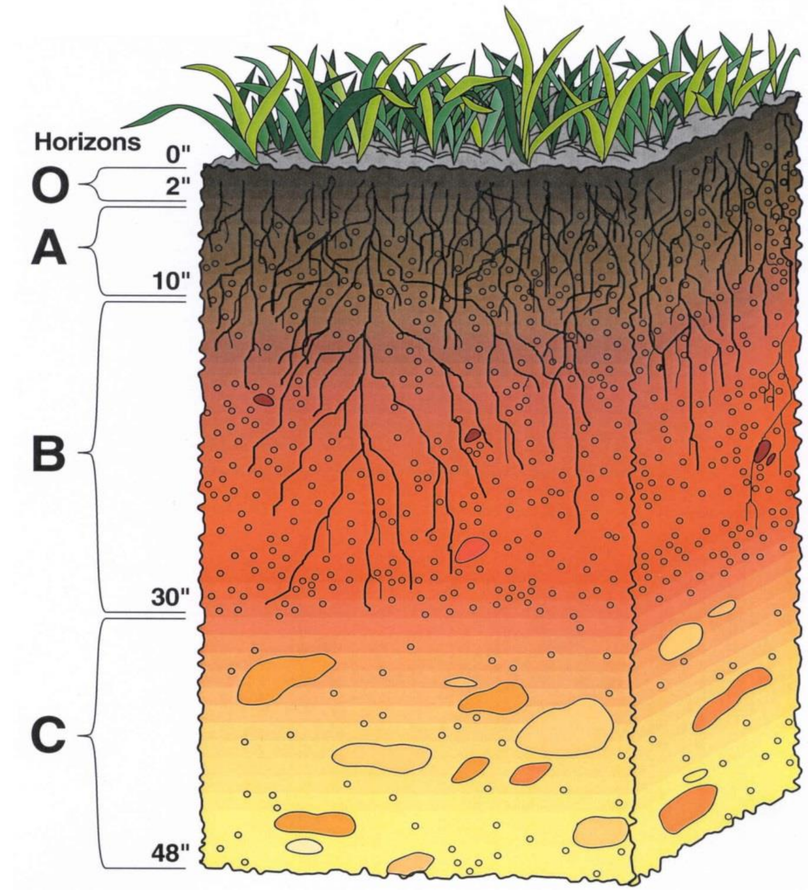
Humics create excellent environment for microbes



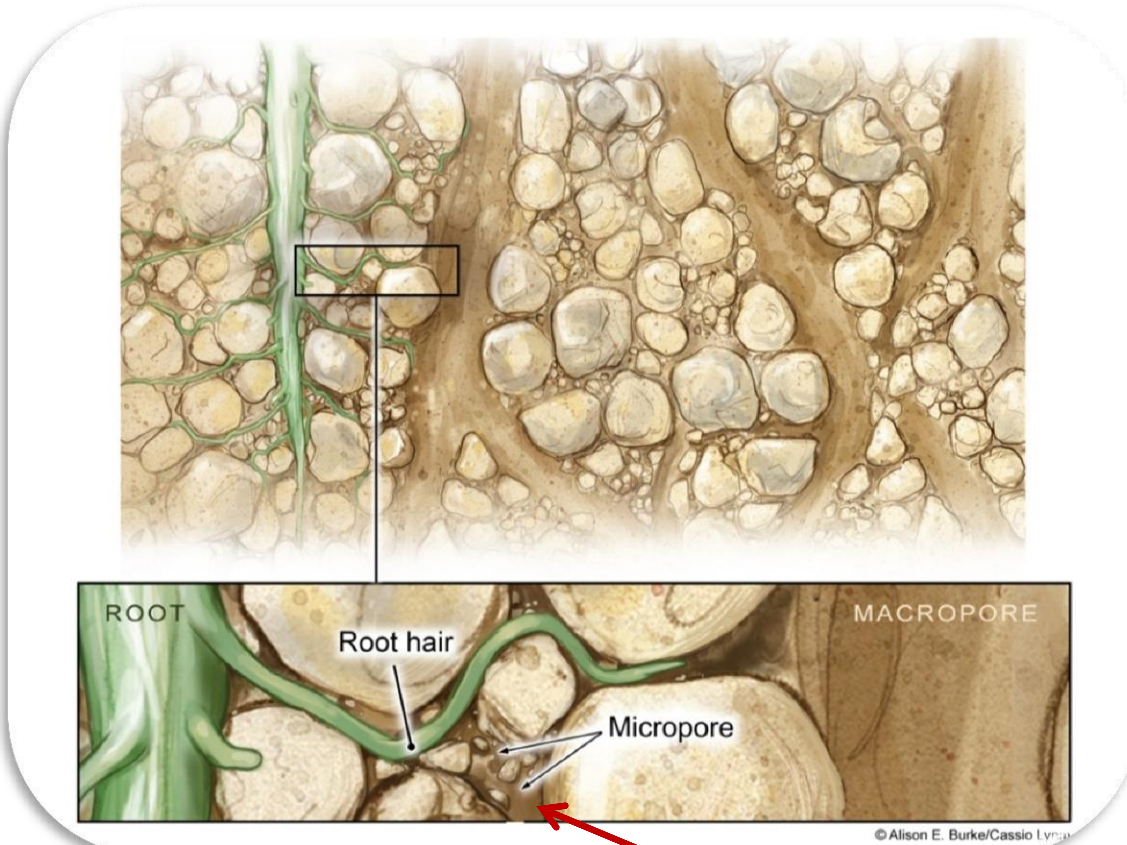
Soil microbes inhabiting the surface of clay-humus crumb, glowing under UV light, stained with acridine orange, as seen under a high-resolution Leitz microscope.

Source: Siegfried Luebke's CMC Group Laboratory; Peuerbach,Austria.

