

***Biologicals: The  
Market, Status, and  
Potential in  
Climate-Smart  
Agriculture***

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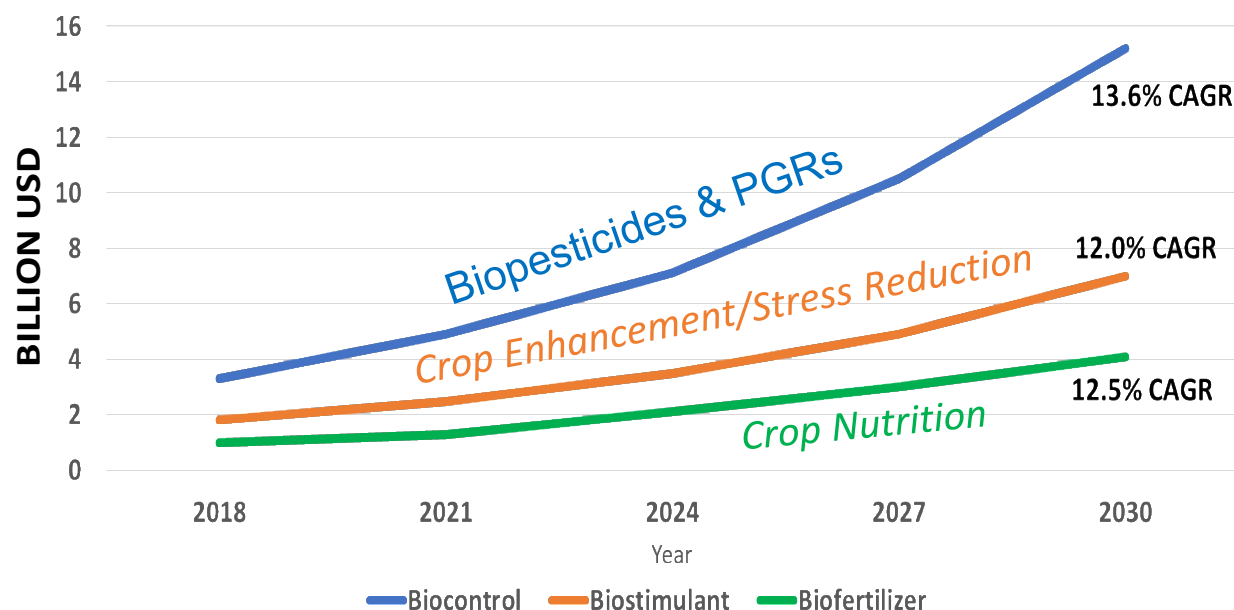
**[www.invasivespeciescontrolcorporation.com](http://www.invasivespeciescontrolcorporation.com)**

