



The Future of Liquid Fertilizers

Dr. Karl Wyant
Director of Agronomy
Nutrien

December 6, 2022

**Current Liquid
Fertilizers**

**“New”
Novel
Ingredients**



Fertilizers 2.0/3.0

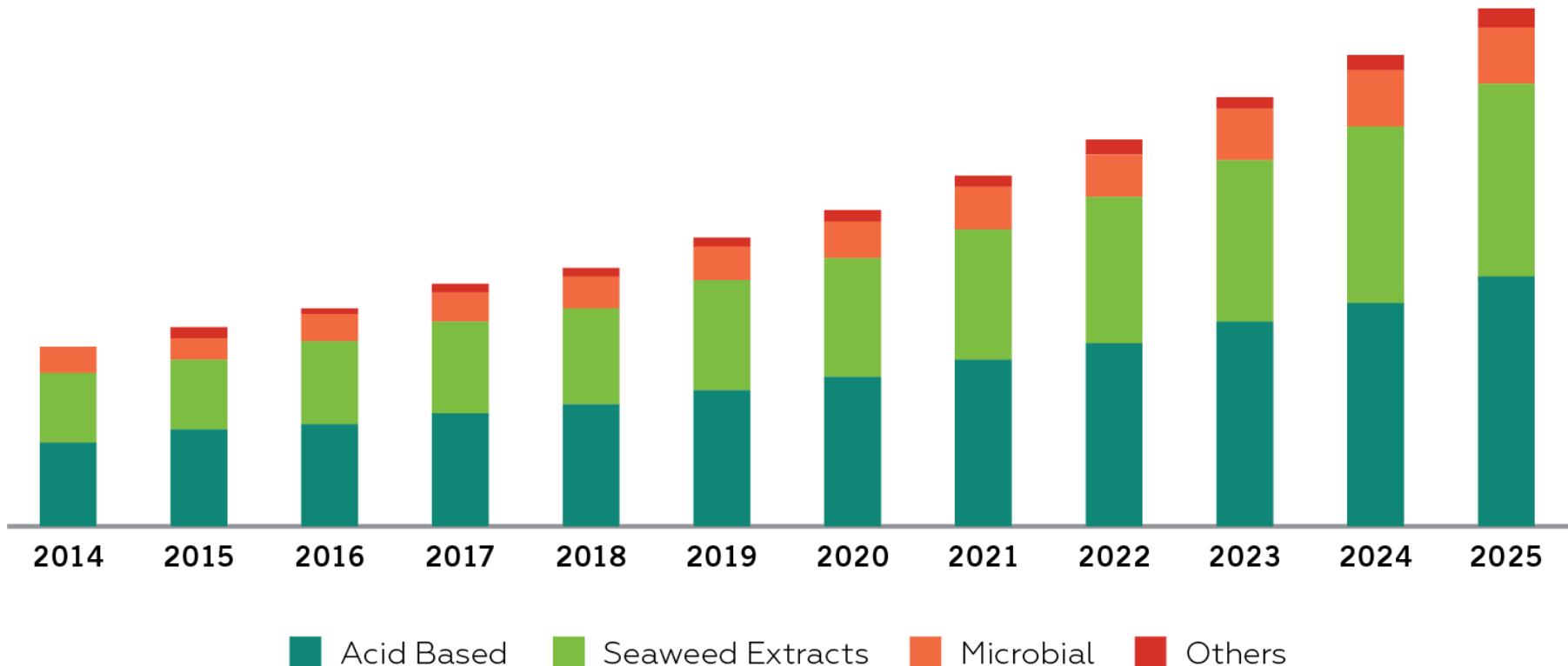
- Clarify the marketplace
- Regulatory changes
- Moving forward –
finding the right fit
- Crucial Questions

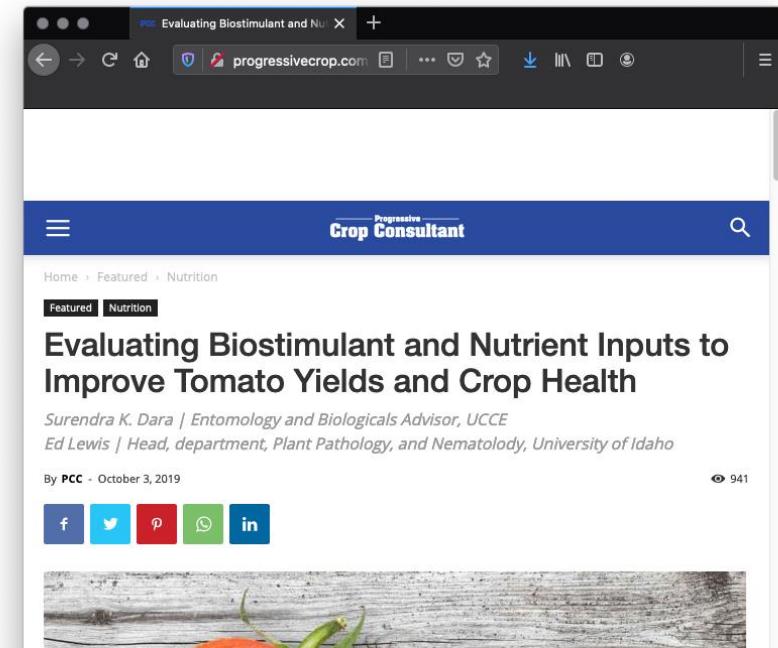




Category Momentum

U.S. BIOSTIMULANTS MARKET SIZE, BY ACTIVE INGREDIENT, 2014-2025 (USD MILLION)





