Overview of the Biostimulant World

Bryan G. Hopkins, Ph.D., CPSS

1

SportsTurf

HOME ABOUT US SUBSCRIBE RESOURCES NEWS & FEATURES MARKETPLACE CONTACT US STMA

BIOSTIMULANT INVESTMENT CONTINUES TO SOAR

FEBRUARY 12, 2019

Robert Arnason writes on *The Western Producer* website about an article from *Wired* magazine that argues that farmers are overly dependent on synthetic fertilizers, which is why companies and scientists are designing microbes (bacteria and fungi) that can deliver nitrogen to crops such as wheat, corn and canola.

Getting microbes to provide nutrients instead of adding fertilizer to the soil is definitely an appealing concept. It could also be lucrative because the global fertilizer market is expected to hit $245 billion by 2020.

Read it all here

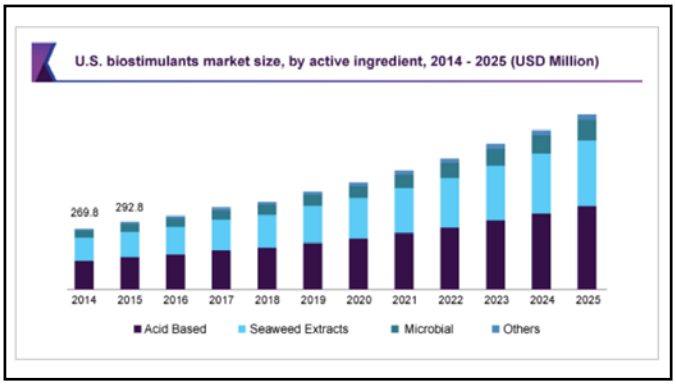
2

Survey Says . . .

Biostimulants – Large companies are "investing heavily"

top trend in agriculture

3



4

RESEARCHANDMARKETS

Plant Biostimulants Market Outlook, 2020-2025 - Spending on Agri Biotech is Projected to Reach $60 Billion by 2024

Dublin, Jan. 27, 2020 (GLOBE NEWSWIRE) -- The "Plant Biostimulants - Market Analysis, Trends, and Forecasts" report has been added to ResearchAndMarkets.com's offering.

The global market for Plant Biostimulants is projected to reach US$3.8 billion by 2025, driven by the growing focus of governments worldwide to reduce agriculture's growing carbon footprint and make it more sustainable.

This goal comes against the backdrop of the challenges involved in feeding a growing global population. As pressure on food production and crop yields increase, there is an even greater need to make agriculture more resilient and efficient in an eco-friendly manner. Comprising of both natural and biosynthetic substances, plant biostimulants offer a green way forward in this direction by promising to reduce and eventually eliminate dependence on toxic and environmentally polluting chemical fertilizers.

Benefits offered by plant biostimulants include enhanced plant tolerance to abiotic stresses; natural enhancement of a plant's metabolism for better quality yield; more efficient nutrient assimilation, absorption, translocation and use; and enhanced soil fertility. A majority of biostimulants available today are biosynthetic as they are extracted from plant and animal sources and processed in a laboratory with engineered biosynthetic production methods that mimics pathways/processes modeled after chemicals reactions in living organisms.

For example are all waste-derived biostimulants i.e. protein hydrolysates (PHs) that include polypeptides, oligopeptides, and amino acids which are manufactured from hydrolyzed protein-rich waste; and other preparations such as enzymes, micronutrients, and other compounds manufactured as a result of chemical or enzymatic hydrolysis. Natural biostimulants are an emerging group of plant biostimulants defined as the use of microorganism such as fungi and bacteria. Popular fungi used as biostimulants include Glomus intraradices; Trichoderma atroviride; Trichoderma reesei; and Heteroconium chaetospira, among others.