# BIOLOGICAL PRODUCTS MARKET LANDSCAPE



**DunhamTrimmer®**  
International Bio Intelligence

## GLOBAL BIOLOGICAL MARKET EVOLUTION



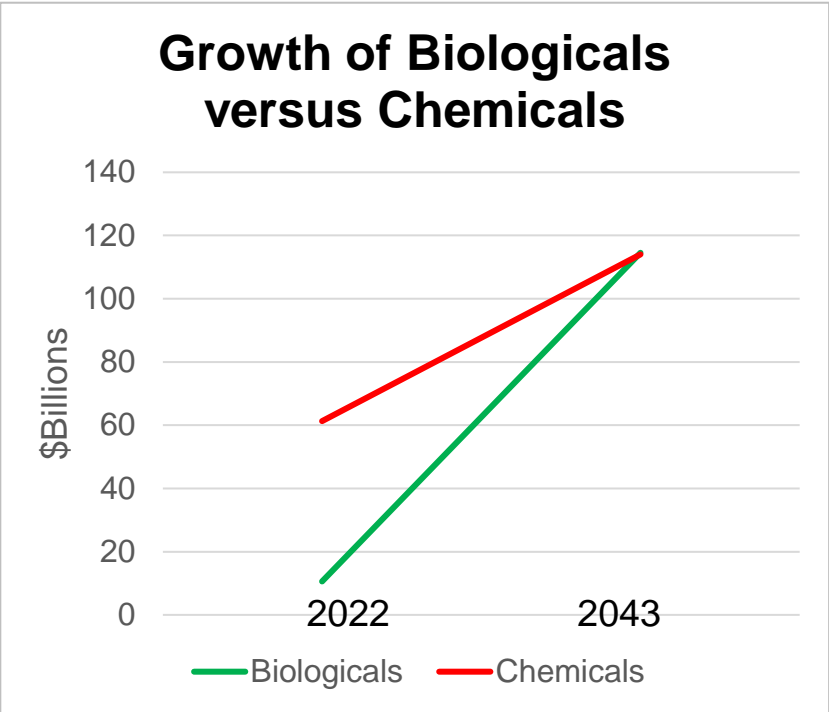
**CAGR 2018 - 2030**

**BIOCONTROL 13.6%**

**BIOSTIMULANT 12.0%**

**BIOFERTILIZER 12.5%**

# Biologicals Market Could Equal Chemicals in ~20 Years!

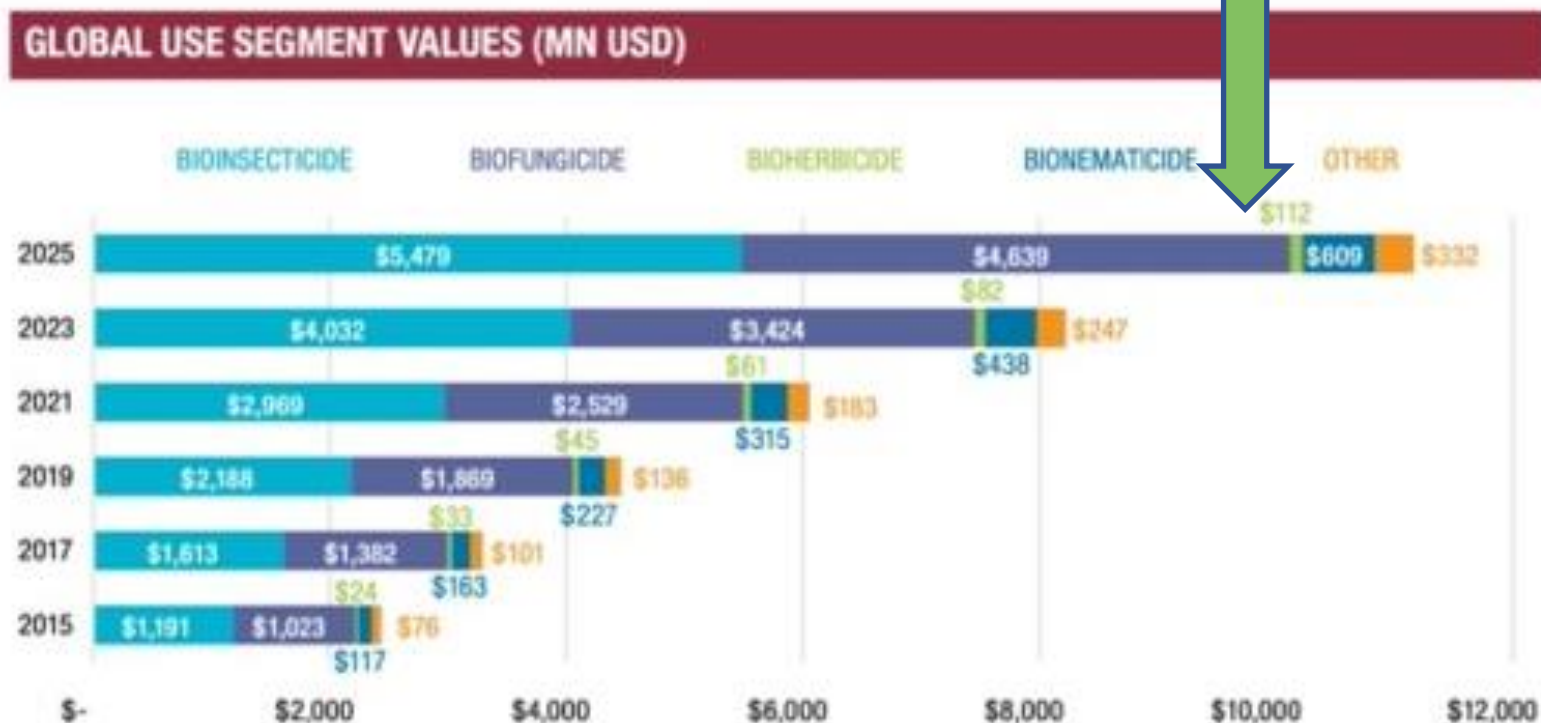


Growth rate (CAGR)		12 %
Number of periods	Biologicals	21
Initial value		10,600,000,000 \$
Final value		114,520,791,603.36 \$

