The Landscape for Ag Biologicals

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Invasive Species Corporation

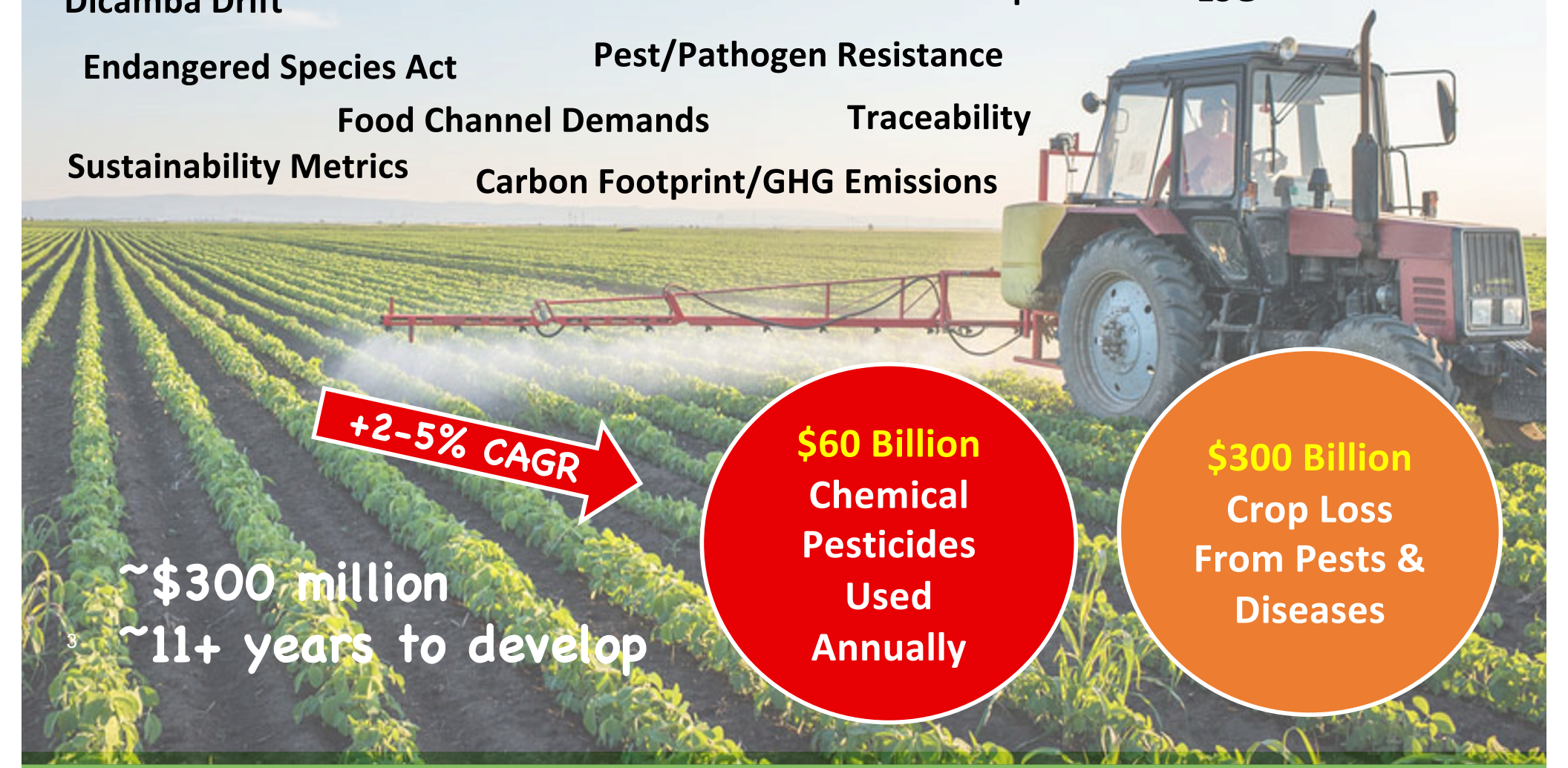
&

Invasive Species Research Institute

www.invasivespeciescorporation.com

Synthetic Chemicals Have Many Challenges

Pollinators
Lawsuits
Chlorpyrifos
Worker Protection Standards
European Green Deal
Glyphosate
Neonics
Nitrates
Supply Chain Disruption
VOCs
EU
Fumigants
Phosphate
MRLs/Residues
Soil Health
Sustainable Use Directive
Spray Drift
Runoff
Dicamba Drift
Consumer Perception
ESG
Endangered Species Act
Pest/Pathogen Resistance
Food Channel Demands
Traceability
Sustainability Metrics
Carbon Footprint/GHG Emissions