These physical bondings will create good aggregate



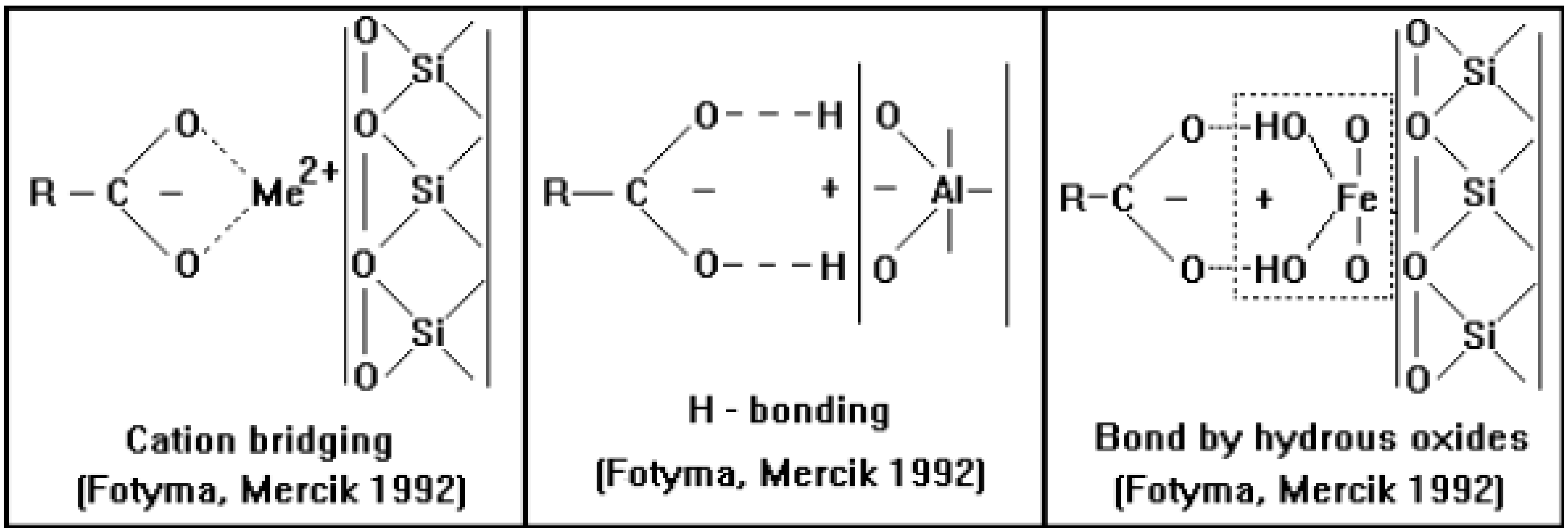
How H.S. helps Soil Micro-pores



- Roots, water, and nutrients reside in **micro pore space**
- Oxygen resides in **macro pore space**

1 c.m. is 10,000,000 n.m.

Humics and Soil Interactions



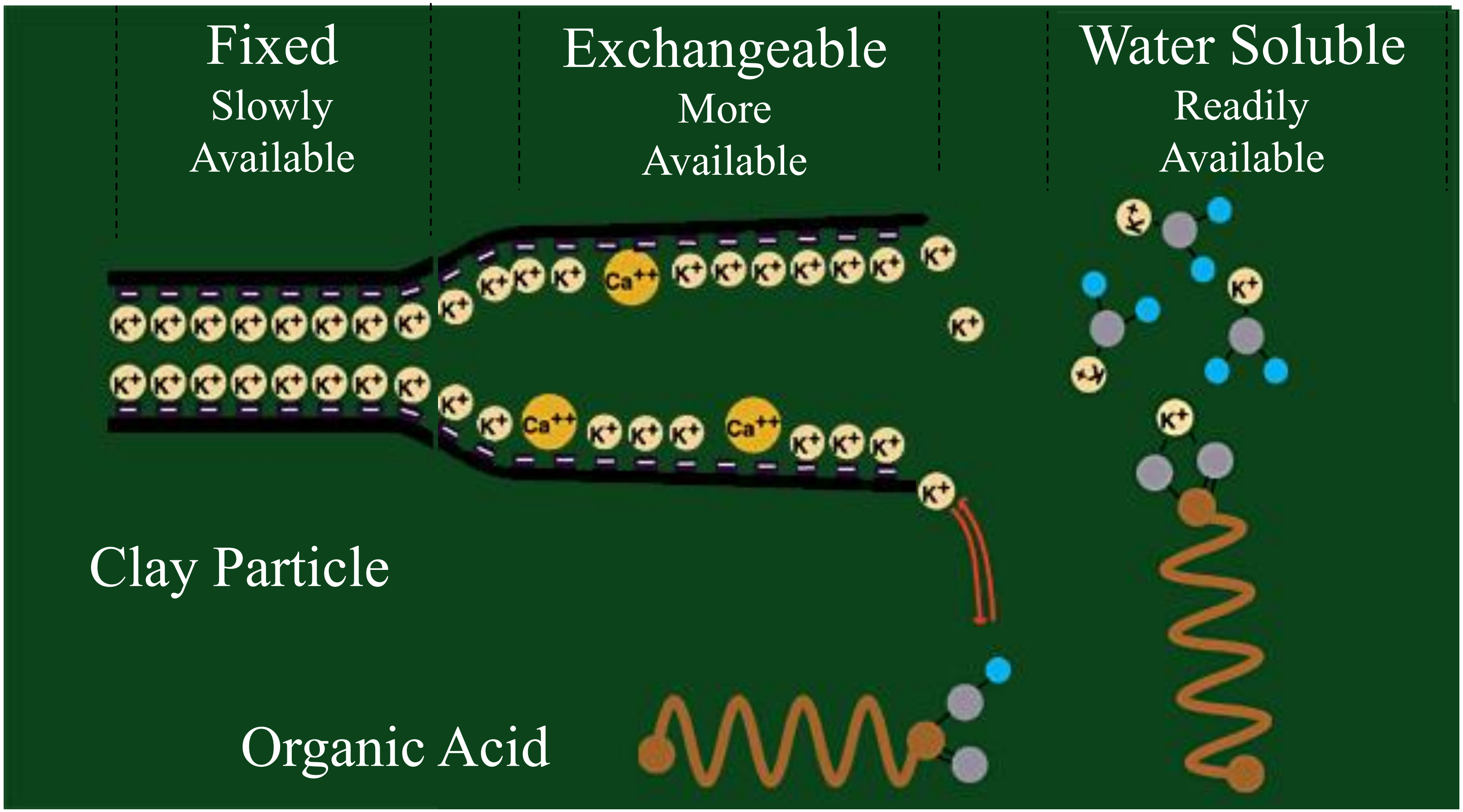
Cation bridging (Fotyma, Mercik 1992)

H - bonding (Fotyma, Mercik 1992)

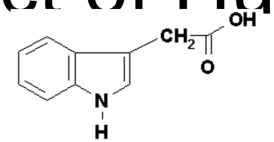
Bond by hydrous oxides (Fotyma, Mercik 1992)

