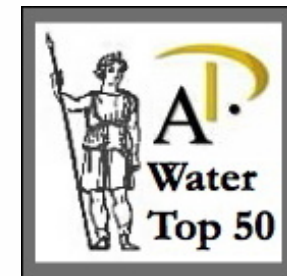




2010 Investors' Circle
Top 20



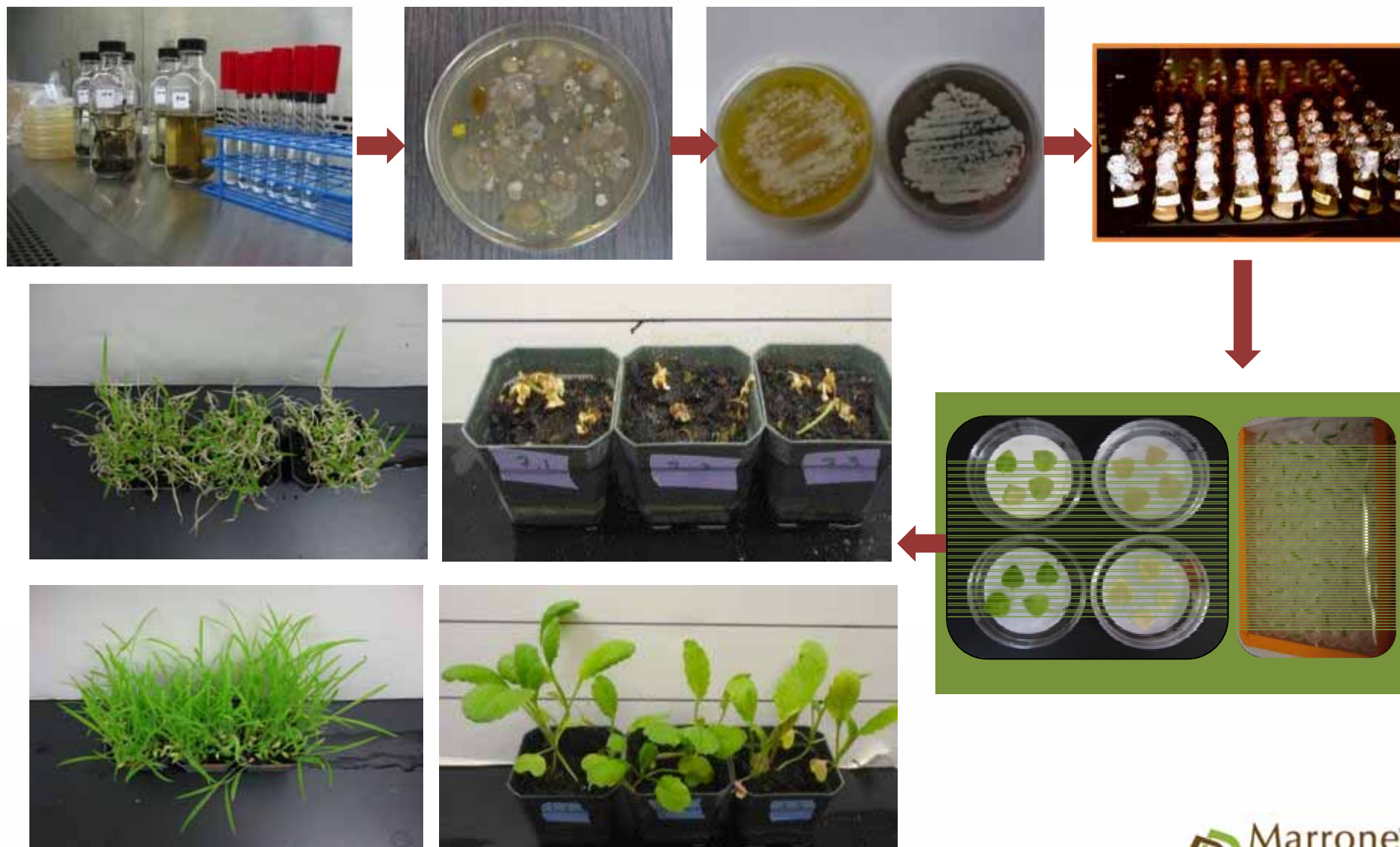
Three New Bio-herbicides

Company Overview



- Dedicated to **discovery, development, manufacturing and marketing of natural products for pest management**
- Founded in 2006 by serial entrepreneur Pam Marrone in Davis, California; 101 employees; 16 PhD, 10 MS, 4 MBA; 54 in R&D
- Selling Regalia[®] biofungicide and Grandevo[®] bioinsecticide, and Zequanox[®] Invasive mussel product
- Opportune[™] Bioherbicide EPA approved; launch late 2013
- Additional bioinsecticide (Venerate[™]) – launch in 2013, upon EPA approval
- Other pipeline candidates: two nematicides, biofumigant, nutrient uptake enhancer, herbicide, fungicide, and many early stage from the screen
- More than three dozen patents pending; \$60 million of investment capital raised

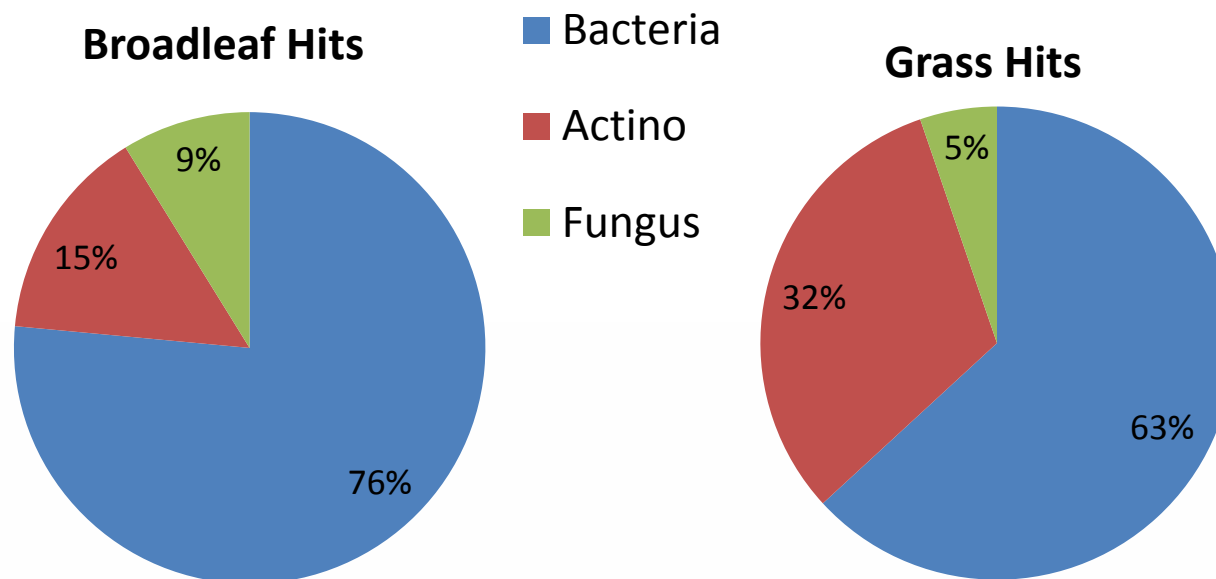
Screening Microbes for Bio-Herbicide Activity



