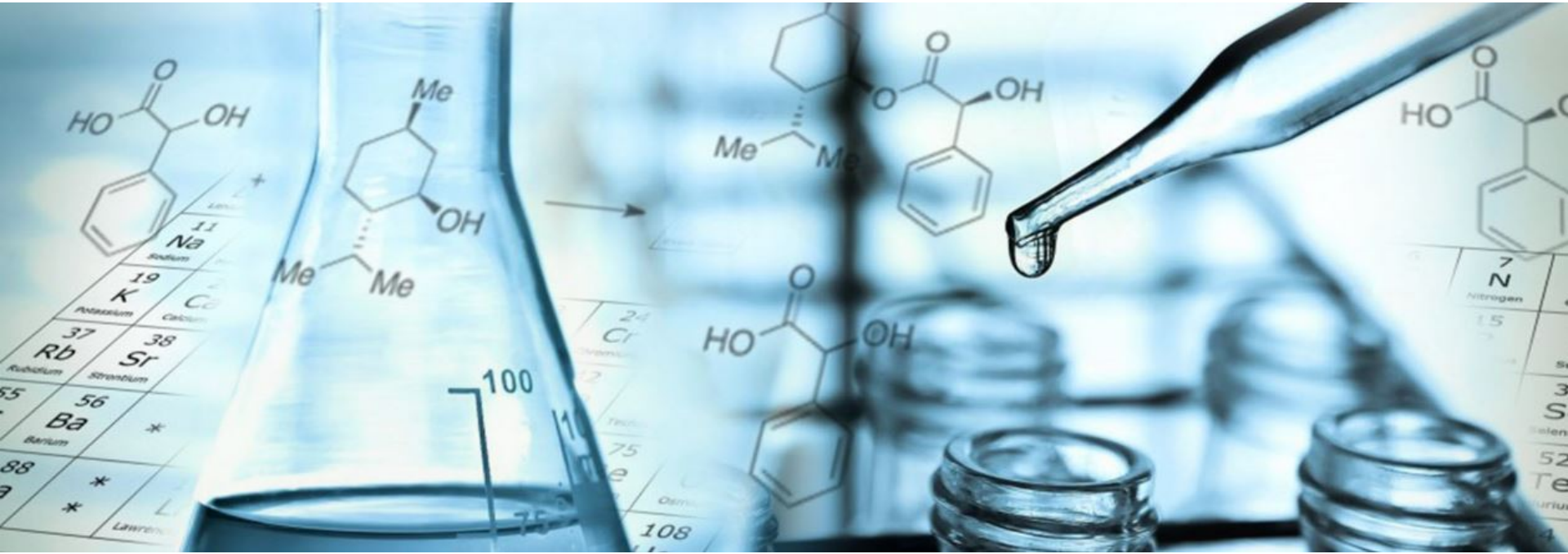
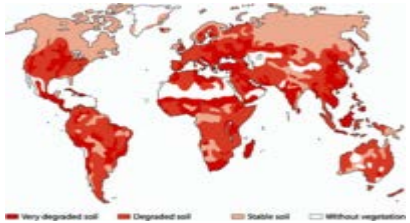
The Applied Technology of Humic Substances and Their Impact on Soil Health, Fertilizer, and Water-Use Efficiency



Mir M. Seyedbagheri, PhD.
Soil Agronomist

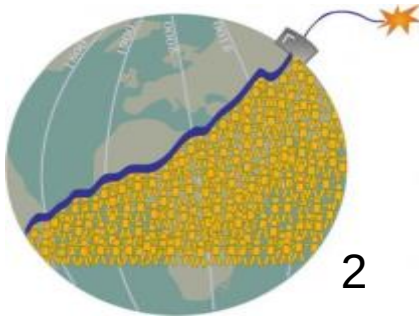
Bio Huma Netics 2016
Bi-Annual World Conference



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. We **MUST** enhance soil health and its sustainability



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

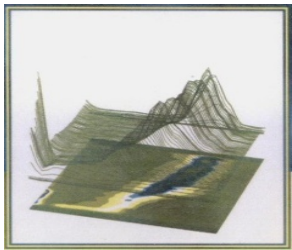
H.S. Molecules/Puzzles

Humic Acids are
"super-mixtures"
There is a clear indication that HS effects of plants are complex and involve non-linear, cross-interrelated and dynamic processes that need be treated with an interdisciplinary view.

How do they work?
These are the functional groups in Humates

Carboxyl	$-CO_2H$
Phenol	-OHp
Hydroxyl	-OHa
Ketone	-C=O
Ester	O=C-O-R
Ether	-C-O-C-
Amine	$-NH_2$,-NH, -N

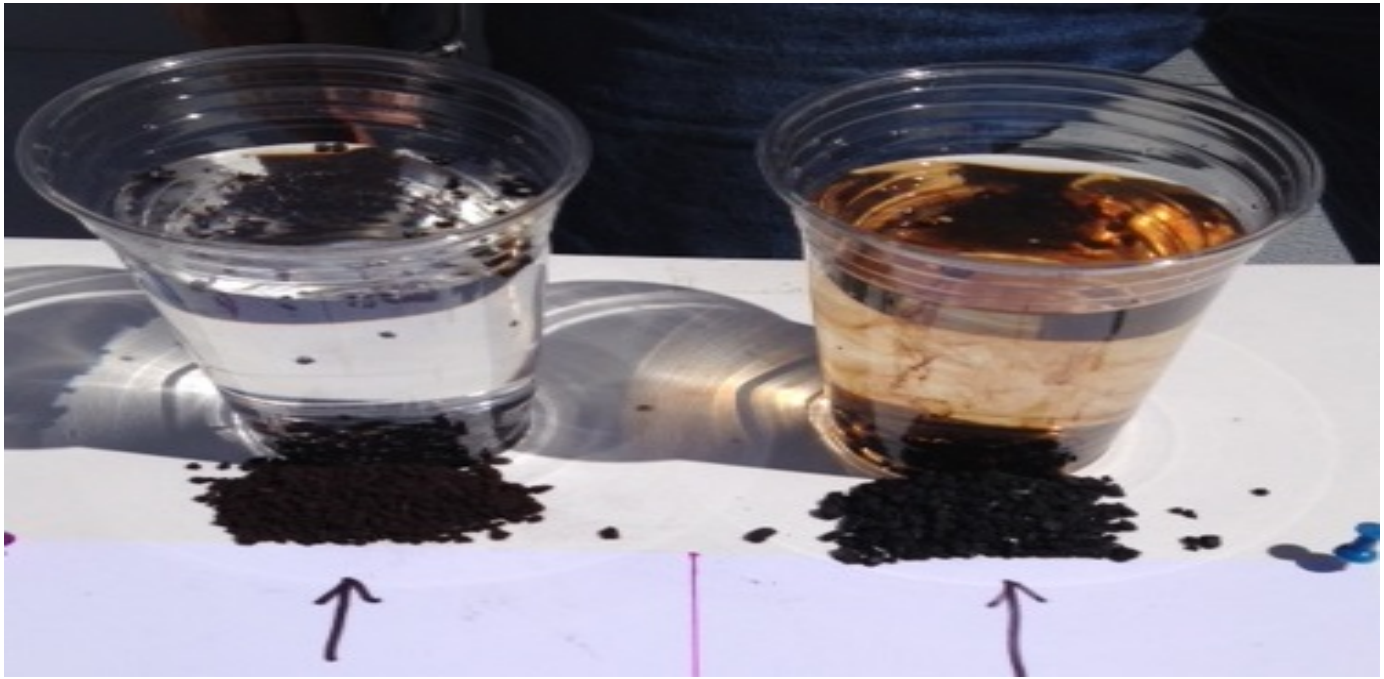
Using hydrolysis methods, we replace Hydrogen and make them more functional, enhancing CEC, buffering, chelation, and complexation.



Raw Humic Ore

Seyedbagheri 2016

30 seconds later



Raw Humate

Wet chemistry then granulated Humate

Solubility Index

Raw Humate

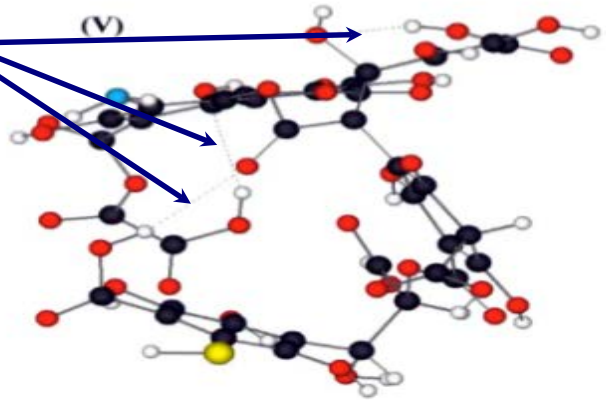
Wet chemistry then granulated Humate

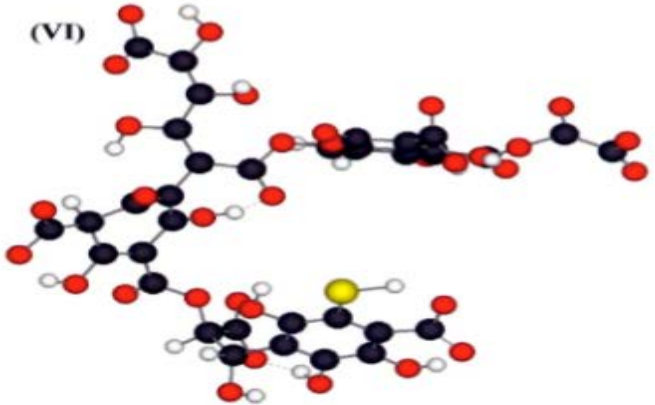
Effect of functional group ionization on conformation of Humic Substances

Non-ioinized-tight conformation

COOH groups ionized-molecule begins to relax

H-bonding





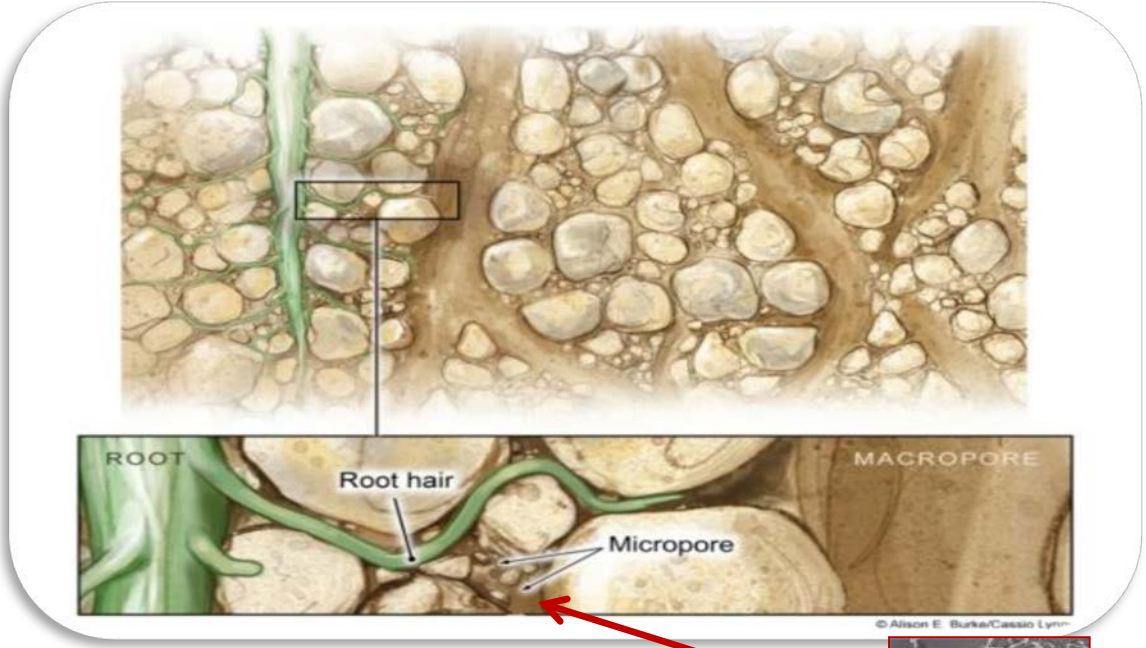
Both COOH and phenolic OH groups ionized molecule completely relaxed

The ionized functional groups will help soil physical, chemical and biological dynamics

It will make more micro-pores where roots, water and nutrients reside.