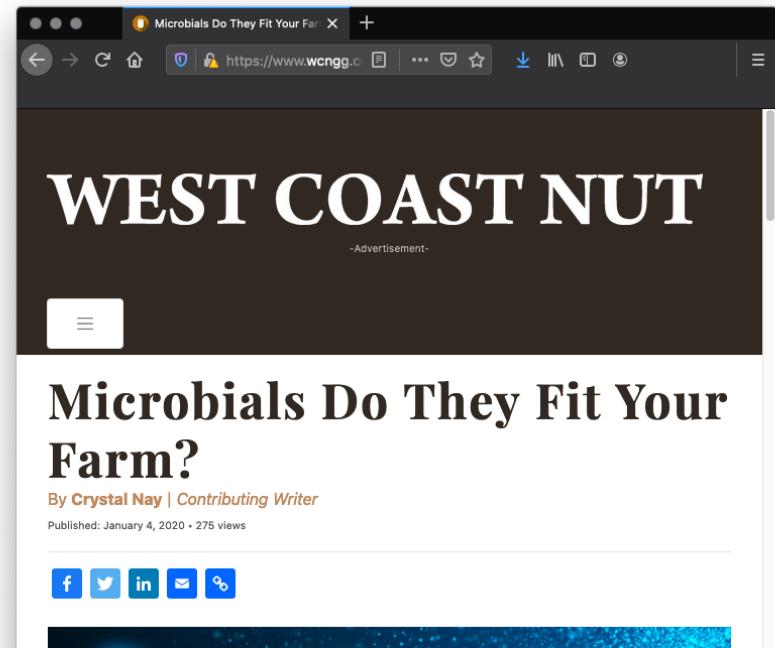
Evaluating Biostimulant and Nutrient Inputs to Improve Tomato Yields and Crop Health

Surendra K. Dara | Entomology and Biologicals Advisor, UCCE
Ed Lewis | Head, department, Plant Pathology, and Nematology, University of Idaho

By PCC - October 3, 2019

941

<https://progressivecrop.com/2019/10/evaluating-biostimulant-and-nutrient-inputs-to-improve-tomato-yields-and-crop-health/>



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Microbials Do They Fit Your Farm?

By Crystal Nay | Contributing Writer

Published: January 4, 2020 • 275 views

<https://www.wcngg.com/2022/01/04/microbials-do-they-fit-your-farm/>

Plant Soil (2014) 383:3–41
DOI 10.1007/s11104-014-2131-8

MARSCHNER REVIEW

Agricultural uses of plant biostimulants

Pamela Calvo · Louise Nelson · Joseph W. Kloepper

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Abstract
Background Plant biostimulants are diverse substances and microorganisms used to enhance plant growth. The global market for biostimulants is projected to increase 12 % per year and reach over \$2,200 million by 2018. Despite the growing use of biostimulants in agriculture, many in the scientific community consider biostimulants to be lacking peer-reviewed scientific evaluation.

Scope This article describes the emerging definitions of biostimulants and reviews the literature on five categories of biostimulants: i. microbial inoculants, ii. humic acids, iii. fulvic acids, iv. protein hydrolysates and amine acids, and v. chemical extracts.

Keywords Microbial inoculants · Humic acid · Fulvic acid · Protein hydrolysates · Amino acids · Seaweed extracts · Biostimulants

Introduction
Plant biostimulants, or agricultural biostimulants, include diverse substances and microorganisms that enhance plant growth. The global market for biostimulants has been projected to reach \$2,241 million by 2018 and to have a compound annual growth rate of 12.5 % from 2013 to 2018 (Anonymous, 2013). According to the

UF IFAS Extension
UNIVERSITY OF FLORIDA

UF IFAS HS1330

Plant Biostimulants: Definition and Overview of Categories and Effects¹

Ute Albrecht²

Introduction

Recent years have seen an explosion of non-chemical crop production materials termed “plant biostimulants” promoted as environment-friendly alternatives to chemical-based products. Although the major driving force for these materials is the organic farming industry, consumer demands for more sustainable crop production along with a growing number of reports regarding their beneficial properties have resulted in increasing popularity among conventional farmers. The global market for biostimulants was valued at \$2.19 billion in 2018 and is projected to reach a compound annual growth rate of 12.5 % from 2019 to 2024. Although the largest market for biostimulants is in Europe (approximately 40 % of the market share), the North American market is estimated to reach \$605.1 million in 2019. This article provides an overview of the definition

biocontrol agent and/or are offered in different combinations that may include fertilizers.

In December 2018, the first statutory language regarding plant biostimulants was provided in the Farm Bill (<https://www.congress.gov/115/bills/hr2/BILLS-115hr2enr.pdf>). It describes a plant biostimulant as “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.” This legal definition of plant biostimulants provides a first step in the process to develop a regulatory framework, appropriate review, approval, and uniform national labeling of these materials that are currently regulated as fertilizers, soil inoculants, or soil amendments at the state level. The definition provided

<https://link.springer.com/content/pdf/10.1007/s11104-014-2131-8.pdf>

<https://edis.ifas.ufl.edu/pdffiles/HS/HS133000.pdf>

SEC. 10111. REPORT ON PLANT BIOSTIMULANTS.

(a) REPORT.—Not later than 1 year after the date of the enactment of this Act, the Secretary shall submit a report to the President and Congress that identifies any potential regulatory, non-regulatory, and legislative recommendations, including the appropriateness of any definitions for plant biostimulant, to ensure the efficient and appropriate review, approval, uniform national labeling, and availability of plant biostimulant products to agricultural producers.