Herbicidal Screening Has Yielded Promising Hits



Hit type	Total #	Hit Rate	One hit per...	What has been screened?
Herbicidal broadleaf	302	1.83%	55	16,500 microbes
Herbicidal grass	135	1%	100	11,500 microbes



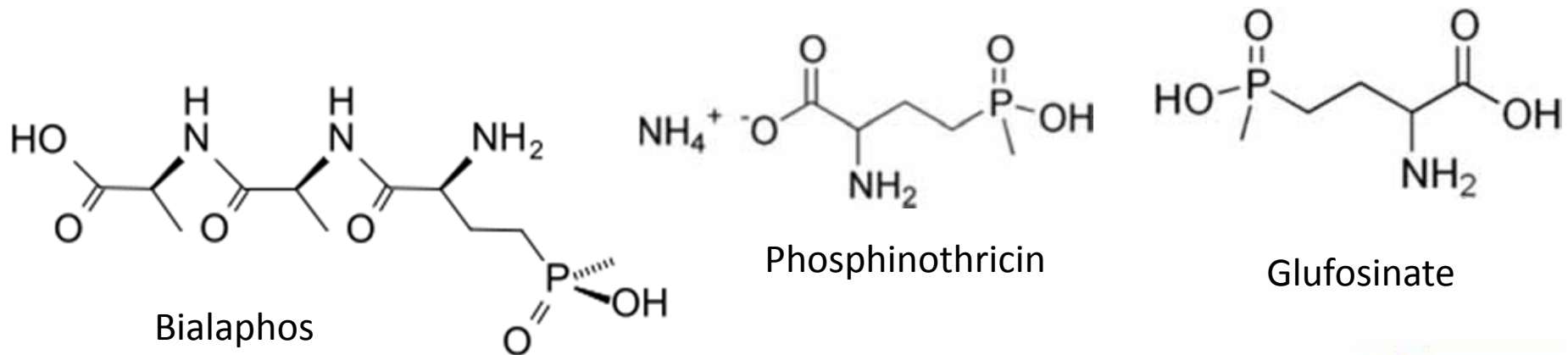


MBI-010 Systemic Bio-herbicide

Screening for Systemic Mode of Action



- Used discovery of bialaphos & glufosinate as a model.
- Phosphinothricin (a breakdown product of bialaphos) discovered from *Streptomyces viridochromogenes* and *S. hygroscopicus* by researchers in Japan.
- Phosphinothricin inhibits the activity of the glutamine synthetase enzyme, which causes ammonia build-up in the cell.
- Why not look for more microorganisms that produce GS inhibitors?



Screening for Systemic Mode of Action (2)

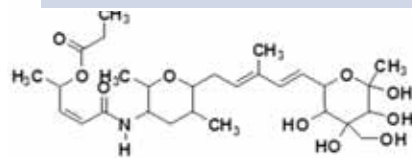


- MBI purified glutamine synthetase (GS) enzyme from a plant
- Screened thousands of microbial extracts against this enzyme
- Several candidates were active in the enzyme assay and selected for further testing
- Bacterial strain A396 (=MBI-010) showed the best herbicidal activity in the in vivo test
- A396 is a new species of *Burkholderia* (DNA sequence shows it is not related to pathogenic species)
- Identified several herbicidal xylem-mobile compounds produced by the bacteria
- MBI filed patent on the strain, chemistry and GS assay

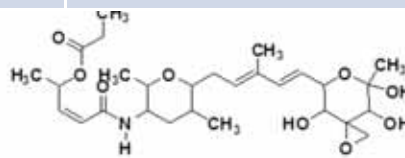
MBI-010 Herbicidal Compounds



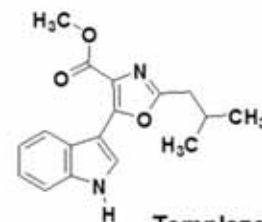
	Compounds	Grass Seedlings (% Mortality)	Lettuce Seedlings (% Mortality)
New	Templamide A (1)	100	88
	Templamide B (2)	0	75
	FR901465 (3)	88	100
	FR901228 (4)	100	88
New	Templazole A	ND	63
	Templazole B	ND	77
	Control (Water)	0	0



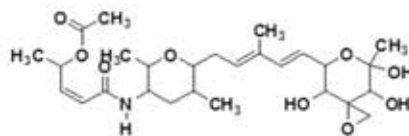
Templamide A (1)



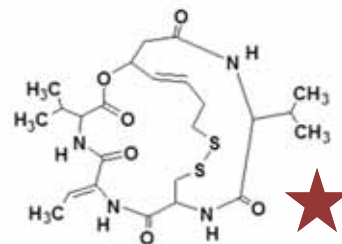
Templamide B (2)



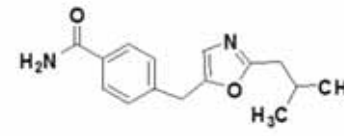
Templazole A



FR901465 (3)



FR901228 (4)