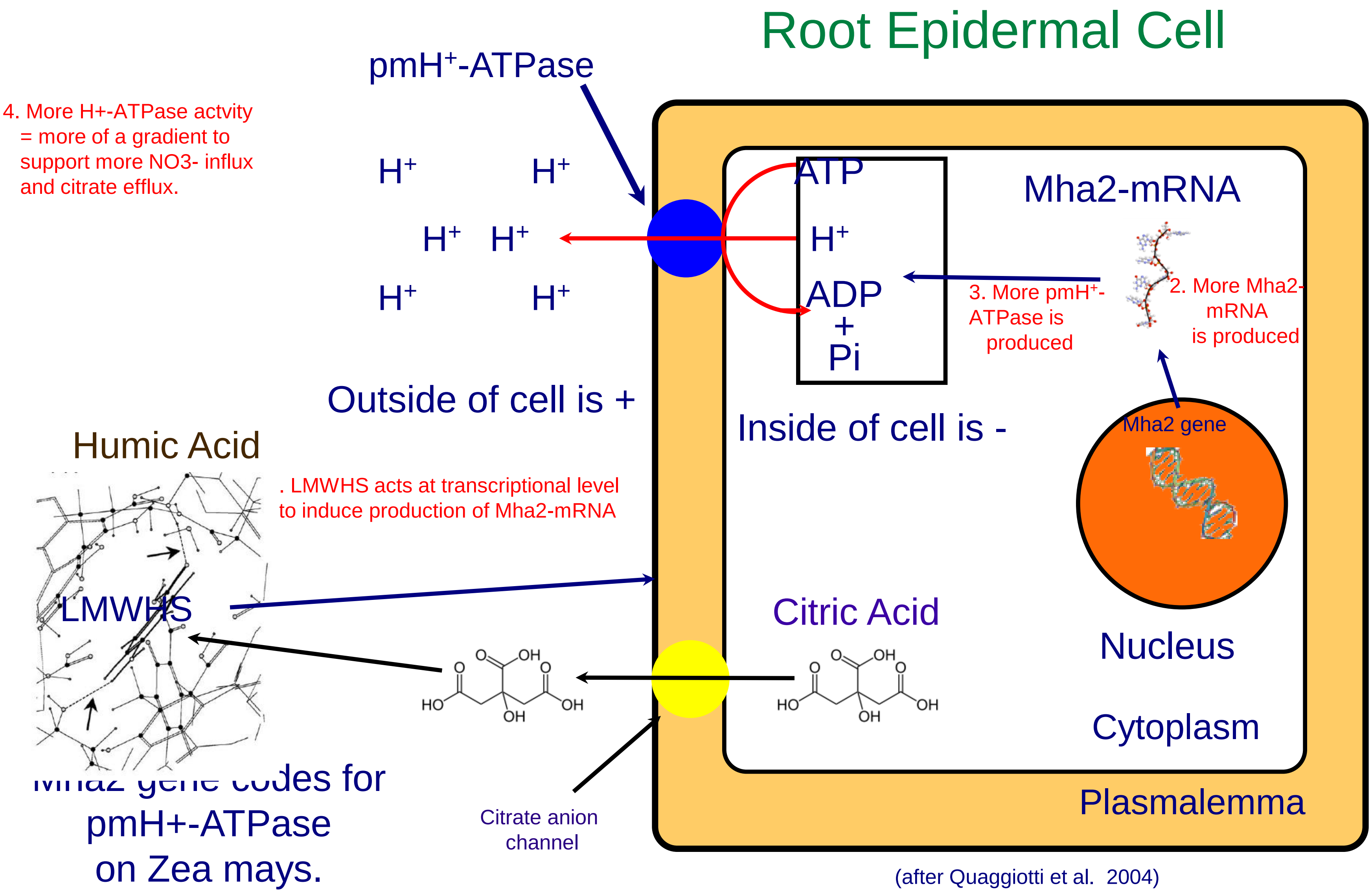
Nutrient Exchange

Clay CEC 20 to 40 ------- Organic Acids CEC 250 to 500



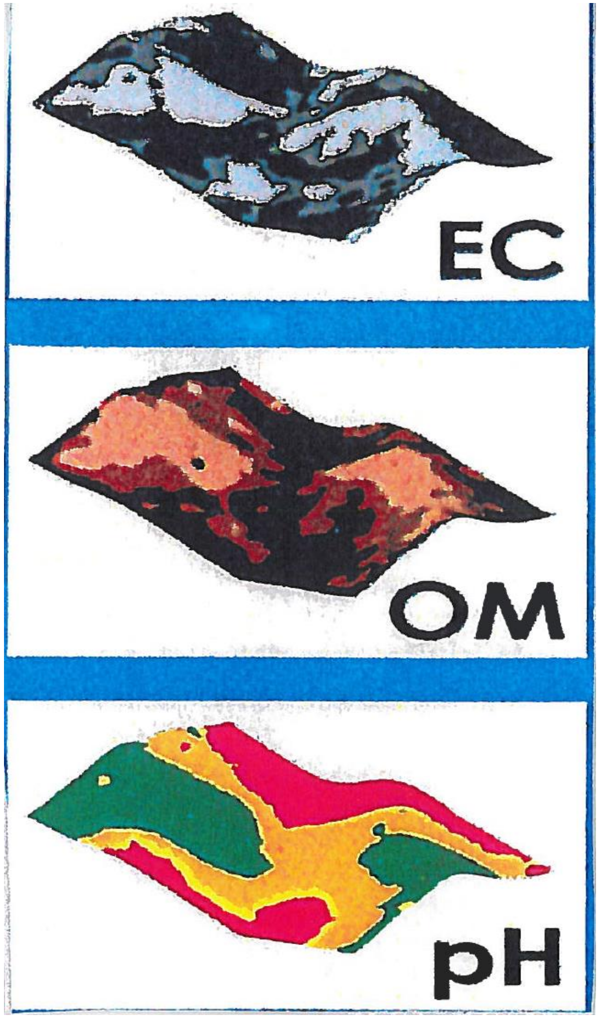
Effect of Humic Substances on Plant Metabolism

IAA  Nutrient Aquisition-NO_3^-



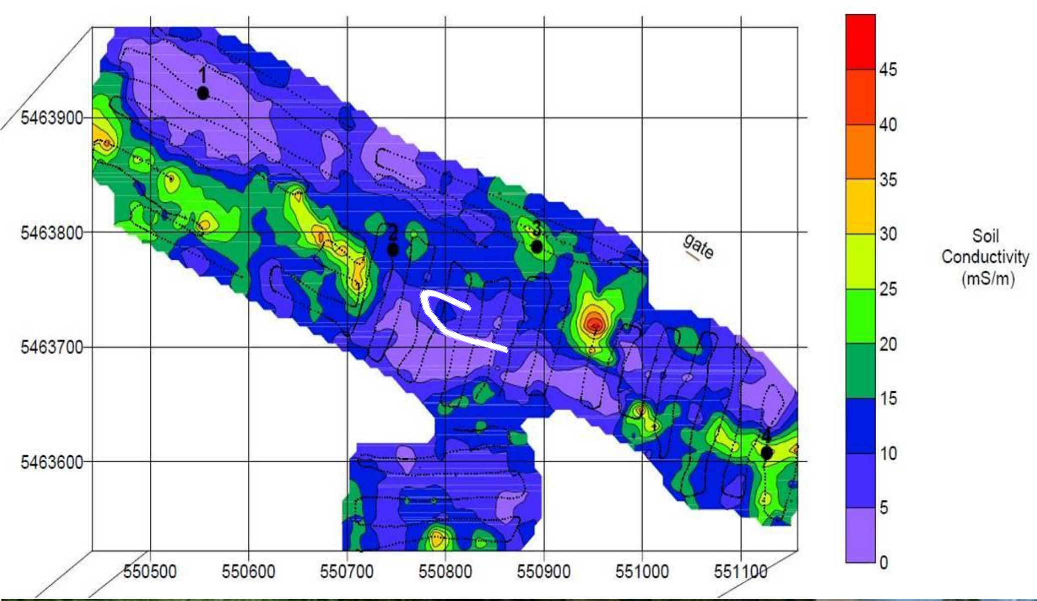
(after Quaggiotti et al. 2004)