(b) CONSULTATION.—The Secretary shall prepare the report required by subsection (a) in consultation with the Administrator of the Environmental Protection Agency, the several States, industry stakeholders, and such other stakeholders as the Secretary determines necessary.

(c) PLANT BIOSTIMULANT.—For the purposes of the report under subsection (a), the Secretary—

(1) shall consider “plant biostimulant” to be a substance or micro-organism 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; and

(2) may modify the description of plant biostimulant, as appropriate.



The image is a screenshot of a web browser window. The address bar shows the URL <https://civileats.com/>. The page content features the Civil Eats logo at the top left. To the right of the logo, the text "116TH CONGRESS" and "1ST SESSION" is displayed. The main title of the article is "S. 2452". Below the title, the text of the bill is summarized: "To provide incentives for agricultural producers to carry out climate stewardship practices, to provide for increased reforestation across the United States, to establish the Coastal and Estuary Resilience Grant Program, and for other purposes." A small, partially visible image of a person wearing a cap is located at the bottom of the article summary.



Challenges for Category

December 6, 2022

What are Biostimulants?

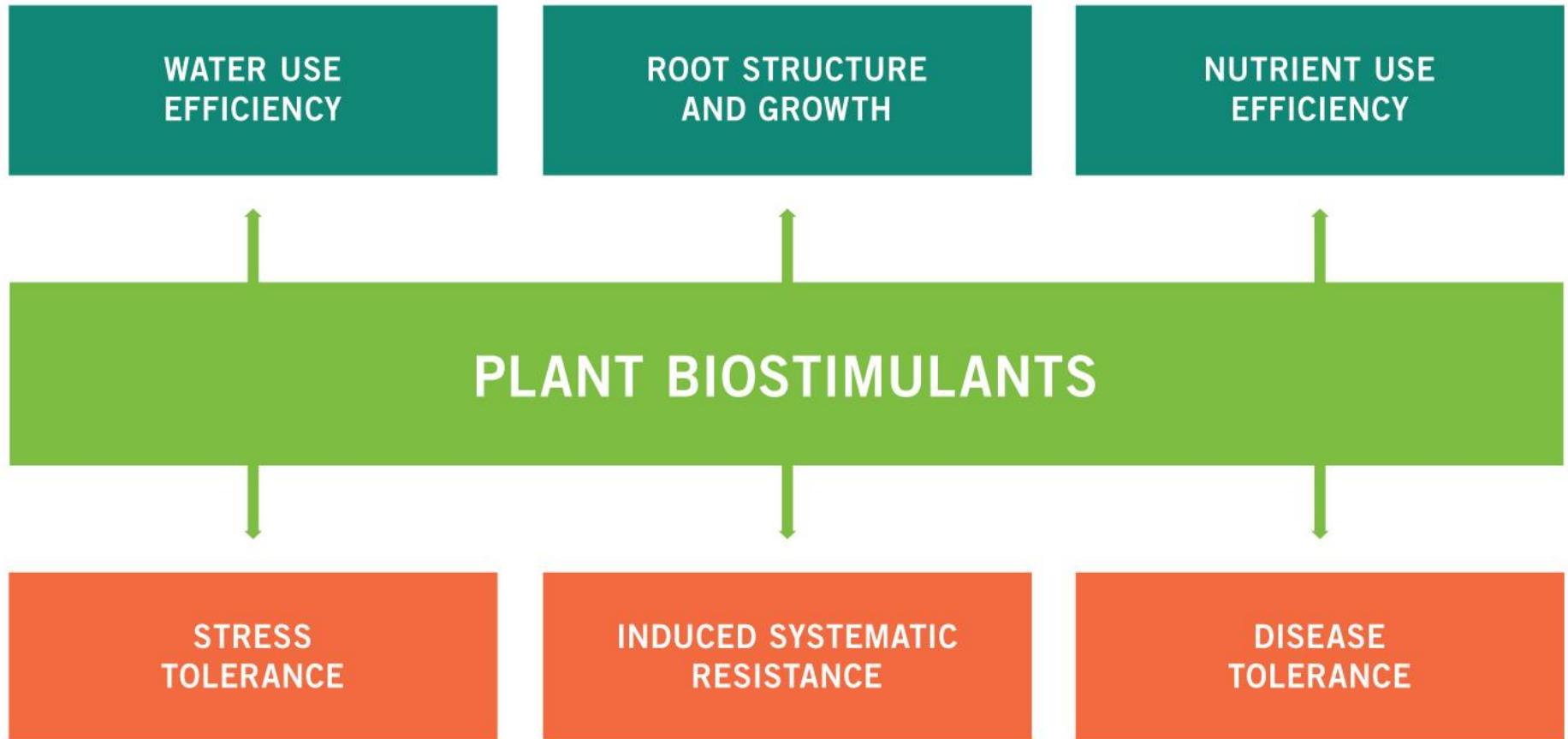
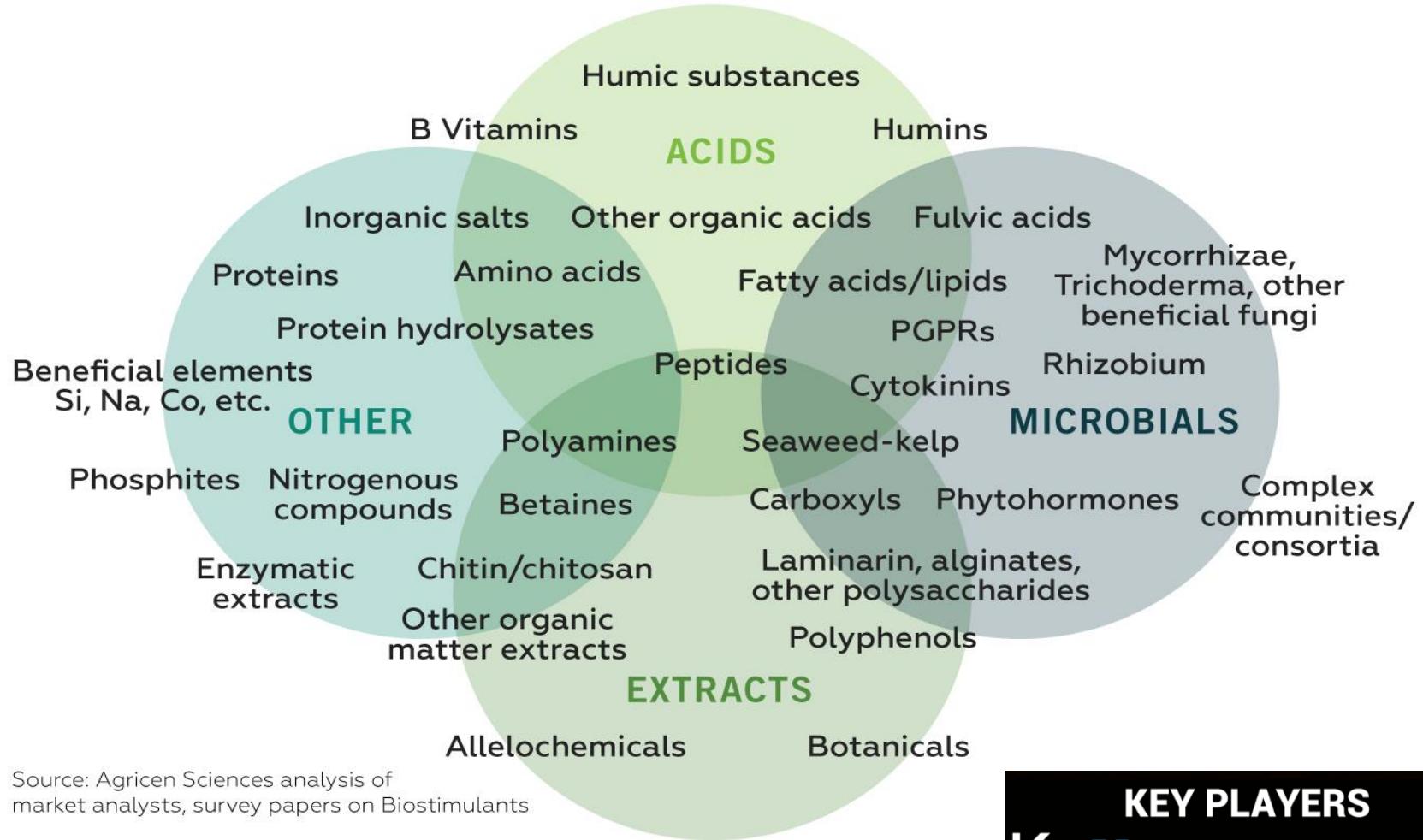