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

# Bioherbicides are Insignificant Part of the Multibillion \$ Biopesticide Market

Bioherbicides



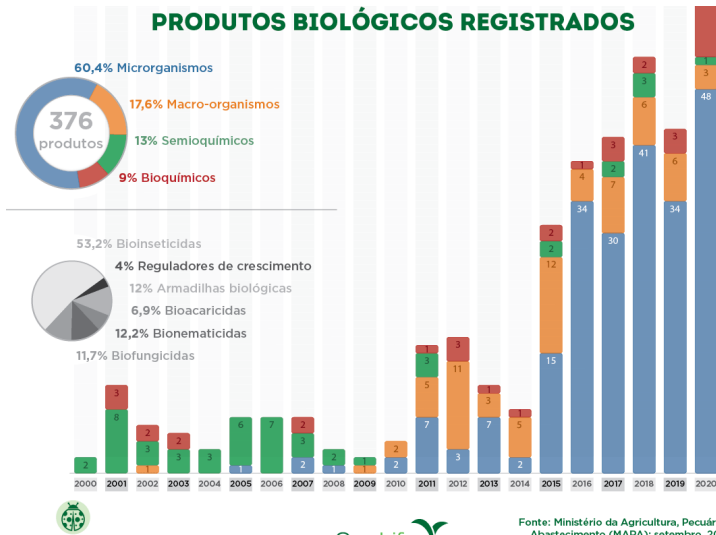
Data from DunhamTrimmer

# Brazil has Become the Largest Biologicals Market

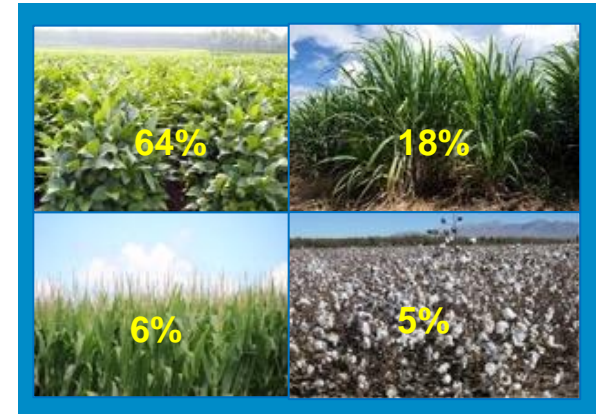
## *Doubling Every Two Years*

8-12 months for a new registration!

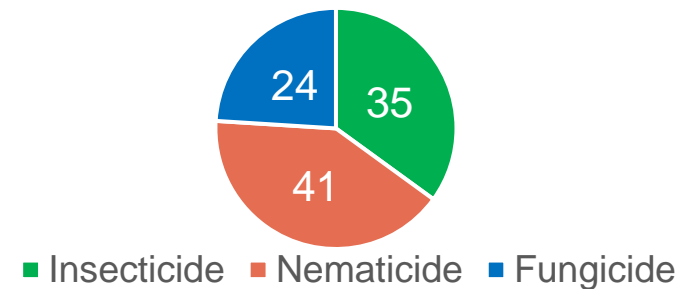
10.2 million hectares treated



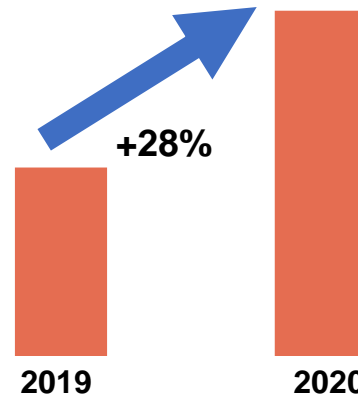
US \$342 million in 2020



Sales Percent



Robust growth possible:  
**Brazil** farmers typically  
use only one  
biopesticide



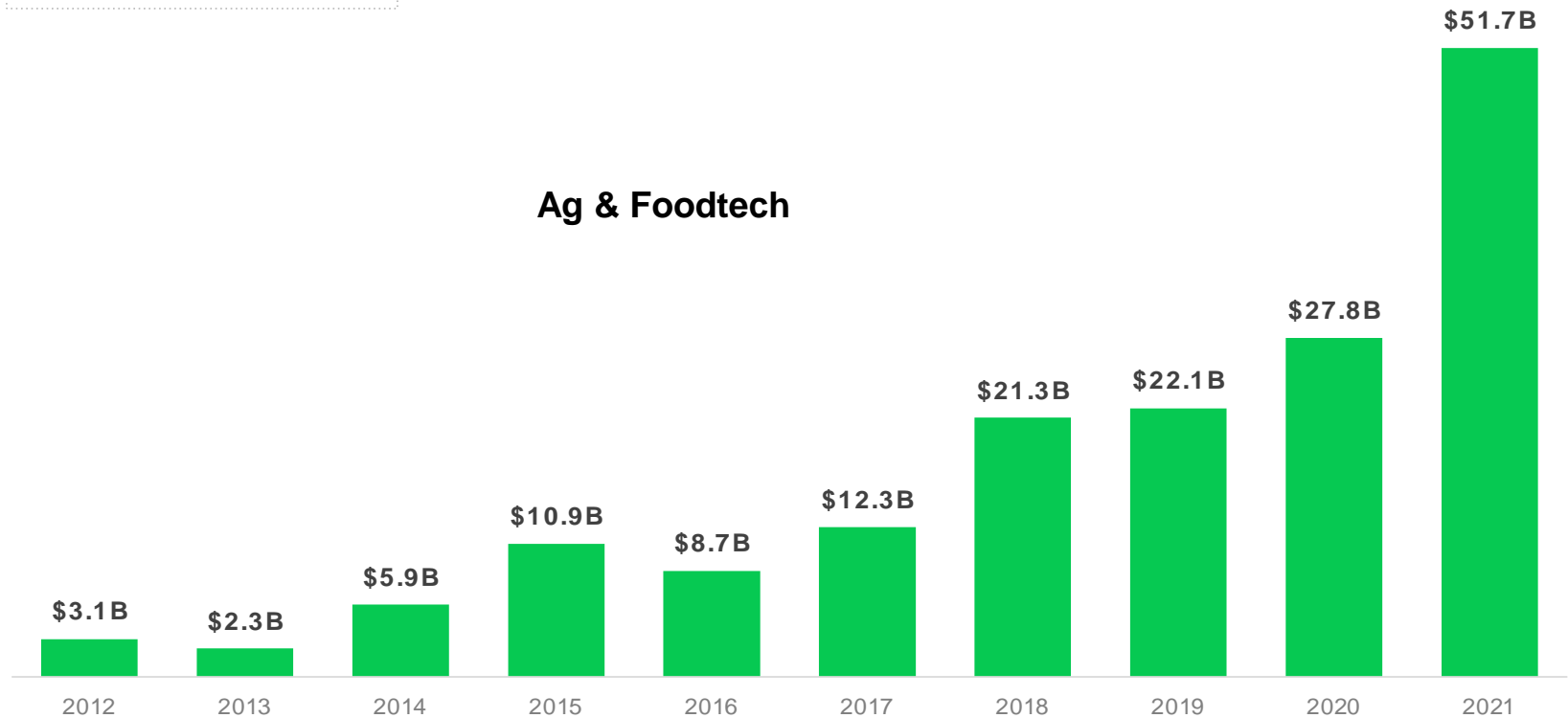
# Big Companies Continue to Jump Into Biologicals (2012-2022)



