Taegro: Development of a new biofungicide for North America

Hugh Frost

Novozymes BioAg

27/10/2011

Taegro: contents

Active ingredient:

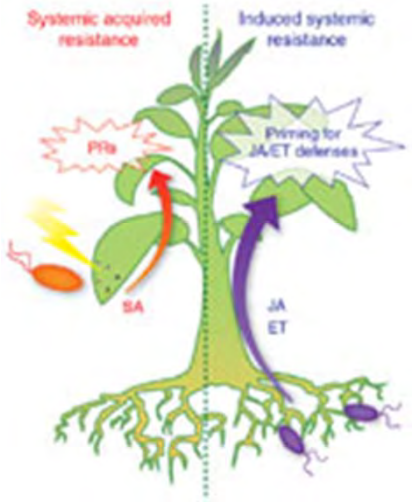
Bacillus subtilis var. *amyloliquefaciens* - strain FZB24 (13%)

5.0×10^{10} Colony Forming Units [CFU]/g

Biocontrol: Taegro - mode of action

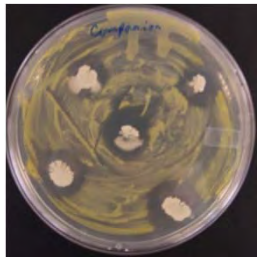
More than 8.5 % of its genetic capacity is dedicated to the production of secondary metabolites (peptides, lipopeptides, polyketides and siderophores) through pathways that do not involve ribosomes. The genome contains nine giant gene clusters directing the synthesis of **Lipopeptides** (Surfactin, Iturins, Fengycin, Bacillibactin, Bacilysin) and **Polyketides** (Bacillene, Difficidin, Macrolactin). These compounds are known to suppress bacteria and fungi within the plant rhizosphere.

Induction of Plant Resistance:
The bacteria can trigger a signal that can be translocated within the plant, also known as the ISR/SAR pathways.

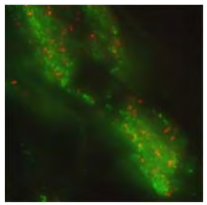


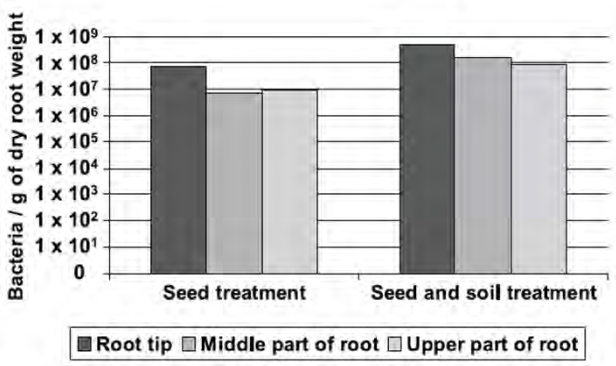
Antibiosis through production of:

1. Surfactin
2. Macrolactin
3. Difficidin
4. Bacillene
5. Bacillomycin D
6. Fengycins
7. Bacillibactin



Competition for colonization of roots:





Re-isolation of Taegro FZB24® from pea roots as a function of the re-isolation location and the application technique.

TAEGRO: laboratory studies

- The product is very stable for over 10 months at room temperature and at 45ºC. It maintains 10^{10} cfu/g of the formulation.

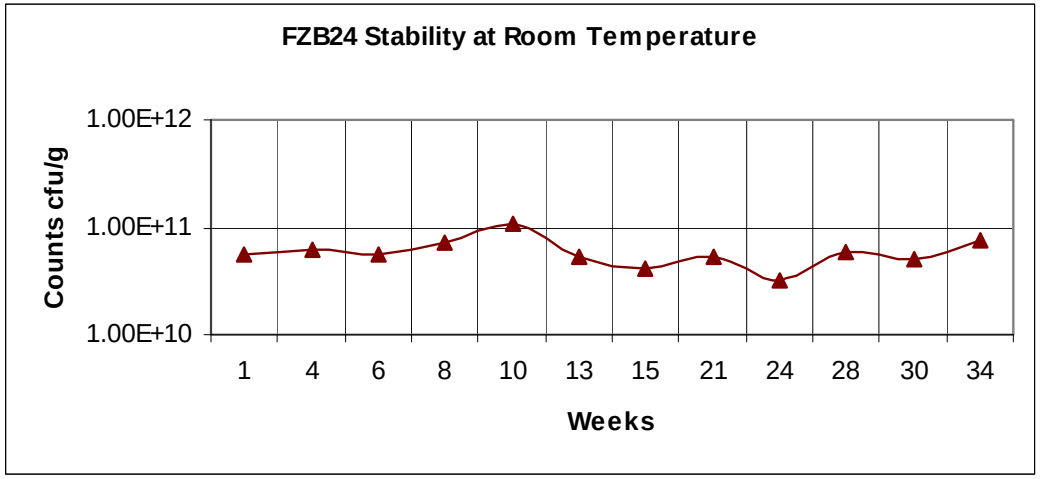
- In bioefficacy assays, Taegro has shown a broad-spectrum of activity towards fungal and bacterial plant pathogens.