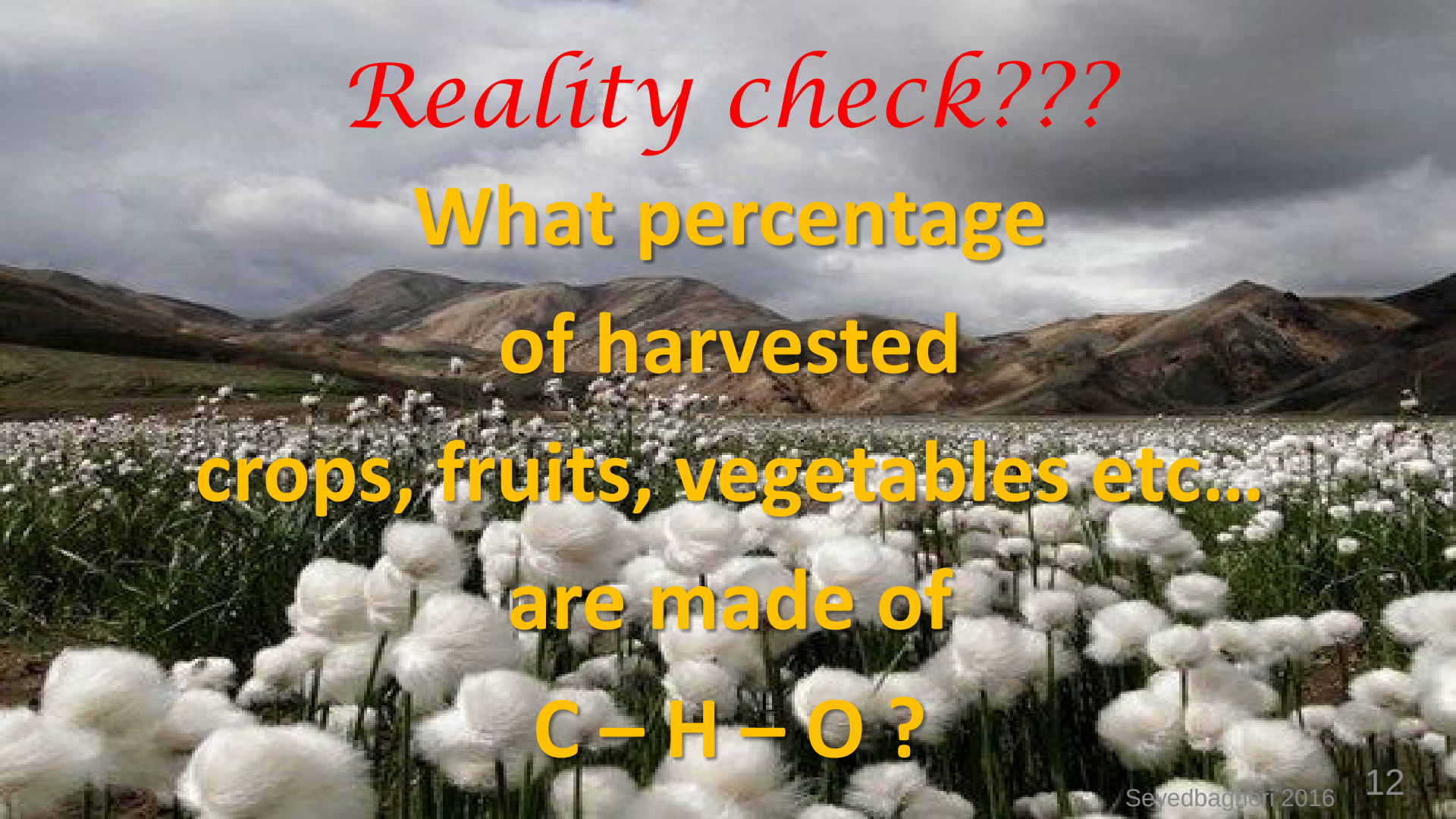
10

How H.S. Helps Soil Micro-pores

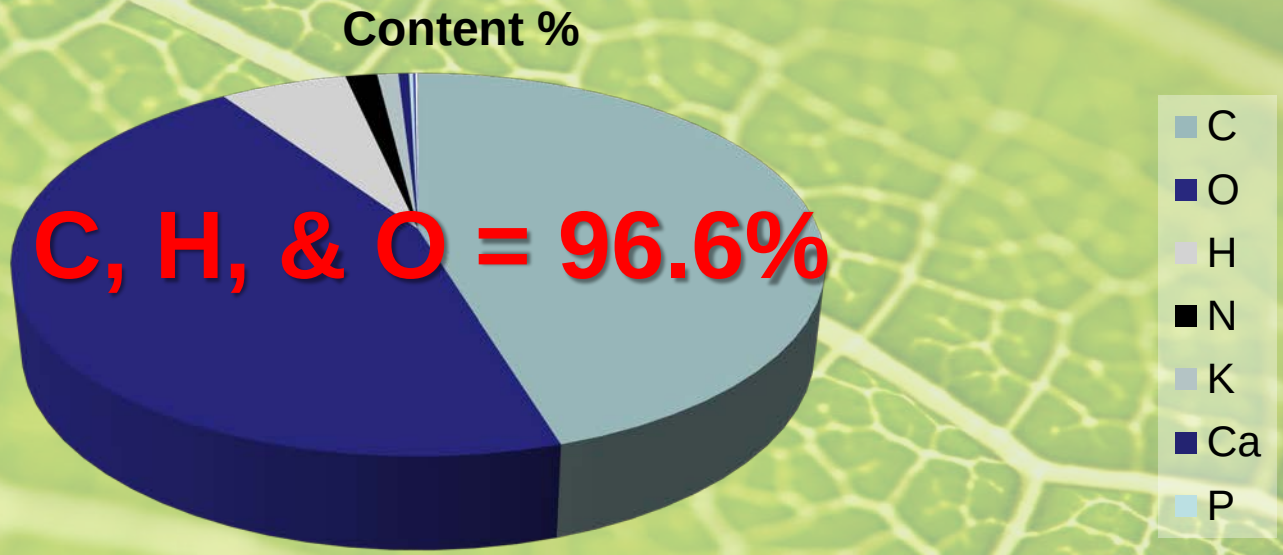


- Roots, water, and nutrients reside in **micro pore space**
- Oxygen resides in **macro pore space**

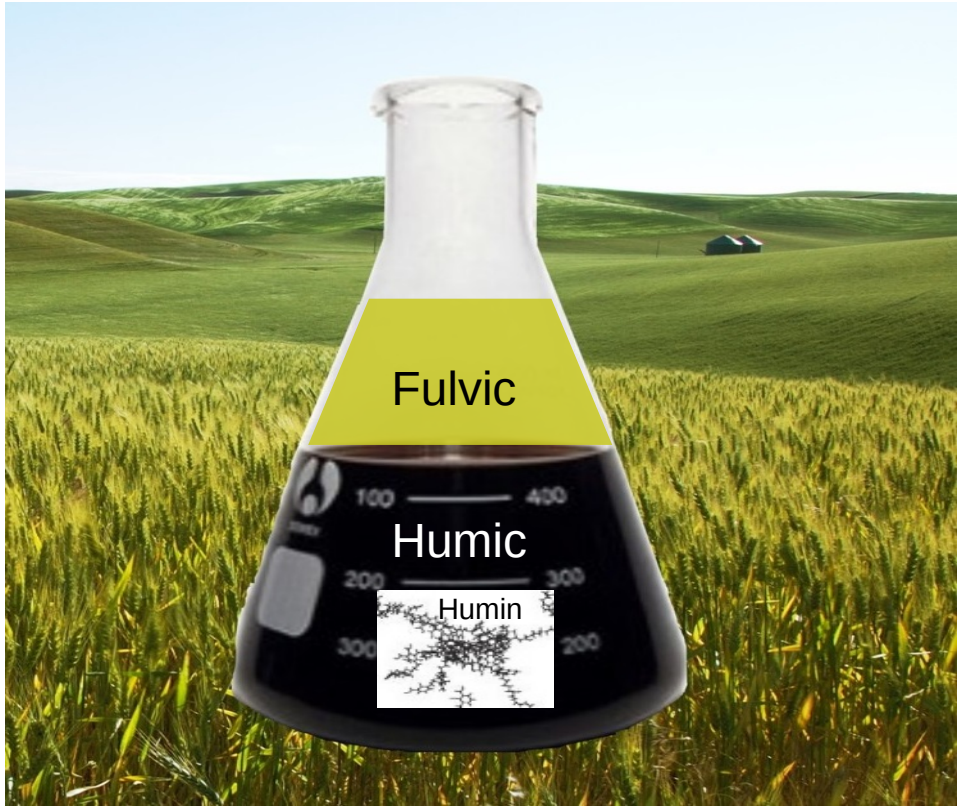
1 c.m. is 10,000,000 n.m.


Reality check???
What percentage
of harvested
crops, fruits, vegetables etc…
are made of
C – H – O ?