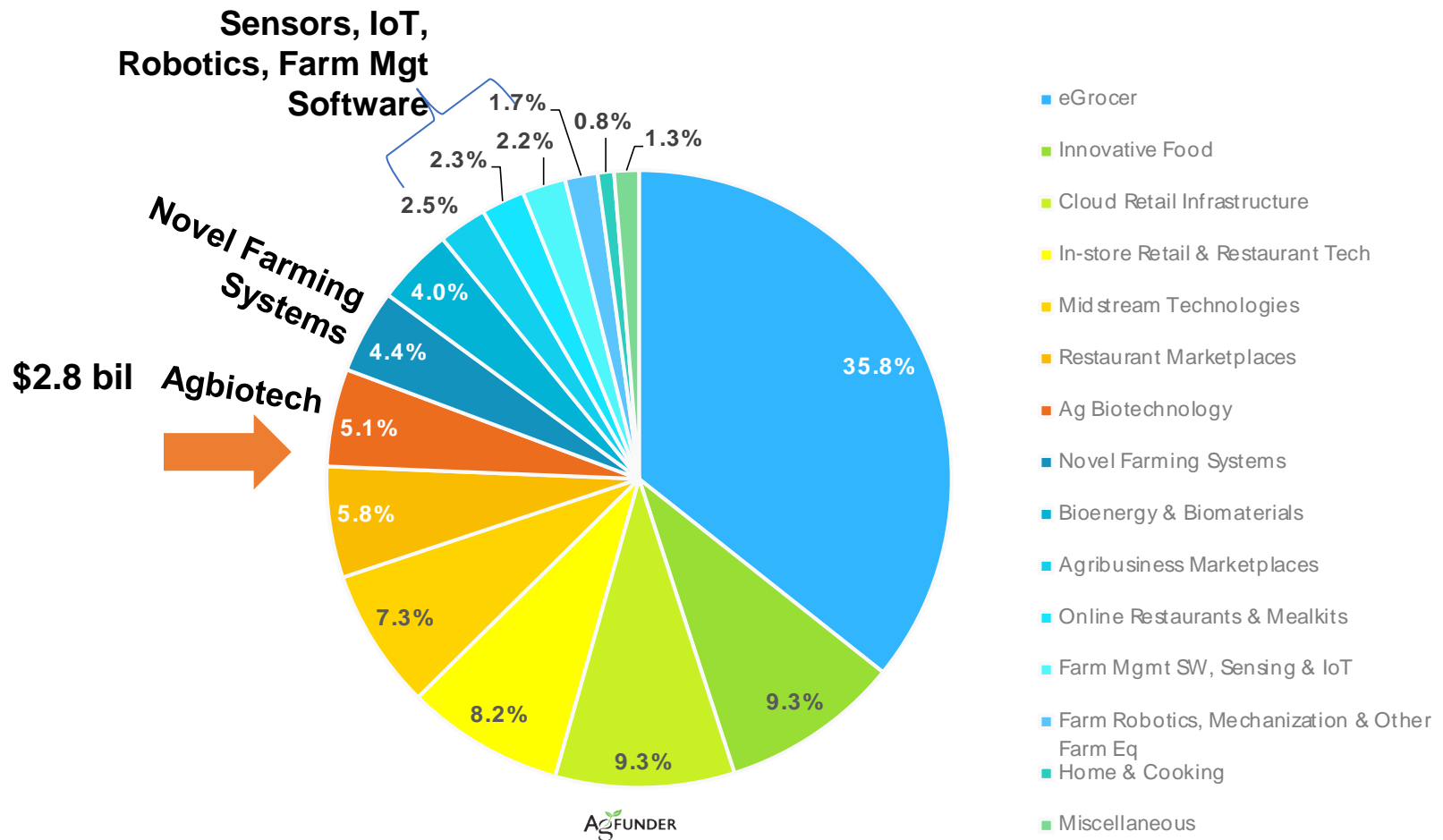
Recent deals

# Annual Financings | 2012-2021

Current total as of Feb 28, 2022



# 2021 Investment in Agri-Food Tech





# Applying the Lean Startup Model

## Minimum Viable Product (MVP)

Version 1.0 (MVP)  
EPA submission,  
formulation &  
manufacturing  
process



Early adopter  
customers try  
Version 1.0  
generating new  
sales



Version 2.0  
developed while  
waiting for EPA  
approval of  
Version 1.0



Version 2.0 is  
placed with the  
same and new  
customers

- **Atypical model for larger agchem**
- **Possible because of biologicals' safety, faster registration & ability to continuously improve microbial processes**
- **Capital efficient; fund as you go**
- **Involve growers early in the process for product vetting**

