

Biological Products and Their Impact on Turf & Soil Health

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TURFGRASS SCIENCE



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Biologicals (AKA – Biostimulants)


- Most major dictionaries and encyclopedic references do not define “biostimulant.”
- The USDA National Agricultural Library does not list it in their glossary of terms.
- Current farm bill *“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.”*
- Biostimulant, in its simplest definition, is anything that stimulates life. For turf managers we will define a biostimulant as anything that helps grass growth, exclusive of nutrients.

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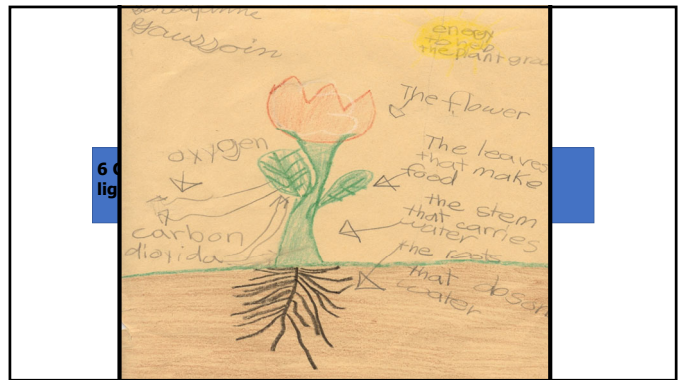
Plant biostimulants: Establishing standards

<https://www.gcmonline.com/course/environment/news/biostimulants-turfgrass>
Mike Fidanza, Ph.D.; Stan Kostka, Ph.D.; Erik Ervin, Ph.D.; and Cale Bigelow, Ph.D.

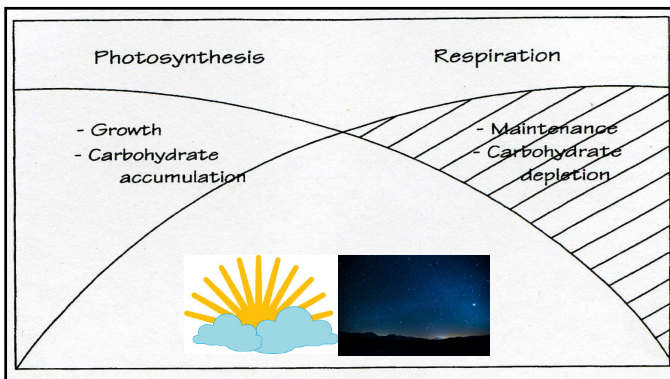
- *“Some products make claims that are substantiated with scientific research in turfgrass systems, while many others lack direct evidence that they actually work within a turf management program”*
- *“European Union has proposed policies and regulations to support and enforce what it calls a claims-based definition of plant biostimulants. In other words, plant biostimulant products should be defined by their function, not by the ingredients inside the container”*
- *“The EU also proposed that plant biostimulant products should be required to have credible demonstrated effects to support the product claims — that is, documented research to support product label statements for the crops and markets targeted”*



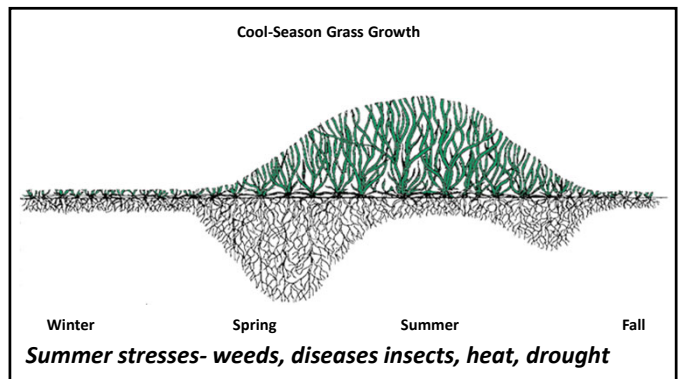
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Manufacturer Reported Benefits of "Biostimulants"