+2-5% CAGR

~$300 million
~11+ years to develop

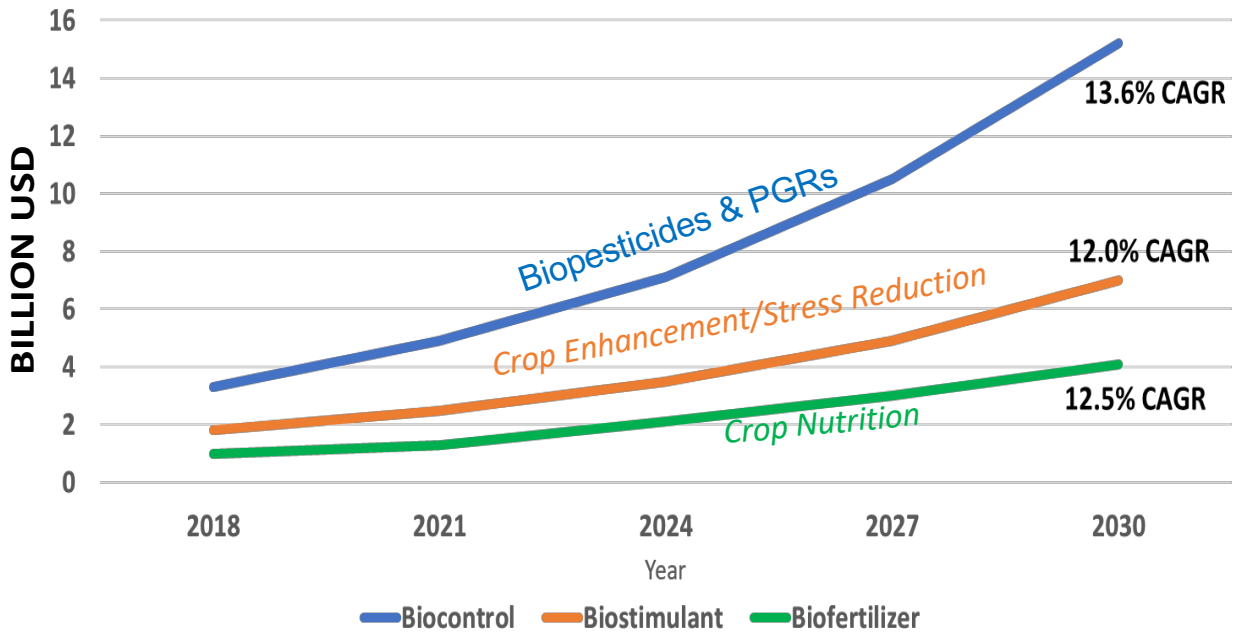
$60 Billion Chemical Pesticides Used Annually

$300 Billion Crop Loss From Pests & Diseases

BIOLOGICAL PRODUCTS MARKET LANDSCAPE

DunhamTrimmer®
International Bio Intelligence

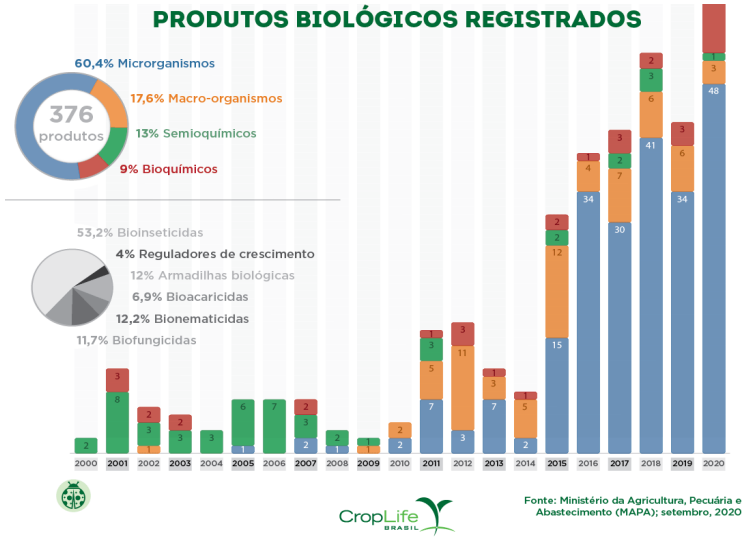
GLOBAL BIOLOGICAL MARKET EVOLUTION



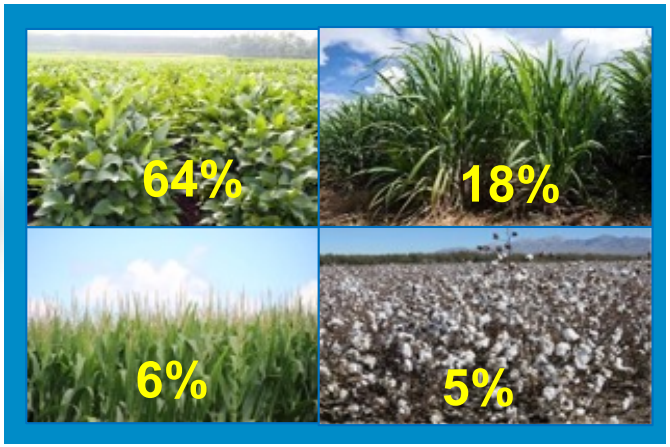
CAGR 2018 - 2030
BIOCONTROL 13.6%
BIOSTIMULANT 12.0%
BIOFERTILIZER 12.5%

Brazil has Become the Largest Biologicals Market *Doubling Every Two Years*

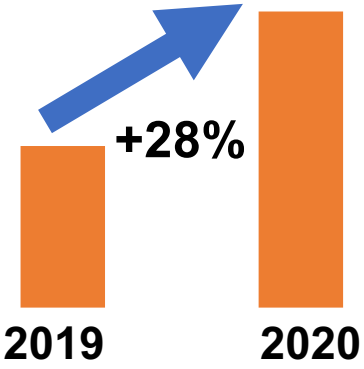
8-12 months for a new registration!
Registered 482 biopesticides in 9 years!!