# Some Biological Innovations for Insect/Nematode

## IPM



**Next Gen Spider  
venom peptides for  
insect control**



**Sprayable, double-  
stranded RNA used  
in agriculture to  
control pests**



LALLEMAND ANIMAL NUTRITION

***Cordyceps javanica*** registered  
against *Bemisia*  
*tabaci* whitefly in Brazil



**Optimizing microbial &  
plant metabolites (e.g.  
MBI-306 *Burkholderia*  
*rinojensis*)**



Pink-pigmented  
methylotrophs for plant/soil  
health/Biocontrol (corn  
rootworm & nematodes)



**Biological insecticide  
Based on Lolines from the  
endophyte fungus *Epichloë*  
*uncinata*, active against  
important insect sucking &  
chewing pests**



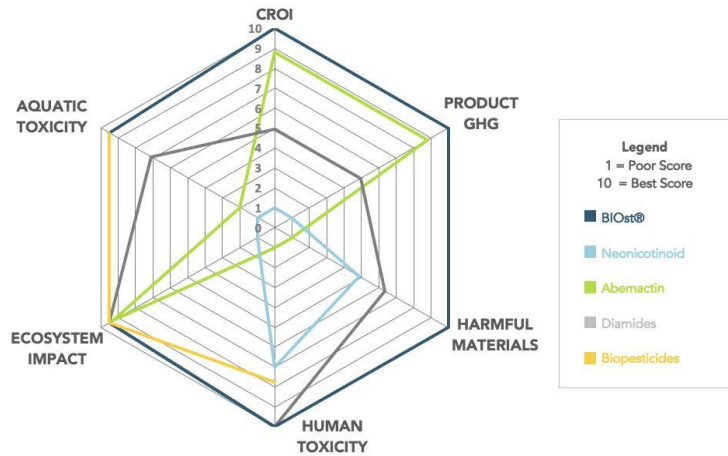
Bacteria for plant health  
and disease/nematode  
control



RNAi for soybean cyst  
nematodes

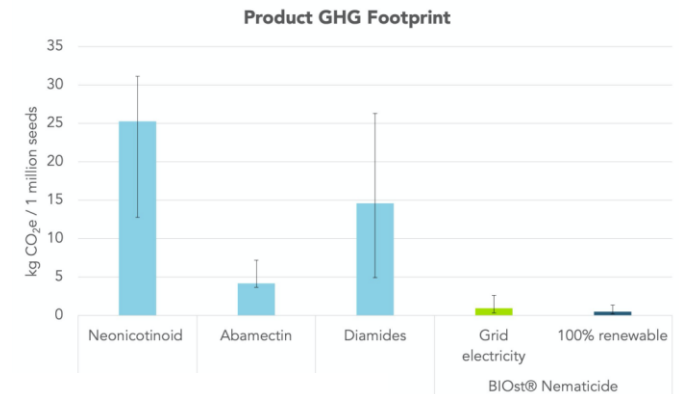
# The Climate Impact Study Showed that BIO<sub>st</sub> Nematicide *(Burkholderia rinojensis)* Reduced Greenhouse Gas (GHG) Emissions by 85% in Soybeans and 87% in Corn Compared with Conventional Pesticides

## Benchmarking and Conclusions



The estimated GHG footprint of BIOst® Nematicide considering 100% renewable electricity supply is:

- 98% lower than that of neonicotinoids
- 88% lower than that of abamectin
- 97% lower than that of diamides.



Climate Impact Score: 9.8/10

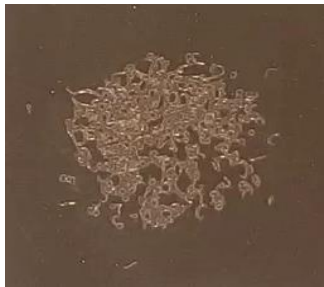


# Who Would Have Thought That Pheromones Would Have Such Innovation?



**Pheronym**

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



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



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



**PROVIVI®**

Provivi uses 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

# Many Companies with Biological Innovations for Disease Control



Bees to deliver  
microbial fungicides



Natural & gene-edited  
microbes as fungicides  
and nematicides,  
biostimulants



Living microbes as  
for pest mgt & plant  
health



Synergistic  
microbes as  
fungicides



Biological  
encapsulation  
technology from  
*Bacillus* micelles



Platform for  
selection of soil  
microbes



Natural plant protection  
Postharvest biofungicides



Antifungal peptide  
platform



Synergistic microbes  
as fungicides &  
biostims



Peptide innovation  
to address Citrus  
Greening



Microbe signaling  
compounds to control  
fungal bacterial  
diseases



Antifungal  
peptides



Plant culture to supply  
key botanical  
products for disease  
control

# Just a Few of the Young Companies Working on Bionutrients and Biostimulants – N fixation – Getting crowded



Gene-edited microbes  
for N fixation



TrueSolum®: liquid with  
metabolites from cultivation  
of microalgae aids in P, Fe,  
Mn, Zn uptake