<ul style="list-style-type: none"> ■ Stimulate plant responses and work in all weather conditions ■ Increase profits, cut operating costs, lead to 50% reduction in fertilizer ■ Increase natural plant toxins, repelling pests ■ Increase microbial root protection from soil pathogens ■ Increase soil nutrient reserve up to 3000% ■ Improve root development ■ Build yields ■ Improve taste and shelf-life ■ Improve drought tolerance ■ Increases nutrient uptake 	<ul style="list-style-type: none"> ■ Stimulate plants' immune system ■ Produce better color ■ Result in better performance ■ Produce deeper roots ■ Improve stress tolerance ■ Accelerate establishment ■ Increases Cation Exchange Capacity ■ Enhances fertilization and reduces leaching ■ Detoxify chemical residues and heavy metals ■ Make urea a long-life nitrogen ■ Improve seed germination rates ■ Increase stomata opening and plant transpiration
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Products are:

- Frequently a mixture of several components
- Often contain nutrient(s)
- Costs range from \$ to \$\$\$
- Many manufacturers or distributors are smaller entities with lower operating budgets, especially research funds
- Heavily marketed

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Do you use any of the following in your program?

Product	Usage Level
Cytokinin	Low
Amino Acids	Medium
Bio-stimulants	Medium-High
Phosphites	High

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Cytokinins (CK) are a class of plant growth substances (plant hormones) that promote cell division. They are primarily involved in cell growth, differentiation, and other physiological processes. Their effects were first discovered through the use of coconut milk in the 1940s by a scientist at the University of Wisconsin–Madison named Folke Skoog.

Cytokinins are involved in many plant processes, including cell division, shoot and root morphogenesis, chloroplast maturation, cell enlargement, auxiliary bud release and senescence. The ratio of auxin to cytokinin is crucial during cell division and the differentiation of plant tissues

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Cytokinin production and movement in cool season grasses

Heat further degrades CK

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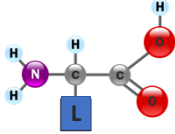
Cytokinin Summary

- Research inconsistent and plentiful
- Better understanding as topical application today
- Seaweed is very high in CK, hence seaweed extract products are widespread
- Synthetic cytokinin does not result in same response as seaweed extract

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Amino acids are molecules containing an amine group, a carboxylic acid group and a side chain that varies between different amino acids.

These molecules are particularly important in biochemistry, and have many functions in metabolism. One particularly important function is as the building blocks of proteins. Amino acids are also important in many other biological molecules, such as forming parts of coenzymes, and in N transport

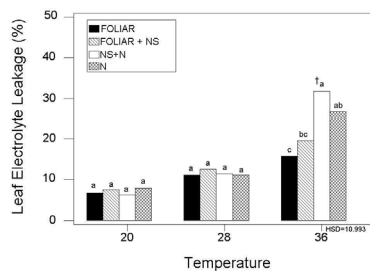


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Activity of Foliar Macro-Sorb Amino Acids

- Gordon Kauffman, Ph.D. (Penn State)
- perennial ryegrass
- “ramped” temperature stress (68-97° F)
- Treatments:
 - FOLIAR
 - FOLIAR plus nutrient solution (NS)
 - NS + an equivalent amount of N contained in FOLIAR
 - NS + N
 - N

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36° C (97° F)



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Amino Acids

- When environmental conditions are optimal the plant produces more than adequate AA's
- Under heat and drought stress production is severely limited
- Much like CK topical applications during stress may be beneficial; research results are inconsistent
- Also like CK, pure AA's do not elicit the same response as extracts

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Phosphites

- Phosphite salts are well documented to increase plant health and resistance to numerous soil borne pathogens.