Figure 1. Biostimulant effects on plants.



Source: Agricen Sciences analysis of market analysts, survey papers on Biostimulants

<https://www.bpia.org/solutions-provided-by-biological-products-biostimulants/#acid-based-biostimulants>

Biostimulant Market Size, Growth, Share | 2022 - 27 (mordorintelligence.com)

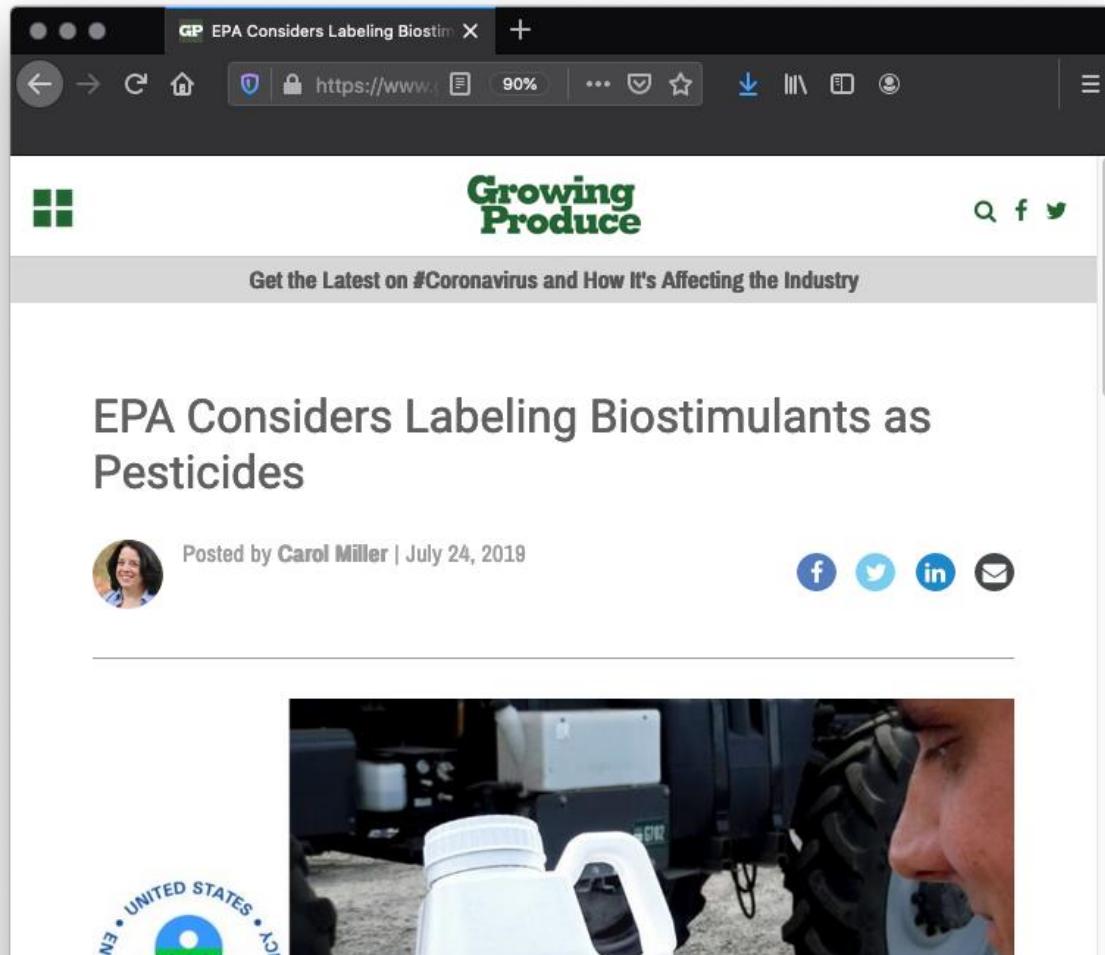
Infographics - Biostimulants Market (fortunebusinessinsights.com)