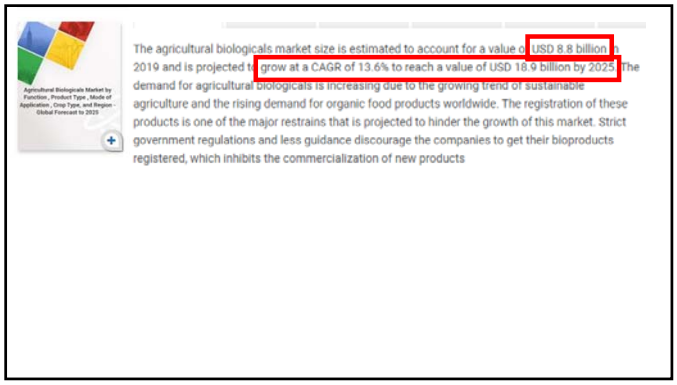
5

Agricultural Biologicals Market by Function (Biocontrol, Biofertilizers, Biostimulants), Product Type (Microbials, Macrobials, Semiochemicals, Natural), Mode of Application (Foliar Spray, Soil and Seed Treatment), Crop Type, and Region - Global Forecast to 2025

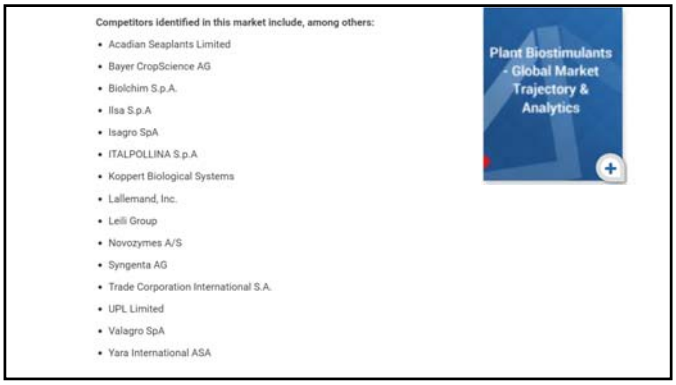
Leading players profiled in this report include:

- BASF SE (Germany)
- Syngenta (Switzerland)
- Marrione Bio Innovation (US)
- Isagro (Italy)
- UPL (India)
- Evogene (Israel)
- Bayer (Germany)
- Vegalab (US)
- Valent (US)
- Stockton (Israel)
- Biolchim (Italy)
- Rizobacter (Argentina)
- Valagro (Italy)
- Koppert Biological Systems (Netherlands)
- Lallemand (Canada)
- Symborg (Spain)
- Andermatt Biocontrol (Switzerland)
- Seipasa (Spain)
- Verdasien Life Sciences (US)

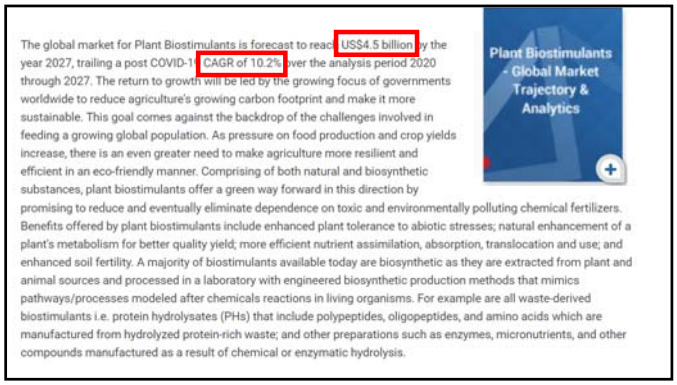
6



7

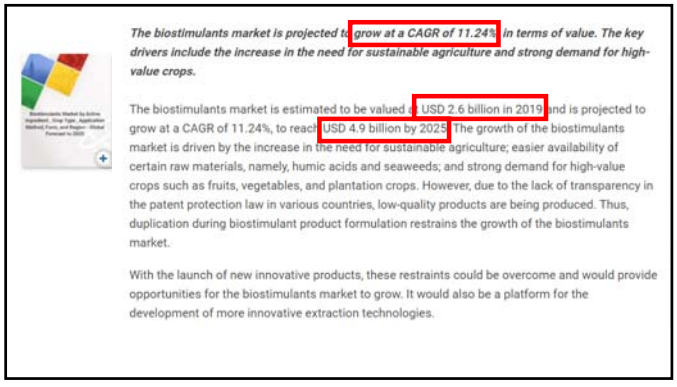


8



9

10



11

- Despite rapid growth, no agreed-upon legal definition for biostimulants in the USA.
- Association of American Plant Food Control Officials (AAPFCO) & Biostimulant Coalition working on regulatory and legislative issues.
- Agreed that "beneficial substances," may be a useful umbrella under which biostimulants could be defined.
- Beneficial substances are considered by AAPFCO to be:
  - "Any substance or compound other than primary, secondary, and micro plant nutrients that can be demonstrated by scientific research to be beneficial to one or more species of plants, when applied exogenously to the plant or soil."