Stability of TAEGRO

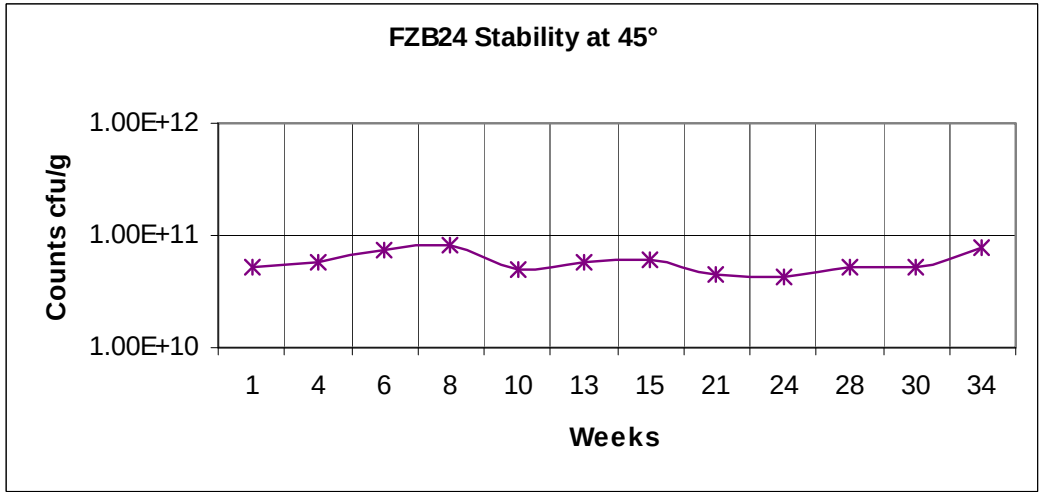
after 34 weeks

Stable at four different temperatures:

4°, 25°, 35° and 45 °C



After 34 weeks, the bacterium still maintains 5.0×10^{10} cfu/g



Crops Tested

- Celery
- Cucumber
- Grape
- Lettuce
- Pepper
- Spinach
- Strawberry
- Tomato

Selected based on high value crops

Taegro: field trials

US trials conducted 2007 – 2010: 156

2011: 91

Use Patterns:

- Rates
  - 2.6 – 5.2 oz per acre
  - 180 – 360 g/ha
- Application Interval
  - 7-28 days (soil-borne diseases)
  - 7-14 days (foliar diseases)
- Application Number
  - 1-12 per season

Tomato: Bacterial wilt and bacterial spot diseases

Southern bacterial wilt (*Ralstonia solanacearum* formerly *Pseudomonas*) moves systemically through the xylem, present here on southern transplants.

[Photo courtesy of T.A. Zitter, Cornell University, Ithaca, NY]

TAEGRO: suppression of bacterial wilt of tomato (Laboratory & Greenhouse)

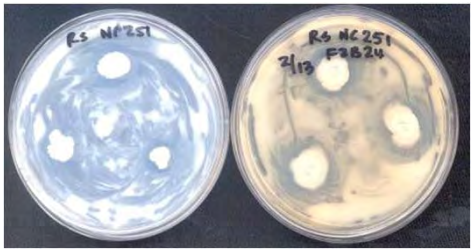


Plate assays that show inhibition of *Ralstonia solanacearum*

strains AW1, NC251 were supplied by Dr. Tim Denny, Univ. of Georgia

Biological suppression of bacterial wilt of tomato-Greenhouse assays.

When seedlings of tomato (cv. Early Girl) were raised from seeds planted in potting mix containing 10^8 cfu/g of *Ralstonia solanacearum* strain NC251 (supplied by Dr Tim Denny, Univ. of Georgia) 12 of 16 seedlings wilted in 2-3 weeks time.

In NC251-inoculated and TAEGRO-amended (@0.02g/gallon pot/33g/cubic yard) pots, only one of 16 seedlings wilted in 2-3 weeks. Thus TAEGO afforded substantial levels (>90%) of wilt control.