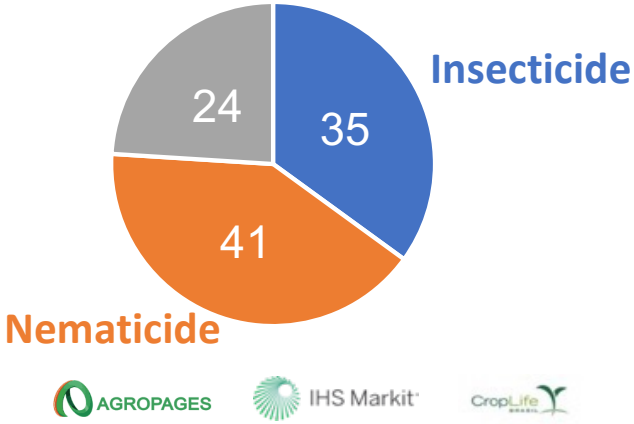
10.2 million hectares treated



Robust growth possible: Brazil farmers typically used only one biopesticide

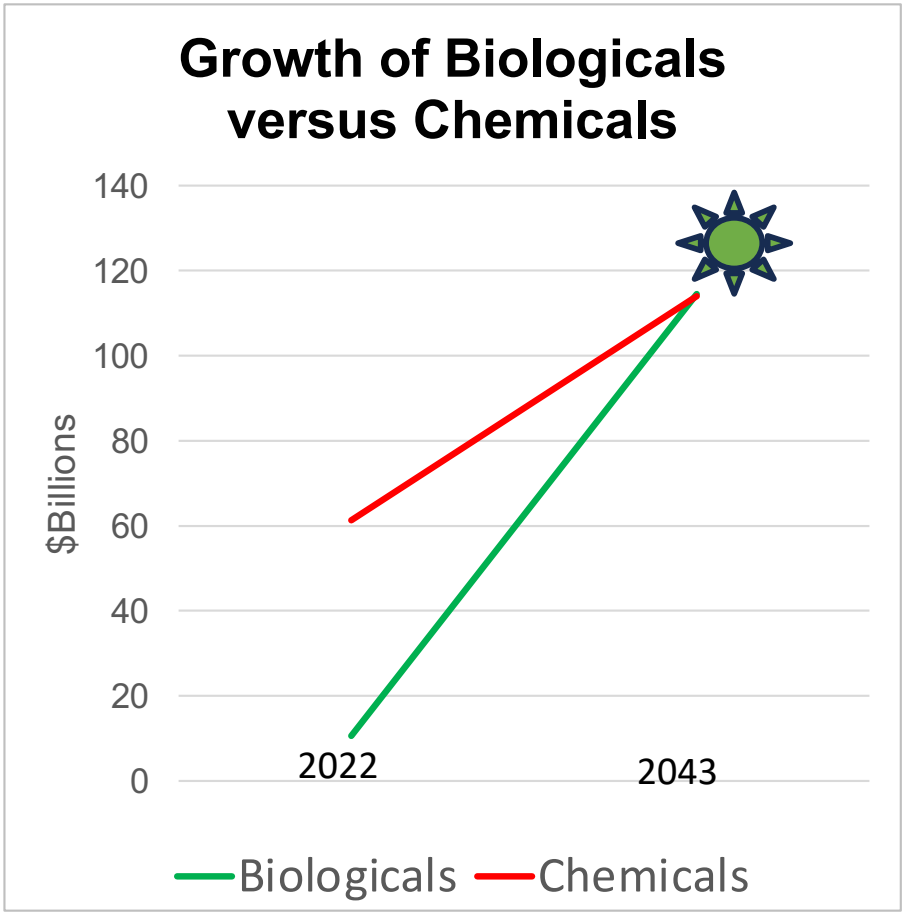


Sales Percent



AGROPAGES IHS Markit CropLife BRASIL

Biologicals Market Could Equal Chemicals in ~20 Years!

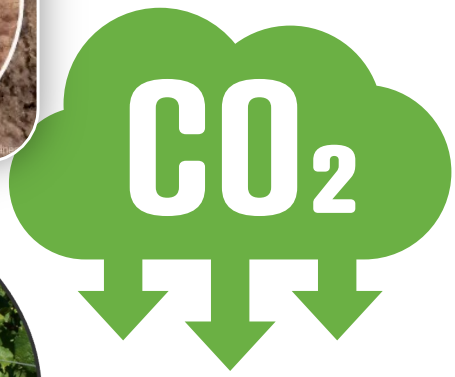


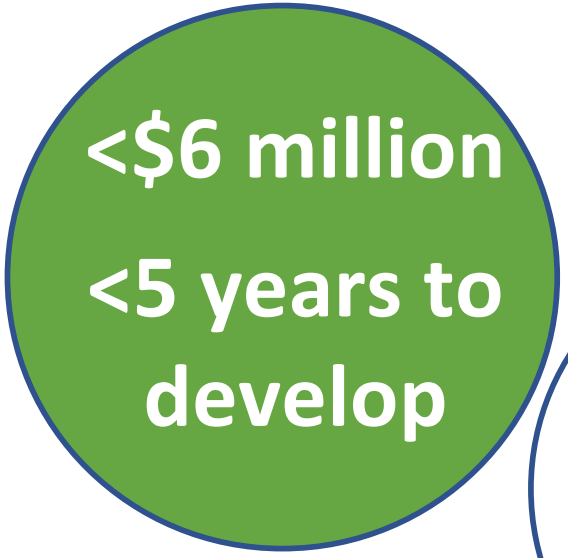
Growth rate (CAGR)		12 %
Number of periods	Biologicals	21
Initial value		10,600,000,000 $
Final value		114,520,791,603.36 $

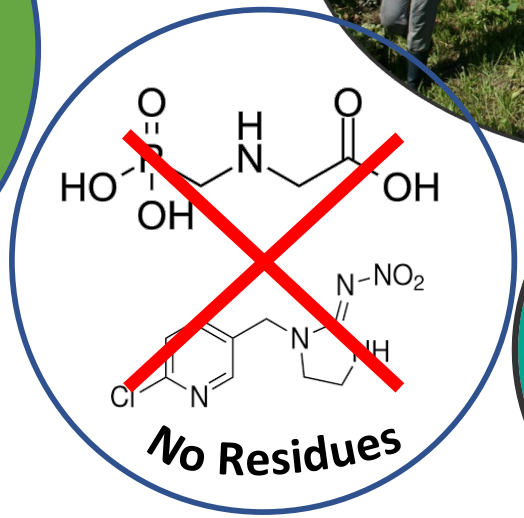
Growth rate (CAGR)		3 %
Number of periods	Synthetics	21
Initial value		61,300,000,000 $
Final value		114,036,057,245.79 $