12

European Biostimulants Industry Council (EBIC) definition:

"Plant biostimulants contain substance(s) and/or micro-organisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and crop quality."

13

According to EBIC,
biostimulants are distinguished from traditional crop inputs as:

- Biostimulants operate through different mechanisms than fertilizers, regardless of the presence of nutrients in the products.
- They differ from crop protection products because they act only on the plant's vigor and do not have any direct actions against pests or disease.

14

What is biostimulant?

- **Misperception**
- **Confusion**
- **Generally lacking credentialed recommendations**

15

Biostimulant definition?

*not in major dictionaries

*not defined in encyclopedic references

*not listed in USDA National Agricultural Library glossary of defined agricultural terms.

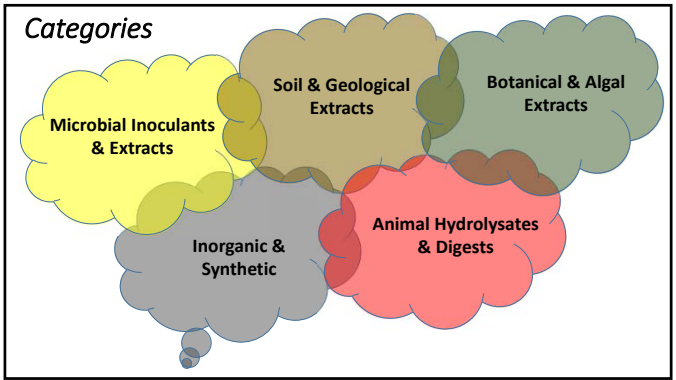
16

Closest thing we have to an official definition comes from the 2018 Farm Bill

"a substance or microorganism that, when applied to seeds, plants, or the rhizosphere, stimulates natural processes to enhance or benefit

****nutrient uptake,***
****nutrient use efficiency,***
****tolerance to abiotic stress, or***
****crop quality and yield."***

17



18

Do they work?

19

A collegue shared this with me

". . . there are a myriad companies and products looking for recognition . . . in this (biostimulant) arena, not all of which have a sound scientific basis . . . (with many in government, etc.) . . . openly promoting biostimulants as the panacea for all things soil health. . .

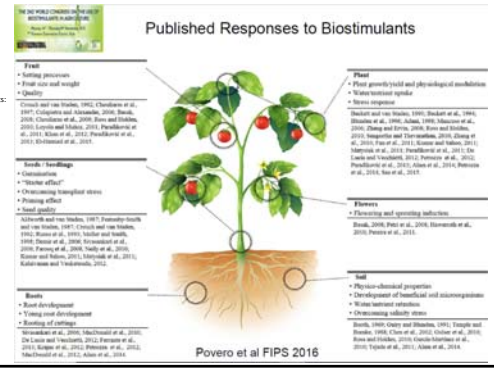
some restraint, reason, and science is sorely needed."

20

For your later reference, some of our work and some reviews are found:

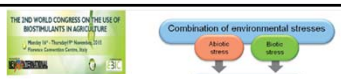
- Brown P.H., S. Saa. 2015. Biostimulants in agriculture. Frontiers in Plant Science. 6:671. doi: 10.3389/fpls.2015.00671
- Calvo, P., L. Nelson, J.W. Kloepper. 2014. Agricultural uses of plant biostimulants. Plant Soil 383: 3-41. doi: 10.1007/s11104-014-2131-8
- Hill, M.W., B.G. Hopkins, and V.D. Jolley. 2015. Maize in-season growth response to organic acid-bonded phosphorus fertilizer (Carbond P®). *J. Plant Nutr.* 38:1398-1415. (*Online first*). DOI:10.1080/01904167.2014.973040.
- Hill, M.W., B.G. Hopkins, V.D. Jolley, and B.L. Webb. 2015. Phosphorus mobility through soil increased with organic acid-bonded phosphorus fertilizer (Carbond® P). *J. Plant Nutr.* 38: 1416-1426. (*Online first*). DOI:10.1080/01904167.2014.973041.
- Olk, D.C., D.L. Dinnes, J.R. Scoresby, C.R. Callaway, J.W. Darlington. 2018. Humic products in agriculture: potential benefits and research challenges—A review. Journal of Soils and Sediments 18: 2881-2891 doi: 10.1007/s11368-018-1916-4
- Summerhays, J.S., B.G. Hopkins, V.D. Jolley, M.W. Hill, C. J. Ransom, and T. R. Brown. 2015. Enhanced phosphorus fertilizer (Carbond P®) supplied to maize in moderate and high organic matter soils. *J. Plant Nutr.* 38: 1359-1371. DOI:10.1080/01904167.2014.973039.
- Summerhays, J.S., V.D. Jolley, M.W. Hill, and B.G. Hopkins. 2017. Enhanced phosphorus fertilizers (Carbond P® and AVAIL®) supplied to maize in hydroponics. *J. Plant Nutr.* 40: 2889-2897. DOI:10.1080/01904167.2017.1384007. Available at: http://www.tandfonline.com/doi/full/10.1080/01904167.2017.1384007
- Yakhin, O.I., A.A. Lubyanov, I.A. Yakhin, P.H. Brown. 2017. Biostimulants in plant science: A global perspective. Frontiers in Plant Science 7: 2049. doi:10.3389/fpls.2016.02049

21



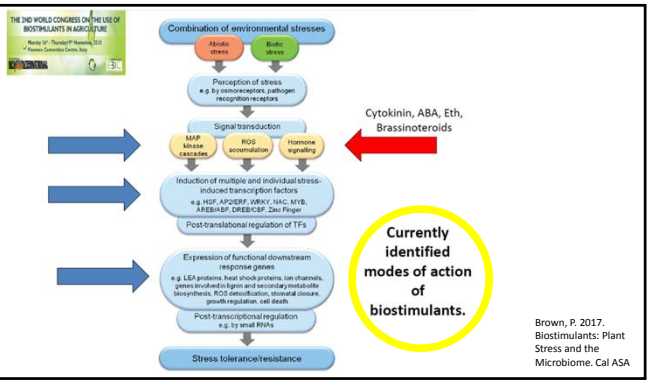
Brown, P. 2017. Biostimulants: Plant Stress and the Microbiome. Cal ASA

22



Brown, P. 2017. Biostimulants: Plant Stress and the Microbiome. Cal ASA

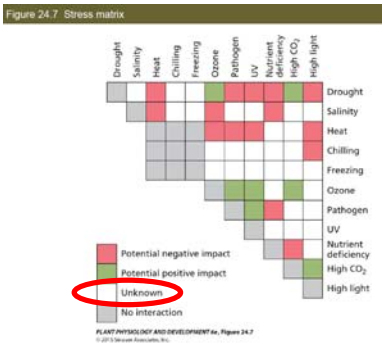
23



Brown, P. 2017. Biostimulants: Plant Stress and the Microbiome. Cal ASA

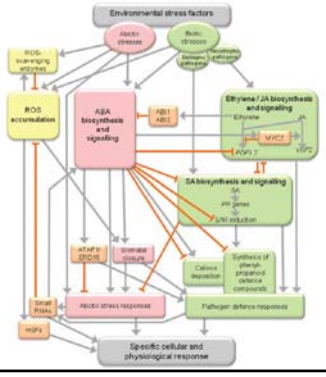
24

Likelihood of response is complicated—interactions between multiple stresses.



25

Is it possible for a biostimulant to positively influence plant response to multiple stresses?



Brown, P. 2017. Biostimulants: Plant Stress and the Microbiome. Cal ASA

26

we've done 31 trials, evaluating "carbon fertilizers" with "biostimulant" claims, using both a negative and positive control.

27

As previously mentioned (EBIC) – Imperative to separate the "fertilizer response" from the "biostimulation"

- Many biostimulants have nutrients in them.
- Research trials need to include both a:
  - Negative Control (untreated)
  - Positive Control (matching nutrients)

28

Not surprisingly, we measured significant yield/quality responses to nutrients.