Plant Composition



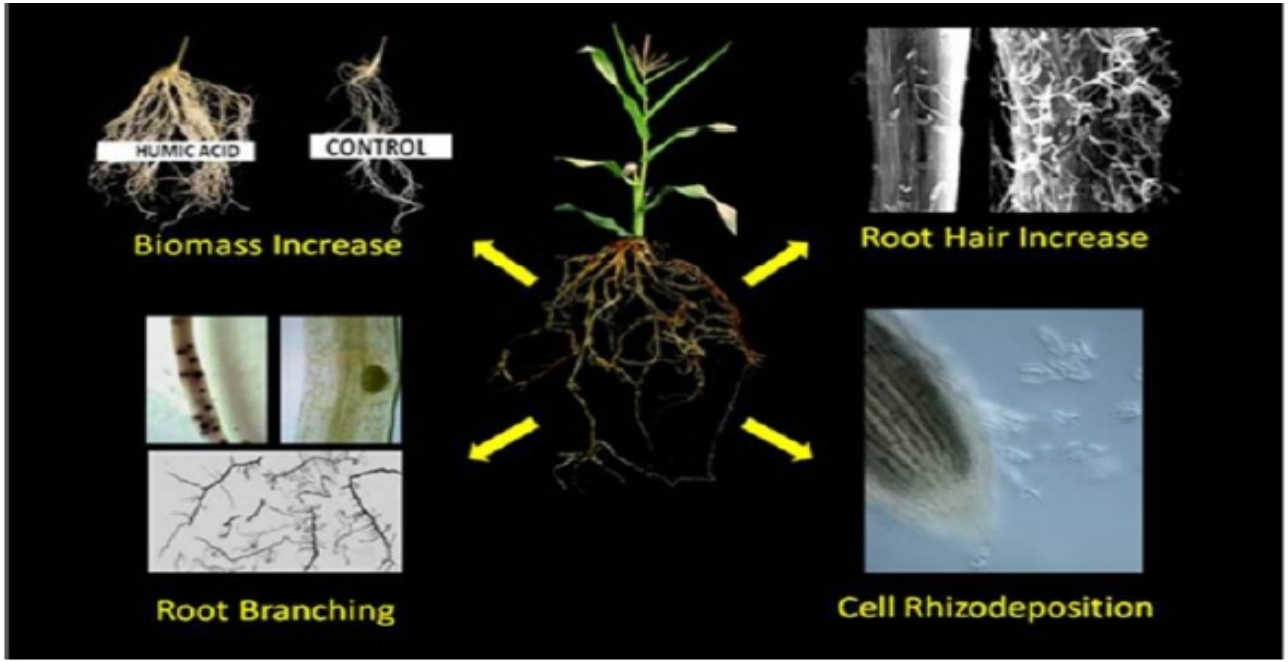
The 5-R's of Nutrient Stewardship



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

5. Right Humic, Fulvic or Humin chemistry

Right Humate



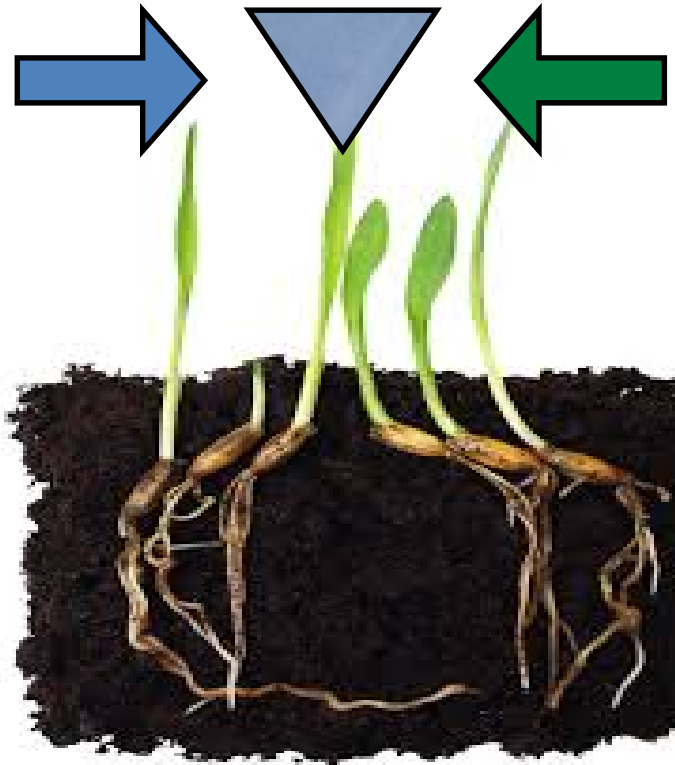
Root architecture, root hair, root exudate and enzyme production by HS

Seyedbagheri 2016

Luciano et al

Culture Conditions
•Soil fertility
•HS placement

Humic Substance
•Source
•Concentration
•Size (molecular wt.)



Plant
•Species
•Age

*Seed Germination

*Shoot Development

*Seedling growth

*Root Initiation and Development

*Enhanced Metabolic Activity

*Enhanced adsorption of macro- and micro-nutrients (e.g. NO_3^-)

Organic Acids Influences Plant Growth and Soil Health

Seyedbagheri 2016

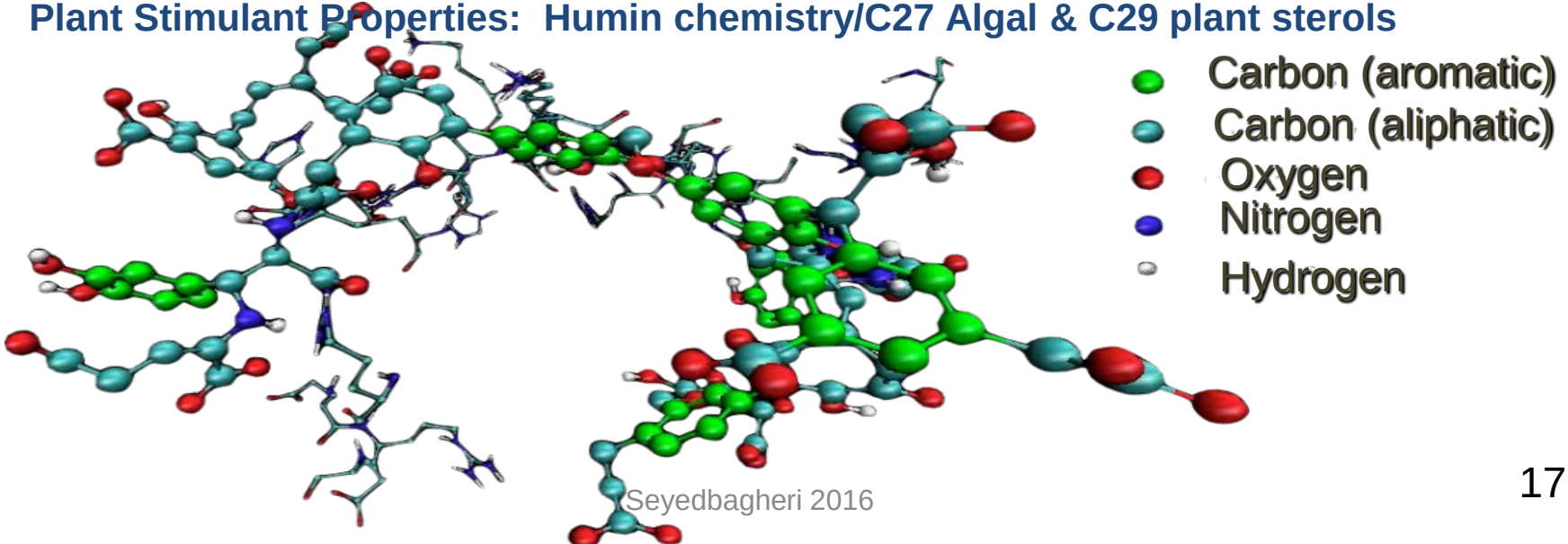
Interactions of soil minerals, humic and microbes

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



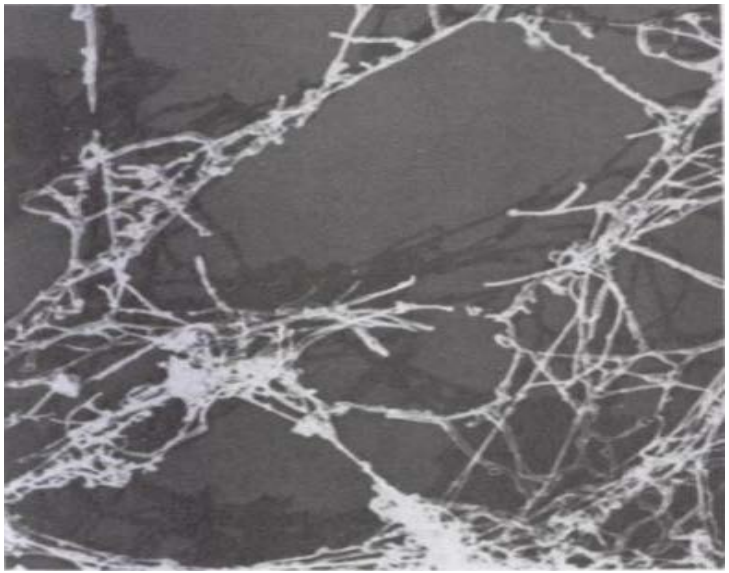
Seyedbagheri 2016

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

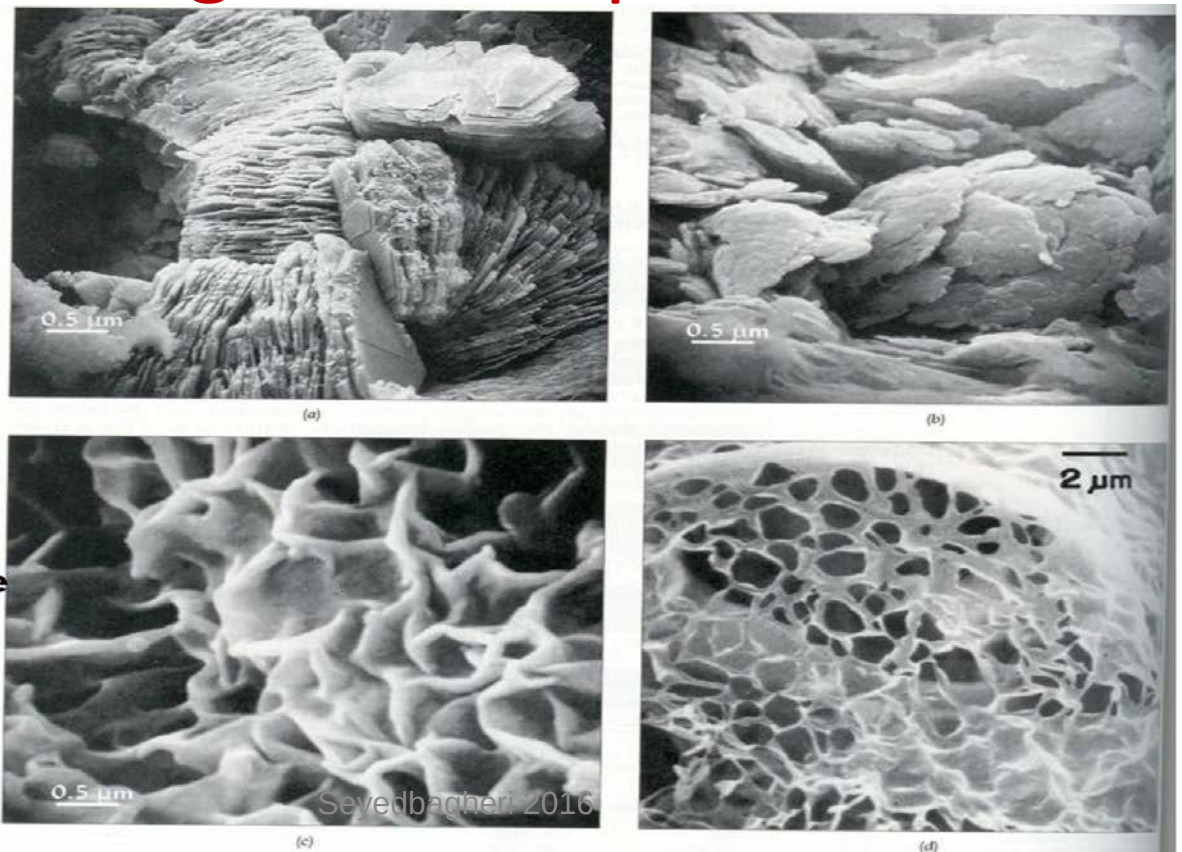
Relative comparison .005 mm = 5,000 nanometers

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



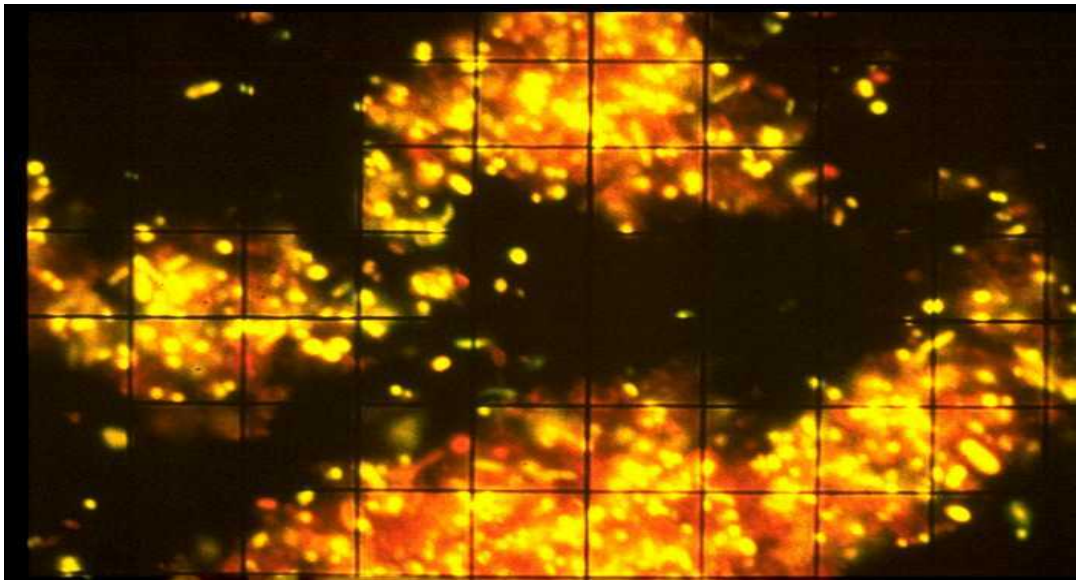
Transmission electron micrograph of a 0.01% (w/v) HA solution. The scale: 0.4 cm = 1 μm. HAs and FAs form flat elongated multi-branched filaments of 20 to 100 nm in width. Smallest particles are spheroids of 9-12 nm in diameter.