Source: Mordor Intelligence





The screenshot shows a web browser window with a dark theme. The address bar displays a URL starting with 'https://www.growingproduce.com/vegetables/epa-consider...'. The page header for 'Growing Produce' includes a green square icon, a search bar, and social media links for Facebook, Twitter, and LinkedIn. A banner at the top of the content area reads 'Get the Latest on #Coronavirus and How It's Affecting the Industry'. The main article title is 'EPA Considers Labeling Biostimulants as Pesticides', posted by Carol Miller on July 24, 2018. Below the title is a photo of a person wearing a respirator mask and a white jug, with a small ENR logo in the bottom left corner. The browser interface includes standard navigation buttons (back, forward, home, search, etc.) and a zoom level indicator of 90%.

<https://www.growingproduce.com/vegetables/epa-consider...>

117TH CONGRESS
2D SESSION

H R 7752

| Date | All Actions |
|------------|---|
| 06/08/2022 | Referred to the Subcommittee on Biotechnology, Horticulture, and Research. Action By: Committee on Agriculture |
| 05/12/2022 | Referred to the House Committee on Agriculture. Action By: House of Representatives |
| 05/12/2022 | Introduced in House Action By: House of Representatives |

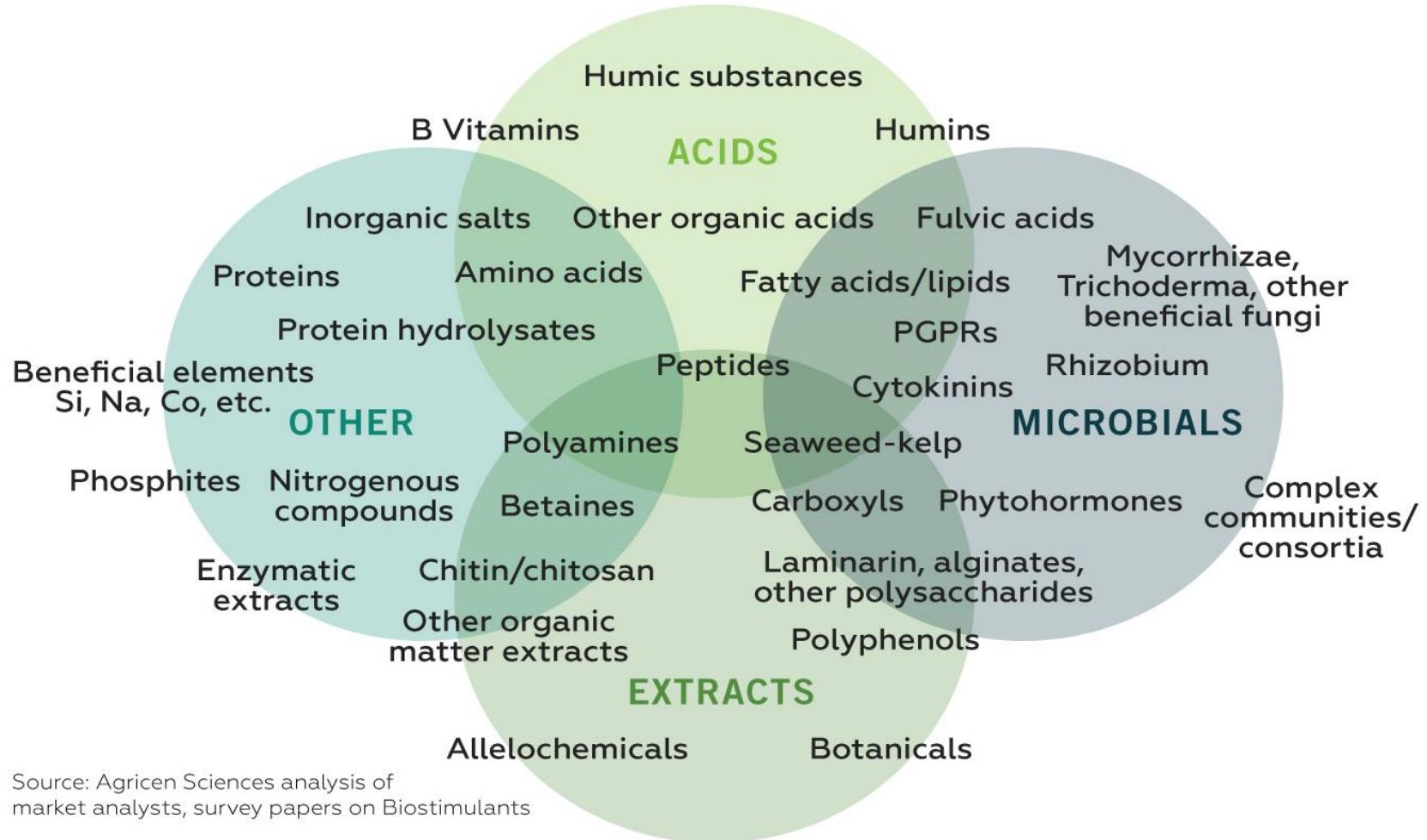
[BILLS-117hr7752ih.pdf \(govinfo.gov\)](#)