Source: Shane Thomas, Upstream Insights

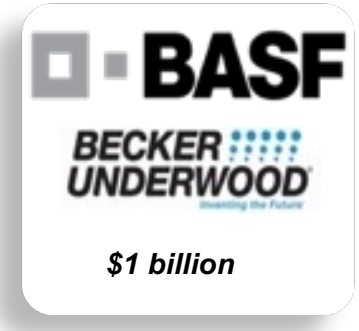
Why Biologicals are Growing Quickly





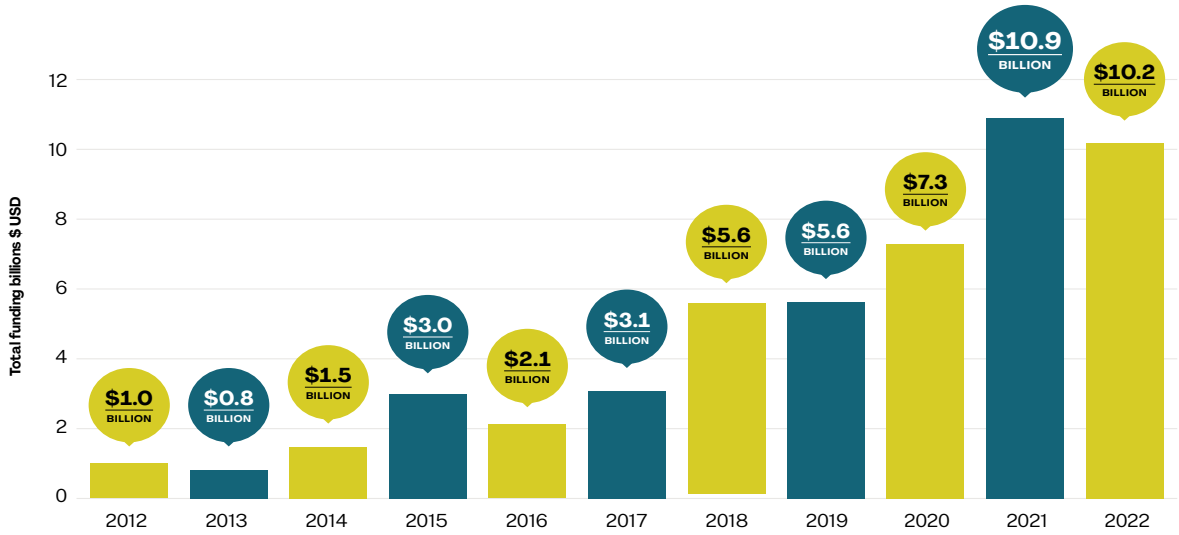


Big Companies Continue to Jump Into Biologicals (2012-2023)

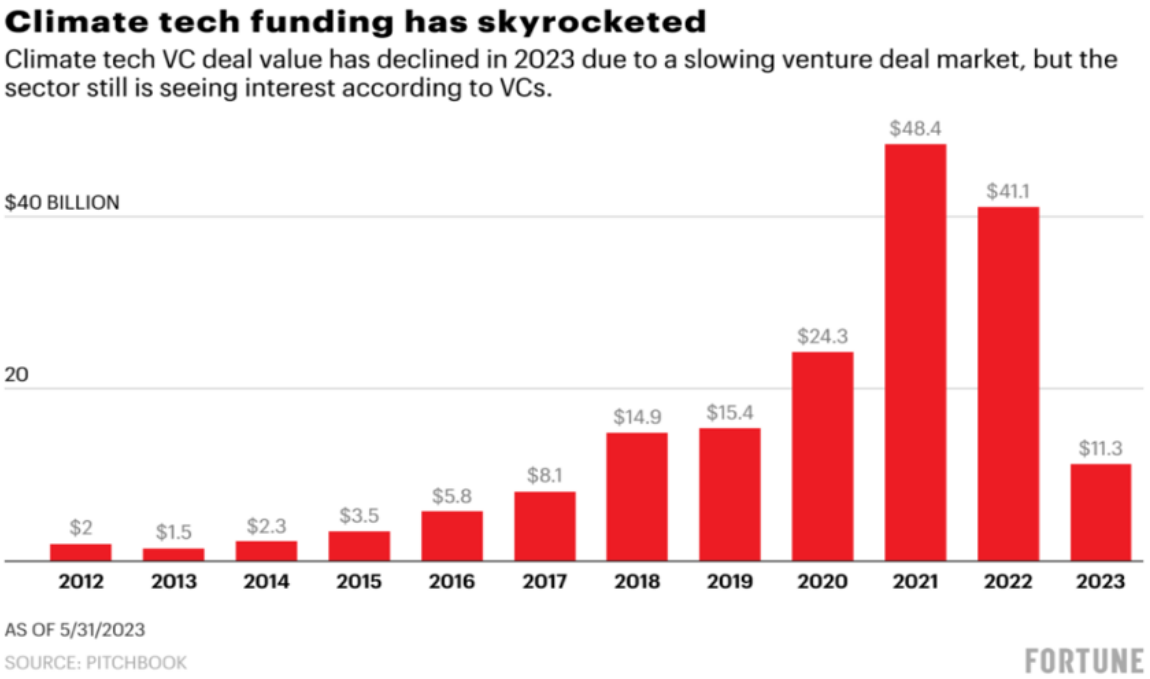


Recent deals

Farmtech Funding by Year (AgFunder)



Ag Biologicals investment did not decrease in Q1 2023!



More than 70% of Biologicals are Used by Conventional Growers But They are Often Seen as "Just for Organic"

Current Biostimulant Definition

Products that improve:

- Crop vigor, yields, quality and tolerance of abiotic stresses
- Plant growth and development throughout the crop life cycle from seed germination to plant maturity

Resulting in

- Modulation of plant metabolism
- Tolerance to and recovery from abiotic stresses
- Improved nutrient uptake, movement and use
- Higher product quality (sugar, color, protein etc.)
- Water use efficiency
- Enhancing soil fertility
- Increase microbiome diversity and types of microbes

Good News:

1. National framework is in the works
2. Panetta & Baird's Plant Biostimulant Act reintroduced

Chemical & Biological: Very Different Business Models

Average Chemical Pesticide

Discovery *~12 Years & ~$300 Million Development Time & Cost* Launch

- Massive upfront capital
- Thousands of global field trials on many crops and pests
- Global launch with large marketing spend; Peak sales in 3 years

Biopesticide

Discovery Launch

3-5 Years & <$10 Million

- Capital efficient but peak sales take longer
- EPA registration granted with small number of pests & crops on label
- Commercial development continues while selling

