Integrating Biologicals for a Holistic Soil Health Management

Northern San Joaquin Valley
Processing Tomato Meeting

29th January 2020

University of California
Agriculture and Natural Resources

Outline

- Defining Healthy Soils
- The Potential of Biostimulants
- What to Expect from Biostimulants
- Integrating Biologicals for Healthy Soils

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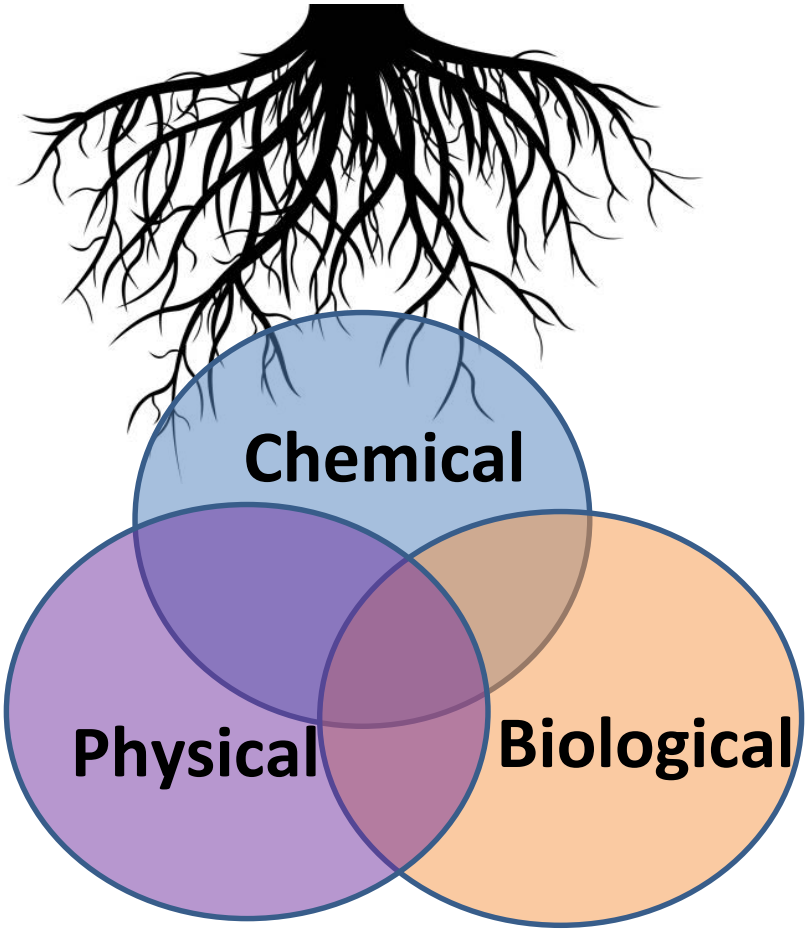
Soil Health

- Integration of chemical, biological, and physical components
- Management impacts all three components
- Imbalance compromises soil health
- Component interactions determine soil health



Healthy Soils

Functions of Soil

- Medium for plant growth
- Regulator of water supplies
- Recycler of raw materials
- Habitat for soil organisms
- Engineering medium
- More??

Nutrient Cycles Regulated by Microbes

- Nitrogen mineralization
- Phosphorus acquisition and availability

Healthy Soils

“Healthy Soil” => Sustained Soil Function

- Cover soil, reduce disturbance, maintain roots, include livestock, maximize crop diversity
- Soil health principles help build resiliency

“Unhealthy soil” => Constrained Soil Function

- Chemical, physical, and/or biological limitations on soil ecosystem services
- Constraints increase plant and soil vulnerability to diseases

Healthy Soils and Microbes

Achieving a 'microbial balance' with management (and biostimulants?)

- Crop characteristics, rotation, fertilization, and tillage
- **Management Practices:** inoculated seed, disease-suppressive plants, and soil amendments
- **Management Tools:** soil solarization, biological soil disinfestation, biofumigation, biocontrol, and biostimulants

"In conclusion, it may be restated that, with very few exceptions, ***all soil inoculants****, other than those for legume bacteria,* ***have so far proven to be worthless****, at best not better than a mere infusion of some stable manure.* ***Repeated, critical, controlled tests of the effects of an inoculant under a variety of conditions are necessary*** *to establish justification for its use in agricultural practice."*

- Waksman and Starkey, The Soil and the Microbe, 1931

Defining Biostimulants

What are plant biostimulants?

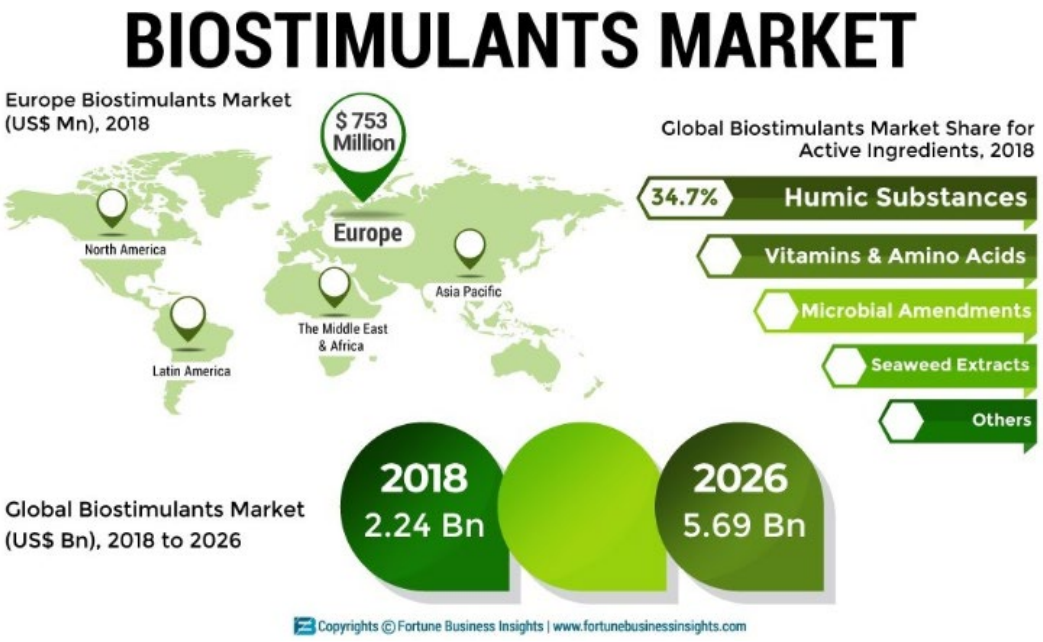
"a substance or microorganism that, when applied to seeds, plants, or the rhizosphere, stimulates natural processes to enhance or benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, or crop quality and yield."