Plant compounds for  
drought tolerance



Seed treatment method **Microprime™**  
produces seeds with embedded beneficial  
microbes with a long shelf life



Nature-identical signaling  
molecules to attract beneficial  
microbes to the root



Produces effective & hardy  
mycorrhizal inoculants for  
commercial agriculture



N-fixing and other  
microbes as seed  
treatments



*Gluconacetobacter  
diazotrophicus* for N  
fixation



Recycling poultry mature to  
provide the live microbes  
essential to healthy soil

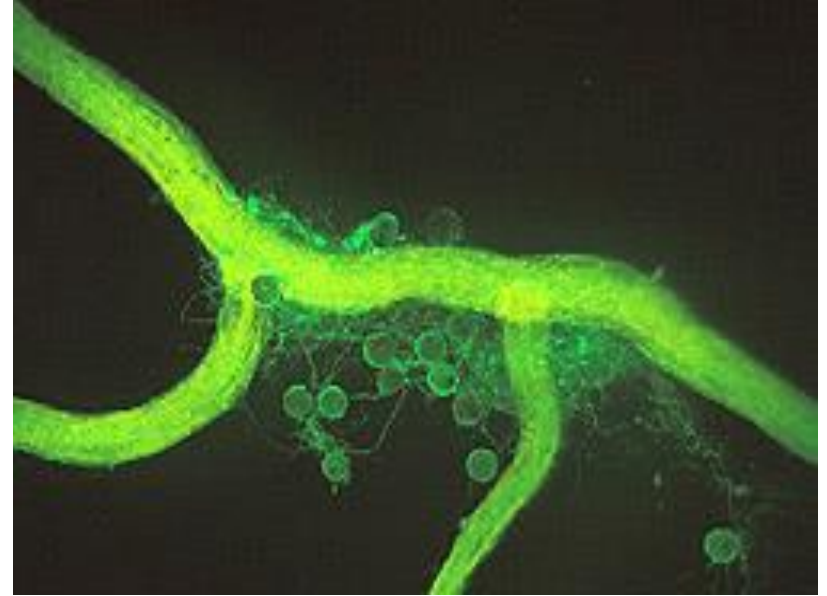


Fortified N-fixing bacteria  
to reduce synthetic N  
fertilizer

+Many more

# Mycorrhizal Inoculants are an Effective Method for Carbon Sequestration

- To date, farmers are mostly ineligible for carbon credits
- **Glomalin** is unique in its ability to store carbon over decades & can be considered a persistent and stable carbon sink
- Arbuscular Mycorrhizal Fungi (AMF) are the only known source of glomalin, and are in fact its namesake
- **Once recognized as an acceptable method of carbon sequestration, farmers should benefit from carbon credits**



Glomalin, dyed green, shown to completely cover mycorrhizal corn root and fungal spores

Photo by Sara Wright

**Groundwork**  
BioAg 



# Paucity of Innovations on Bioherbicides



Specific strains of the fungus *Fusarium oxysporum* as bioherbicides



Two microbes  
and one plant  
extract in  
development



Plant extracts as  
bioherbicides



Platform for new  
microbial natural  
products



Short natural  
peptide molecules  
as fungicides & for  
resistant weeds

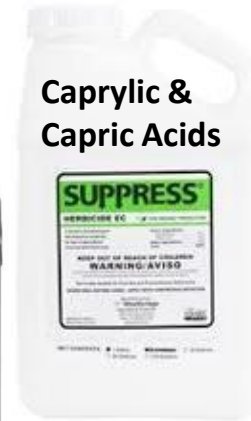
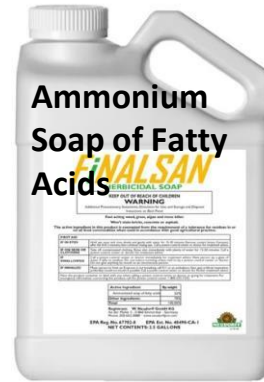


Exploiting sterility to  
win the battle against  
resistant weeds

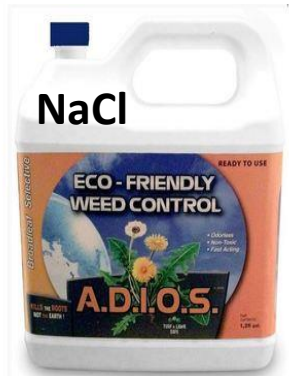


# Commercial Biochemicals

- Contact
- Non-selective
- Fast acting
- Need re-application



Pelargonic Acid



## Microbials – Narrow Host Range

### *Phoma macrostoma*

Dandelion, field bindweed, annual sow thistle and wild mustard (82%).