Bacterial Diseases

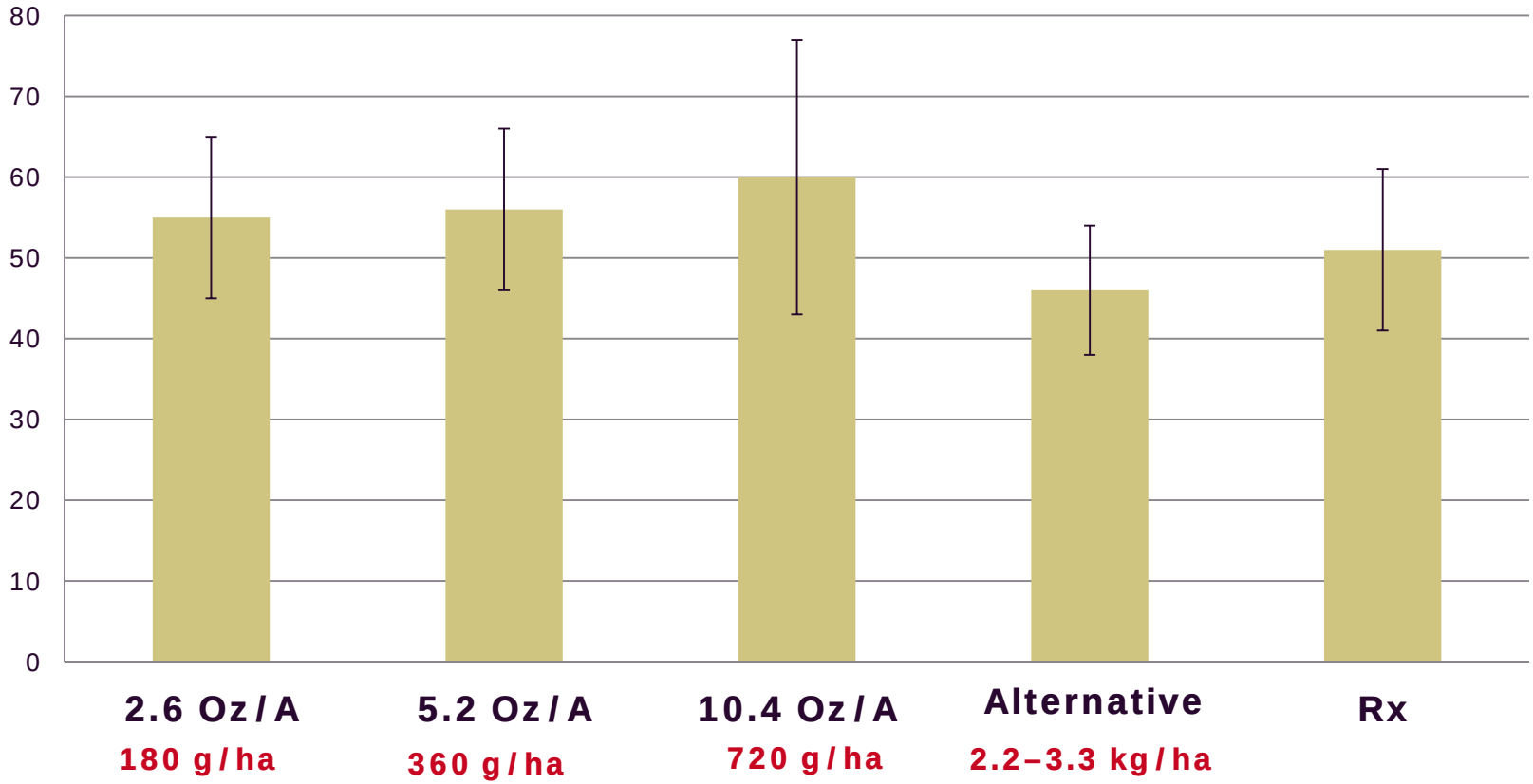
novozymes
Rethink Tomorrow

Crop	Disease	State	Rx	180 g/ha 2.6 Oz/A	270 g/ha 3.9 Oz/A	360 g/ha 5.2 Oz/A	720 g/ha 10.4 Oz/A	2.2 – 3.3 kg/ha Alternative	Rx
Pepper	Bac. Speck	CA	Kocide	64		90	84	74	90
Tomato	Bac. Speck	CA	Kocide	87		87	93	48	91
Tomato	Bac. Speck	CA	Kocide	93				76	21
Tomato	Bac. Speck	CA	Kocide	63	89				58
Tomato	Bac. Speck	CA	Kocide	25		25	27	22	31
Tomato	Bac. Speck	CA	Kocide	17		29	35	26	21
Tomato	Bac. Speck	CA	Mancozeb	34	27	49		43	54
Tomato	Bac. Speck	CA	Kocide	56	43	56		31	41
			(averages)	55	53	56	60	46	51