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Phosphites

- Phosphite (H_2PO_3) differs from Phosphate (HPO_4) in that one O atom is replaced by one H atom
- There are many salts of phosphites
- Several phosphite salts are now registered as fungicides and several are used in liquid nutrient formulations
- Phosphite is not a fertilizer and may be problematic when applied to phosphorous deficient soils

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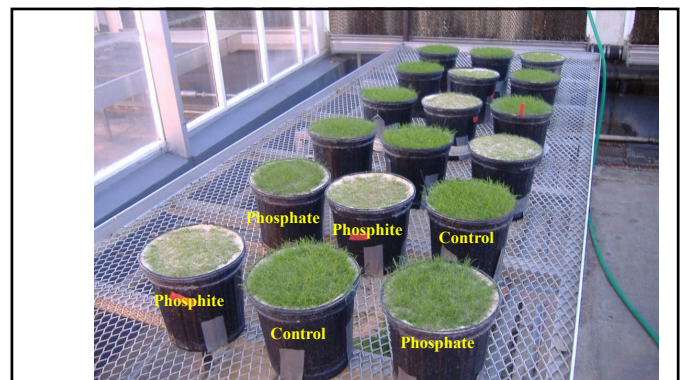
Phosphites

- Research shows that the phosphites do have a direct effect on plant health and restrict some pathogens.

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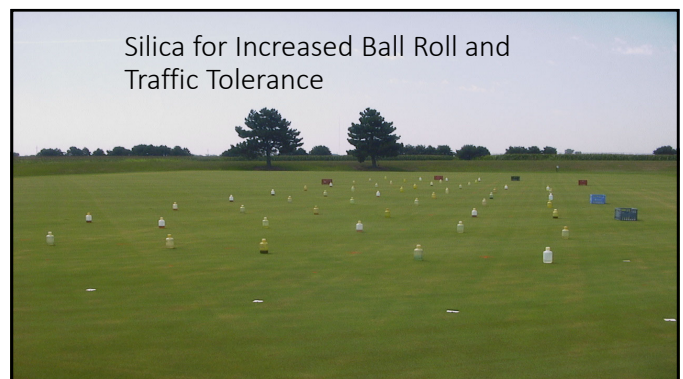
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Silica

- The positive properties of silica against plant disease have been recognized for centuries.
- Several researchers are now looking at recent evidence that silicon may also induce 'systemic acquired resistance' in plants, sometimes referred to as SAR.

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Silica for Increased Ball Roll and Traffic Tolerance



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Treatments

- 3 commercial products
- 3 technical grade materials
- 2-3 rates of each material
- Silica containing material
 - 0.2 to 85 g Si per 1000 ft²
- Applications made every 14 days
- Stimpmeter (Ball Roll Distance) 1 and 3 DAT
- Traffic tolerance with traffic simulator

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- Treated Control
 - 22g Na
 - 26g K
- Tech Grade #1-2
 - 43 or 85g Si
 - 12 or 24g Na
- Tech Grade #3-4
 - 43 or 85g Si
 - 31 or 62g K
- Tech Grade #5-6
 - 43 or 85g Si
 - 37 or 74g K
- Ocean Organics #1-6
 - 2 formulations
 - 8, 16 or 32g Si
 - Other stuff
- Floratine #1
 - 43g Si
 - ~0.4 g K
 - Other stuff
- Grigg Bros. #1
 - 1.1g Si
 - 26g K
- Grigg Bros. #2
 - 0.2g Si
 - 26g Ca
- Grigg Bros. #3
 - 0.9g Si
 - 17g Ca
 - 17g K

All Rates per 1000 ft²

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Results

- No differences between
 - Ball Roll Distance
 - Color
 - Quality

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Traffic Simulator



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Traffic Results

- No differences among treatments for increased traffic tolerance or recovery unless K was the carrier

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Silica – Take Home

- Mowing quality is “*observed*” to increase
- Evidence exists that there is greater resistance of plants well supplied with Si to some forms of fungal attack.
- Soil is comprised of 28% silica, most of this is solid & not accessible by plants, but there is ample soluble silica floating in soil solution.

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Soil Inoculants

- Beneficial organisms frequently packaged with other ingredients (biostimulants, fertilizer)
- Sensitive to UV light
- Heat instable
- Sometimes packaged as spores
- Do they work?