### *Pseudomonas fluorescens* Strain BRG 100

Green foxtail & wild oats

### *Pseudomonas fluorescens* Strain D-7

Cheatgrass, medusahead, and jointed goatgrass

### SolviNix® LC Tobacco

mild green mosaic

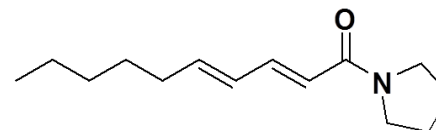
tobamo virus strain U2

Tropical soda apple (*Solanum viarum* Dunal)

# Three Bioherbicides with Novel Modes of Action [Still] in Development



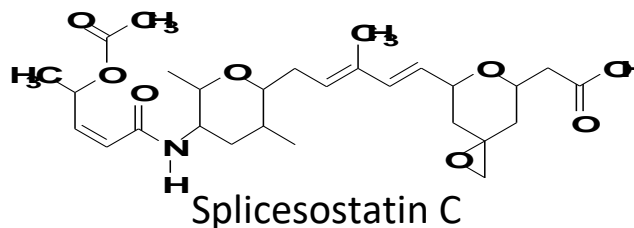
## MBI-011: Burndown



Sarmentine

## MBI-014/015: Systemic against pigweeds

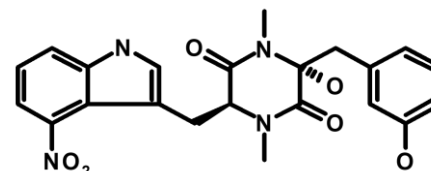
*Burkholderia  
rinojensis* A396



Splicesostatin C



## MBI-005/007: Broad spectrum pre-emergence, selective post



Thaxtomin



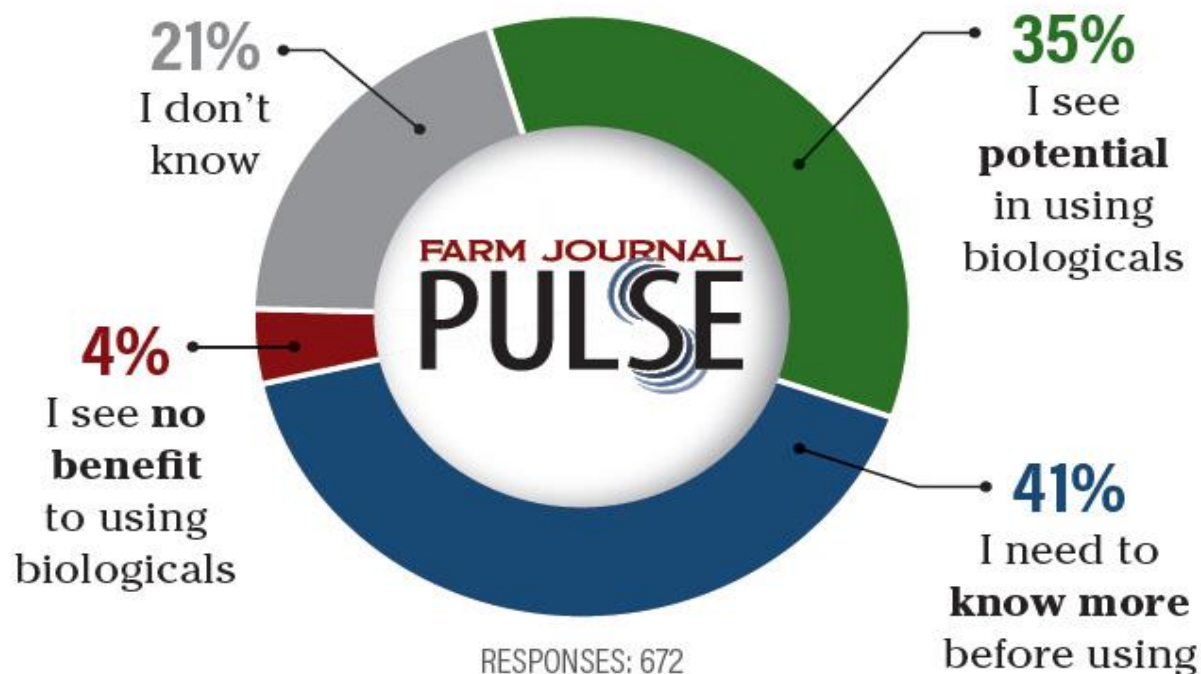
# What is Needed for Bioherbicides

- Need unwavering, sustained and dedicated multimillion \$ resources to bioherbicide development
- High risk but high reward speaks to need for government money/grants in EU and USA to support innovators in their early stages before investors or partners will be interested
- New tools of synthetic biology and molecular biology/genomics/metabolomics will speed up microbial fermentation optimization & development; fermented plant compounds are possible
- Some new formulation technology may help compound instability (e.g., nanotech; encapsulation)
- Microbial metabolites are the most exciting and promising area for bioherbicides but regulatory packages will be expensive

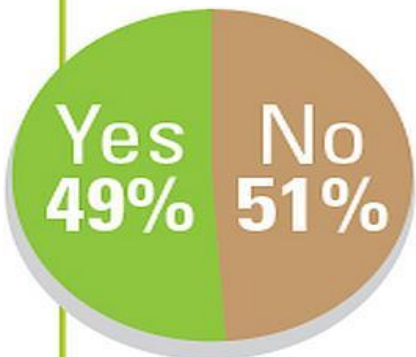
# **WHAT DO FARMERS THINK ABOUT BIOLOGICALS**