Templazole B

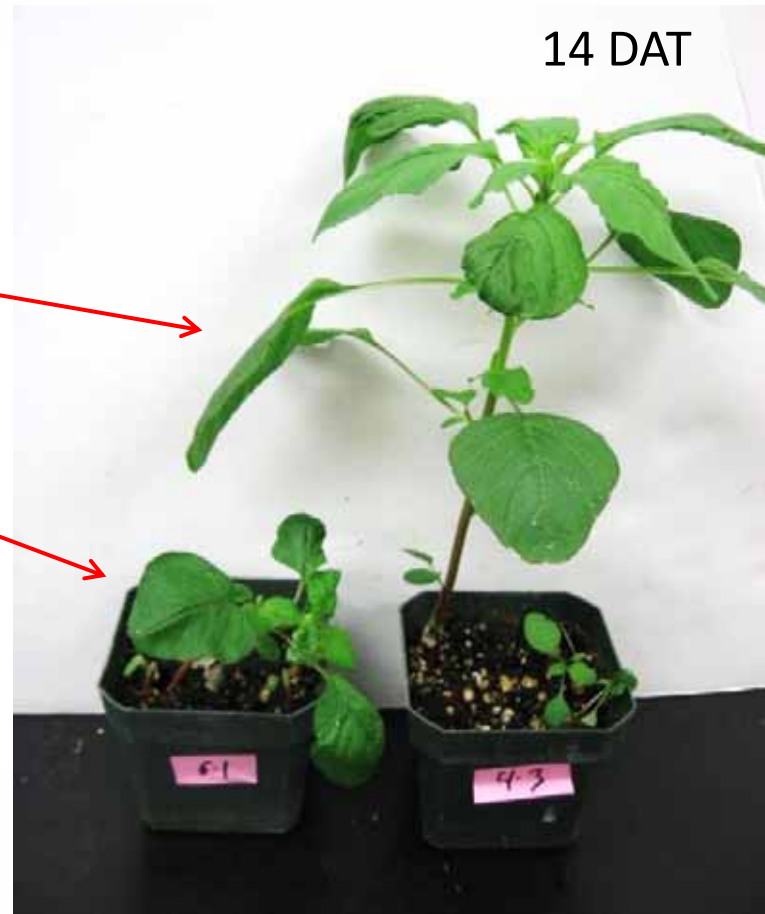
★
Show GS
inhibition

MBI-010 Systemicity (Pigweed) – Xylem Mobility

Treating **one** petiole/plant kills leaf quickly and subsequently stunts entire plant