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Theoretical Example

- Products may contain up to 10^9 organisms per ml
- Applied at 1-6 oz/M
- Soil contains 10^8 bacteria/gm of soil
 - 100X less actinomycetes; 100X less fungi

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Assuming:

All applied microorganisms survive and maximum use rates, the ratio of applied vs. native bacteria is approximately:

6000 native : 1 applied

or the applied represent *0.02 %* of the total population

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Further:

Boehm's work at OSU showed that at approximately 2 years post construction in a soil/sand/compost vs sand/peat green microbial diversity was relatively the same even though the former green was significantly higher at establishment

Similar work at UNL in the late 1990's confirmed response

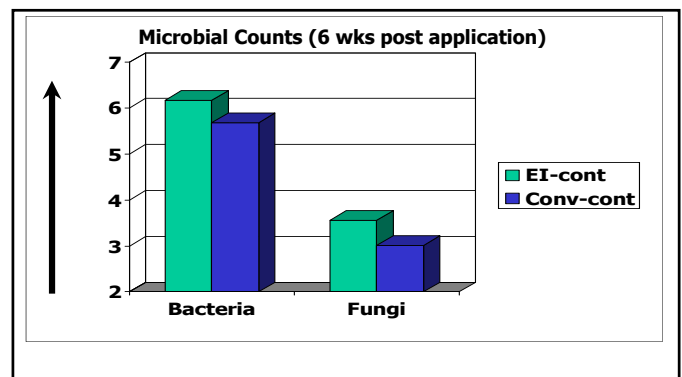
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Do microbial inoculants have merit?

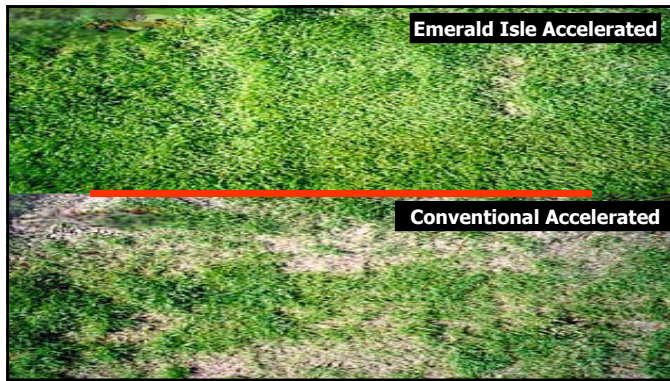
- Some have shown pest suppression potential
- Structured research is limited, but work in this area is increasing
- When soils are limited in microbial diversity there may be merit to there use

Emerald Isle Inoculum Study on a Sand Based Rootzone

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Summary of Emerald Isle Work

- The EI grow-in resulted in faster establishment than the conventional grow-in
- Fungi and bacteria levels were higher in EI plots *short term*
- EI treatments had less seedling *Pythium* injury than the conventional grow-in

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Seed Priming, what is it?

- What? - Hydration treatment
 - Activates germination process
- Decreases germination time
- Biostimulents are marketed for this process

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Priming with water or
“biostimulent”

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Prime Time – Enhancing Seed Germination

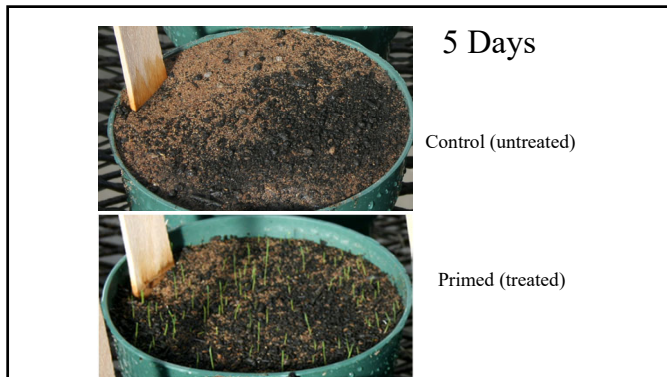
Alex Kohel
Graduate Student
University of Nebraska-Lincoln

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Research-NSP Method

- UNL research greenhouse
 - Kentucky bluegrass
 - Primed vs. Untreated (control)
 - Days to germination
 - Establishment
 - Cultivar

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Summary

- We have consistently seen decreased establishment time with Biostimulents + Priming vs. unprimed or water-only priming.
- Decreased time is between 7-10 days.
- Treated areas 2-3 months after seeding are not different in density.