Understanding Soil Mineralogy is a must for calculating H.S. rate per acre/hector



Seyedbagheri 2016

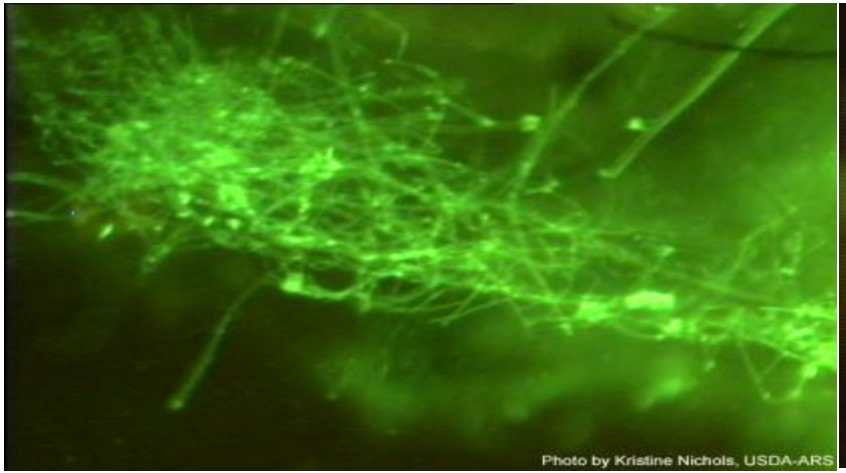
Clay Humus Creates Excellent Environment for Microbes

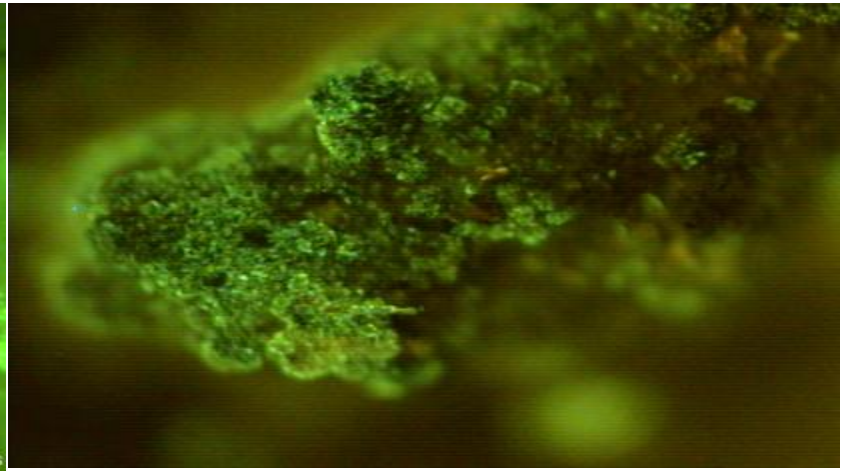


Soil microbes inhabiting the surface of clay-humus crumb, glowing under UV light, stained with acridine orange, as seen under a high-resolution Leitz microscope.

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

Humic Substances Help Soil Microbes & Glomalin Formation

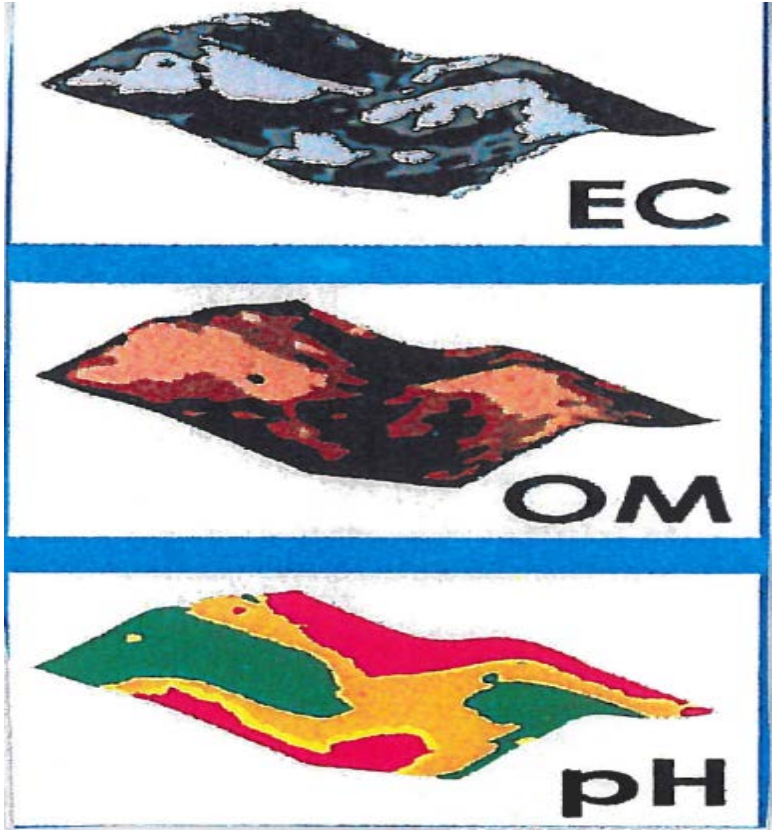




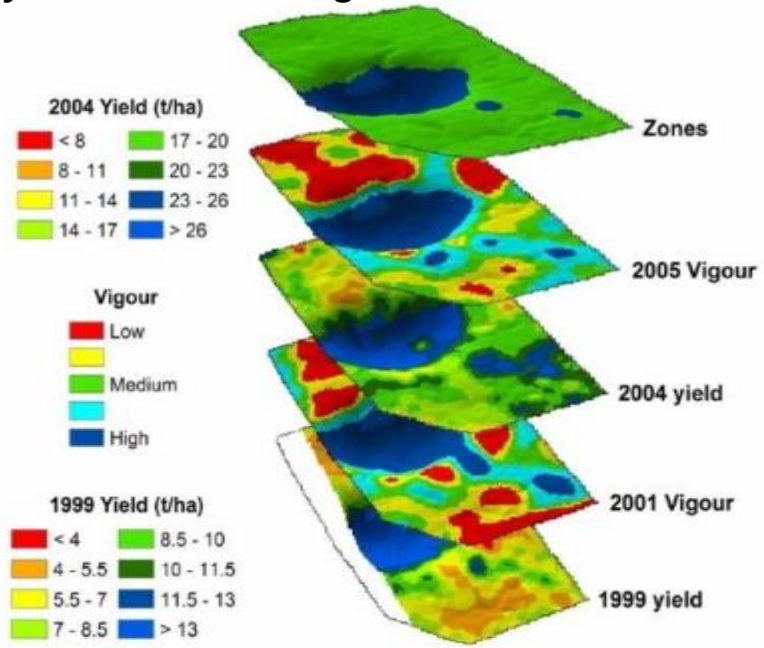
Glomalin (bright green) is a sticky substance that creates tiny soil aggregates.

Seyedbagheri 2016

Variations in soil fertility & how **Humic Substances** help to buffer



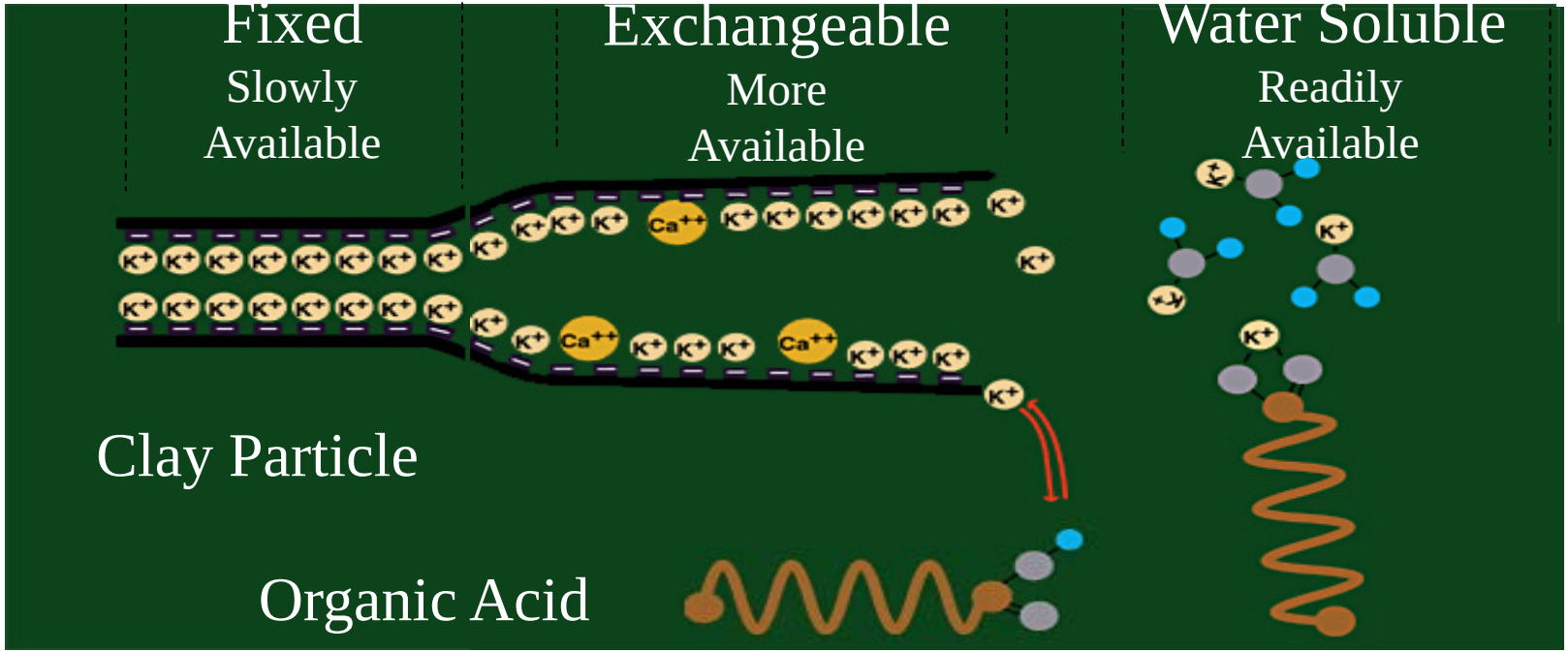
Enhancing yield potential
6 years after using Humic Substances