EPA submission of Version 1.0 **(MVP)** → V 1.0 Sales with early adopter customers → V 2.0 developed while waiting for 1.0 approval → V 2.0 placed with existing and new customers

Characteristics of Your MVP

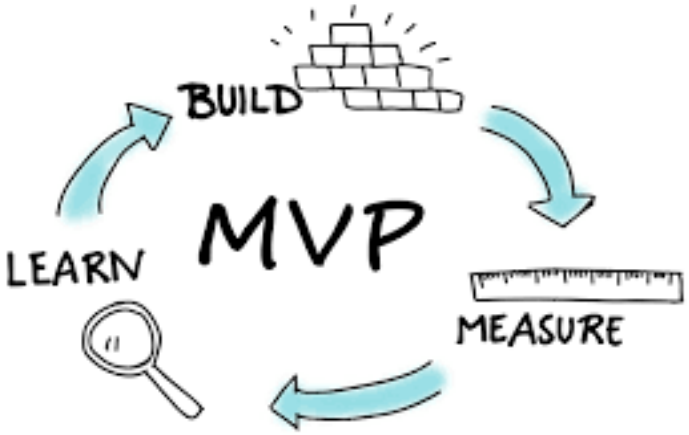
- Walt Duflock from Western Growers had an excellent LinkedIn post about agtech MVPs
- What are the characteristics of a "good enough" MVP for biologicals/agbiotech products?

***You have an idea about**: crop safety, human safety, level of efficacy vs. standards, spectrum, application & some field trials.*

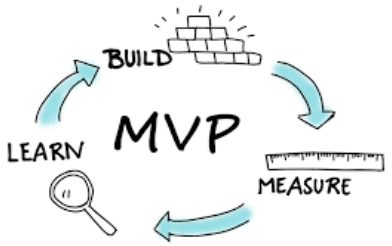
***You do not need:** a fully optimized formulation and manufacturing process.*

"Perfect is the enemy of good" (Voltaire)

"Perfection is the enemy of progress" (Churchill)



Ask your [potential] customers!



Fill unmet market needs

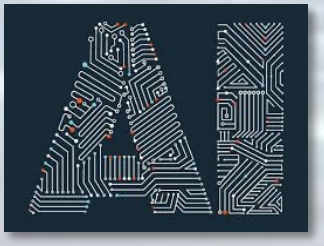
Find the early adopters & demo with them

Compare to their existing programs

Growers still have many issues that current solutions do not solve well

You Can Take Several Years to Perfect Your Product, but the Landscape will be Very Different When You Launch

Speed of change in the world and in agriculture is accelerating



New tools, new science, new tech

New entrants

New pests

New regulations

New investors

M&A

Innovations in Microbials and Related

New microbes or microbial consortia from nature:

- Fix Nitrogen
- Sequester carbon
- Reduce drought/water stress
- Control difficult pests and pathogens

Fermentation-enhanced microbial metabolites

Amping up the pesticidal activity

- Reducing the use rate
- Compete with chemicals

Waste to Biofertilizer:

- Biochar from almond hulls
- Food waste conversion
- Manure conversion

Engineered or gene-edited microbes:

- To produce fungicides on the roots
- To deliver pesticidal RNAi, peptides to the roots
- To take up P +/or micronutrients, fix N

Natural Compounds/Plant Extracts for IPM, Plant Health and Yield

LESAFFRE Romeo

Cerevisane, a purified extract of the yeast, *Saccharomyces cerevisiae* Strain LAS117 biofungicide

fyteko The Science of Biopossible

'Signal' molecule capable of 'priming' crops to cope with abiotic stresses as seed treatment

elemental enzymes®

Target essential soil and plant health through enzyme, peptide and biochemistry solutions

Elicit Plant

Phytosterol compounds for drought tolerance

BotanicalSolution

Plant bioreactors to supply key botanical products for disease control (esp *Botrytis)*

ascribe

Microbe signaling compounds to control fungal & bacterial diseases

AgroSpheres

Bio-encapsulation from *Bacillus,* 1st product from Thyme oil

Sound™ Agriculture

Nature-identical signaling molecules to attract beneficial microbes to the root for N & P uptake

True Algae™

Metabolites from liquid microalgae cultivation aids in P, Fe, Mn, Zn uptake

Peptide Innovations for Insect, Nematode & Plant Pathogen Control

VESTARON
THE POWER OF PEPTIDES™

Spider venom peptides for insect control

SOLASTA Bio
Nature Inspired

Based on insect neuropeptides that disturb pest physiological processes that kill the pest.

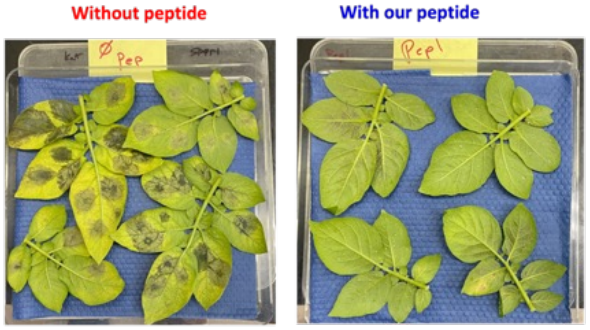
biotalys
reinventing food protection

AGROBODY Foundry™ for rapid generation of biocontrol solutions to tackle a wide range of crop pests and diseases.

Evoca™ is the first product, for disease control (*Botrytis*)

INNATRIX

Antifungal peptide platform



invaio sciences
A FLAGSHIP PIONEERING COMPANY

Peptide innovation from key limes to address Citrus Greening

RNAi for Insect, Nematode and Plant Disease Control

trillium Ag
INNOVATIVE BIO-AGRICULTURE

"Agrisome" RNAi platform provides new ways to deliver a range of biopesticides with far greater precision and efficacy

INNATRIX

RNAi for soybean cyst nematode control

RNAiSSANCE AG

Our RNAi designs have dramatically improved the efficacy of RNAi-based pesticides for Lepidoptera, including diamondback moth, for which we are currently in early field trials.