- **Problem:** *What exactly is a biosimulant?*
- Unclear definition - pg. 419 pf [2018 Farm Bill](#)
- [EPA Draft Guidance – 2019](#) - **Table 4** list of ingredients ([pg. 11](#))
- Clear up what product label language claims and FIFRA categories
- **Conflation of ingredients** - PGRs, ag chem, and fertilizers
- **Alignment issues** - USDA, EPA, and a variety of state regulators
- Clarify international standards and pathways to market

How do we **innovate** liquid
fertilizers with **new and**
novel ingredients?



Which New Ingredient Do I Pick?



Source: Agricen Sciences analysis of market analysts, survey papers on Biostimulants

<https://www.bbia.org/solutions-provided-by-biological-products-biostimulants/#acid-based-biostimulants>

Biostimulant Market Size, Growth, Share | 2022 - 27 (mordorintelligence.com)

Infographics - Biostimulants Market (fortunebusinessinsights.com)

- New active ingredients have **utility**
- **Species identity** determines role in soil:
 - Living inoculants
- **Carbon chemistry** determines function in soil:
 - Size
 - Charge
 - C:N ratio
 - Macromolecule diversity - *food sources*

Yeasts/protein mixes
– nutrient delivery source for plants (amino acids, NPK, etc.)

***Trichoderma* species**
– a beneficial **fungus** that helps protect the plants against pathogens

Mycorrhizae – a beneficial plant/fungal symbiosis that help trees get more water and phosphate

Bradyrhizobia – nodule forming, living **bacteria** that helps with N fixation on legumes.

Azospirillum/Klebsiella – free-living **bacteria** that helps with N fixation on *non-legumes*

Bacillus species – **bacteria** that helps with pathogen control and nutrient availability

Pseudomonas species – **bacteria** that helps with pathogen control and nutrient availability

Aspergillus species - **bacteria** that produce enzymes that break down hard-to-digest plant fibers

- **Viability** is a concern
- **Living vs. spore form**
- Sensitive to fluctuations in environment –
moisture, temperature, UV, competition
- Some labs can help **confirm label CFU count**
- Challenges with **mixing and compatibility** in the field

- **Key question: how alive is your product?**



Non-living Carbon Products: Spotlight on Food Sources, Organic Acids, Enzymes & Seaweeds



- New active ingredients have **utility**
- **Species identity** determines role in soil:
 - Living inoculants
- **Carbon chemistry** determines function in soil:
 - Size
 - Charge
 - C:N ratio
 - Macromolecule diversity - *food sources*

Feed the Microbiome

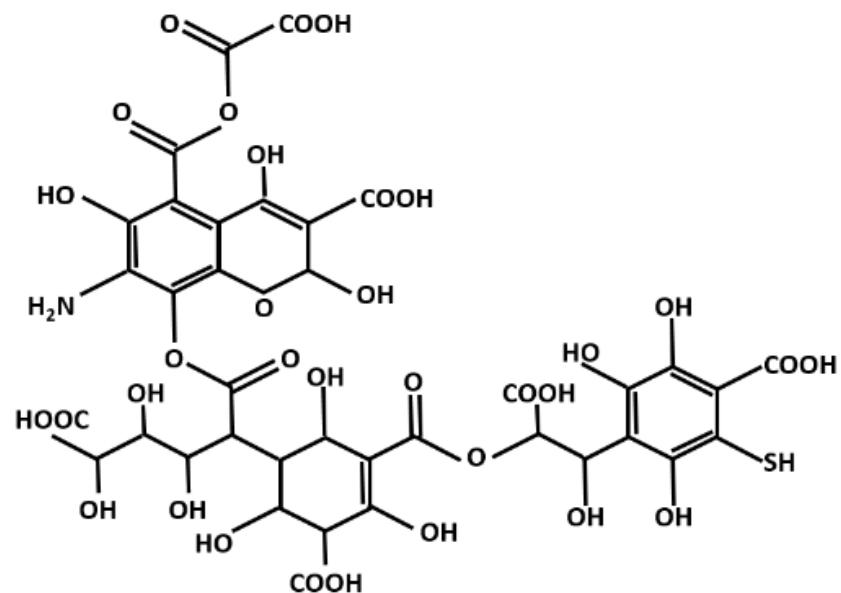
From: Kallenbach et al. 2016 *Nature Comm.*



Images of sugar-treated model soils over time (a); the far-left panel is an uninoculated sterile kaolinite and sand mixture, and the far-right panel is the same mixture, inoculated and treated with **weekly glucose additions for 15 months**.

Lots of sources: molasses, sugars, microalgae, etc.