- USDA Farm Bill, 2018

Biostimulant Potential

Current market for biostimulants is huge (billions USD) and continues to grow

Majority of products aim to support and improve nutrient availability and acquisition



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Supporting sustainable and environmentally friendly crop production by:

- Increasing crop yield/quality
- Improving nutrient use efficiency
- Reducing fertilizer inputs and losses
- Protecting against abiotic stresses
- Promoting beneficial soil microbes

Potential and Peril of Biostimulants

Using Biostimulants to Achieve Soil Health Goals:

- Increase rooting activity
- Increase activity and structure of microbial community
- Increase nutrient availability
- Building resiliency in suboptimal conditions

Challenges

- Can added biologicals produce consistent effects in the field?

- Link between microbial manipulation and soil health improvements?

Biostimulant Expectations

Promoting Soil Health with Biostimulants

- Can meaningful changes occur from application?
- Are changes consistent and repeatable?

Microbial Biostimulants and Other Substances

- Beneficial bacteria and fungi
- Seaweed extracts, humic/fulvic acids, protein hydrolysates, phytohormones

Biostimulant Expectations

Things to keep in mind:

- Not a fertilizer replacement

- Crop incompatibility
  - Ex. *Brassicas* and mycorrhizal fungi
- Ensure proper transportation, handling, and storage
- Results from laboratory may not translate to field
- Microbial biostimulants may have limited capacity to effectively establish and maintain activity in rhizosphere

Biostimulant Expectations

Method and Timing of Application

- Foliar spray
- Roots, side dressing, or irrigation
- Before/After transplanting

Transplanting stress can impact tomato productivity

- Effective rooting promotes adaptability
- Increase scavenging of water and nutrients
- Increase early season growth rate

Biostimulants and Crop Response

	Humic Acids	Seaweed Extracts	Protein Hydrolysates	Plant growth promoting rhizobacteria (PGPR)
Physiological Function	Increased root growth and biomass	Increased nutrient transport	Protection by flavonoids against stress	Increased lateral root growth
Agricultural Function	Increased root foraging, enhanced use efficiency	Improved mineral composition	Increased crop tolerance to abiotic stress	Increased root foraging, enhanced use efficiency
Economic and Environmental Benefit	Higher crop yield, reduced fertilizer losses	Enhanced nutritional value	Higher crop yield under stress	Higher crop yield, reduced fertilizer losses

Du Jardin, Scientia Horticulturae, 2015

Integrating Biostimulants

Humic Acids

- Formed as a result of crop residue degradation
- Most characteristic compounds of soil humic substances
  - Humic acids, Fulvic acids and Humin
- Extracted from compost, coal, and peat
- Liquid and granular commercial products

Humic Acids Link to Soil Health

- Physical (improved aggregation), Chemical (increased nutrient retention) and Biological (microbial composition)

Integrating Biostimulants

Seaweed Extracts

- Brown seaweed commonly used for agriculture
  - 'Norwegian Kelp' (*Ascophyllum nodosum*)
- Direct and indirect contribution to crop growth
  - Mineral nutrients and plant growth hormones
  - Polysaccharides (e.g., polyuronides)
- Increase root:shoot biomass ratio
- Improve nutrient translocation

Seaweed Extracts Link to Soil Health

- Chemical (nutrient enrichment) and Biological (stimulation of mycorrhizal fungi)

Integrating Biostimulants

Protein Hydrolysates

- Mixture of polypeptides, oligopeptides, and amino acids
- Chemical or enzymatic hydrolysis of plant or animal tissues
- Enhance nutrient uptake (changes to root growth patterns)
- Stimulate enzyme activity (nitrate assimilation)

Protein Hydrolysates Link to Soil Health

- Chemical (chelating nutrients), Biological (support microbial community of rhizosphere)

Integrating Biostimulants

Plant Growth Promoting Rhizobacteria (PGPR)

- Rhizosphere has unique microbial community
  - Ex.) N-fixing rhizobia of legumes
- Plant roots drive composition of rhizosphere
  - Influence changes with distance to surface
- PGPR free-living, soil bacteria
  - Facilitate nutrient acquisition
  - Ex.) Bacteria (*Pseudomonas*, *Bacillus*)

PGPR Link to Soil Health

- <u>Biological</u> (augment microbial community of rhizosphere; suppress soil pathogens; produce plant growth hormones)

Summary

Holistic soil health management is focused on building cropping system resilience

Biostimulants may have role in holistic soil health management in tomato cropping systems by promoting root growth, nutrient cycling and uptake

Integrating biostimulants in tomato cropping systems has opportunities and challenges

- Opportunity: Alleviating transplanting stress and early season nutrient deficiency
- Challenge: Demonstrating benefits across space and time

Thank You!

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