Bacterial Diseases

novozymes
Rethink Tomorrow

Tomato / Bacterial Speck (Pseudomonas)



Phythophthora

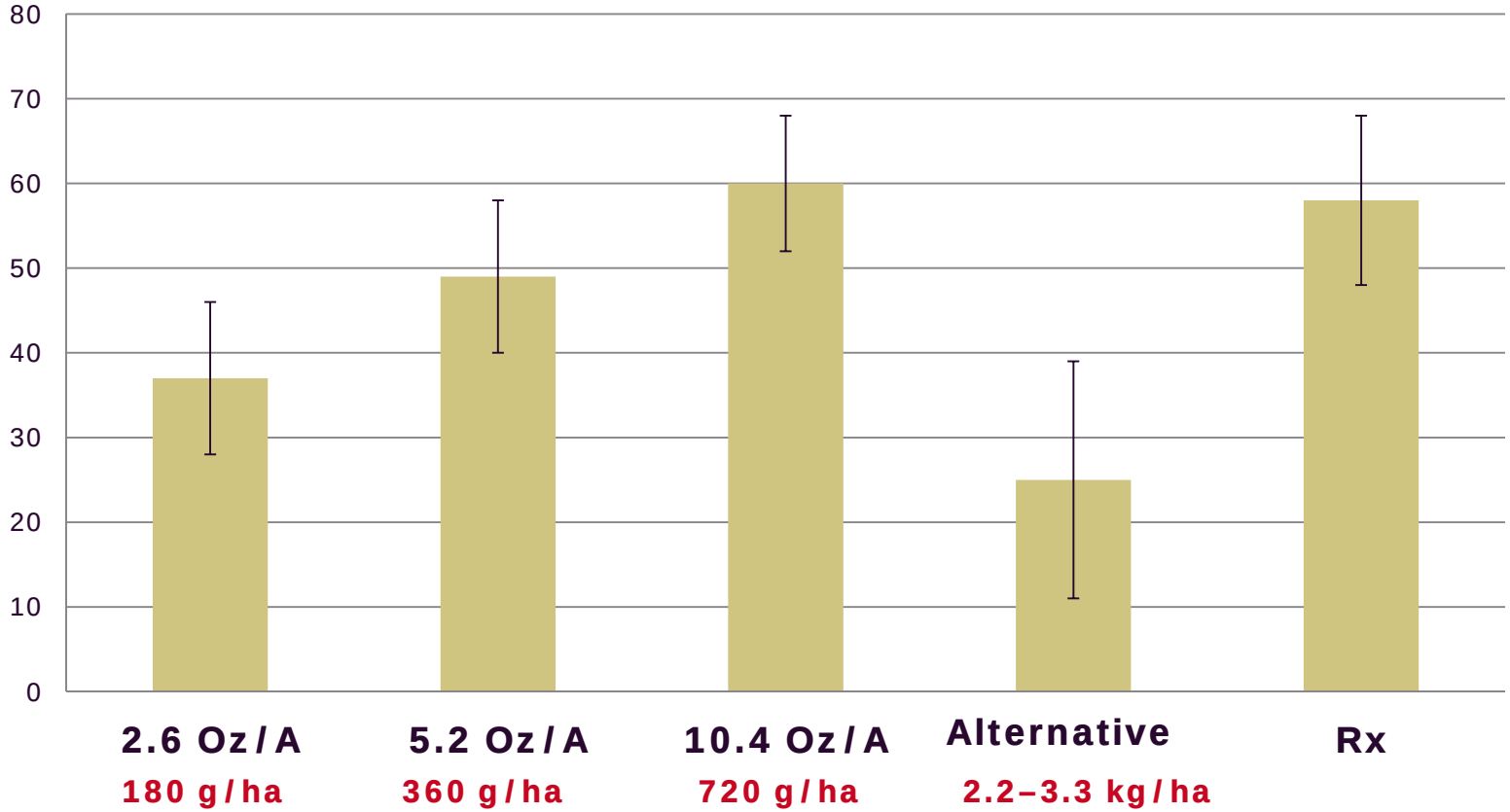
novozymes
Rethink Tomorrow

Crop	Disease	State	Rx	180 g/ha 2.6 Oz/A	360 g/ha 5.2 Oz/A	720 g/ha 10.4 Oz/A	2.2 – 3.3 kg/ha Alternative	Rx
Tomato	Phythophthora	CA	Ridomil	0	84	79	0	90
Tomato	Phythophthora	CA	Ridomil	77	74		77	82
Pepper	Phythophthora	CA	Fosphite	63	20		0	27
Pepper	Phythophthora	CA	Ridomil	29	57	53	50	84
Tomato	Phythophthora	CA	Ridomil	18	56			12
Pepper	Phythophthora	CA	Ridomil	44	44			58
Pepper	Phythophthora	CA	Ridomil	38	38			58
Tomato	Phythophthora	CA	Fosphite	29	16	49	0	52
			(averages)	37	49	60		58