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Experimental Process

- **Solicited cooperators**
 - Follow each company's recommended protocol
 - Included treatments to separate out each component of each protocol
- Kentucky bluegrass blend
- 90:10 Spec. sand:Dakota Reed Sedge Peat
- Data collected on % cover and roor strength

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From N to Mycorrhiza

- **Biostimulants**
 - cytokinins, AA's etc.
- **Mycorrhiza**
 - *"form a mutualistic relationship with the roots of most plant species"*

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Experimental Process

- **Two planting dates:**
 - Mid-summer (Suboptimal)
 - Late-summer (Optimal)
- **37 treatments; 111 plots**
- **Analyze**
 - Fertilizer
 - Mycorrhizae
 - Biostimulant
 - Liquid (foliar) fertilizer

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Treated Control

- **Preplant incorporated**
 - 21-3-20 Poly S
 - 16-25-12 Poly S
 - A-TEP Hi-Mag
 - 3.3#N, 2.5 #P, 2.4 #K / 1000 ft²
- Weekly applications after germination**
 - 17-3-7
 - 0.8 #N / 1000 ft²
- **Also used in combination with other products**

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Company 1

- **Mycorrhizae (Mix with seed)**
- **Biostimulant (Preplant)**
- **Fertilizer (Preplant)**
 - Slow release N-38%N
 - Slow release N-40%N
 - 16-25-12
- **Recommended use rates**
- **Used alone and in combination**

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Company 2

- **Mycorrhizae (Mix with seed)**
 - every 30 days
 - biostimulant
- **Fertilizer**
 - 4-6-4 (Preplant + 30 days)
 - 5-2-4+Fe (60 + 90 days)
- **Recommended use rates**
- **Used alone and in combination**

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Company 3

- **Preplant**
 - Fert/biostim Blend
- **Foliar (Weekly after germination)**

– Foliar N	19-1-6
– Foliar P	6-12-6
– Foliar K	3-0-10
– Foliar Silica	2-0-16
– Organic Source	4-0-1
- **Recommended use rates**

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Company 4

- **Preplant**
 - seed nutrients
- **Foliar (Weekly after germination)**
 - Even weeks
 - experimental 103
 - micronutrients
 - humic based nutrients
 - non-fungicide pathogen protection
 - Odd weeks
 - experimental 203
 - Foliar silica
 - organic amino acids, proteins, and carbohydrates
 - non-fungicide pathogen protection
- **Recommended use rates**
- **Summer seeding did not include Foliars with Conventional fertilizers**

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Company 5

- Preplant
 - Conventional Fertilizer
- Foliar (Weekly after germination)
 - Foliar 1
 - Foliar 2
 - Foliar 3
- Recommended use rates

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Top Treatments (for cover & Root Strength)

1. Any treatment with fertilizer
 - Mycorrhizae and/or biostimulant did not significantly speed up establishment
 - Foliar fertilizers did not speed up establishment

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Bottom Treatments

1. Untreated
2. Mycorrhizae and/or biostimulant alone

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Bottom Line for Establishment

- Amount of N and P applied
 - At establishment
 - During first 30 days after germination
- Readily available fertilizers provide best establishment
 - Quick vs. slow release
- Little benefit was realized from mycorrhizae, biostimulants or foliar fertilizers

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

Hopkins research lab has conducted 178 field and greenhouse biostimulant trials, on a variety of plant species, over the past two decades. <https://sportsturfonline.com/2019/06/11/biostimulants-boom-or-bull/>

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From:
<https://sportsturfonline.com/2019/06/11/biostimulants-boom-or-bull/>

- *“Biostimulants are an exciting trend with lots of promise. However, don’t abandon proven practices for promises that seem too good to be true. Be optimistically pessimistic. Keep an open mind, but realize that most of these won’t likely work, especially if the turf is well managed and healthy. In the meantime, independent and industry scientists will continue to search for reliable products and ways to manage them. We advise to not be on the cutting edge of the biostimulant world to the point of throwing caution to the wind and chasing every new product with miracle claims.”*



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Bottom Line on Biostimulents

- Do they work?
- Will they work at my facility?