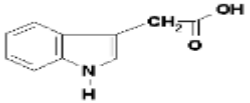
Seyedbagheri 2016

Nutrient Exchange

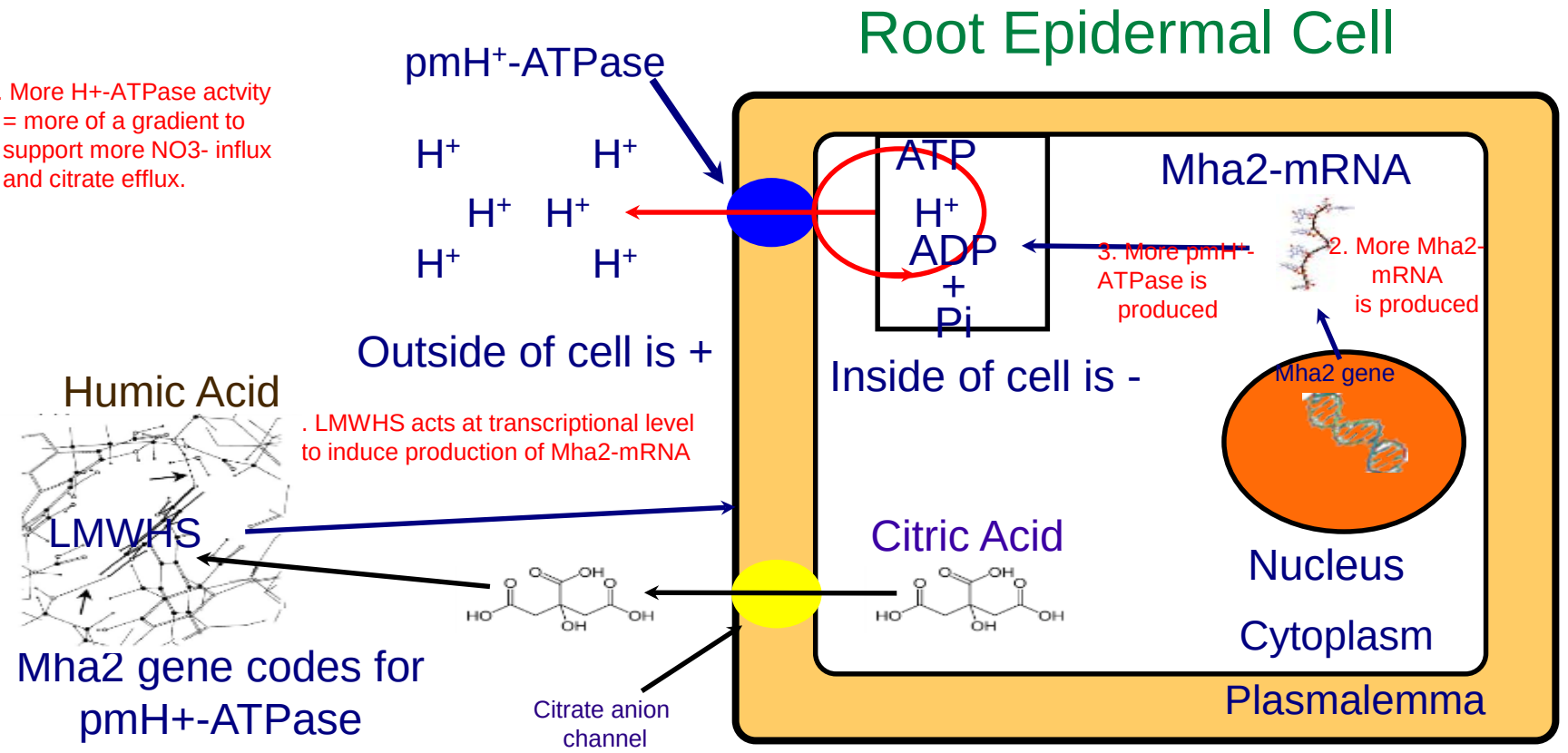
Clay CEC 20 to 40 ------- Organic Acids CEC 250 to 500



Effect of Humic Substances on Plant Metabolism

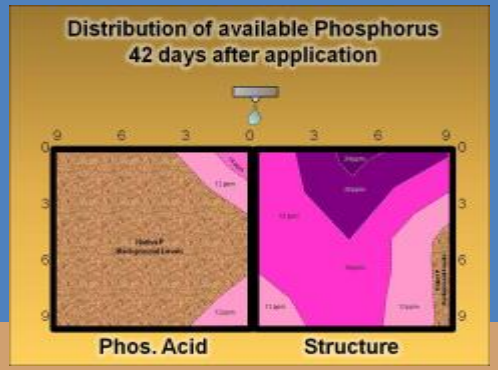
IAA 

Nutrient Aquisition-NO_3^-



(after Quaggiotti et al. 2004)

Humic Substances Influence on P-Use Efficiency



Component | Input to soil | Loss from soil

Crop harvest

Respiration

Mineral fertilizers

Phosphofructokenase

Phospho-glucose isomerase

Plant uptake

Adsorption

Desorption

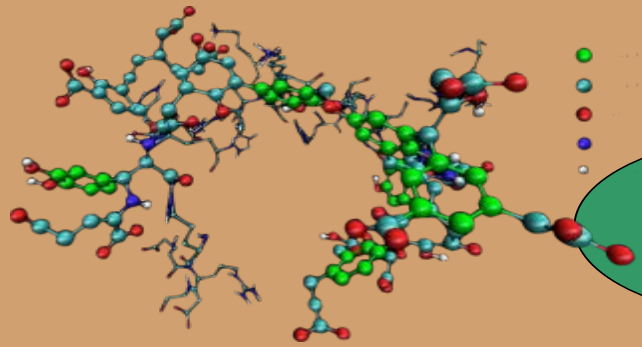
Mineral surfaces (clays, Fe and Al oxides, carbonates)

Soil solution phosphorus
•HPO_4^{-2}
•$H_2PO_4^{-1}$

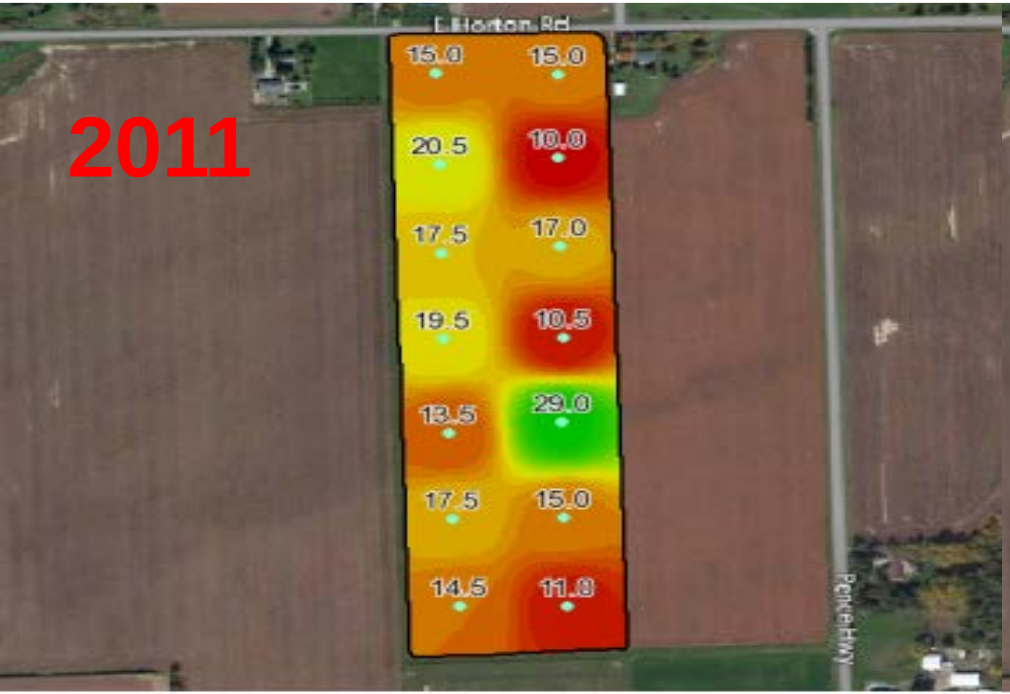
Dissolution

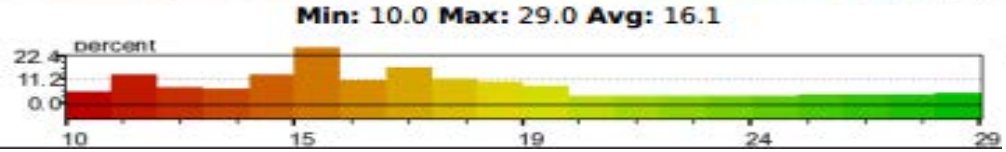
Precipitation

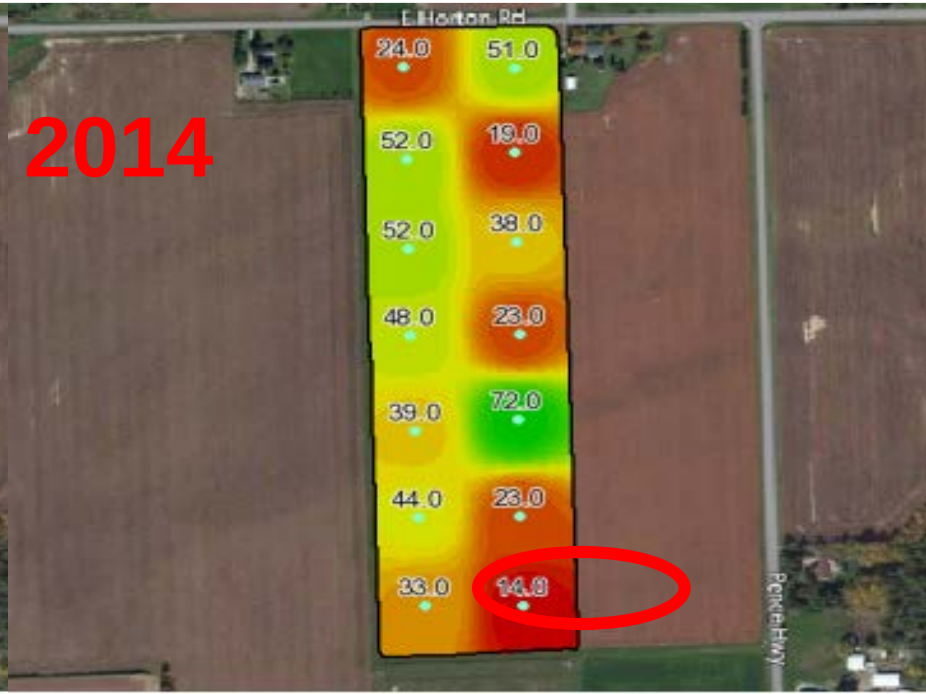
Secondary compounds (CaP, FeP, MnP, AlP)