Phythophthora

novozymes
Rethink Tomorrow

Fruiting Vegetable / Phythophthora



Tomato

Crop Group 4

Efficacy Overview

novozymes
Rethink Tomorrow

Chemical Equivalent	Pseudomonas				
Solid Efficacy	Soil Phythophthora	Rhizoctonia	Fusarium		
Some Positive Indications	Ralstonia	Pythium	Verticillium	Blights	Powdery Mildew
Some Negative Indications	Verticillium	Blights	Botrytis		

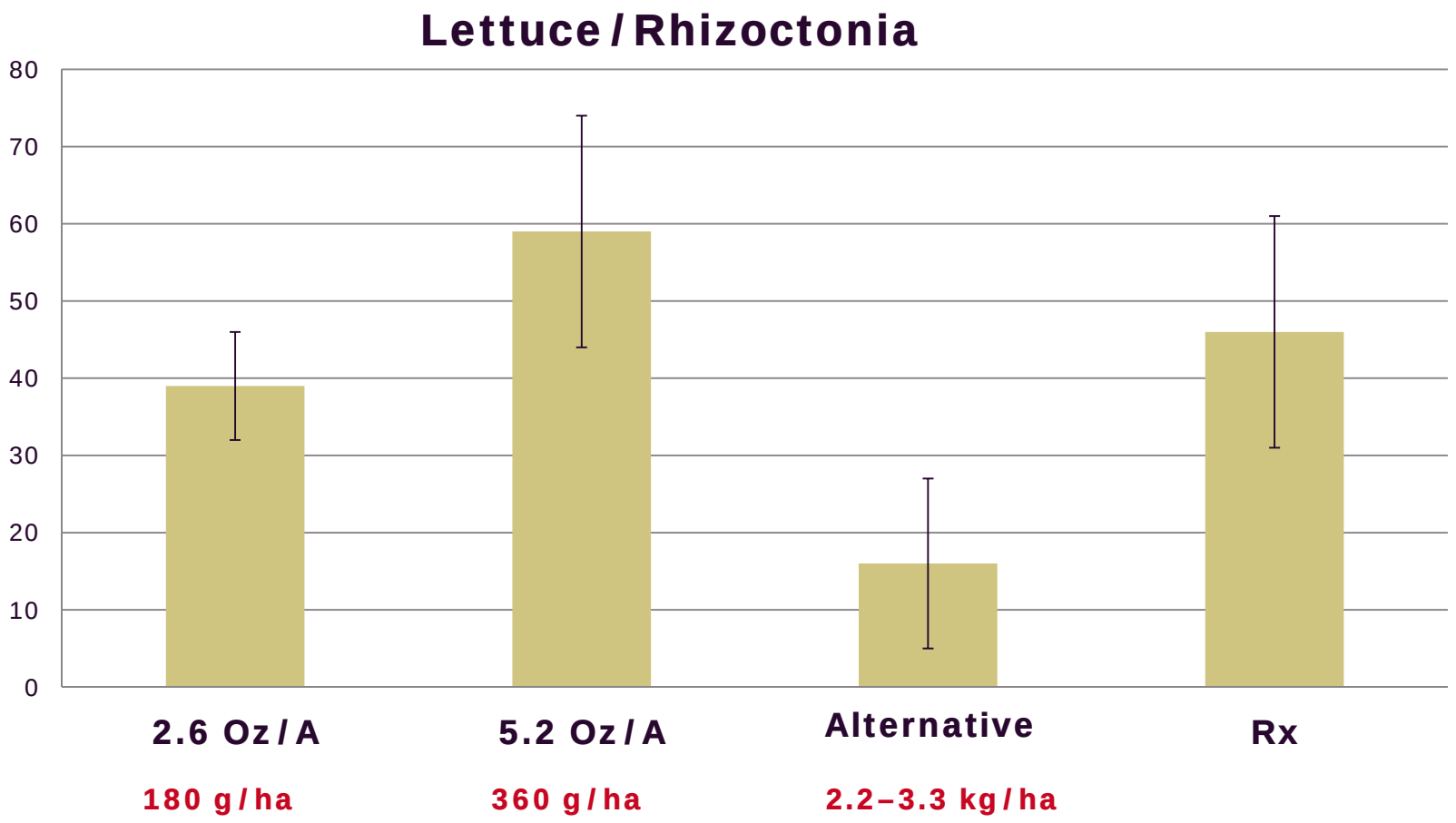
Rhizoctonia
- 'Bottom Rot'