Water

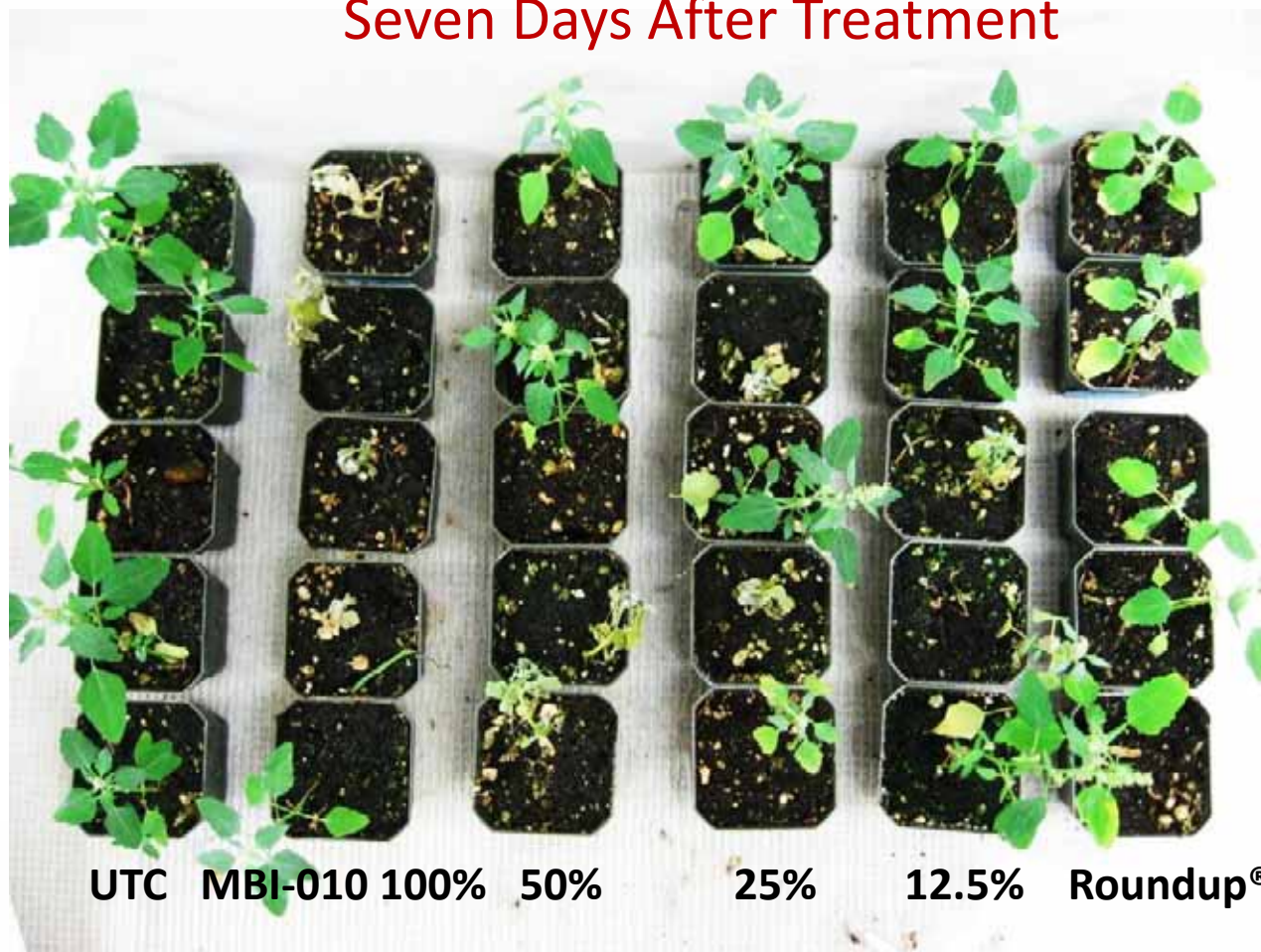


MBI-010 is xylem-mobile

MBI-010 Root Efficacy

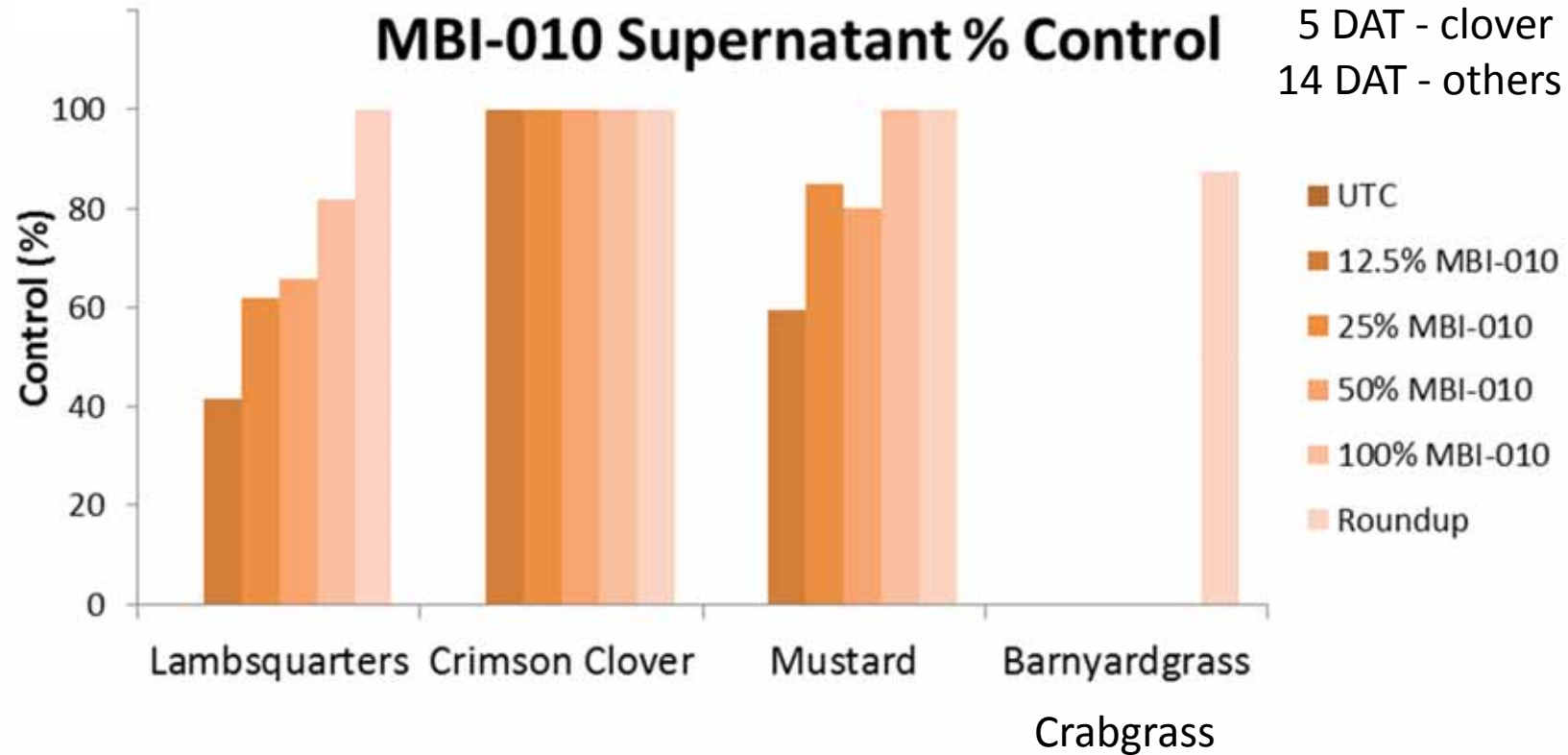


Seven Days After Treatment



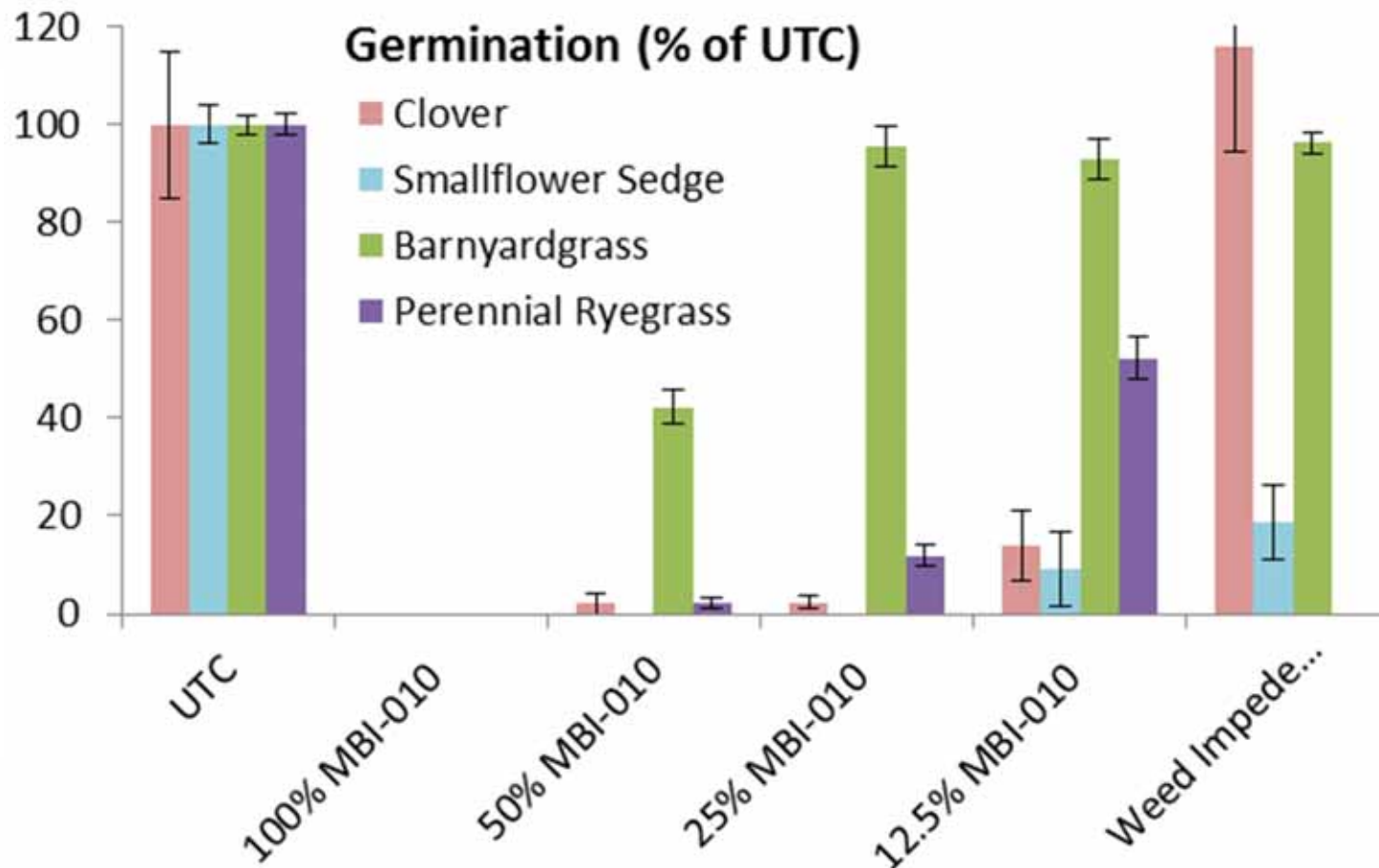
MBI-010 is rapidly taken up by the roots into the xylem

