

# ***BioDirect Technology for Biocontrol***

## ***Annual Biocontrol Industry Meeting***

### ***Borderlines in Biocontrol Session***

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# Biologicals Complement Monsanto's Systems Approach to Increasing Yield in a More Sustainable Way

## Emerging Trend

- Regulatory Pressure on Some Chemistry

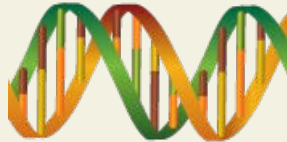


### BREEDING



Highest yielding genetics for target environment

### BIOTECHNOLOGY



Complementary agronomic and yield enhancing traits

### BIOLOGICALS



- Resistance Management
- Reduced Residues
- Complementary MOA's
- Ag Chemistry Enhancement

### CHEMISTRY



Traits & Germplasm provide platform for Ag chemistry Products

### AGRONOMICS



Farm management practices and optimizing genetic placement on the farm

# Biologicals Can Complement Traditional Fertilizers and Chemicals

## MONSANTO AG BIOLOGICALS TECHNOLOGY PLATFORMS



### Microbials

Weed Control



Disease Control



Insect Control



Bee Health



Yield Focus



Disease Control



## DELIVERY METHODS

Seed Treatment



Foliar Applications

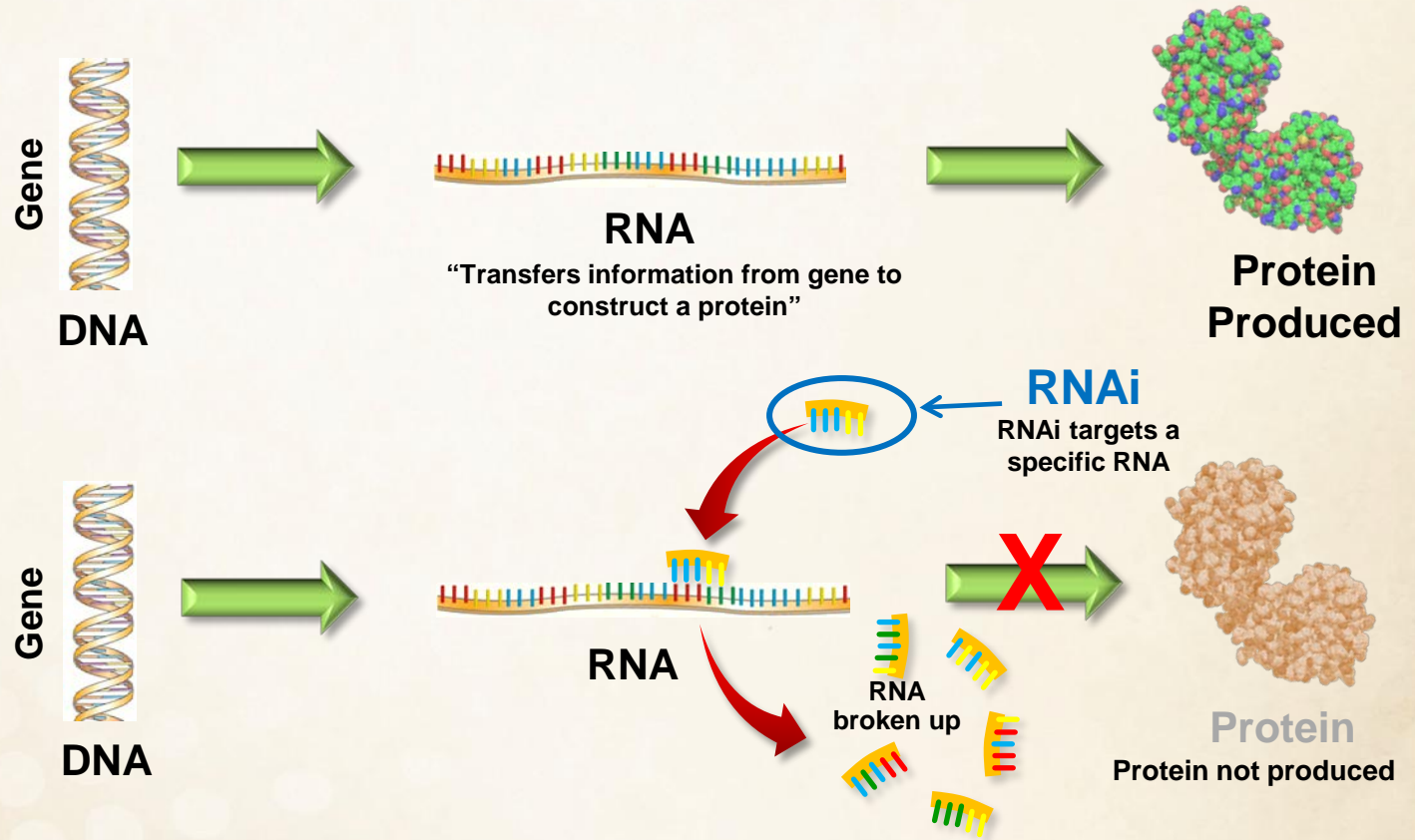


Agronomic Practices



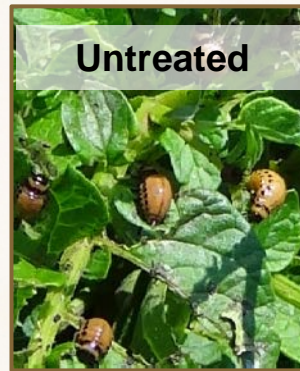
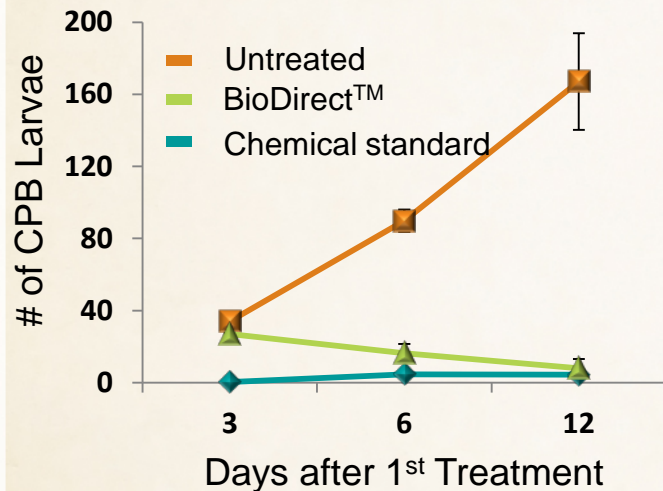
# BioDirect™ Technology is Based on New Applications of known RNAi Technology

RNAi is  
A Natural  
Mechanism  
to Control  
the  
Expression  
of a Gene



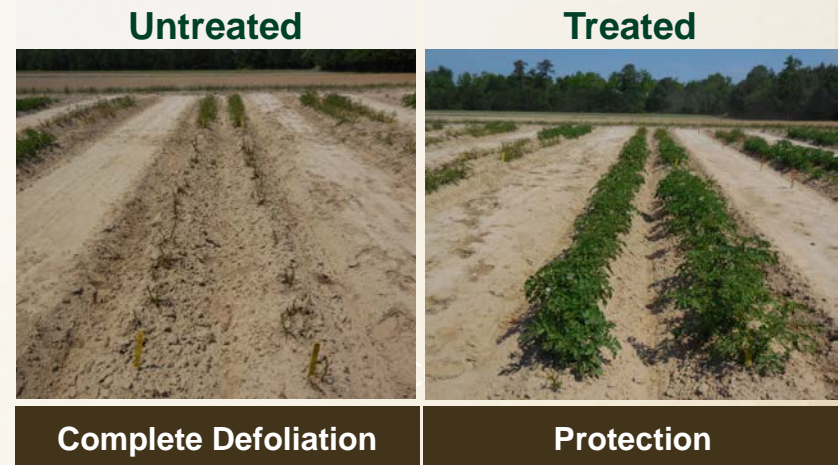
# Plant protection against Colorado Potato Beetle with BioDirect™ technology treatment