novozymes
Rethink Tomorrow

Crop	Disease	State	Rx	180 g/ha 2.6 Oz/A	270 g/ha 3.9 Oz/A	360 g/ha 5.2 Oz/A	2.2 – 3.3 kg/ha Alternative	Rx
Lettuce	Rhizoctonia	CA	Rovral	50		83		67
Lettuce	Rhizoctonia	CA	Rovral	42		78	8	30
Lettuce	Rhizoctonia	CA	Rovral	42	51	45	24	70
Lettuce	Rhizoctonia	CA	Botran	21		30		18
			(average)	39	51	59		46

Rhizoctonia
- 'Bottom Rot'

novozymes
Rethink Tomorrow



Downey Mildew

novozymes
Rethink Tomorrow

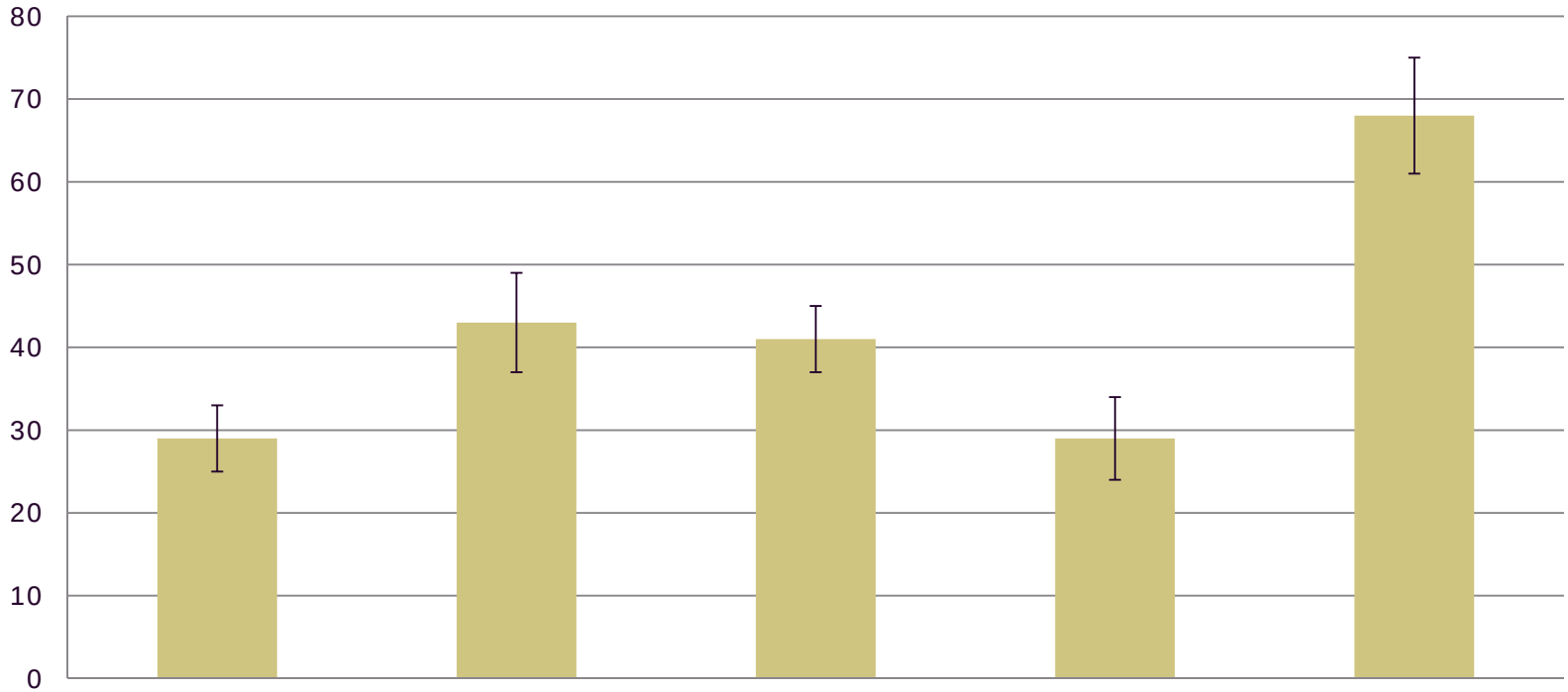
g/ha:	180	270	360	720	2.2 –3.3 kg/ha

Crop	Disease	State	Rx	2.6 Oz/A	3.9 Oz/A	5.2 Oz/A	10.4 Oz/A	Alternative	Rx
Lettuce	Downey	CA	Maneb	33		79			92
Lettuce	Downey	CA	Maneb	65	67	75		55	93
Lettuce	Downey	AZ	Reason	30		53		48	96
Lettuce	Downey	CA	Reason	43	51				65
Lettuce	Downey	CA	Fosphite	24		48			92
Lettuce	Downey	CA	Reason	36	35				65
Lettuce	Downey	CA	Maneb	17	23	41		0	63
Lettuce	Downey	CA	Maneb	33		41	49	24	69
Lettuce	Downey	CA	Maneb	27		29	46	16	59
Lettuce	Downey	CA	Fosphite	28		28	35	40	88
Lettuce	Downey	CA	Maneb	23		20	35	17	16
Lettuce	Downey	CA	Rovral	6		13			23
Lettuce	Downey	CA	Maneb	19				32	66
			(averages)	30	44	43	41		68

Downey Mildew

novozymes
Rethink Tomorrow

Lettuce / Downey



180 g/ha **360 g/ha** **720 g/ha** **2.2–3.3 kg/ha**

Efficacy Overview

novozymes
Rethink Tomorrow

- Chemical Equivalent
- Solid Efficacy
  - Downey Mildew
  - Rhizoctonia
- Some Positive Indications
  - Sclerotinia
  - Pythium
  - Verticillium
- Some Negative Indications