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"scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity"

A scientifically literate person has an understanding of the scientific method and reasoning; innate curiosity about how things work or don't work, and; the use of science-based information to debate or convince others of an idea or project.

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W. S. Weed, 2004, Popular Science

- On average an individual, thru mass media, will encounter one scientific claim every 10 minutes
- Majority of claims came from advertisers
- Very few were totally true while several were blatantly false

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Examples

- bread is "bromate free"
- cereal has "no cholesterol"
- walnuts have "omega-3's"
- "built to last"
- yeast is "gluten free"
- non-GMO or gluten free

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Scientific Method

- Observation and description of a problem or group of problems.
- Formulation of a hypothesis to explain the problem(s).
- Use of the hypothesis to predict the existence of other problems, or to predict quantitatively the results of new problem(s).
- Performance of experimental tests of the predictions by several independent experimenters and properly performed experiments.

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Statistics (or experimental statistics or biometry) are critical to the scientific method

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Statistics Defined

- Figures Lie and Liars Figure
- Three Kind Of Lies
 - Lies
 - Damn Lies
 - Statistics
 - Benjamin Disraeli (1804-1881)

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Statistics are the fabric of our lives

- I live 6.5 miles from work
- There is a 50% chance of rain today
- Politician X is ahead in the polls
- "choosey mothers choose Jif"
- "Americans consume an average of 22 gallons of beer per year"
- "4 out of 5 dentists choose Trident for their patients who chew gum"
 - What does the other dentist recommend??

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Statistic Personalities

- Awestruck
 - clueless
- Naive
 - accepting
- Cynical
 - suspicious
- Critical
 - does it make sense?

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Average

- Mean
 - Arithmetic average
- Median
 - Middle value
- Mode
 - Most frequent value

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Average Comparison

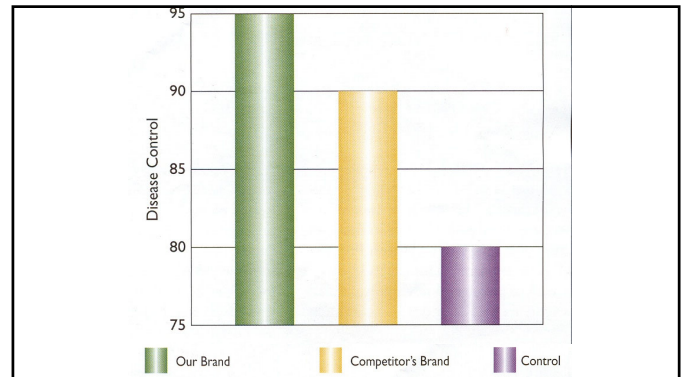
Salary	Mean	Median	Mode
14			14
14			
17			
18		18	
19			
22	29		
96			

72

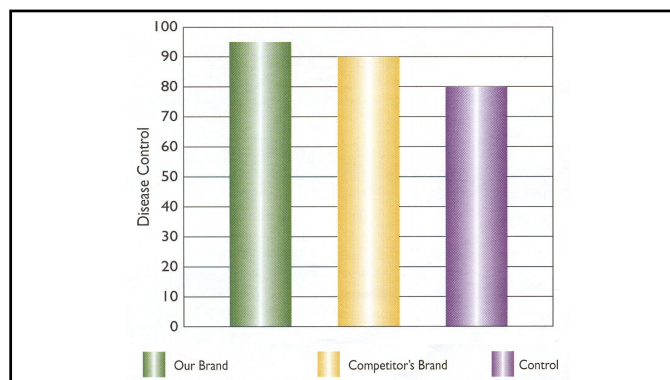
The “gee-whiz” graph

- Figures lie and liars figure

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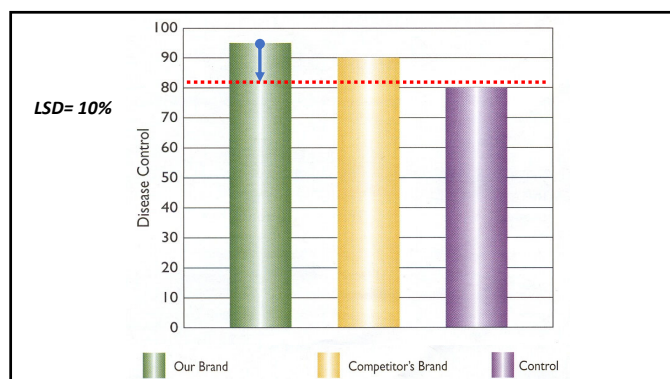