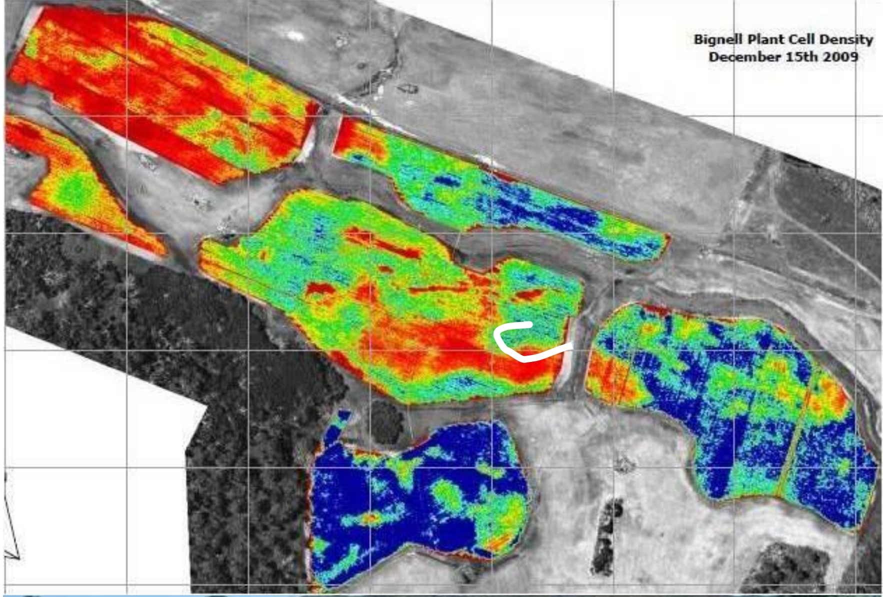
Variations in soil fertility & how O.A. helps to buffer



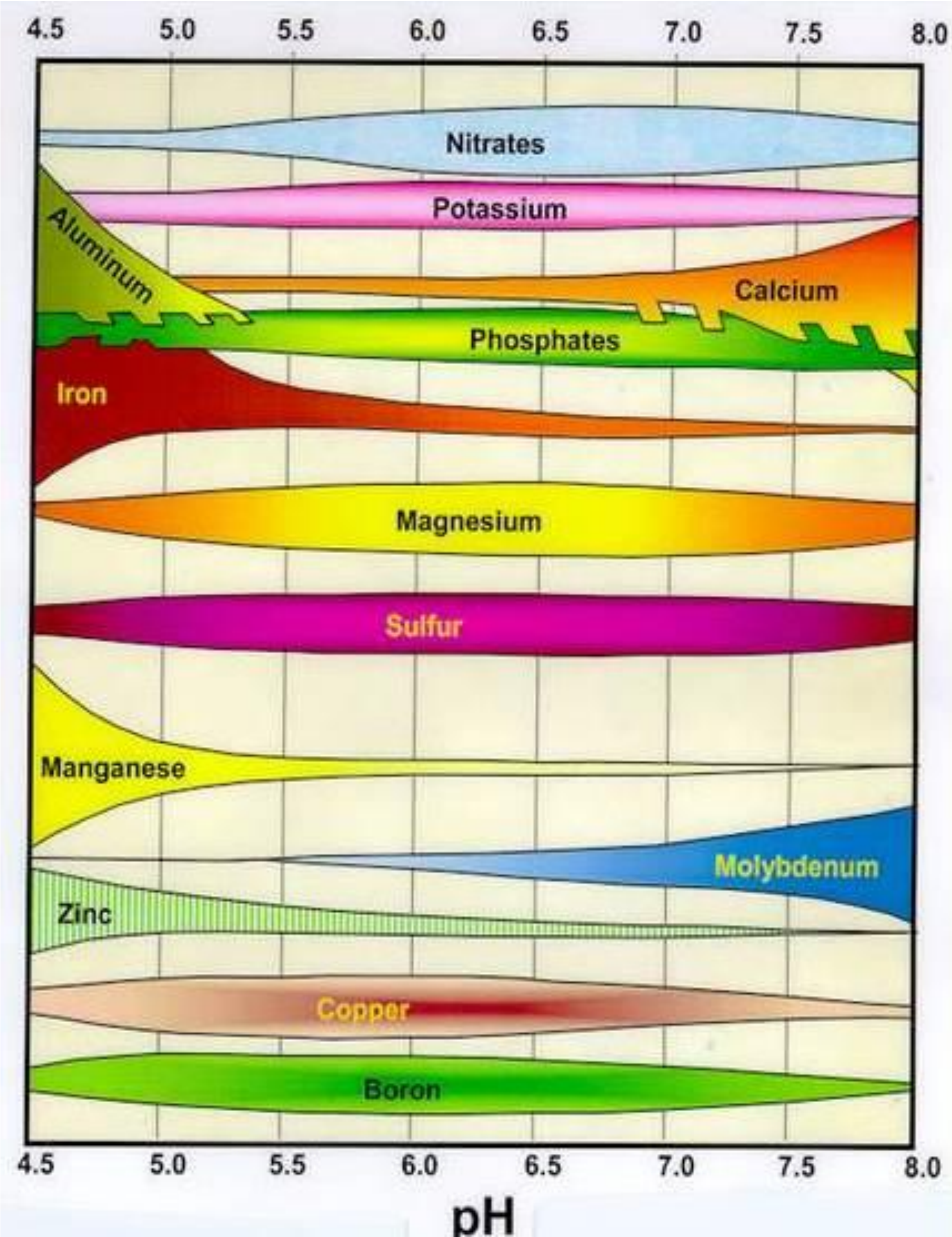
What do you think the yield variation will be?