MBI-010 Efficacy after Soil Application



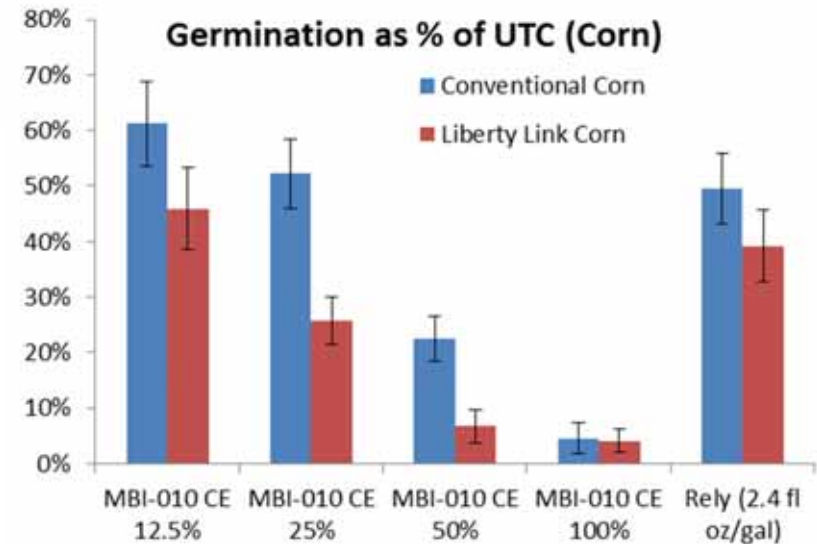
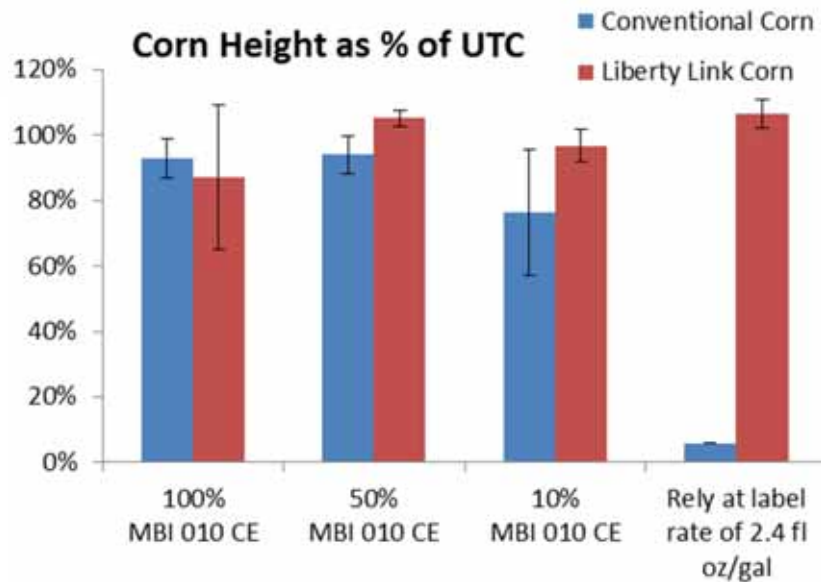
More active on broadleaves than grasses when soil applied

MBI-010 Dose-dependent Pre-Emergence Efficacy

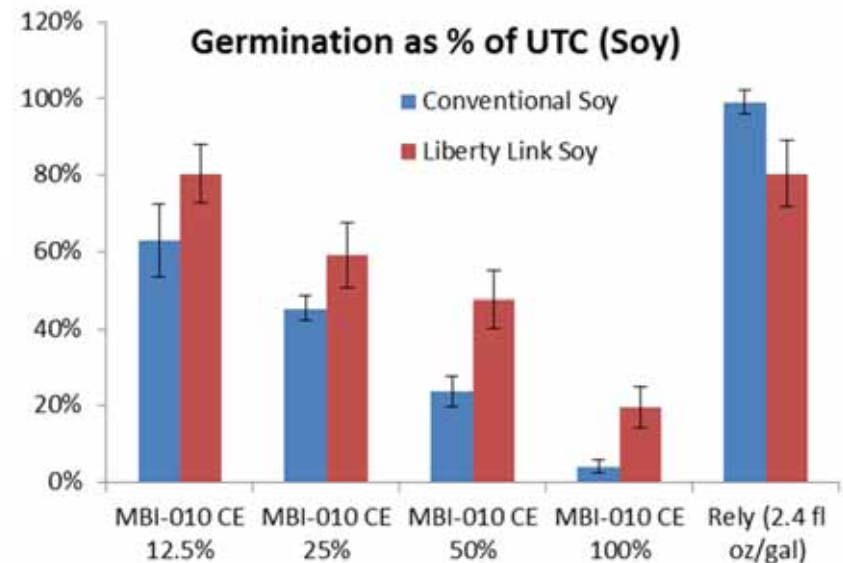


MBI-010 is more active on broadleaves than grasses, but 1X dose kills all species

MBI-010 Efficacy on Liberty Link Seeds



- Poor control of corn POST
- Little PRE differentiation between LL and conventional seed
- MBI 010 compounds are non-Phosphinothricin novel GS inhibitors



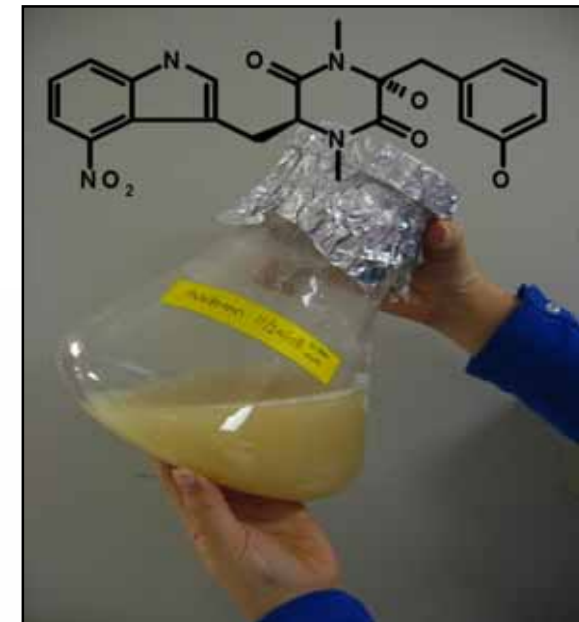
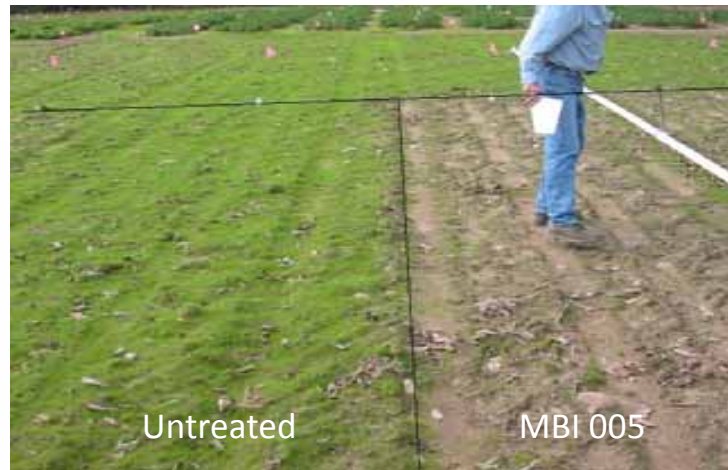