GreenLight™
BIOSCIENCES

Sprayable, double-stranded RNA for control of Varroa mite, Colorado Potato Beetle, Powdery mildew, *Botrytis*, Downy mildew

PEBBLE LABS

Naturally occurring microbes from crops to deliver the power of RNA for solutions for pests and disease control

Some Bioherbicide Innovations

Specific strains of the fungus *Fusarium oxysporum* as bioherbicides

Two microbials and one plant extract with novel modes of action

Plant extracts as bioherbicides

Microbial natural product discovery platform for controlling algae, aquatic and terrestrial weeds

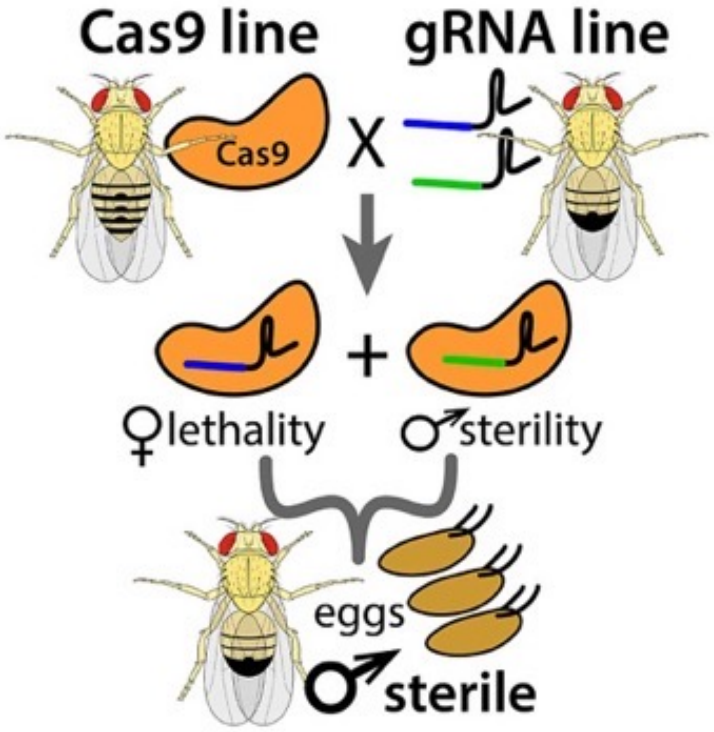
Platform for new pesticidal natural products

Short natural peptide molecules as fungicides & for resistant weeds

Exploiting sterility to win the battle against resistant weeds

Natural herbicidal compound from onion rot pathogen

New Sterile Male/Gene Editing Solutions



NC STATE UNIVERSITY

UC San Diego

AGRAGENE

BioSis™
WORKING WITH MOTHER NATURE

Our first two (non-GMO) solutions are approved for sale in England & four USA states (WA, OR, CA and FL) for control of spotted wing *Drosophila* (SWD) and codling moth.

Navel orangeworm

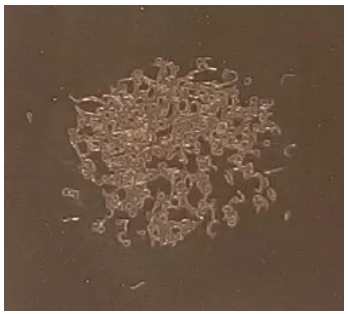
california almonds
Almond Board of California

USDA

Pheromone Innovations

Pheronym

Developing Nematode pheromones for better pest control of both insect and nematode pests



BioPhero

We produce our pheromones using renewable raw materials in a single fermentation step using yeasts

FMC

W2 Biocontrol

- Innovative synthesis
- Controlled release formulations
- Weevils, vine mealybug, caterpillars, fruit flies, red scale, others

BAYER

PROVIVI

Proprietary (bio)catalysts and low-cost raw materials to reduce the steps needed to synthesize pheromones and increase yields.

semios

Tech enabled pheromone traps and application for orchards and vineyards

Convergence of Tech and Biology

- Soil moisture, chemistry, Carbon, physical structure on the fly
- Optical/digital recognition of species
- Real time pathogen & pest detection
- Soil health & microbiome analysis
- Smart sprayers, precision application, drone scouting & application, harvesting & weeding robots

Use Rate Reduction
Targeted Application
Improved Efficacy

Benefits	Benefits
Grower	$ ↑
Environment	Residues ↓
Soil Health	Fertilizer ↓

How Do You Succeed in this Competitive Market?

Is #2 even possible anymore?

Business Model 1

Biological company with one technology is focused on unmet needs in the market; Partnering for sales and marketing) (e.g. most bio cos.)

Business Model 2

Biological company develops a broad product portfolio across multiple market segments; Vertically integrated (e.g. Marrone Bio)

Business Model 3

Biopesticide companies add precision technologies and shift from being just product supplier to solution provider (eg. Semios, Koppert, Biobest, FMC). SaaS models increase.