## BioDirect™ Controls Colorado Potato Beetle Larvae



## BioDirect™ Protects Crops from CPB Damage

Virginia, 2014

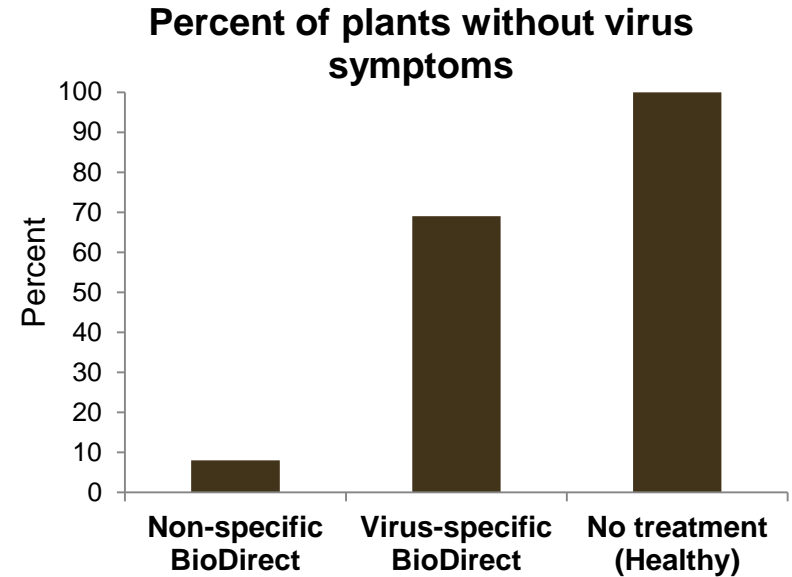
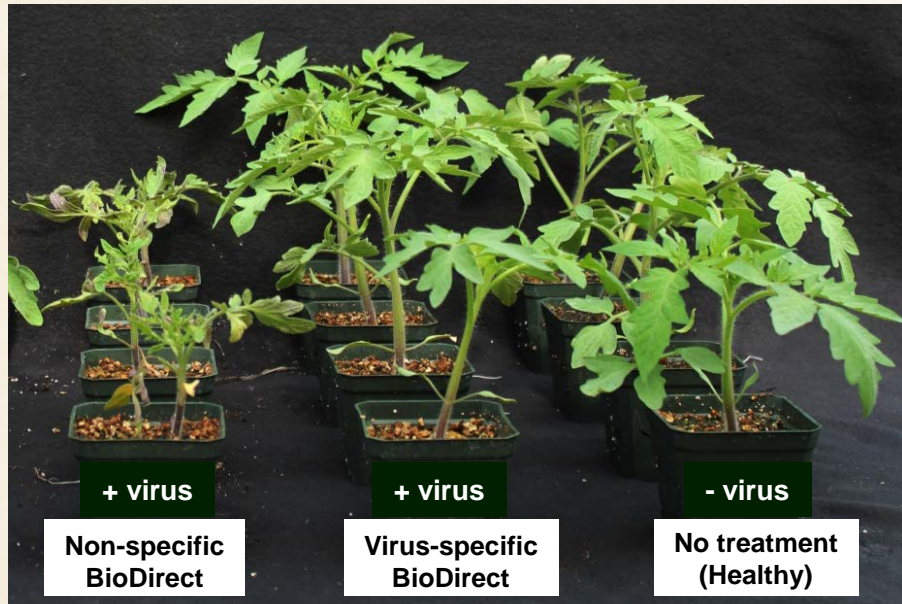


Wisconsin, 2013

- **Goal: Colorado Potato Beetle control on potato and other solanaceous crops**
- **CPB is a highly destructive defoliator causing significant yield loss**
- **BioDirect treatments reduced CPB larval infestation comparable to synthetic insecticides, decreased adult emergence, and lessened plant defoliation across multiple field trial locations**
- **Similar work in progress and planned for corn rootworm and other beetles**



# BioDirect™ technology demonstrates improved plant health by targeting Tomato Spotted Wilt Virus in tomato



Greenhouse trials with an aggressive strain of TSWV on a commercial tomato hybrid show early progress towards Tospovirus control

- Goal: protect susceptible cultivars and broaden germplasm resistance against TSWV and other tospoviruses that cause >\$1B annual losses.
- BioDirect treatments have suppressed virus concentration, decreased disease symptomology, and improved plant health in tomato and pepper.
- Focused on improved active ingredient design and delivery optimization.