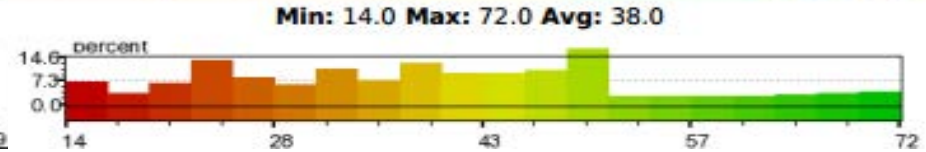


Influence of H.S. on P Availability

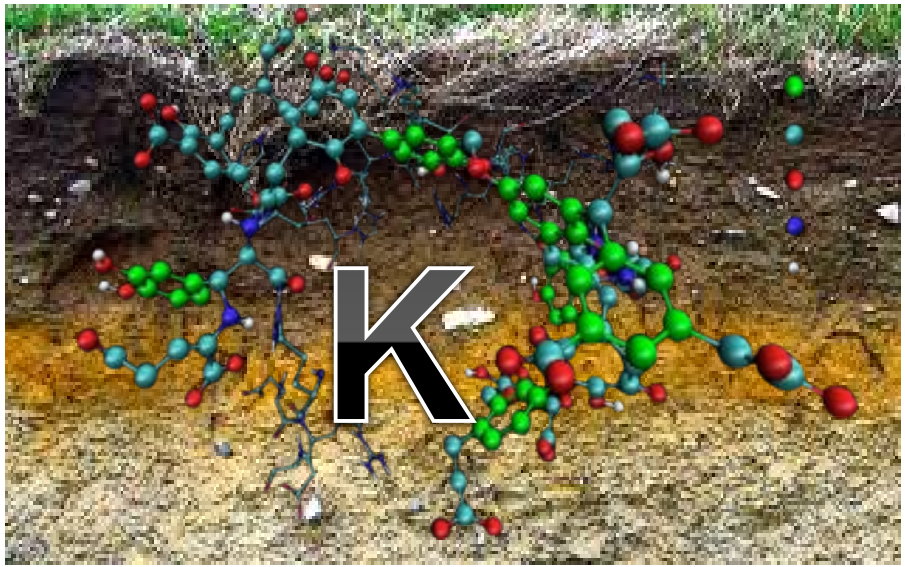








K Dynamics in the Soil & HS Priming Effect



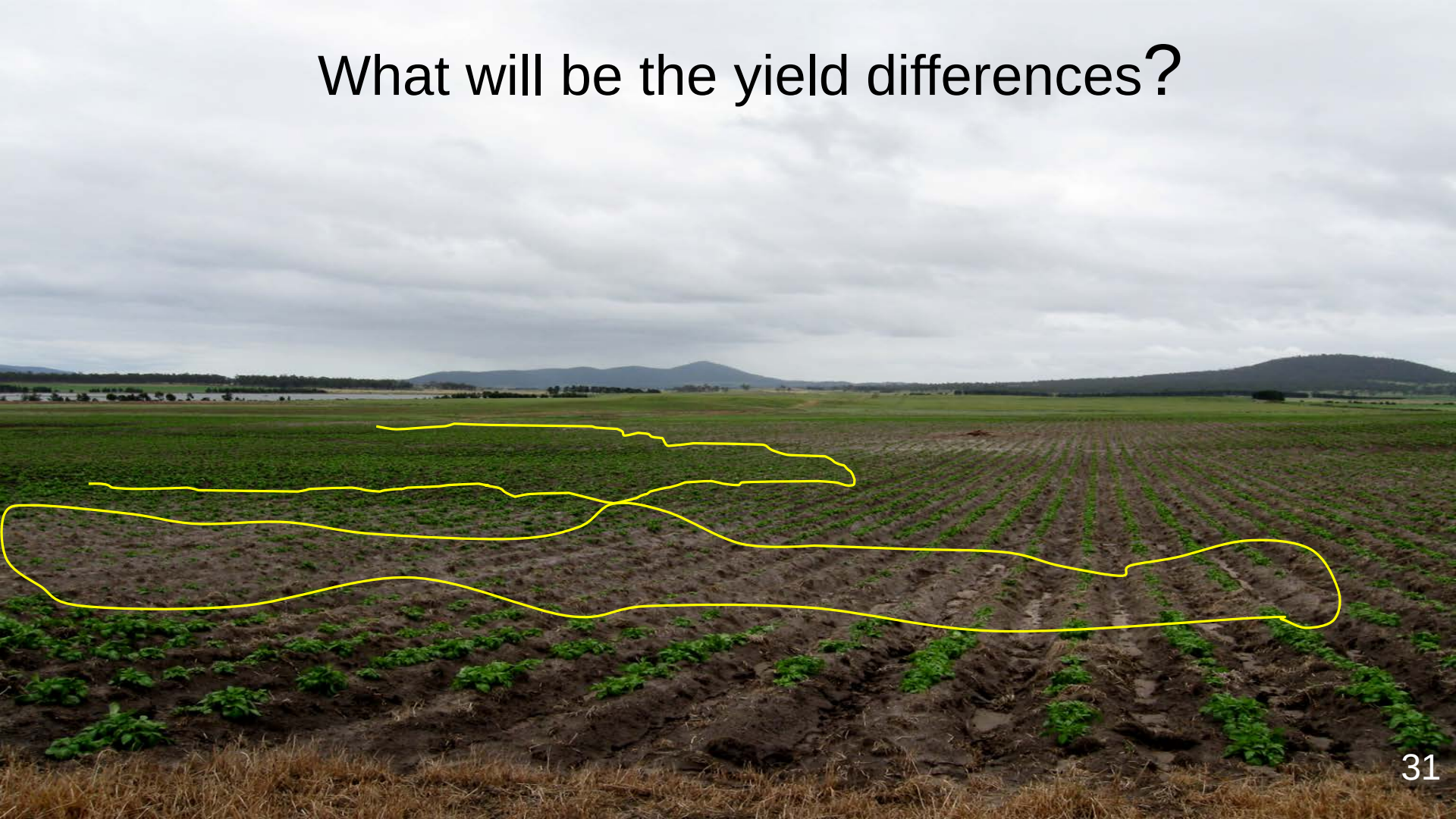
1. Mobilization of plant defense system
2. Increases cuticle thickness
3. Carbohydrate synthesis with Boron
4. Tolerance to adverse conditions such as Heat, drought and cold

Seyedbagheri 2016

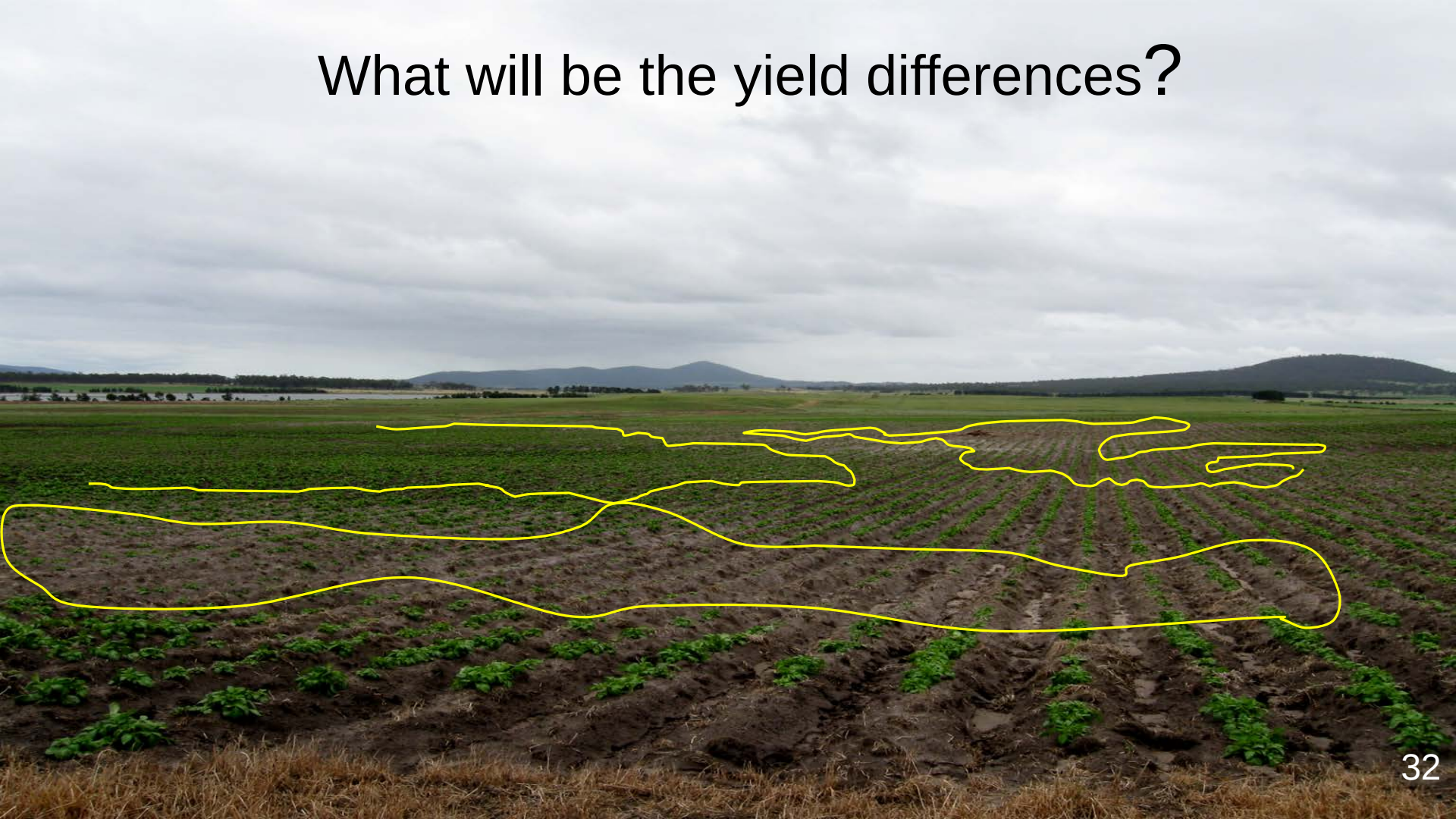
What will be the yield differences?

What will be the yield differences?

What will be the yield differences?