MBI-005 Opportune™

Opportune™ Bioherbicide (MBI-005)



- Thaxtomin compound produced by *Streptomyces* sp.
- Works by disrupting cellulose biosynthesis
- Selective control of broadleaves and sedges post-emergence;
Good safety to turf, wheat, corn, rice
- Potent broad spectrum pre-emergence activity
- Shows synergistic activity with several chemical herbicide chemistries
- May 2012 EPA approval; Targeted launch late 2013



MBI-005 Shows Good Pre-Emergent Activity



Common name	Scientific name	Efficacy Rating at 0.1 mg/ml
Crabgrass	<i>Digitaria sanguinalis</i>	++++
Bluegrass	<i>Poa annua</i>	+++
Perennial Ryegrass	<i>Lolium perenne</i>	++
Ragweed	<i>Ambrosia artemisifolia</i>	++++
Plantain	<i>Plantago lanceolata</i>	++++
Mustard	<i>Brassica kaber</i>	++++
Lambsquarters	<i>Chenopodium album</i>	+++

Active at 1/10
the dose of
post-emergence

rating	symbol	% Germination
Poor	+	41-100
Fair	++	16-40
Good	+++	6-15
Very Good	++++	0-5

MBI-005 Has Selective Post-Emergent Activity

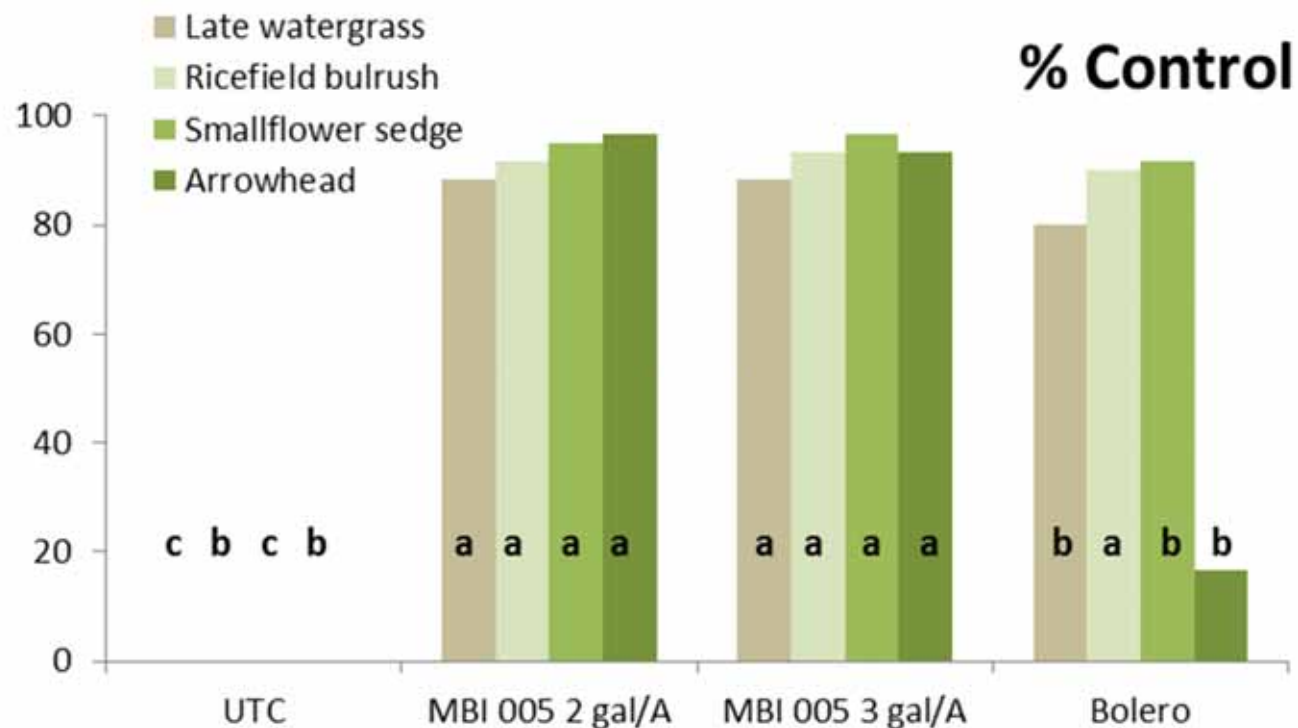


Common name	Scientific name	Rating at 1 mg/ml
Late watergrass	<i>Echinochloa phyllopogon</i>	+++
Smallflower	<i>Cyperus difformis</i>	++++
Bulrush	<i>Scirpus mucronatus</i>	++++
Yellow Nutsedge	<i>Cyperus esculentus</i>	+
Redstem filaree	<i>Erodium cicutarium</i>	++
Mustard	<i>Brassica kaber</i>	++++
Pigweed	<i>Amaranthus retroflexus</i>	++++
Lambsquarters	<i>Chenopodium album</i>	+++
Arrowhead	<i>Sagittaria montevidensis</i>	++++
Velvetleaf	<i>Abutilon theophrasti</i>	++
Shepherd's Purse	<i>Capsella bursa-pastoris</i>	++++
Hairy Galinsoga	<i>Galinsoga ciliata</i>	+++
Nightshade	<i>Solanum ptychanthum</i>	++
Oxalis	<i>Oxalis pes-caprae</i>	++++
Clover	<i>Trifolium hirtum</i>	++
Dandelion	<i>Taraxacum officinale</i>	++
Plantain	<i>Plantago lanceolata</i>	+

rating	symbol	POST % control
Poor	+	0-50
Fair	++	51-80
Good	+++	81-90
Very Good	++++	91-100

Wide spectrum activity on sedges and broadleaves

MBI-005 Rice Trial in 2012 Post-emergence Application



Application Timing

MBI 005: Split between 3 lf rice & 2 tiller rice stages (Silwet adjuvant)