Yield variation 38t/ha – 108t/ha


5463900
5463800
5463700
5463600
550500
550600
550700
550800
550900
551000
551100
1
2
3
4
gate
45
40
35
30
25
20
15
10
5
0
Soil
Conductivity
(mS/m)

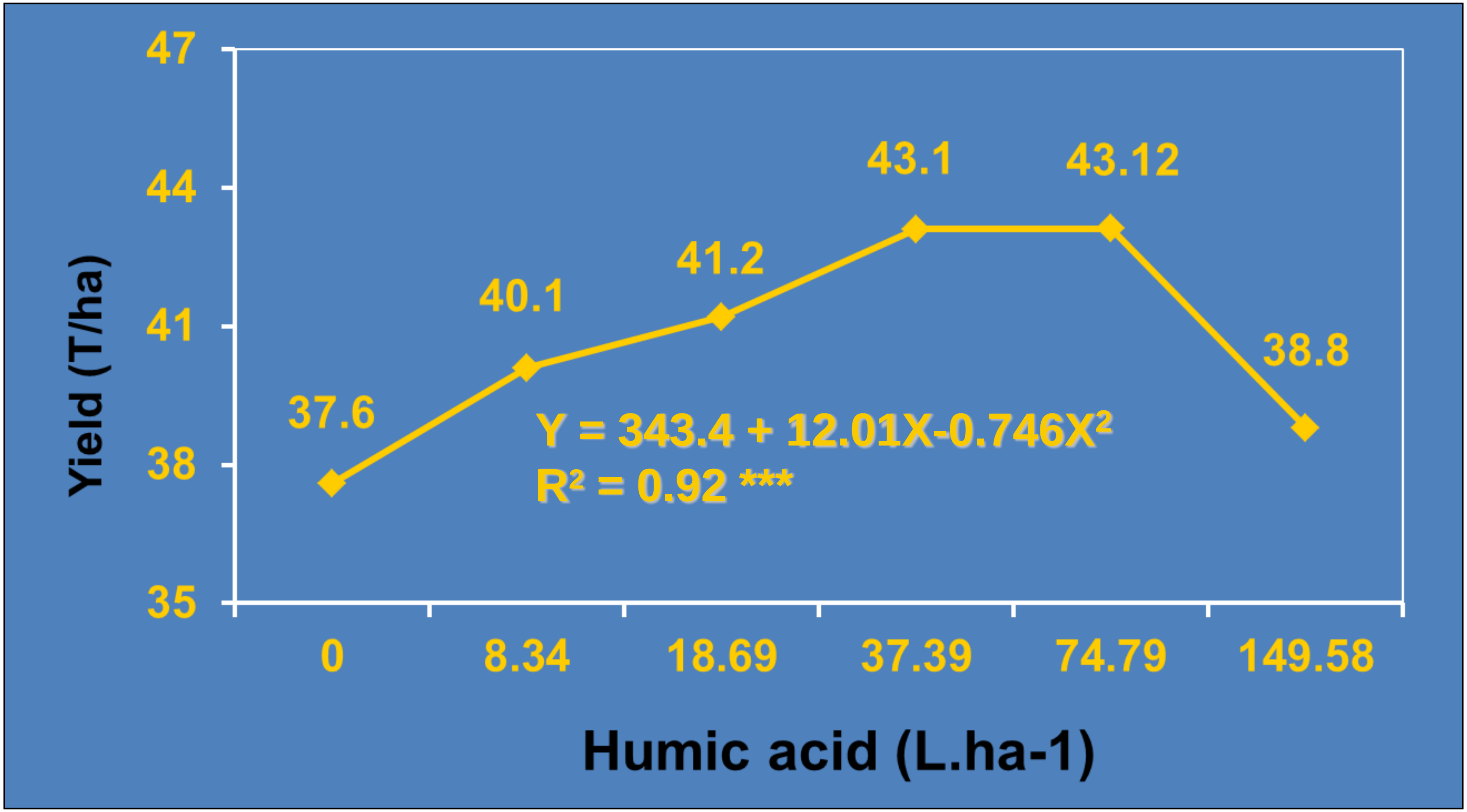

Bignell Plant Cell Density
December 15th 2009

Harvested 10 days earlier



O.A./pH influence on Nutrient Availability

Effects of Humic Acid Rate on Potato Yield at Three Sites



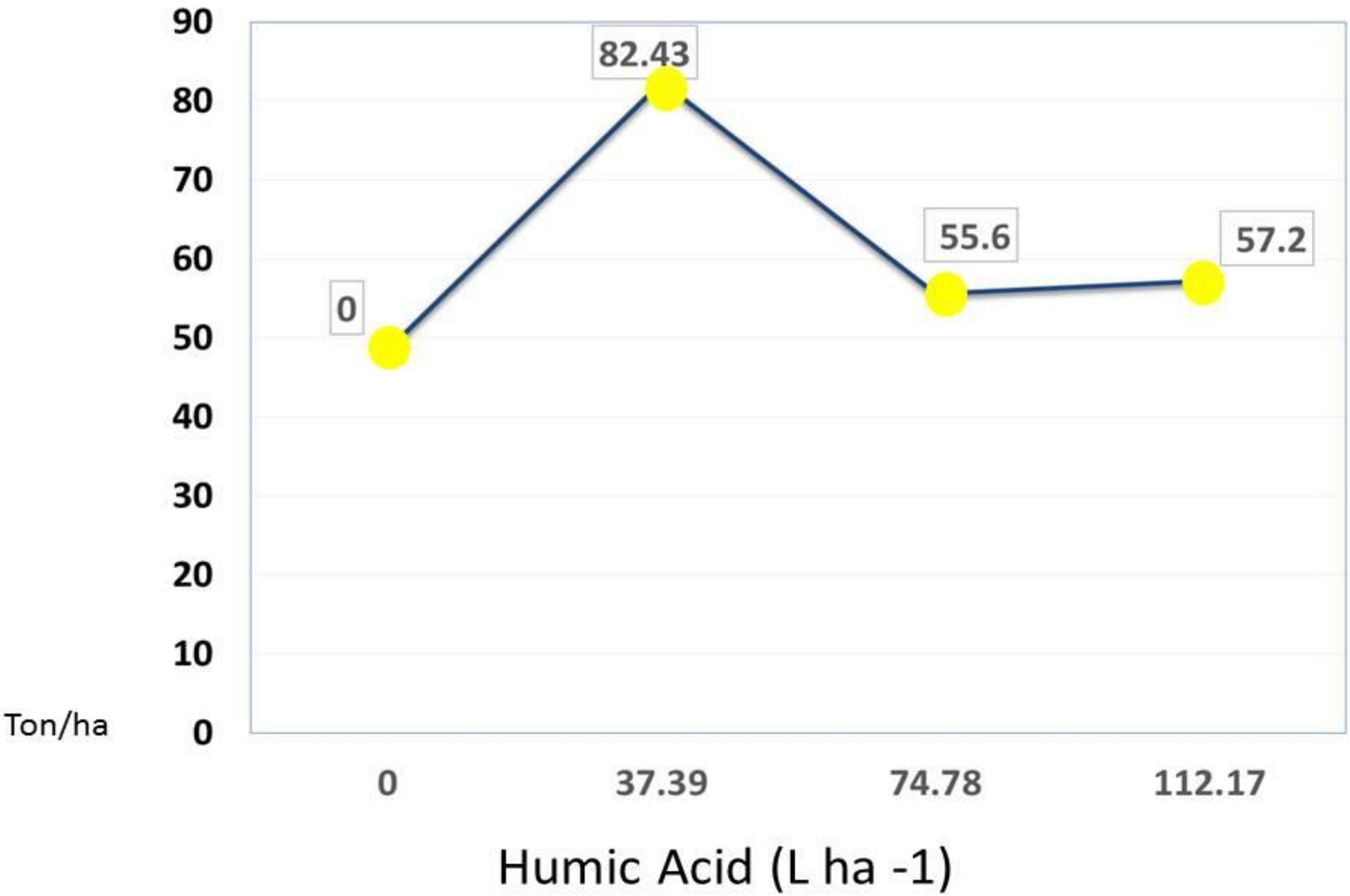
2014 Field Potato Research

- Variety: Norkotah
- Soil Texture: Sandy Loam
- Ph 7.9
- Organic matter 1.4%
- Plot design: randomized plots
- Four replications of each treatment:

1. Control: farmers usual fertility application
2. 1X = 37.39 Liters/ha
3. 2X = 74.78 Liters/ha
4. 3X = 112.17 Liters/ha

Hand-harvested and graded on Aug. 5, 2014

Effects of Different Rates of Humic Acids on Potato Total Yield, 2014



Comparisons of Control, 1X, 2X & 3X

Sugarbeet Harvest Raw Data

Row 1X
- 220.5 lbs.

Row 2X
- 301.5 lbs.

Row 3X
- 197 lbs.

Row Control
- 242.5 lbs.

Between 2X & Control there is 19.6% difference in yield

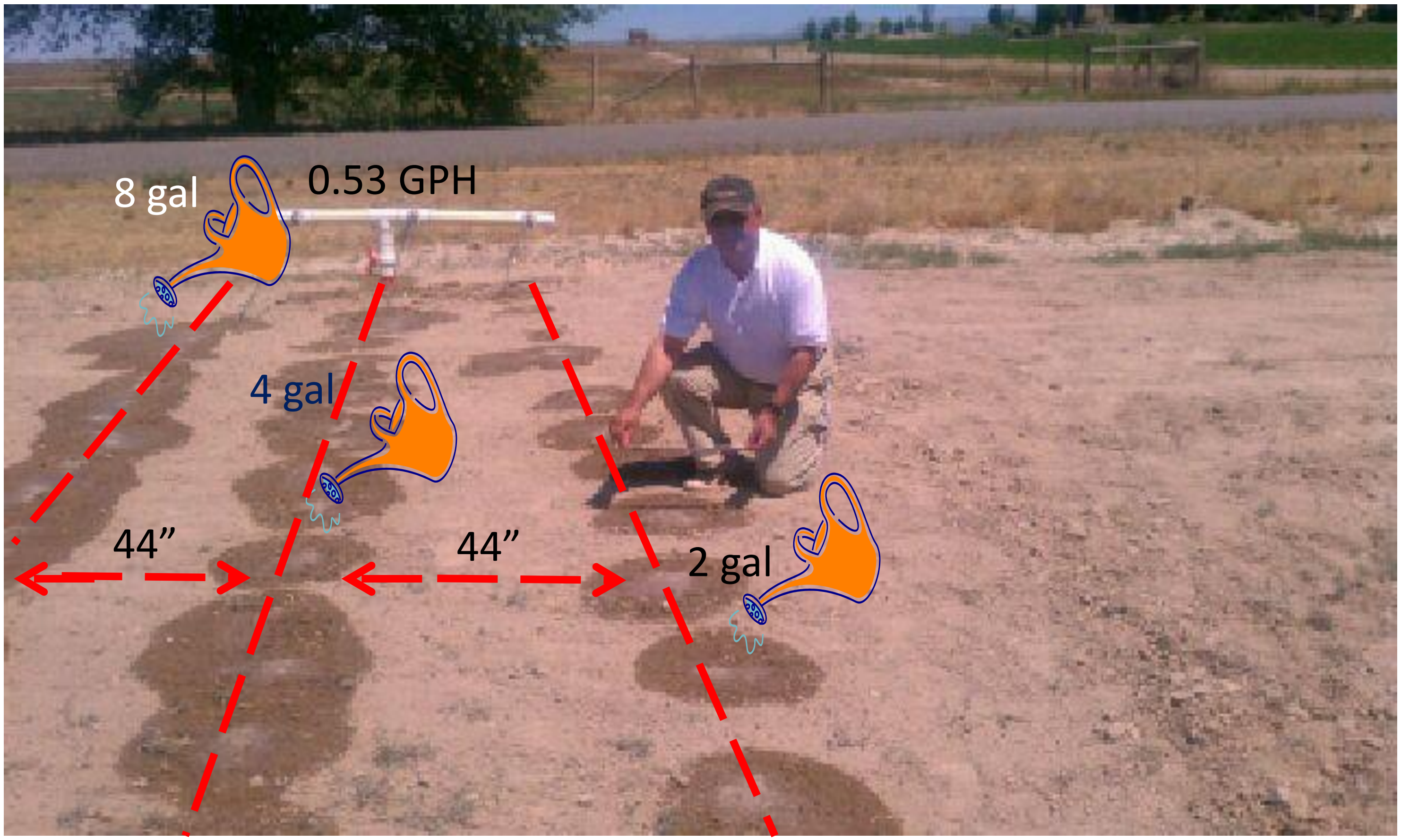
Statistical analysis will be run at a later date