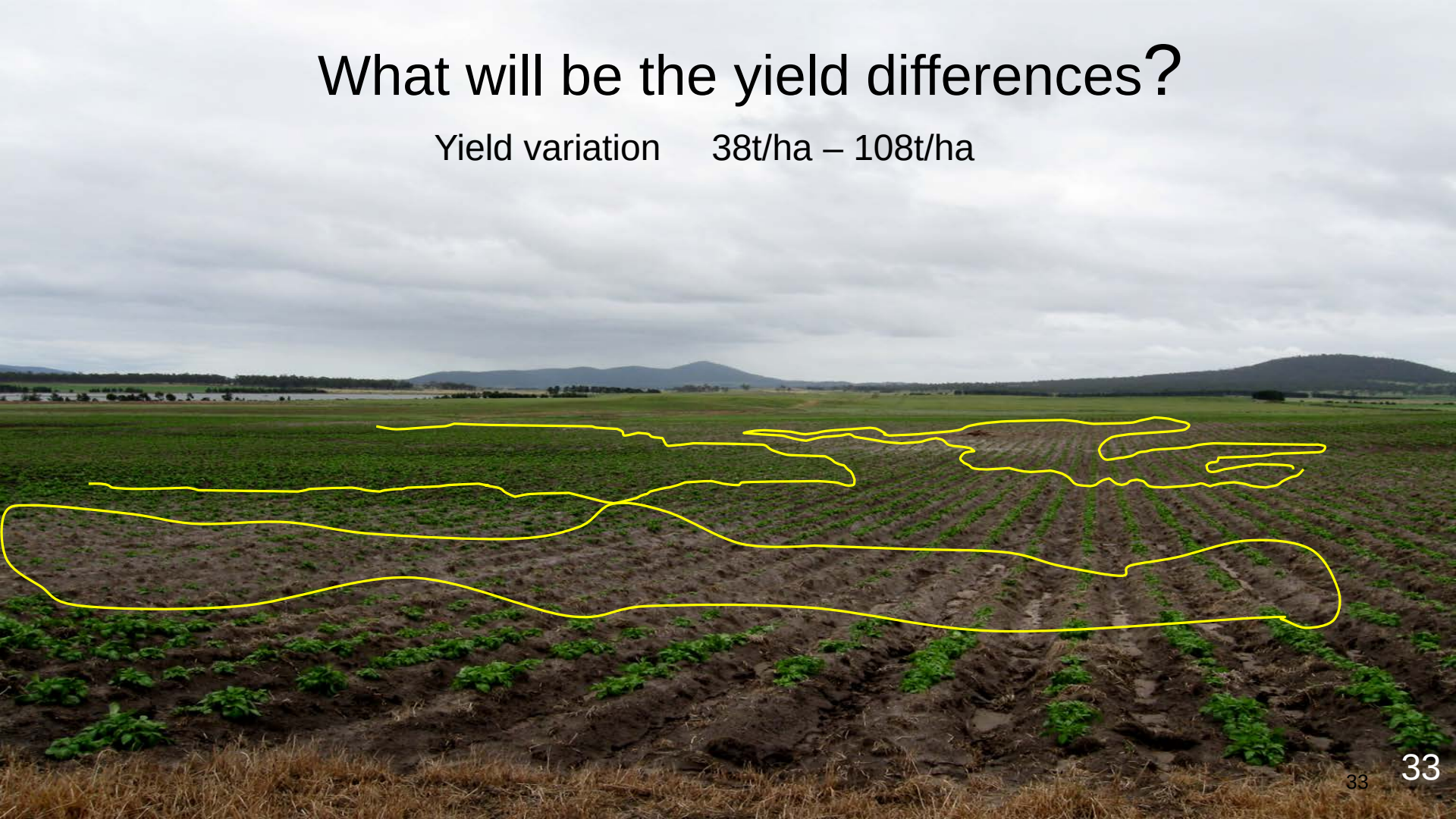


What will be the yield differences?



What will be the yield differences?

Yield variation 38t/ha – 108t/ha



33

Buffering Properties of HS

Potentiometric titration studies clearly indicate that H.S. and their salts act as natural soil buffers. Warchulska, 2008

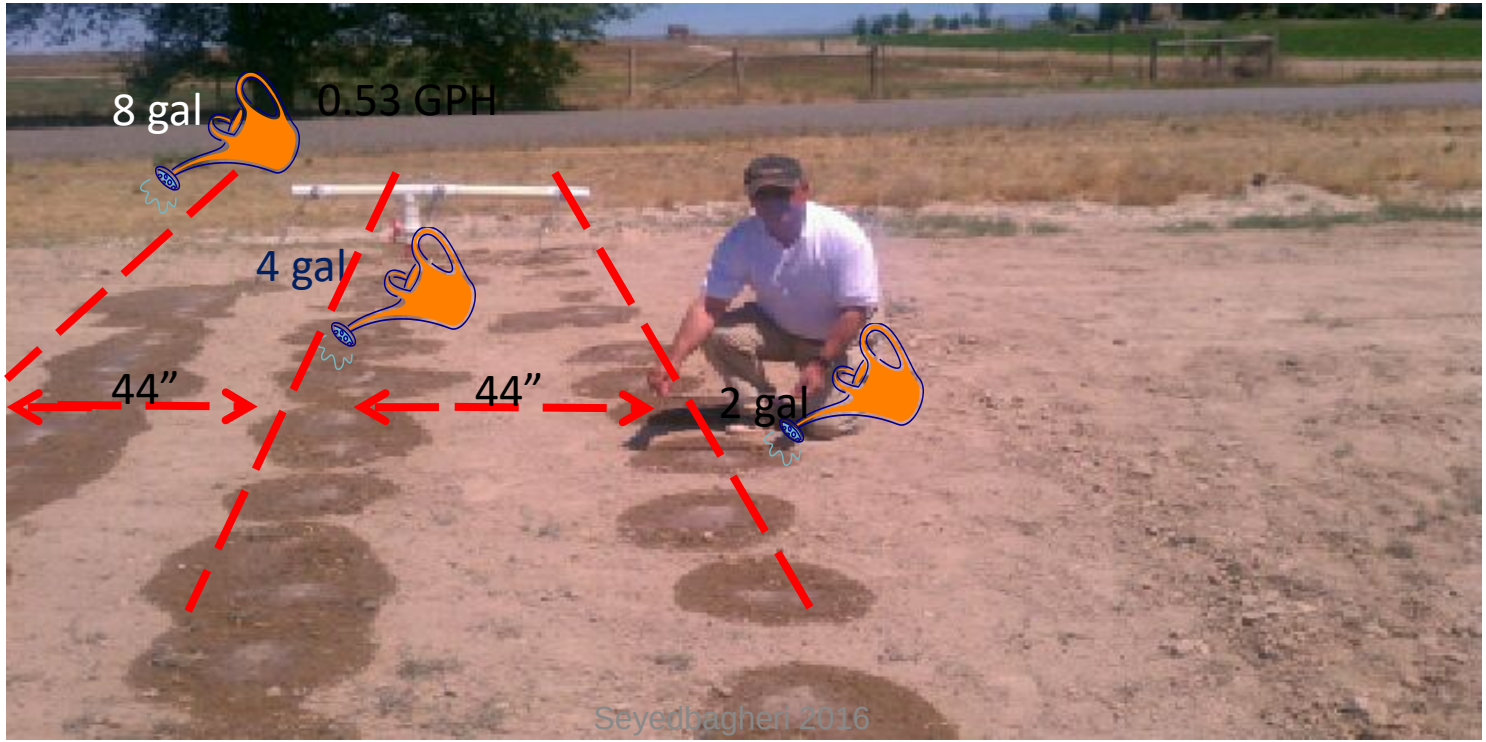
Electromagnetic induction (EM38)

H.S. buffers and enhances stand and vigor

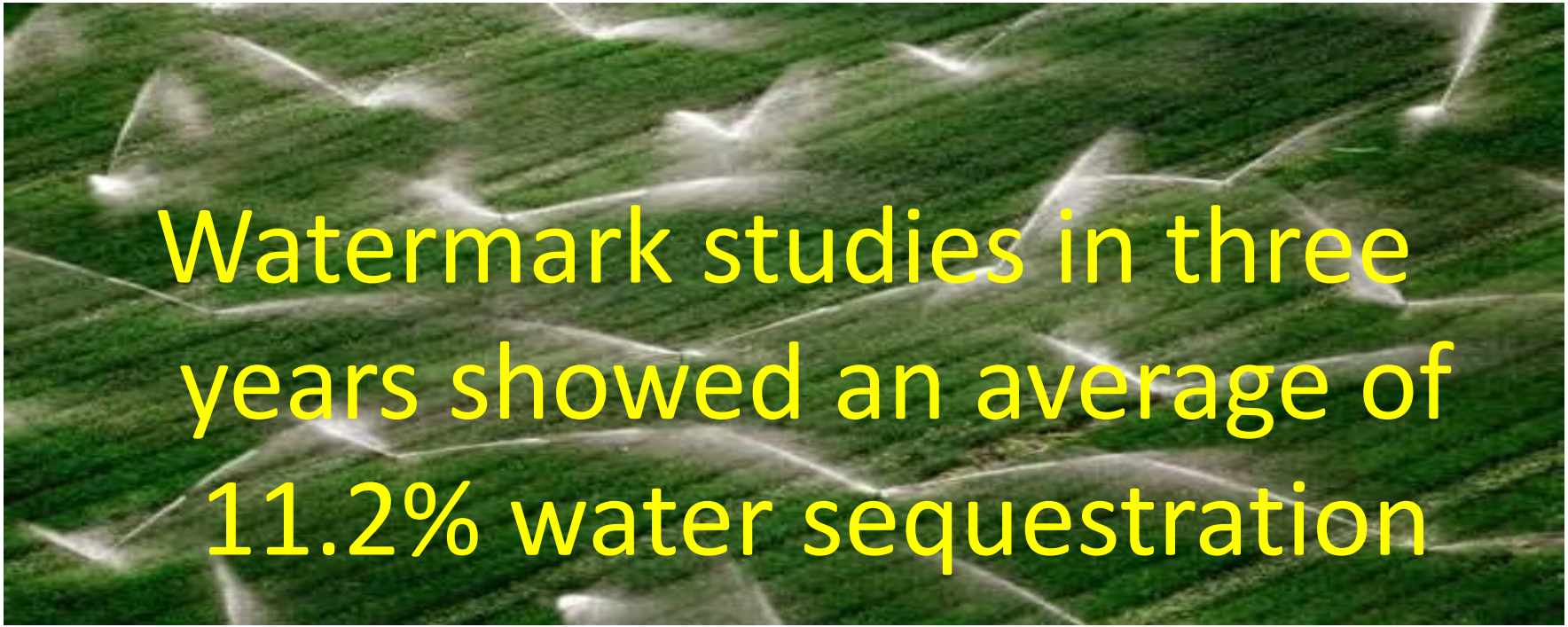
H.S. & Water-Use Efficiency

Influence of O.A. on Water-Use Efficiency

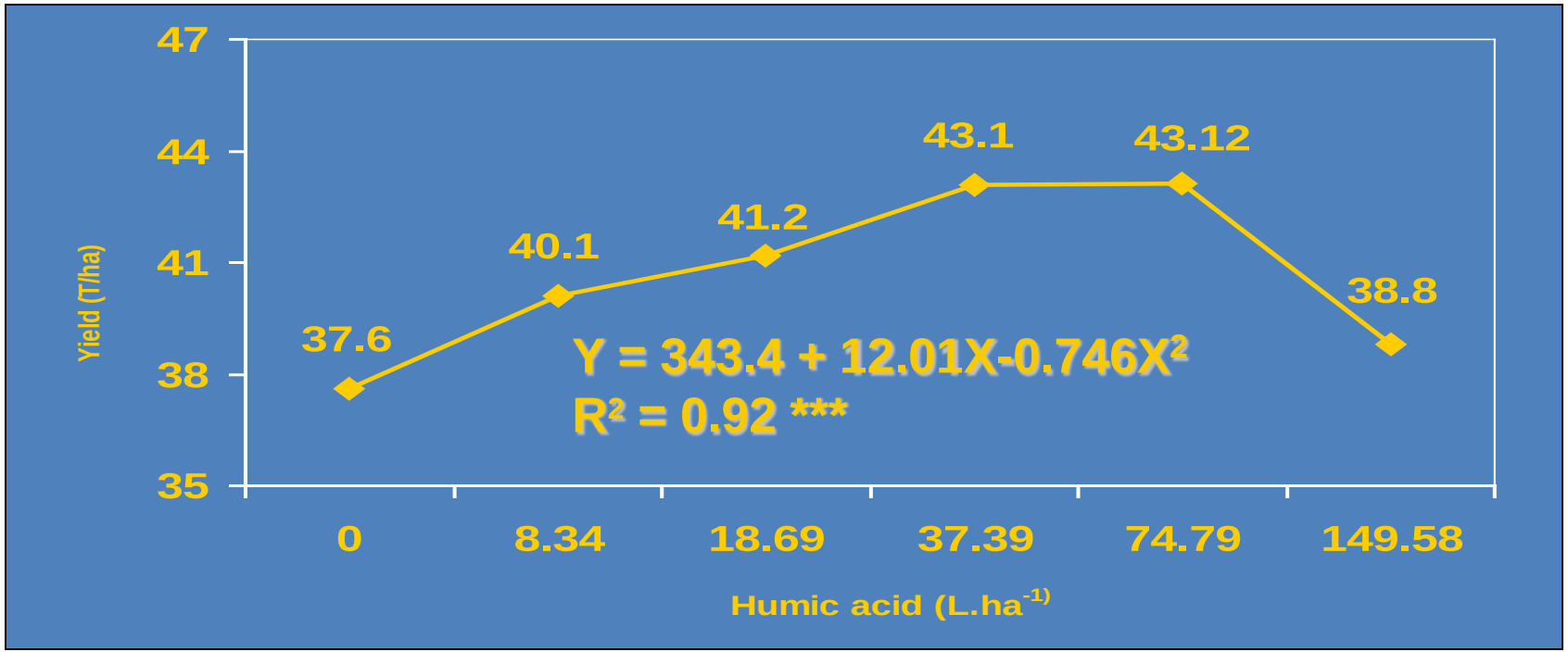
Wetting Patterns after 6 hours for 10-20 cm emitter depths