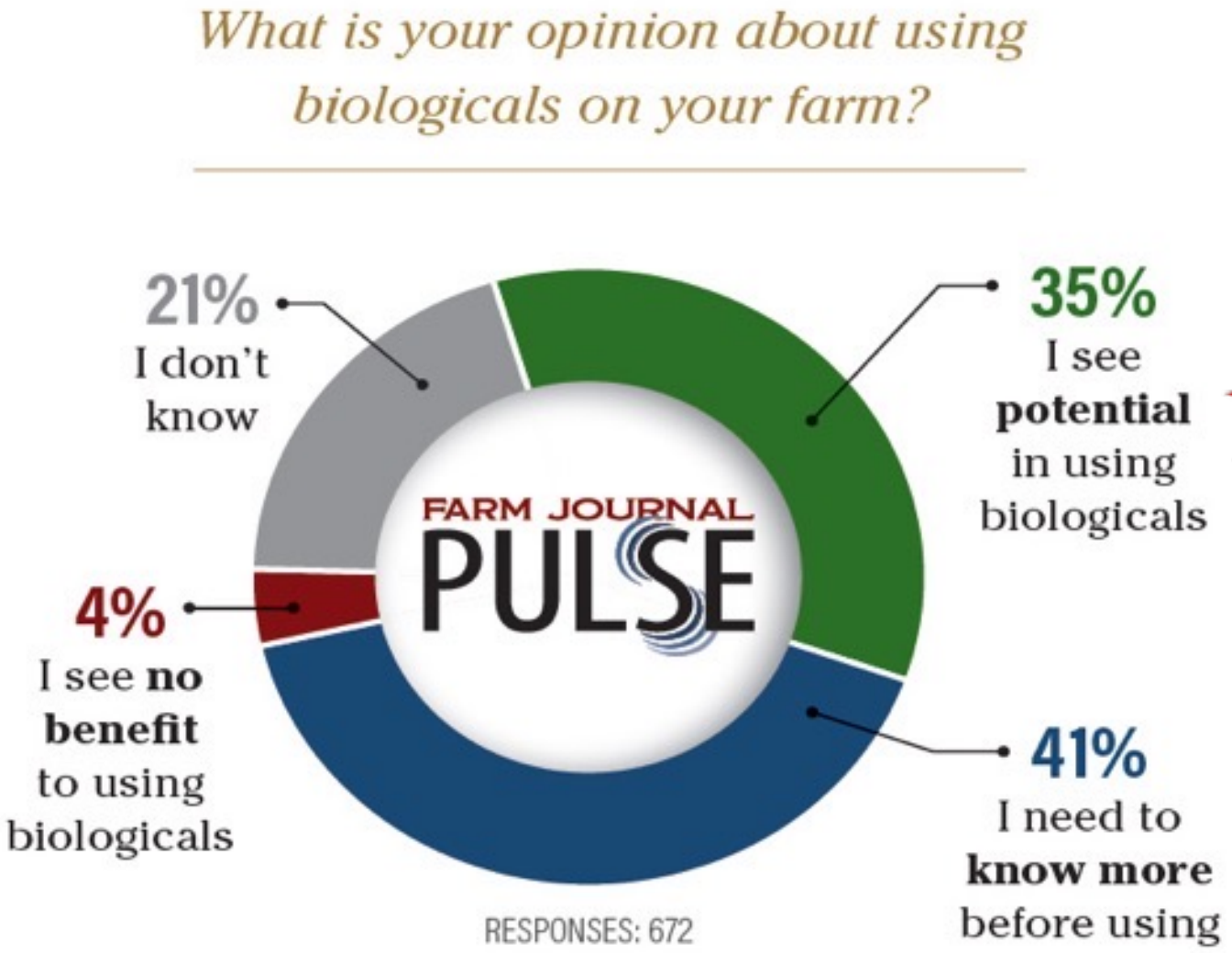
Suffice to say, new entrants need to have differentiated technology with clearly articulated competitive advantages

Filling an Unmet Need!

How to Sort Through so Many Innovations?

- What **field data** does the company have behind their products?
- Standalone small plot data are useful but not the whole story.
- **On farm demos** in real world programs can provide powerful information.
- **Yield/quality** more important than **percent control or # of bugs.**
- Look for **ROI calculations** and **marketable yield and quality** improvement data (value proposition).
- What is the **science** behind the products? Must be clearly articulated (do not accept, “it’s proprietary”).
- How is it **differentiated** from others? What is **unique**?
- What other benefits - **Carbon footprint reduction, soil health improvement, residue management, resistance management, increase in beneficials, pollinator safety**, etc.

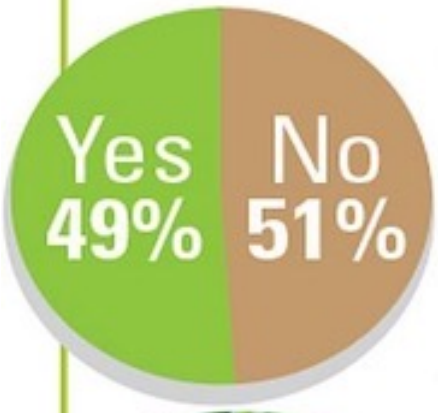
US Farmers Have Low Understanding of Biologicals



FARM|JOURNAL AGWEB

A huge opportunity here!!

DO YOU USE BIOLOGICAL PRODUCTS?



WHAT TYPES OF BIOLOGICAL PRODUCTS DO YOU USE?

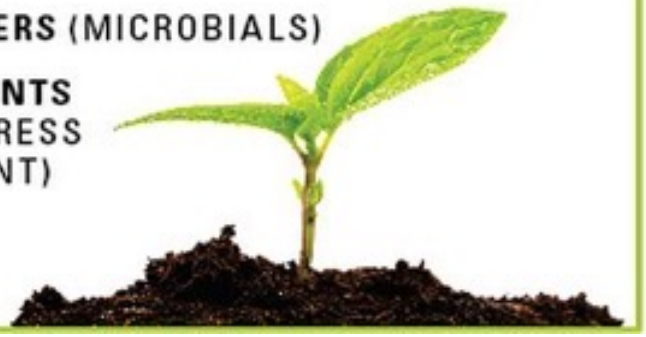
58% — **MICROBIALS** (MICROORGANISMS THAT CONTROL PESTS)

51% — **BIOCHEMICALS** (PLANT EXTRACTS, PGRS, ETC.)

48% — **PHEROMONE-BASED MATING DISRUPTION** (MACROORGANISMS THAT CONTROL PESTS)

37% — **BIOFERTILIZERS** (MICROBIALS)

28% — **BIOSTIMULANTS** (ABIOTIC STRESS MANAGEMENT)



Growing Produce

AMERICAN FRUIT GROWER

"Looking into it but haven't figured out how to best use them."

"I need to get a better understanding of how they'd fit with our operation,"

"I do find, when timed correctly, bio-products work just as good if not better."