- Smaller than humic acids and honey colored
- High CEC (**500-600!**) – holds nutrients like humic acids
- Nutrient **carrier** into plant
- Stimulates plant roots



[What is Fulvic Acid – Fulvic Force](#)

<https://soilsolutions.net/humic-acid-vs-fulvic-acid/>

<http://www.earthgreen.com/humic-vs-fulvic-acids>

<https://pubchem.ncbi.nlm.nih.gov/compound/5359407#section=2D-Structure>

- Old technology to improve soil
- **Macro-algae** – brown algae *Ascophyllum nodosum* is common
- Complex, variable extracts
- Plant growth promoting
- Helps with plant stress tolerance
- **Plant response well studied**
- **Regulatory path looks rough**

Exact mechanism
needs work

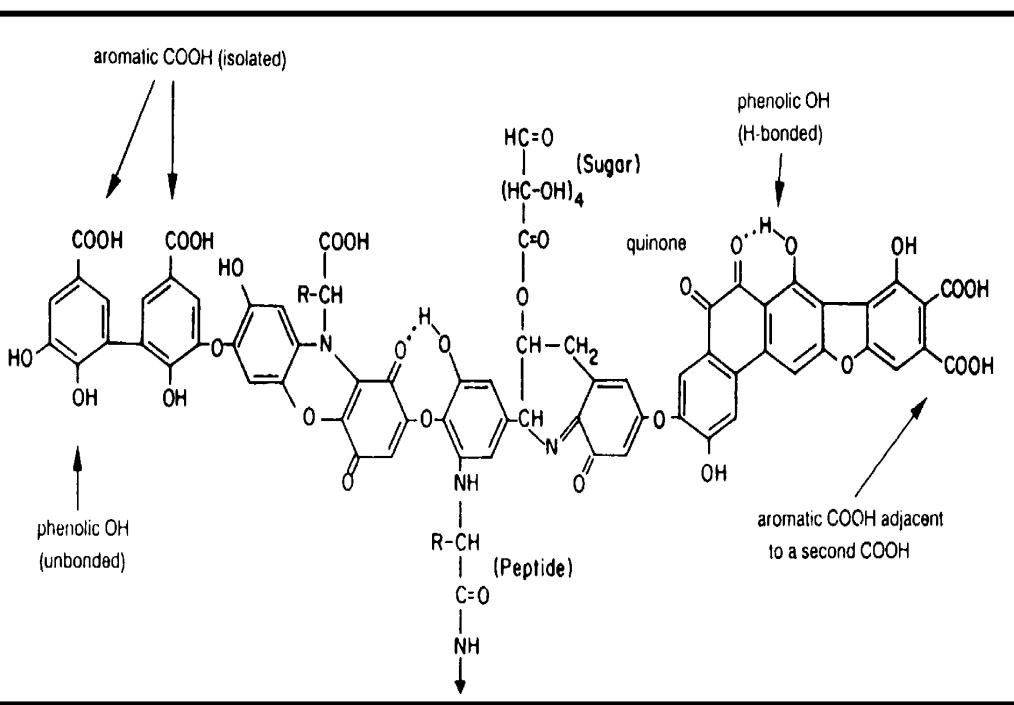


Breakdown
insoluble phosphate
into available P

Enzymes - a substance produced by a living organism that acts as a catalyst to bring about a specific biochemical reaction

<http://www.m.elewa.org/JAPS/2013/18.2/3.pdf>; http://web.mit.edu/12.000/www/m2015/2015/microbial_background.html

- Protease
- β glucosidase
- Amidase & Urease
- Phosphatase & Sulfatase
- Protein breakdown
- Cellulose breakdown
- N cycle
- P and S release

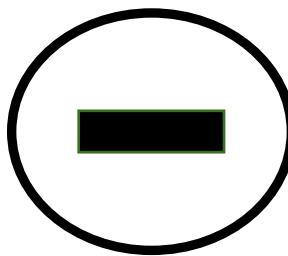
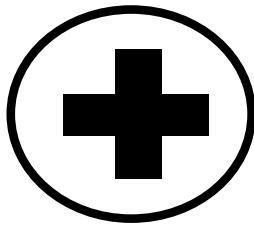
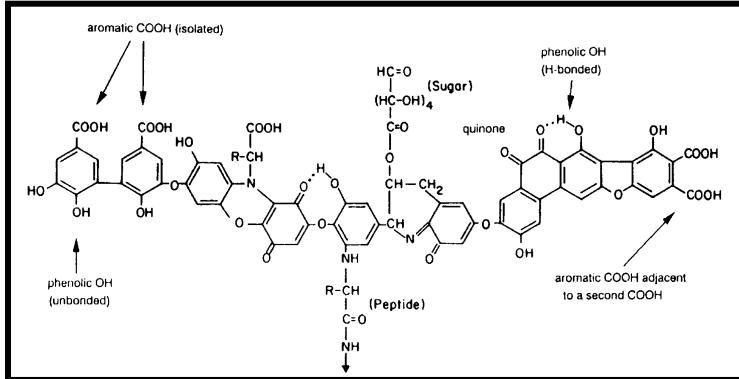


F. J. Stevenson, Humus Chemistry, 1994, 289

- Dual charge (+/-)
- Large size
- *Poor food choice*

Promotes:

- Nutrient retention
(high CEC)
- Physical Structure



NO_3^-

NH_4^+

- Humic acids **reduced peak urea → ammonia gas loss by ~68%** (Ahmed et al. 2006)

- Humic acids slowed down conversion of **ammonium → nitrate** (Dong et al. 2009)