Strawberry

Botrytis

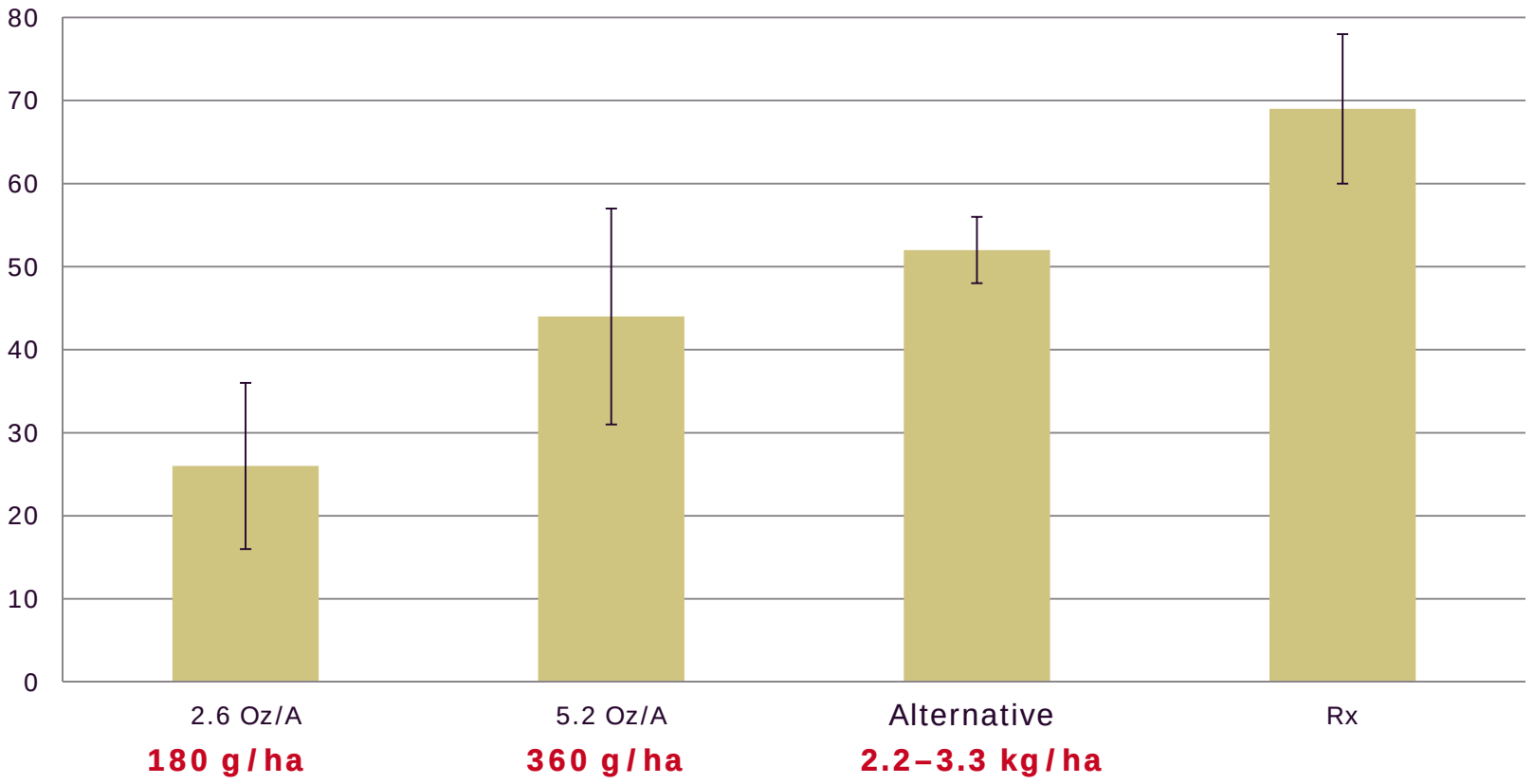
novozymes
Rethink Tomorrow

Crop	Disease	State	Rx	180 g/ha 2.6 Oz/A	270 g/ha 3.9 Oz/A	360 g/ha 5.2 Oz/A	720 g/ha 10.4 Oz/A	2.2 – 3.3 kg/ha Alternative	Rx
Grape	Botrytis	CA	Pristine	21	37	59		60	61
Grape	Botrytis	CA	Pristine	19	39	60		59	63
Strawberry	Botrytis	CA	Pristine	0		0			46
Strawberry	Botrytis	OR	Pristine	33		43		47	91
Strawberry	Botrytis	OR	Pristine	57	52	58		42	83
			(averages)	26	43	44		52	69

Botrytis

novozymes
Rethink Tomorrow

Berry / Botrytis



Strawberry
Grape

Efficacy Overview

novozymes
Rethink Tomorrow

- Chemical Equivalent
- Solid Efficacy
- Some Positive Indications
  - Botrytis
  - Powdery Mildew
- Some Negative Indications
  - Powdery Mildew

Others Crops

Other Soil Diseases

novozymes
Rethink Tomorrow

Crop	Disease	State	Rx	180 g/ha 2.6 Oz/A	270 g/ha 3.9 Oz/A	360 g/ha 5.2 Oz/A	2.2 – 3.3 kg/ha Alternative	Rx
Cantelope	Pythium	CA	Fosphite	76		88	72	64
Cucumber	Pythium	CA	Fosphite	50				40
Bean-Snap	Pythium	CA	Fosphite	43				51
Melon	Pythium	CA	Fosphite	26				39
Lettuce	Damping Off	CA	Rovral	85				57
Bean - Dry	Damping Off	CA	Apron	64				55
Beans - Dry	Damping Off	CA	Ridomil	55				45