Bolero: 2 lf rice stage

*Trial Run by Helena Chemical

MBI-005 Turf Trial - Chico, California (2011)

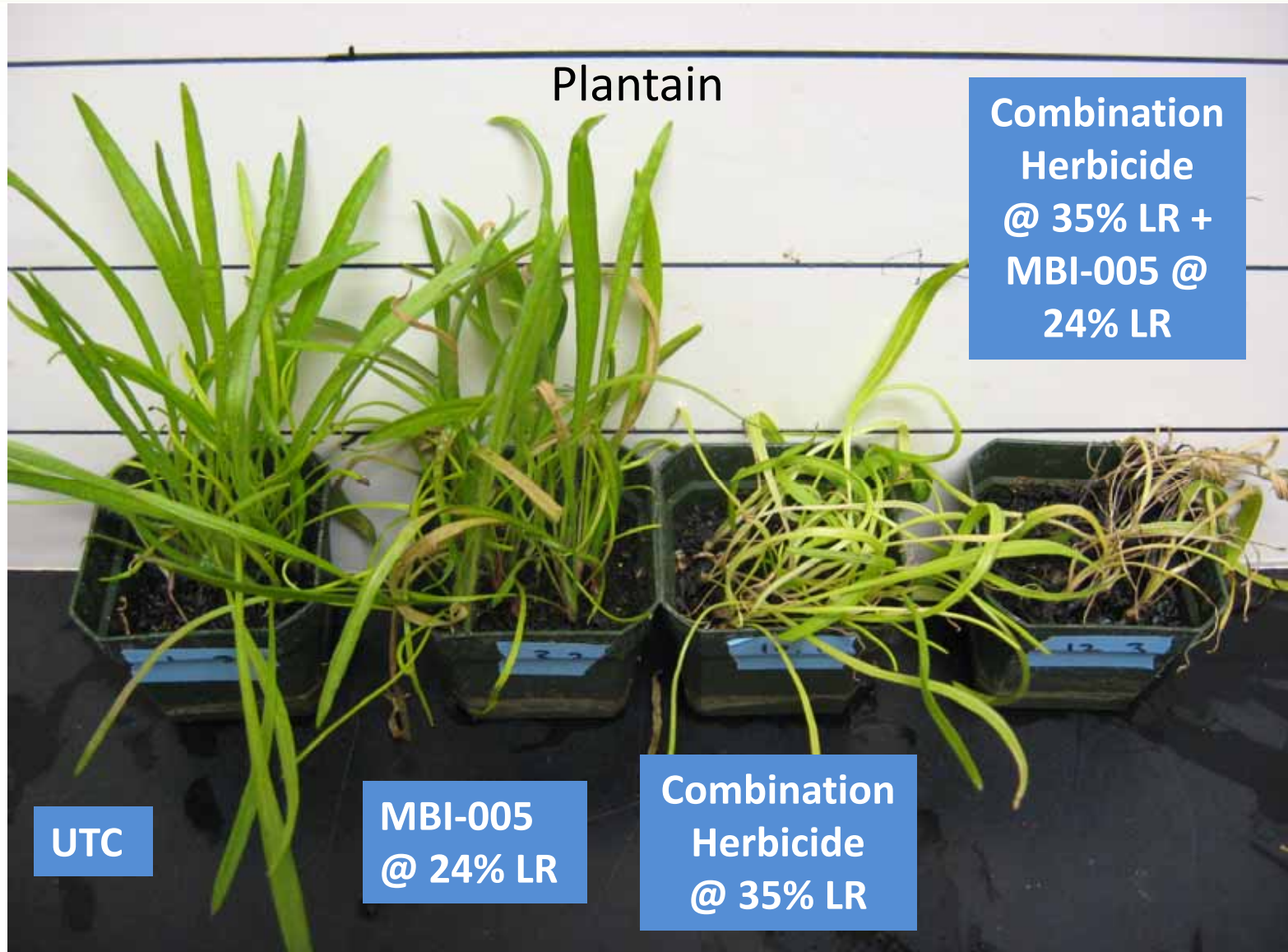


Treatment	Stunting to turf	Rose Clover % control	Oxalis % Control
UTC	0 a	0 c	0 c
MBI-005 (6oz/1000ft ²)	0 a	45 b	100 b
MBI-005 (12oz/1000ft ²)	0 a	50 b	100 b
Battle Ship (2,4-D) (4pt/a)	0 a	62.5 a	100 b
Speed Zone (2,4-D) (6pt/a)	0 a	67.5 a	100 b