# BioDirect™ Demonstrates Control of Glyphosate Resistant Palmer Amaranth & Waterhemp in the Field 2013

## Glyphosate-Resistant Palmer Amaranth

Illinois, 2013

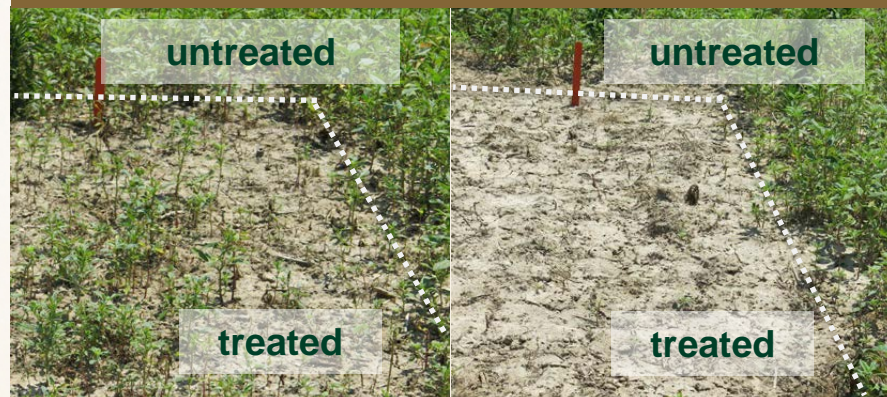


Roundup WeatherMAX®

Roundup WeatherMax®  
+ BioDirect

## Glyphosate-Resistant Waterhemp

Illinois, 2013



Roundup WeatherMAX®

Roundup WeatherMAX®  
+ BioDirect

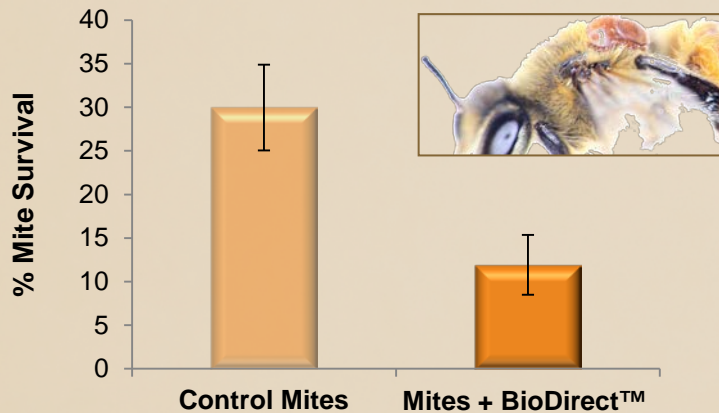
- Goal: BioDirect can be used with existing herbicides to create new value through improved weed control
- Target gene sequences common to Palmer and Waterhemp were selected, produced as double stranded RNA, and shown to be effective against both species



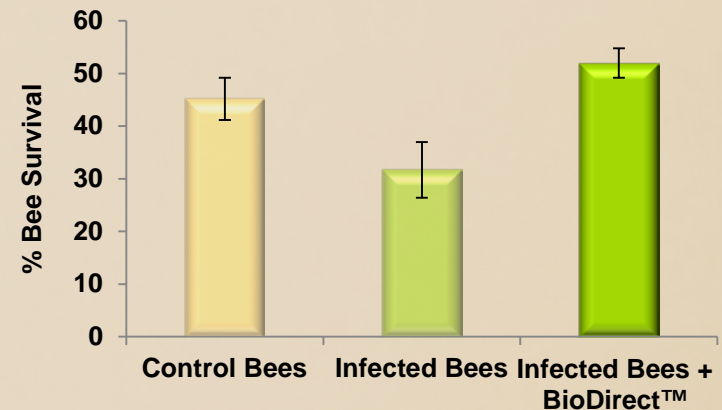


# BioDirect™ Technology to Improve Honey Bee Health

## BioDirect™ Causes Varroa Mortality in Lab Trials



## BioDirect™ for Multiple Viruses Increases Bee Survival in Lab Trials



- **Goal: Use BioDirect to treat Varroa mites and pathogenic bee viruses in the hive**
- **BioDirect treatments trigger Varroa mortality and improve bee survival in laboratory assays**
- **BioDirect for Bee Health field implementation is being developed**



# Regulatory Considerations for BioDirect

- RNA-based suppression is based on a naturally occurring process, and has been used as a longstanding approach to achieve desired phenotypes
- RNA has a history of safe consumption
- RNA offers specific gene suppression that greatly reduces potential impact on non-target organisms
- The current safety assessment strategy for exogenously applied RNA-based products is based on the same tiered safety assessment paradigm used for other biological products
- RNA-based technologies offer **new modes of action** in managing hard to control pests and viruses

# How Can RNA-Based Technologies used for Biocontrol Help Agriculture?

- An **important tool** derived from a **naturally occurring process** that supports **sustainable agriculture**.
- Offer growers **new modes of action** in managing hard to control pests and viruses, thereby enabling them to **increase yields and maintain productivity and durability**.