O.A. & Water-Use Efficiency

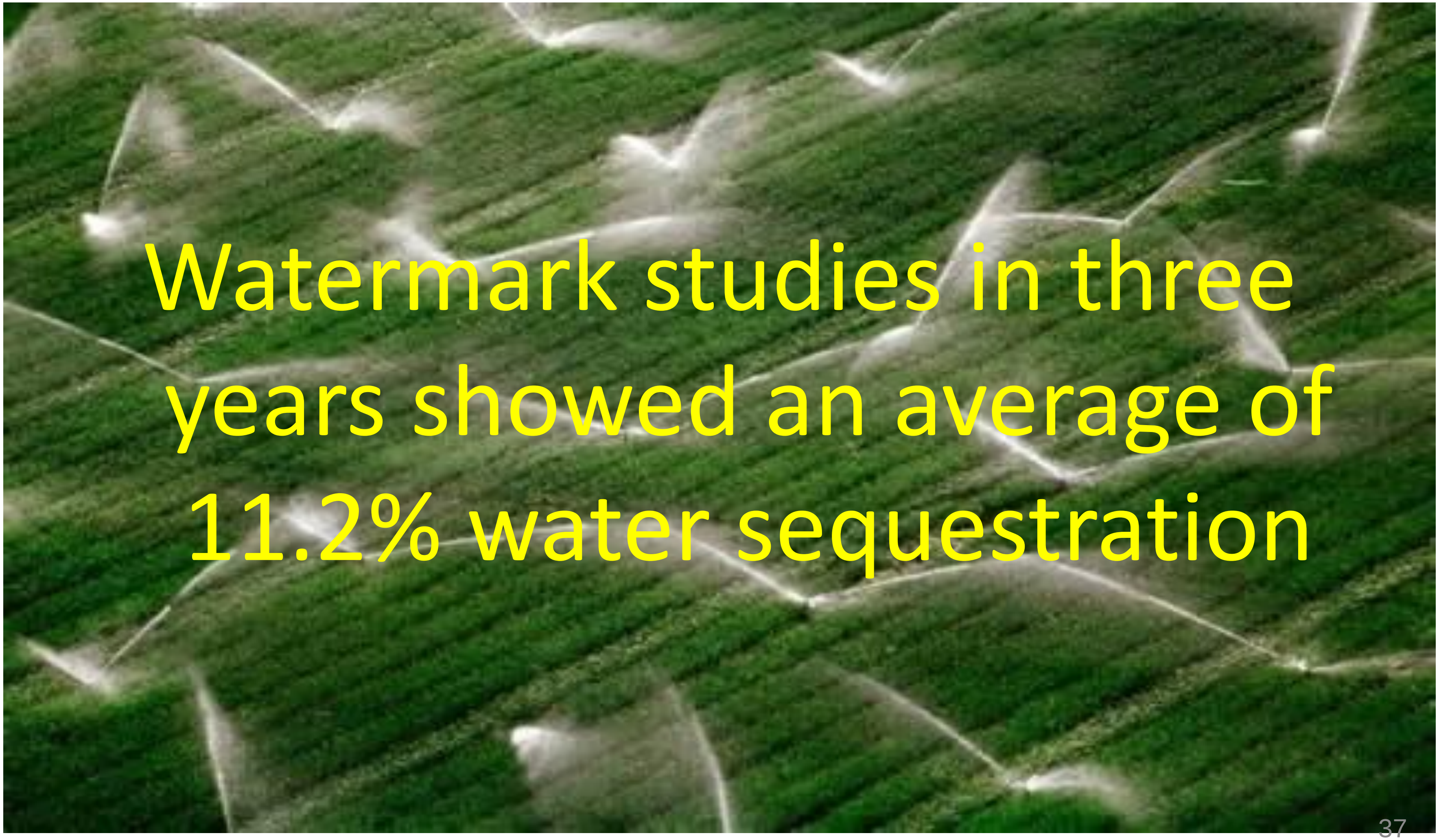
POTATOES ARE WATER SENSITIVE

Influence of HS on Water-Use Efficiency

Wetting Patterns after 6 hours for 10-20 cm emitter depths

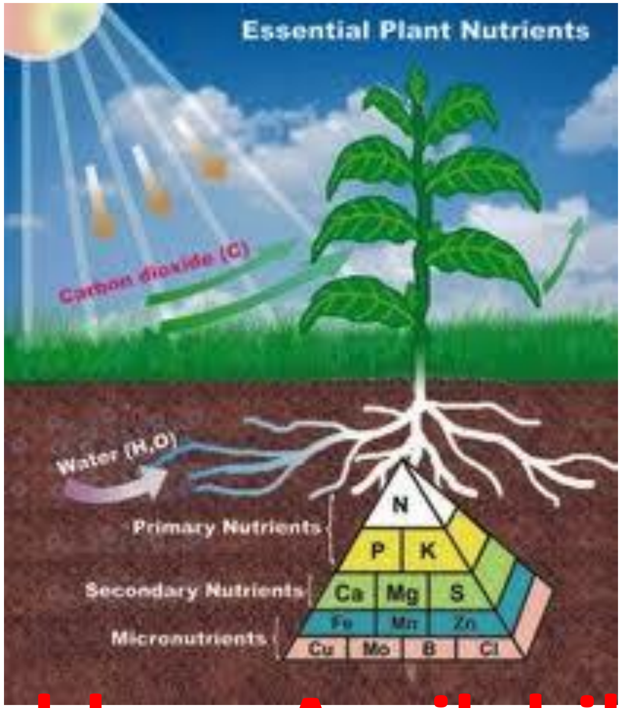


Humics Influence on Water Sequestration



Disease Resistance

Sufficient Quantities of all Essential Nutrients Must be Delivered to the Plants



Problem: Availability

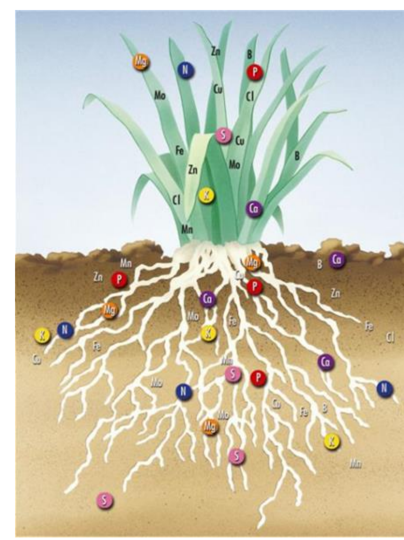
O.A. = soluability/availability

Most Important Nutrients for Disease Resistance

K, Ca, Cu, Zn, B,

Mn, S, Si, Cl

P



Importance of Humic Substances in Soil Nutrient Management

Based on scientific research

Humic Substances help to solubilize macro-micro nutrients, chelate, complex, buffer and make them more available to plants.