Humic Substances Influence on Water Sequestration



Effects of Humic Acid Rate on Potato Yield at Three Sites



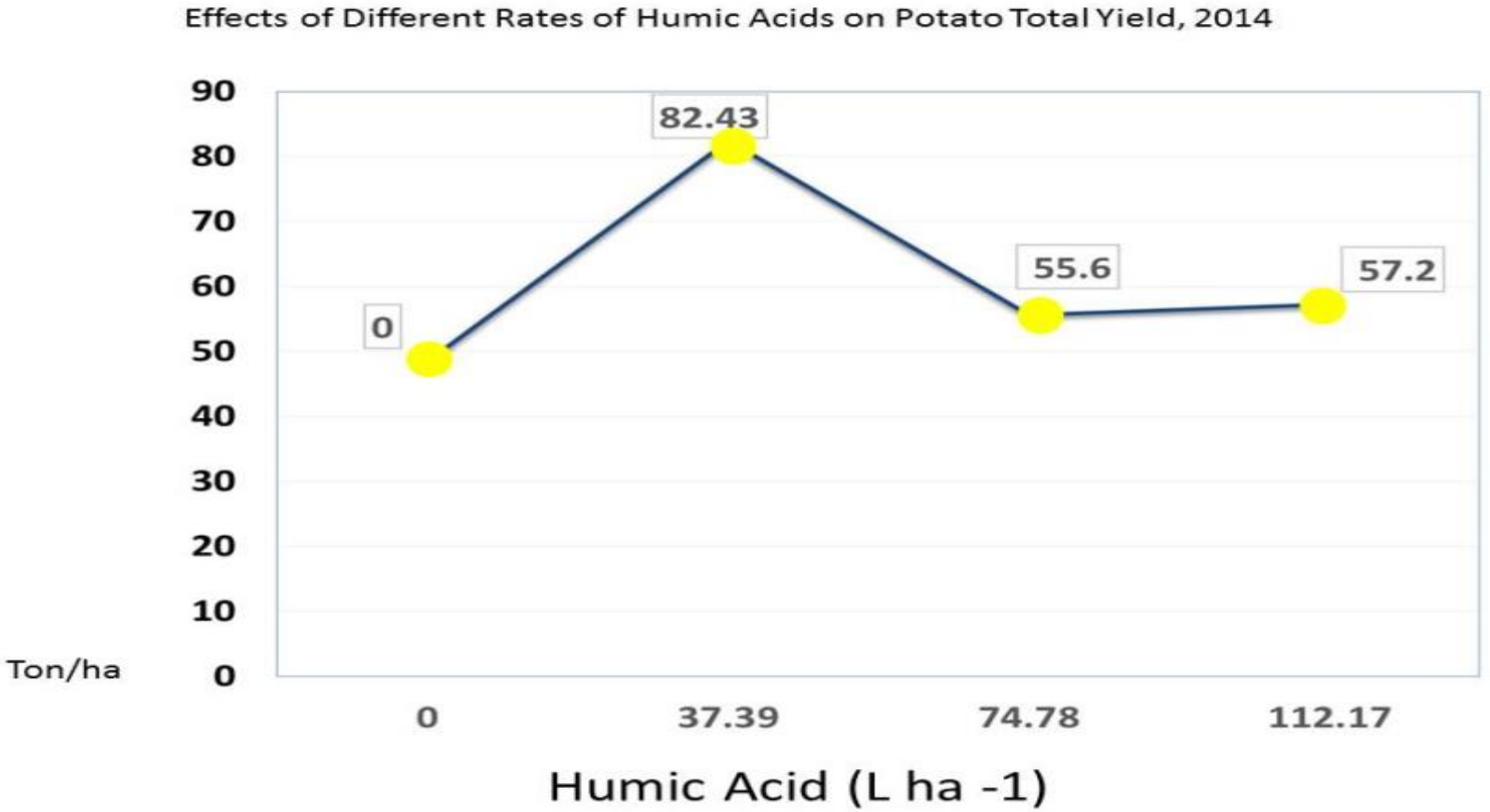
Seyedbagheri 2016

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



Seyedbagheri 2016

Harvested 10 days earlier

Quantitative Field Observations on Yield and Quality

H.S. Influence on Small Grain Yield and Quality

Influence of H.S. on seed germination & plant vigor
Winter Wheat

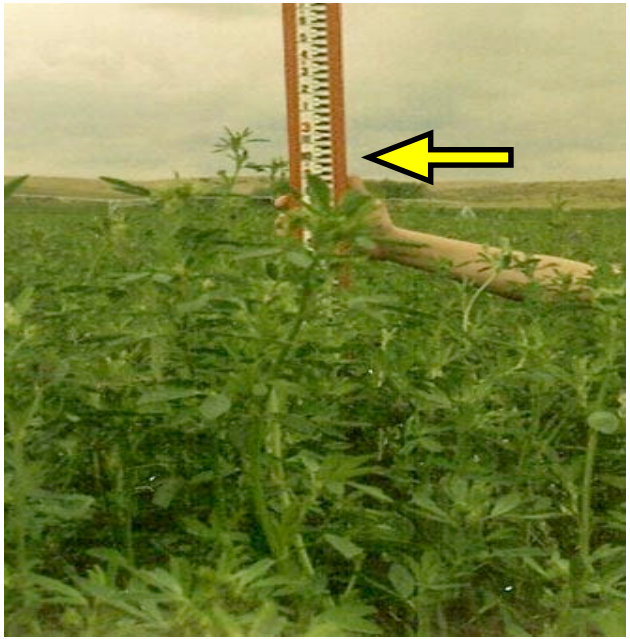
Seyedbagheri 2016

HS Influence
Healthy Stand & Vigorous Roots

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

Alfalfa-not treated

Alfalfa-treated with OA @ 2 g/acre



Seyedbagheri 2016

Alfalfa High RFV, Good Yield and Vigor

H.S./Quality & Yield Increase

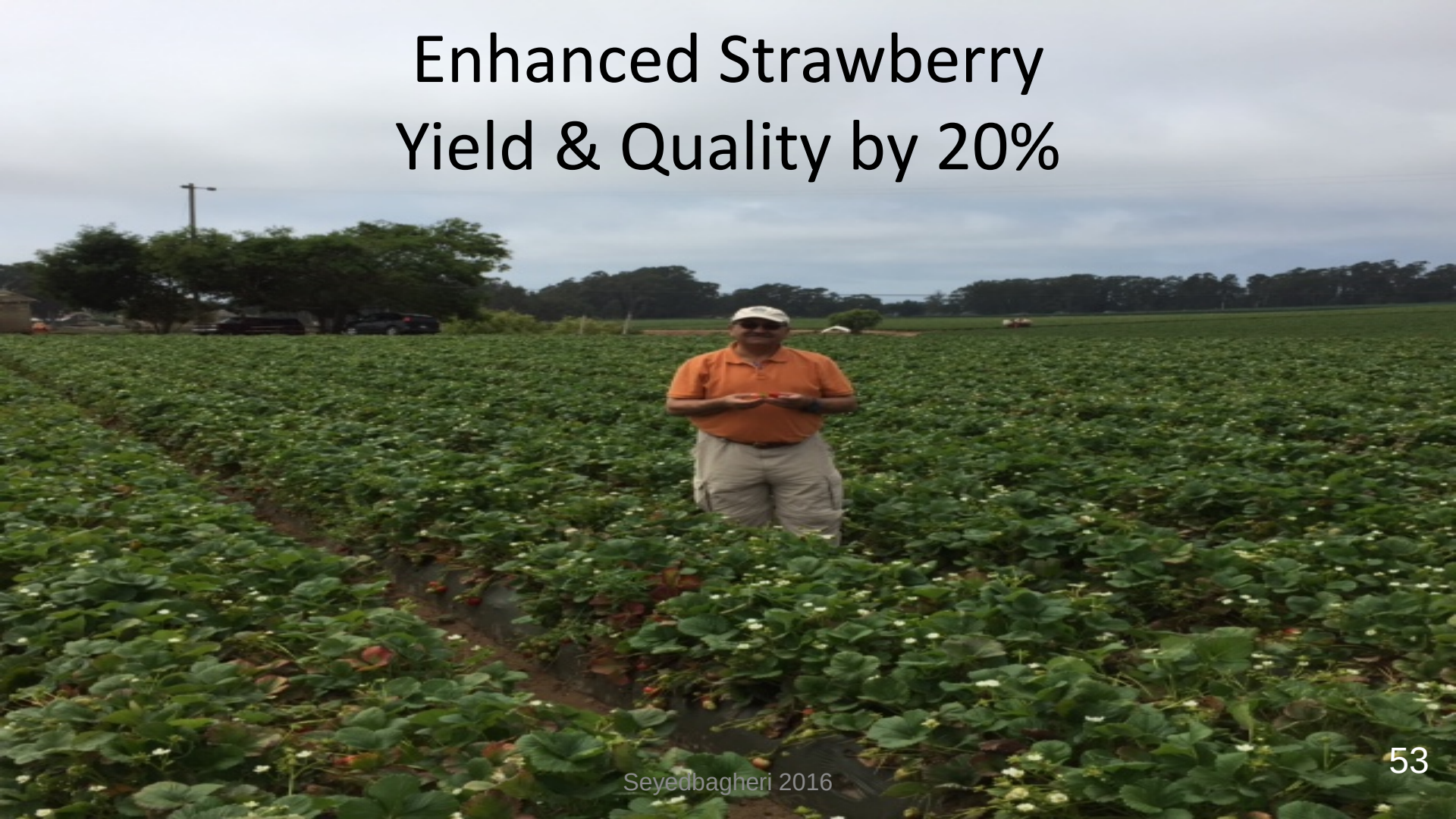
Effect of H.S. on Plant Growth

Corn at 6-8th vegetative leaf stage

Working with applied field test plots, H.S. helped to increase Yield up to 30%

Enhanced Lettuce Yield & Quality by 15-25%

Enhanced Strawberry Yield & Quality by 20%



H.S. Influence on N.M. & Soil Health

very compacted soil to healthy soil

Research findings on the effects of HS on soil and plant metabolism

1. **Solubilization of Micro (e.g., Fe, Zn, Mn) and some Macro nutrients (e.g., K, Ca, P)**
2. **Buffers salts, reducing burning**
3. **Forms a bond with fertilizer preventing “Tie-up”**
4. **Increases crop production by 10-40%**
5. **Enhances plant nutrient translocation**
6. **Accelerates the ripening period 5-10 days**

Seyedbagheri 2016

Summary of Research Findings

7. Enhances soil & plant health
8. Increases water sequestration by 11%
9. Decreases the content of nitrates and other harmful substances in fruit & improves nutritional quality
10. Increases plants' resistance to disease, frost damage and drought

Thank you

This is a combined research of many scientists as well as
my research with various humic companies.

Thanks

HUMA GRO™

Dr. Mir Seyedbagheri
Soil Agronomist