Both fertilized treatments (positive control & "carbon biostimulant") > negative control (untreated)

29

Summary of 31 trials
(potato, corn, wheat, bean)

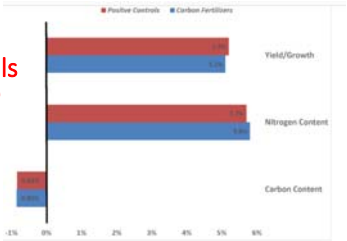


Fig. 2. Average increase/decrease over an unfertilized control for yield/growth and carbon and nitrogen plant concentration for 31 trials of carbon-based fertilizers compared with conventional fertilizers (all mineral nutrients were applied at equivalent rates for both). Values shown are significantly different from the untreated control, but there are no differences between the carbon vs. non-carbon fertilizer sources.

30

Showing the positive control (red bars) and "carbon biostimulant" fertilizer (blue bars) increase/decrease compared to the negative control

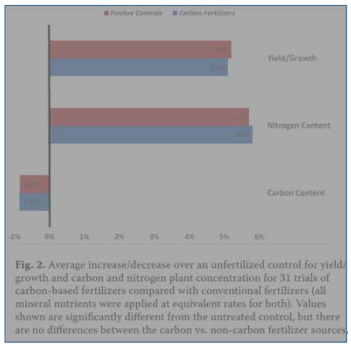


Fig. 2. Average increase/decrease over an unfertilized control for yield/growth and carbon and nitrogen plant concentration for 31 trials of carbon-based fertilizers compared with conventional fertilizers (all mineral nutrients were applied at equivalent rates for both). Values shown are significantly different from the untreated control, but there are no differences between the carbon vs. non-carbon fertilizer sources.

31

No difference in yield/growth

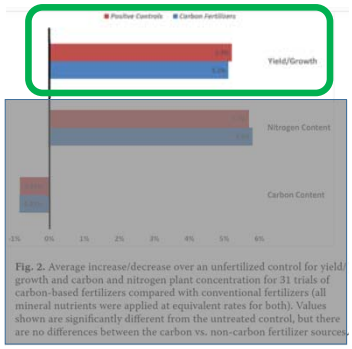


Fig. 2. Average increase/decrease over an unfertilized control for yield/growth and carbon and nitrogen plant concentration for 31 trials of carbon-based fertilizers compared with conventional fertilizers (all mineral nutrients were applied at equivalent rates for both). Values shown are significantly different from the untreated control, but there are no differences between the carbon vs. non-carbon fertilizer sources.

32

Plant N concentrations not impacted

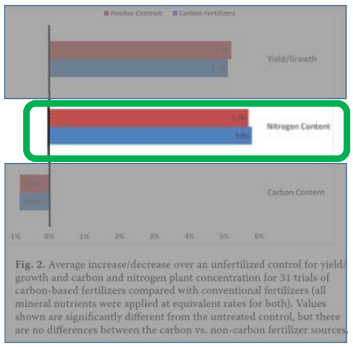


Fig. 2. Average increase/decrease over an unfertilized control for yield/growth and carbon and nitrogen plant concentration for 31 trials of carbon-based fertilizers compared with conventional fertilizers (all mineral nutrients were applied at equivalent rates for both). Values shown are significantly different from the untreated control, but there are no differences between the carbon vs. non-carbon fertilizer sources.

33

Plant carbon not increased

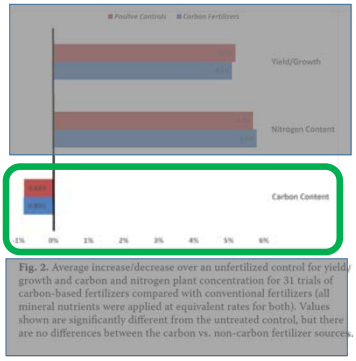


Fig. 2. Average increase/decrease over an unfertilized control for yield/growth and carbon and nitrogen plant concentration for 31 trials of carbon-based fertilizers compared with conventional fertilizers (all mineral nutrients were applied at equivalent rates for both). Values shown are significantly different from the untreated control, but there are no differences between the carbon vs. non-carbon fertilizer sources.