- Humic acids soils leached **~54%-60% less nitrate** (Liu et al. 2009)

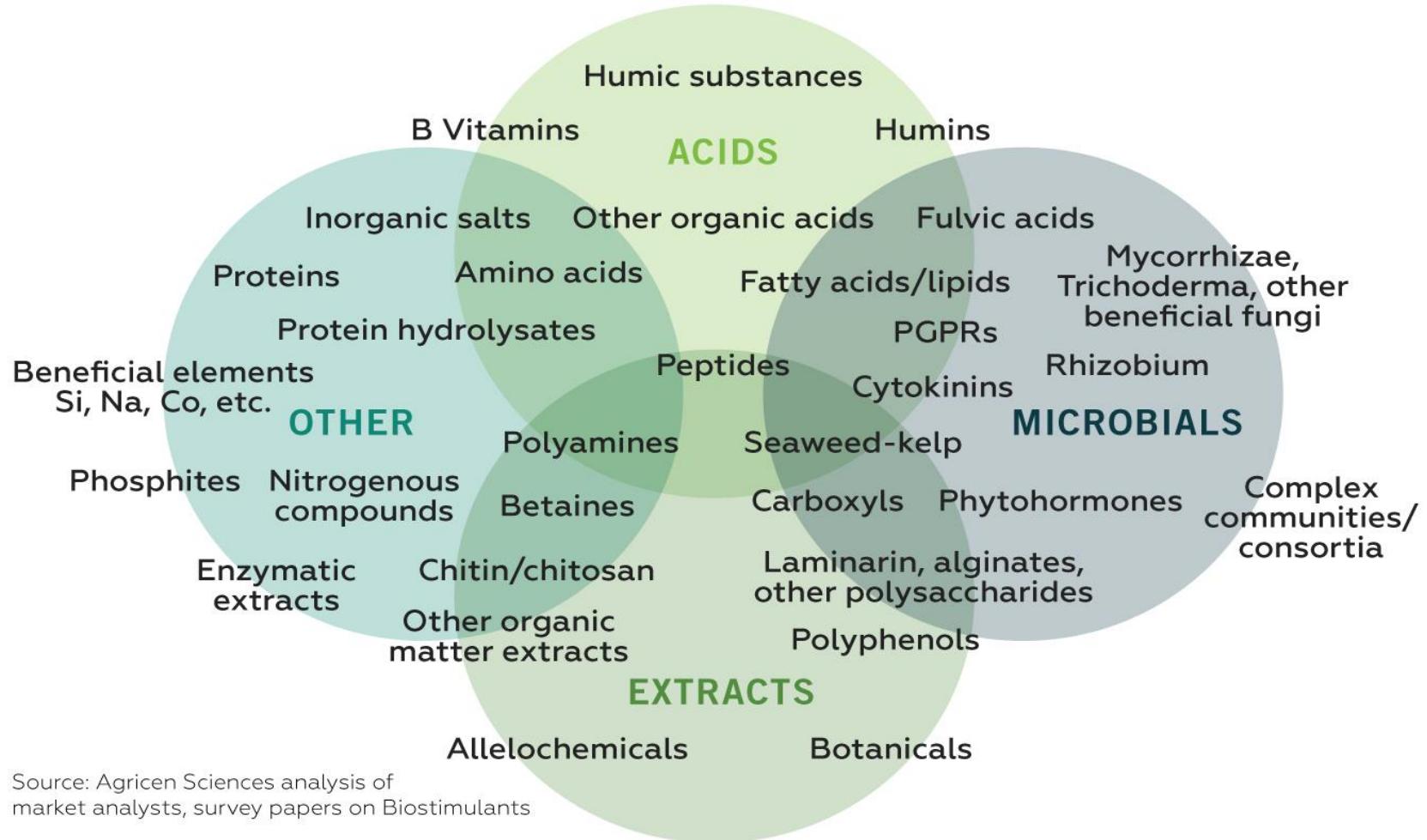
<https://udextension.s3.amazonaws.com/factsheet/wp-content/uploads/2015/01/N-loss.jpg>

F. J. Stevenson, Humus Chemistry, 1994, 289

- Variance in quality and efficacy
- **Will it blend?**
- Laundry list of label claims – **what does it do best?**
- Logistics at all levels – *need for agitation?*
- **Biostimulant/fertilizer mixtures**



Closing Statements



Source: Agricen Sciences analysis of market analysts, survey papers on Biostimulants

<https://www.bbia.org/solutions-provided-by-biological-products-biostimulants/#acid-based-biostimulants>

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Robust Trial
Data?

Clear
MOA?

Probability
of +ROI?

Patents and
IP?

Regulatory
Future?

Portfolio
Fit?

VC \$
Source?

- Consultants/advisers are crucial for translating MOA into product selection – the ‘WHY’
- Nuanced functionality/crowded marketplace
- Watch out for wild claims
- Start with the end goal in mind
- Focus on blending and in-can options
- **Unknowns for blend safety**
- Proposed regulatory changes are sure to shake things up

- Academic review
- Complete Academic Overview (600+ pages)
- UF Extension Article



Making Sense of Biostimulants for Improving your Soil

By Karl Wyant - July 14, 2020

5059



<http://progressivecrop.com/2020/07/making-sense-of-biostimulants-for-improving-your-soil/>

An aerial photograph of a rural landscape, showing a patchwork of agricultural fields in various shades of green and brown. The fields are arranged in a grid-like pattern, with some fields appearing to be in different stages of crop growth or have different soil types. A single road or path cuts across the fields from the bottom left to the top right.

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Thank You!