Cucumber	Rhizoctonia	AL	Ridomil				74	46
Cucumber	Rhizoctonia	CA	Triology (Neem)	32		66	51	31
Beans - Dry	Rhizoctonia	CO	Maxim	49	62			92
			(averages)	53	62	77	66	52

Others Crops

Other Foliar Diseases

novozymes
Rethink Tomorrow

Crop	Disease	State	Rx	180 g/ha 2.6 Oz/A	270 g/ha 3.9 Oz/A	360 g/ha 5.2 Oz/A	2.2 – 3.3 kg/ha Alternative	Rx
Pepper	Powdery	AZ	Bravo	74		75		95
Summer Squash	Powdery	CA	Rally	20	60	64	39	39
Summer Squash	Powdery	CA	Pristine	51	45	62	44	95
Melon	Powdery	AZ	Bravo	15		58		54
Summer Squash	Pseudomonas	CA	Kocide	41	47	40	9	82
Pumpkin	Anthracnose	CA	Quadris	32	58	35	21	38
Bean-Dry	Sclerotinia	OR	Endura			0		74
Bean-Snap	Sclerotinia	OR	Endura			0		78

Cucurbits

Efficacy Overview

novozymes
Rethink Tomorrow

- **Chemical Equivalent**
- **Solid Efficacy**
  - Powdery Mildew
  - Rhizoctonia
- **Some Positive Indications**
  - Rhizoctonia
  - Pythium
  - Pseudomonas
  - Anthracnose
- **Some Negative Indications**

Path forward

- Yield data in many trials
- Efficacy at different pressures
- Soil characteristics
- Varietal and type differences
- Link trial performance to relevant parameters
- IPM strategy

Thank you

Hugh Frost
EU Agronomy
Novozymes BioAg.

25th October 2011