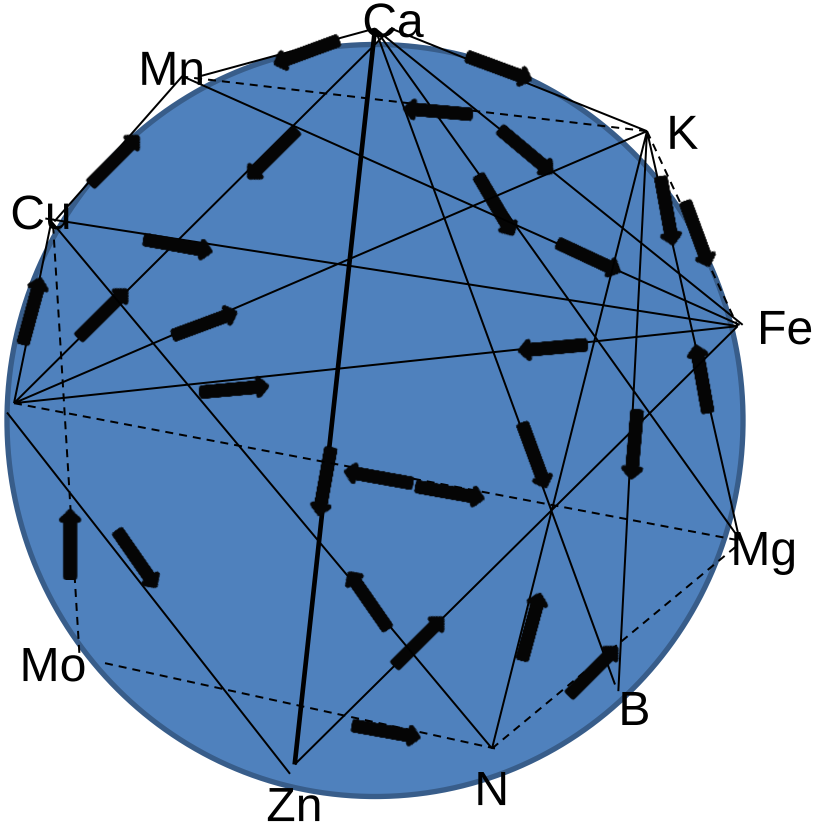
Soil Society of America

Humics/Elements Interactions = Better Nutrient Balance

Mulder's chart Interaction of Elements

Synergize
Increase availability to plant

Antagonize
Decrease availability to plant



GENERAL CONCEPT FOR MACRO & MICRO-NUTRIENT RATIOS

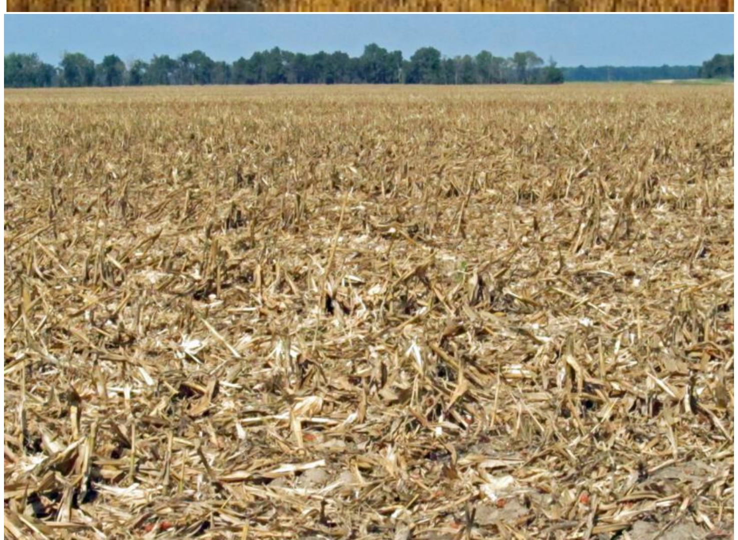
Ratios	Ideal
N:S	5-10:1
Ca:Mg	6-20:1
Ca:K pH>7	15:1
Ca:K pH<7	10:1
Ca:P ph>7	100:1
Ca:P ph<7	40:1
P:Zn	15:1
P:Mn	4:1
P:Cu	25:1
Zn:Cu	2:1
Mn:Zn	3:1
Mn:Cu	5:1
K:B	200:1
Mg:K	2:1

Quantitative Field Observations

O.A. Influence on Small Grain Yield and Quality

O.A. and Stubble Digestion

(Nitrogen Mineralization)



L.H. and Stubble Digestion

Nitrogen Mineralization in Sugarbeets

Site	Depth	Initial N Level	June	July	Aug	Sept	Oct	Soil N Supply
G.V.	0-12	98.42	174.0	185.4	241.3	217.4	256.5	354.92
	12-24	78.66	98.8	100.7	118.8	150.9	119.3	197.98
Total		177.08	272.8	286.1	359.48	368.3	375.82	552.90

Watermark Sensor locations for O.A. Research

Alfalfa

Shale Oak, CA Project

O.A. transformed very high salt, high H2S and poor canopy into productive vineyard

Shale Oak Trials: Good Yield Potential

Organic Acids
Enhance Vigor and Stand

Humics Influence Vigorous Healthy Roots

O.A. Influence on N.M. & Soil Health

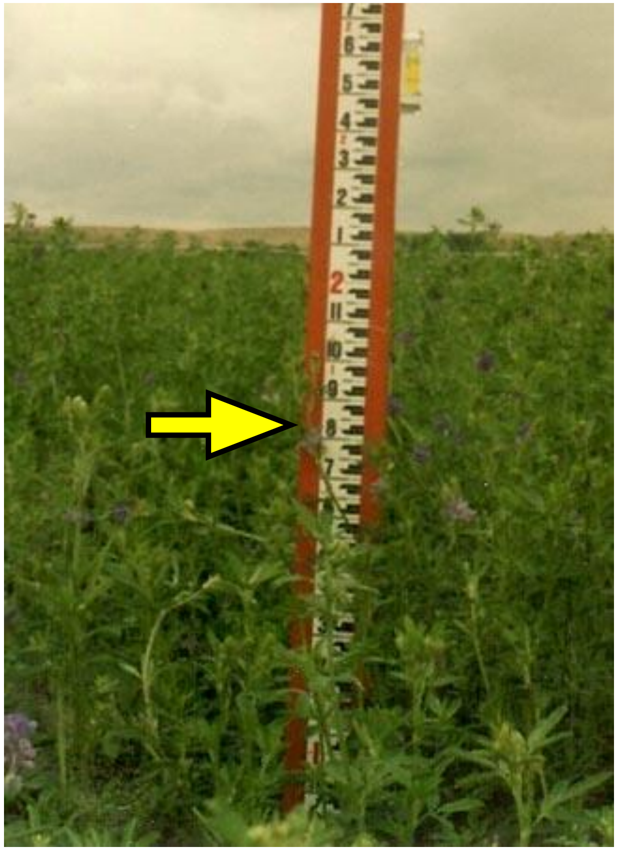
very compacted soil
to healthy soil

Effect of H.S. on Plant Growth

Corn at 6-8th vegetative leaf stage

Effect of H.S. on Plant Growth: Plant Physiology and Morphology

Alfalfa-not treated



Alfalfa-treated with OA @ 2 g/acre

Q.A./balanced nutrients = uniformity and quality

O.A. Enhances Quality


Studies suggest that humics (synergize)
increase availability of macro-micro
nutrients to the plants

Summary of Research Findings

1. **SOLUBILIZATION OF MICRONUTRIENTS (e.g. Fe, Zn, Mn) & SOME MACRONUTRIENTS (e.g. K, Ca,P)**
2. **Buffers salts, reducing burning**
3. **Forms a bond with fertilizer preventing "Tie-up"**
4. **Increase crop production by 10-40%**
5. **Enhance plant nutrient translocation**
6. **Accelerate the ripening period 5-10 days**

Summary of Research Findings

7. Enhance soil & plant health
8. Increase water sequestration by 11%
9. Decrease the content of nitrates and other harmful substances i fruit & improves nutritional quality
10. Increased plant's resistance to disease, frost damage and drought

THANK YOU