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The “naked” statistic

- Any average (or value) without a measure of its variability

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Probability

- A quantitative measure of the “confidence” in a particular data set
 - Product “A” was better than “B” based on $P=0.05\%$
 - A 95% probability that the observed difference was due to treatment not chance

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Probability

- P=0.05%, P=0.01% - Conventional
- P<0.01% - Occurs but seldom reported
- P>0.05 - Data variability is of major concern
- P=0.50% Flip a coin!!
- If probability (P) is not reported = "naked statistic"

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"semi-attached" statistic

- Average American walks 900 miles/yr

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Variability of Data

- May or may not be controllable
- Measured with a standard deviation, standard error or other method
- Value of data is based on probability (*confidence*)

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"semi-attached" statistic

- Average American walks 900 miles/yr
- Average American drinks 22 gallons of beer/yr
- Therefore.....

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"semi-attached" statistic

- Average American walks 900 miles/yr
- Average American drinks 22 gallons of beer/yr
- Therefore.....

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"semi-attached" statistic

- Average American walks 900 miles/yr
- Average American drinks 22 gallons of beer/yr
- Therefore.....

$$\frac{900 \text{ miles/yr}}{22 \text{ gallons/yr}} =$$

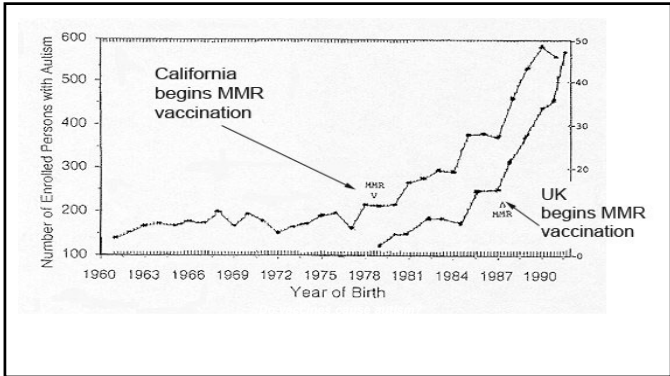
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“semi-attached” statistic

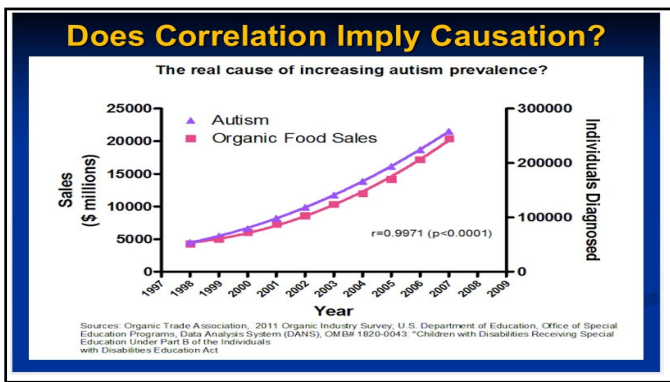
- Average American walks 900 miles/yr
- Average American drinks 22 gallons of beer/yr
- Therefore.....

~~900 miles/yr~~
~~22 gallons/yr~~ 41 miles/gallon

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Caveat Emptor (buyer beware)

- Must have data, not testimonials or impressive pictures
- Independent source of data increases confidence, multiple sources even better
- Be a “critical thinker”
- Test in your operation
 - Great info at: https://www.paceturf.org/PTRI/Documents/Cultural/Sup_res.pdf

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Unlike traditional pest control products, where the response is either yes or no and government registration is required, many biostimulents may/can alter physiological processes at the organelle, cell or genetic level, resulting in inconsistencies in response. We continue to discover more about these processes. Time will tell.....

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