All treatments were applied twice

Four replications per treatment

Combination Herbicide with MCPP+dicamba+2,4-D



Plantain

Combination
Herbicide
@ 35% LR +
MBI-005 @
24% LR

UTC

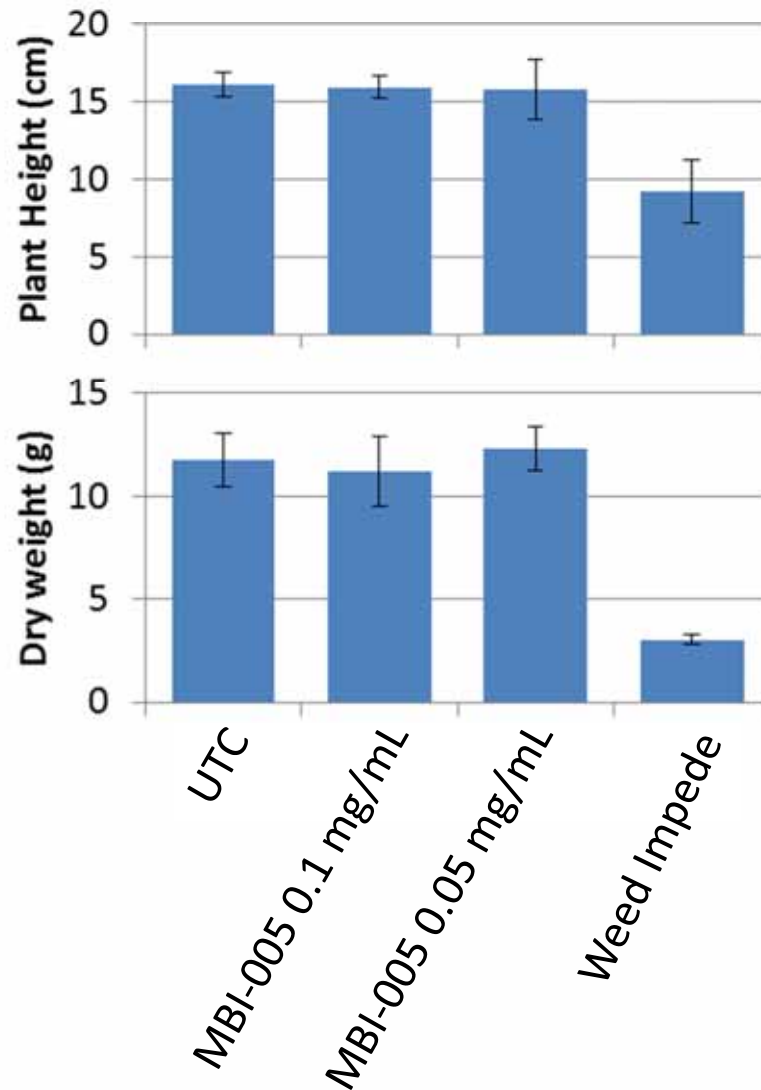
MBI-005
@ 24% LR

Combination
Herbicide
@ 35% LR

MBI-005 Residual Effects in Field Soil



Corn (seed planted 7 DAT)



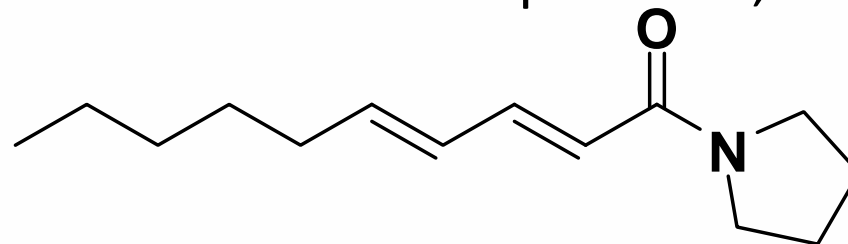
No adverse effect of MBI-005 at pre-emergent rates

MBI-011 Sarmentine Herbicide

New Herbicide Discovery (MBI-011)



- Single pyrrolidine compound isolated from a Chinese pepper plant; can be made synthetically
- Used in Chinese medicine and as an anti-oxidant and solubilizer of hydrophobic compounds in cosmetics
- At >5 mg/mL has good activity against most grass and many broadleaf weeds
- Burndown activity (works well in field trials); Formulation is critical for activity
- MBI filed a patent application for use of the active compound to control weeds
- EPA classified it as a biochemical biopesticide; EPA submission in late 2012



Control of Different Plant Species When Treated With 5.0 mg/mL Sarmentine

Plant name	Control	Plant name	Control
Pigweed (<i>Amaranthus retroflexus</i> , L.)	80-100%	Lambsquarters (<i>Chenopodium album</i> L.)	80-100%
Barnyard grass (<i>Echinochloa crus-galli</i> L.)	80-100%	Bluegrass (<i>Poa annua</i> L.)	80-100%
Bindweed (<i>Convolvulus arvensis</i> , L.)	80-100%	Wild mustard (<i>Brassica kaber</i> L.)	80-100%
Crabgrass (<i>Digitaria sanguinalis</i> L.)	80-100%	Black nightshade (<i>Solanum nigrum</i> L.)	80-100%
Horse weed (<i>Conyza Canadensis</i> L.)	< 20%	Curly dock (<i>Rumex crispus</i> L.)	80-100%
Sedge (<i>Cyperus difformis</i> L.)	20-40%	Sweet corn (<i>Zea mays</i> S.)	80-100%
Sprangletop (<i>Leptochloa fascicularis</i> Lam.)	80-100%	Wheat (PR 1404) (<i>Triticum aestivum</i> L.)	80-100%
Dandelion (<i>Taraxacum officinale</i> F.)	80-100%	Rice (M 104) (<i>Oryza saliva</i> L.)	0%

Velvetleaf – 7DAT : Plant Bioassay Results for Various Experimental Formulations



UTC



F2 (20 mg/mL) – 91.7% control



F4 (20 mg/mL) – 95.8% control



F3 (20 mg/mL) – 100% control



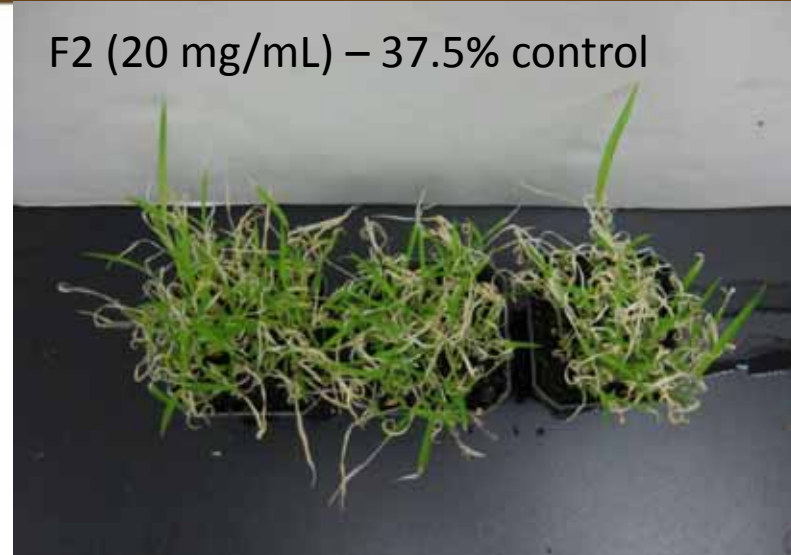
Crabgrass – 7DAT: Plant Bioassay Results for Various Experimental Formulations



UTC



F2 (20 mg/mL) – 37.5% control



F4 (20 mg/mL) – 100% control



F3 (20 mg/mL) – 95.3% control



MBI-011 is Synergistic with MBI-005



Barnyardgrass, 7 DAT

Description	Observed Control	SE	Expected Control	Obs/Exp
Untreated Control	0.0	0.0		
60% 011	3.3	1.7		
50% 005	5.0	0.0		
62.5% 005	5.0	0.0		
60% 011 + 50% 005	20.0	5.0	5.0	4.0
60% 011 + 62.5% 005	10.0	0.0	5.0	2.0

Good synergy with MBI-005

Sedge, 7 DAT

Description	Observed Control	SE	Expected Control	Obs/Exp
Untreated Control	0.0	0.0		
45% 011	0.0	0.0		
2% 005	3.3	1.7		
3% 005	3.3	1.7		
45% 011 + 2% 005	18.3	6.7	3.3	5.5
45% 011 + 3% 005	18.3	6.7	3.3	5.5

Values over 1 indicate synergy

THANK YOU TO THE MARRONE BIO INNOVATIONS R&D TEAM

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