# US Farmers Have Low Understanding of Biologicals

*What is your opinion about using biologicals on your farm?*



## 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**

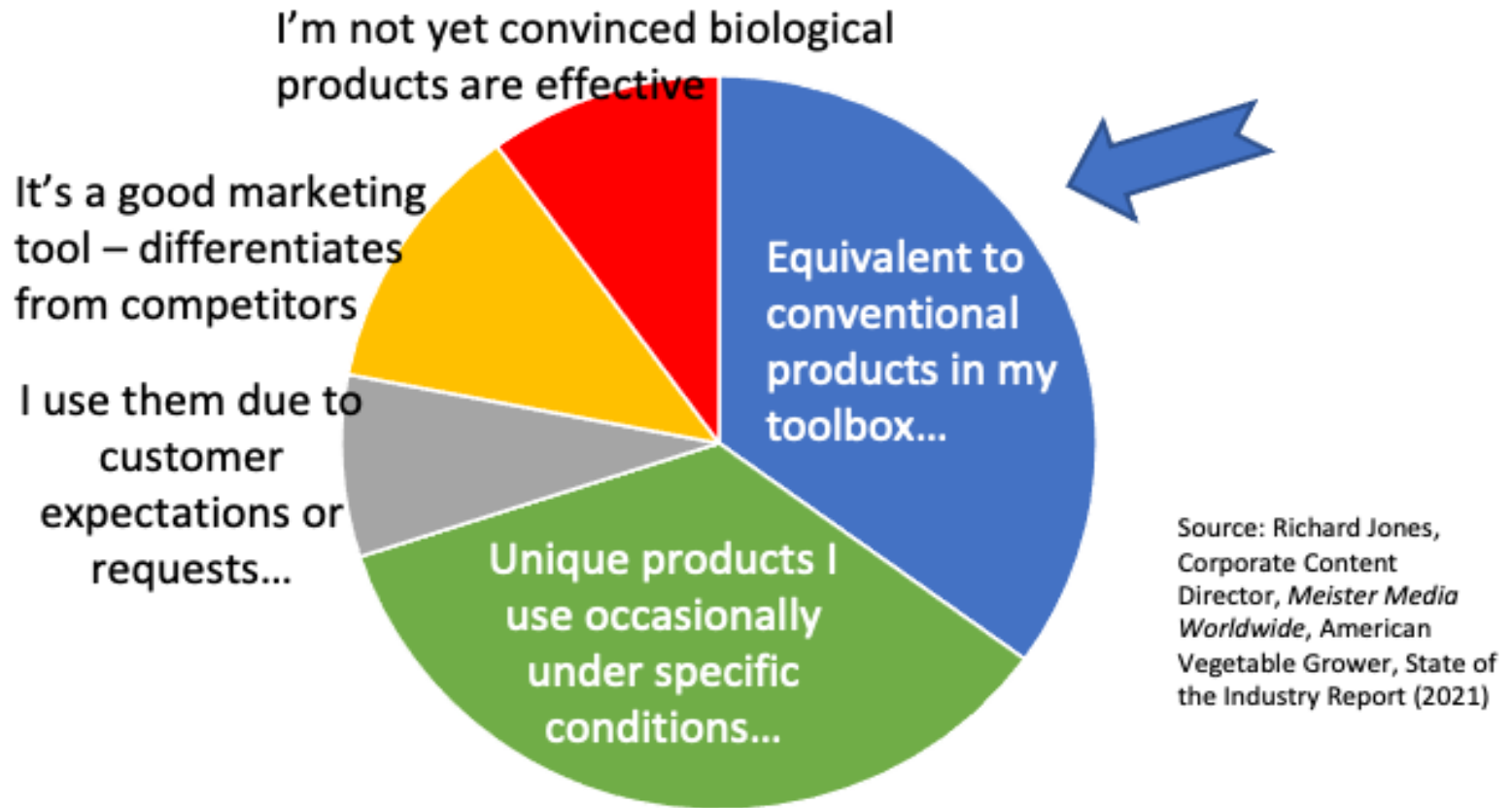
— AMERICAN —  
**FRUIT GROWER**

"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."*

# How Do You View Biological Products?





# 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.
- Trials should be conducted in realistic **integrated programs** rather than just stand-alone comparisons. **Large block trials** vs. small plots.
- **Systems integrators needed!** Development & implementation of **holistic, systems-based, integrated** programs with cultural tools, tailored crop varieties, soil health practices, biologicals, precision tools, data, etc.





## Biological Products Industry Alliance Advancing Sustainability Through Biological Solutions

[www.bpia.org](http://www.bpia.org)



**The International Biocontrol Manufacturers' Association (IBMA) is the worldwide association of biocontrol industries producing microorganisms, macroorganisms, semiochemicals and natural pesticides for plant protection and public health.**



<https://attra.ncat.org>



<https://www.agronomy.org>



<https://soilhealthinstitute.org>



<https://understandingag.com/why-soil-health/>

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