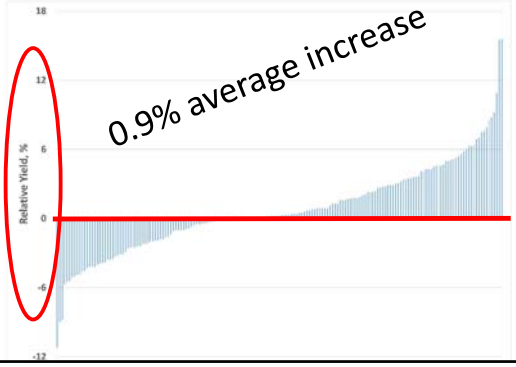
34

Our work – Meta-Analysis

- **178 trials over two decades**
- **Well managed, high yield environments**
  - **potato**
  - **wheat**
  - **barley**
  - **corn**
  - **sugar beet**
  - **alfalfa**
  - **soybean**
  - **dry bean**
  - **turfgrass (mostly Kentucky bluegrass)**

35

178 "biostimulant" trial yields



36

Summary of field and greenhouse trial results as a function of biostimulant type.

		Number of Trials	Significant Positive Response	Significant Negative Response	Average, %
1	Soil & Geological Extracts	87	28	4	1.9*
2	Animal Hydrolysates & Extracts	26	5	1	0.1
3	Botanical & Algal Extracts	19	2	1	-0.1
4	Inorganic & Synthetic Chemicals	15	1	0	-0.3
5	Microbial Inoculants & Extracts	31	3	1	-0.1

37

Rest were basically zero or negative.

		Number of Trials	Significant Positive Response	Significant Negative Response	Average, %
1	Soil & Geological Extracts	87	28	4	1.9*
2	Animal Hydrolysates & Extracts	26	5	1	0.1
3	Botanical & Algal Extracts	19	2	1	-0.1
4	Inorganic & Synthetic Chemicals	15	1	0	-0.3
5	Microbial Inoculants & Extracts	31	3	1	-0.1

38

Our work

- 22% significant yield increase
- All categories had at least one positive response (could be random or possibly showing "potential")
- Most positive responses were with use of organic acids in combination phosphorus (P) fertilizer

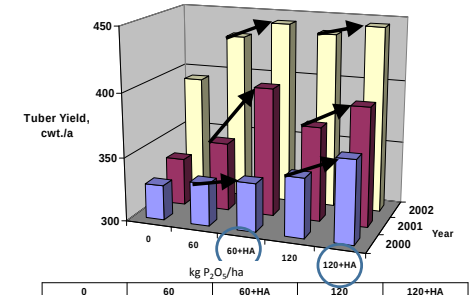
39

3 year trial on Russet Burbank potato (UI – Jeff Stark)

- calcareous soil
- medium soil test P

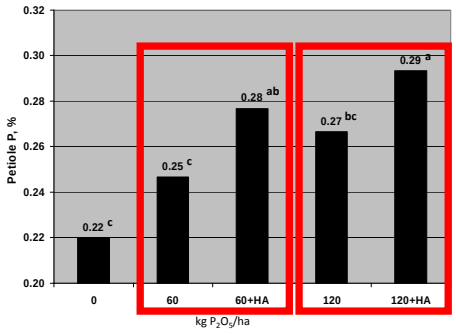
- Ammonium polyphosphate (10-34-0)
- Concentrated band 3 inches to the side of seed piece
- with and without Humic Acid (HA)
  - 1:10 ratio of humic acid to 10-34-0
    - control
    - 60 or 120 kg P_2O_5/ha with or without HA