What Else Needs to Happen to Help Drive Biologicals to Greater Acceptance and Adoption

NOT IF They Work, but HOW to Make Them Work

- **More education & training needed** on how the products work based on their unique modes of action. **Prevention vs. knockdown or curative.**
- **Go beyond counting bugs** or **leafspots.** Because of the unique modes of action, **marketable yields & quality** (incl. **nutrient density**) can be the **same as or better than** chemical programs.
- Look at **season long** beneficial **soil & plant health** effects + **beneficials, ghg reduction**.
- Trials should be conducted in realistic **integrated programs** rather than just stand-alone comparisons**. Large block trials** vs. small plots.

"The chemical is doing all the hard work" [in the rotation or tank mix]

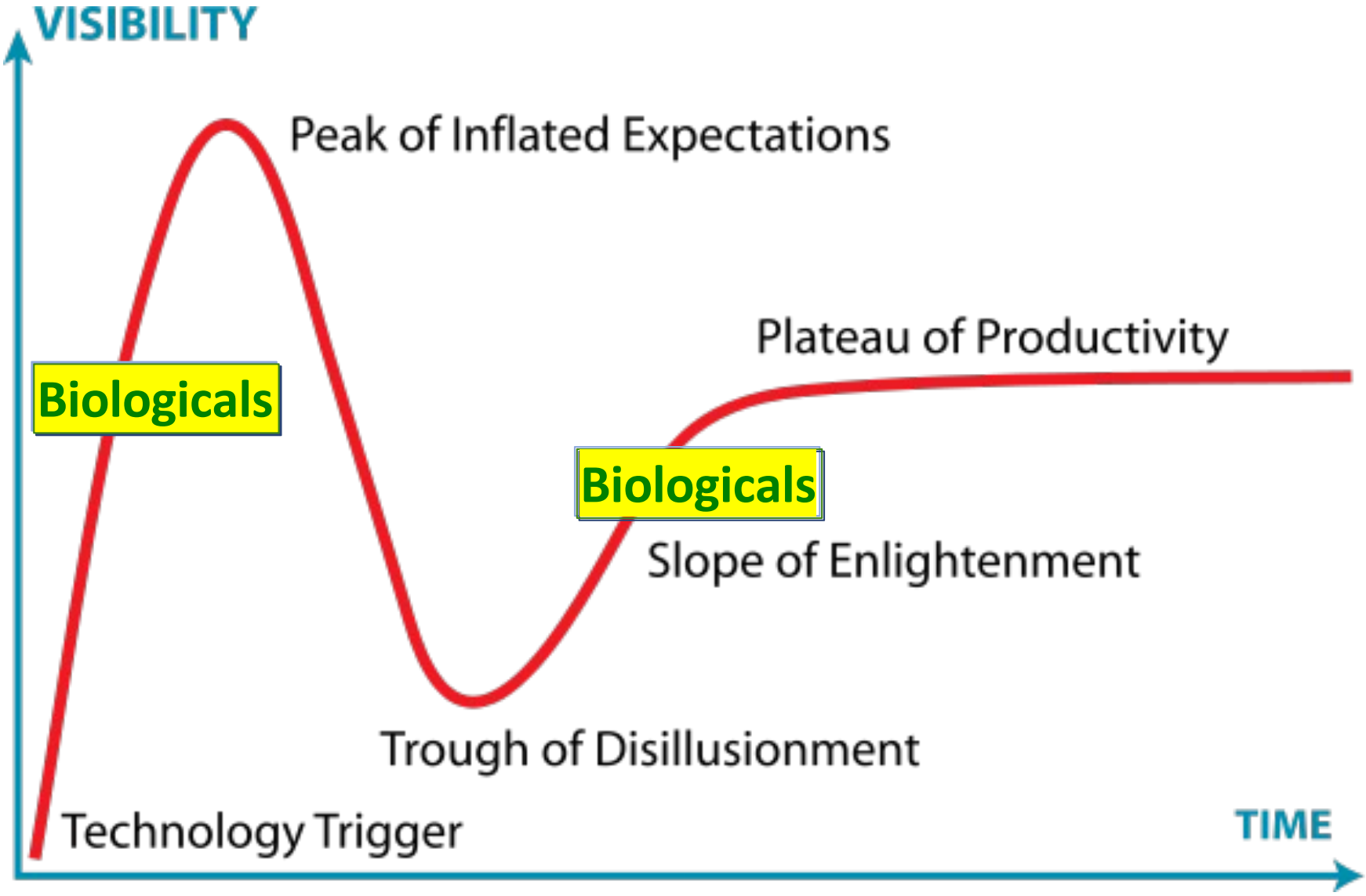
"I used that biological 5 years ago and it did not work so I won't use it again."

"The chemical did not work so I thought I'd try your biological." [for the first time]

Research report:
"The biological did not statistically separate from the untreated so it was not effective."
[Note the chemical was the same as the untreated but was not reported as ineffective!]

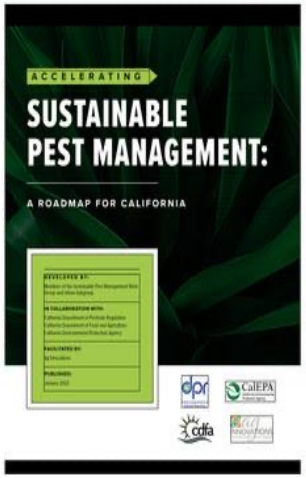
"I'll put you on my organic acres where I need more solutions."

Gartner Hype Cycle
(as Applied to Biologicals)




The SPM Work Grouo

A BOLD PLAN FOR A SUSTAINABLE FUTURE



"By 2050, pest management approaches in both agricultural and urban contexts in California will promote human health and safety, ecosystem resilience, agricultural sustainability, community wellbeing, and economic vitality. The implementation of these approaches will help steward the state's natural and cultural resources, enabling healthy lives for all and an abundant, healthy food supply for future generations."

READ THE ROADMAP
www.cdpr.ca.gov/docs/sustainable_pest_management_roadmap/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