40



	0	60	60+HA	120	120+HA
2000	327	333	338	347	364
2001	337	354	401	374	393
2002	394	431	444	438	446

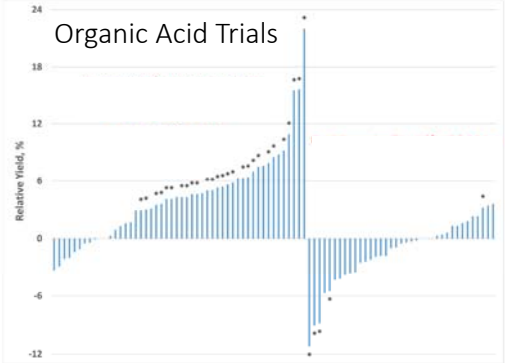
41



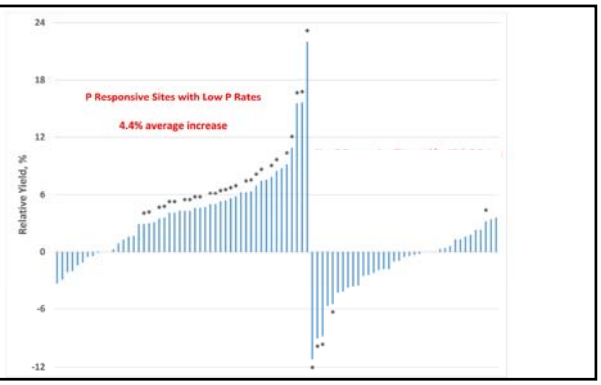
42

Additional trials with organic acids chemically bonded with P (Carbond P)

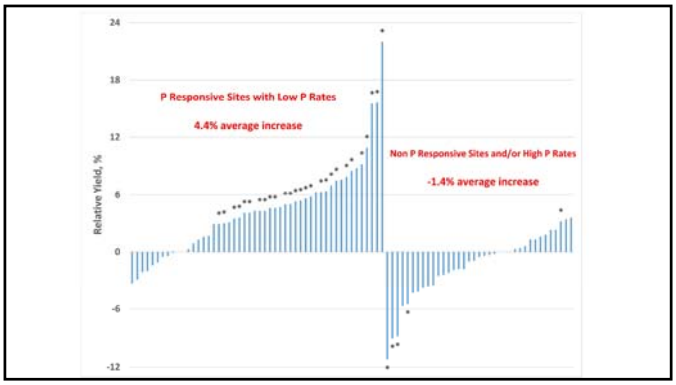
43



44



45



46

Summary of these trials

- **Improved P solubility and plant uptake in calcareous, low OM**
  - **Other soil and cropping systems?**
- **Equal or increased yields with 30-40% less P when:**
  - **soil test P is low/medium and**
  - **fertilizer P rate is relatively low.**

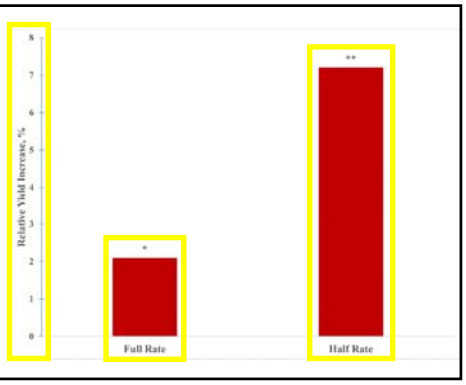
47

Mode-of-action was increased P nutrition and not any other "stimulation"

- **Summerhays, J.S., V.D. Jolley, M.W. Hill, and B.G. Hopkins. 2017. Enhanced phosphorus fertilizers (Carbond P® and AVAIL®) supplied to maize in hydroponics. *J. Plant Nutr.* 40: 2889-2897. DOI:10.1080/01904167.2017.1384007. Available at: http://www.tandfonline.com/doi/full/10.1080/01904167.2017.1384007**

48

Summary of our organic acid trials. (Largely "enhanced efficiency" of the fertilizer, but some biostimulation?)



49

Liquid Humic Products

Dan Olk, USDA-ARS, Ames, Iowa

- Not a phosphorus related response in their studies.
- Can improve corn and soybean growth and grain yield in Iowa.
- Corn root growth responded more consistently than did grain yield.
- Evidence for toxicity at excessive rates.
- Evidence for improved soil physical properties with long-term product use, likely due to increased root biomass.
- Suggest that their effectiveness is primarily as mitigators of abiotic stress?

50

Is the use of biostimulants a best management practice in agriculture?"

51

- David Holden, Holden Research and Consulting

"During those periods of abiotic or biotic stress, I have seen products in the biostimulant category help to supplement the crop . . . in a significant way."

52

Conclusions

- **Do biostimulants work?**
  - **It depends**
- **Buyer beware (data reliability?)**
- **Significant evidence for organic acids improving P nutrition and biostimulation**
- **Potential for the other categories as well, most likely as a response to stress.**

53

In God We Trust . . . Everyone else needs (reliable) data!

hopkins@byu.edu

54