

*Bacillus subtilis*, Strain QST 713  
Use in Integrated Pest Management

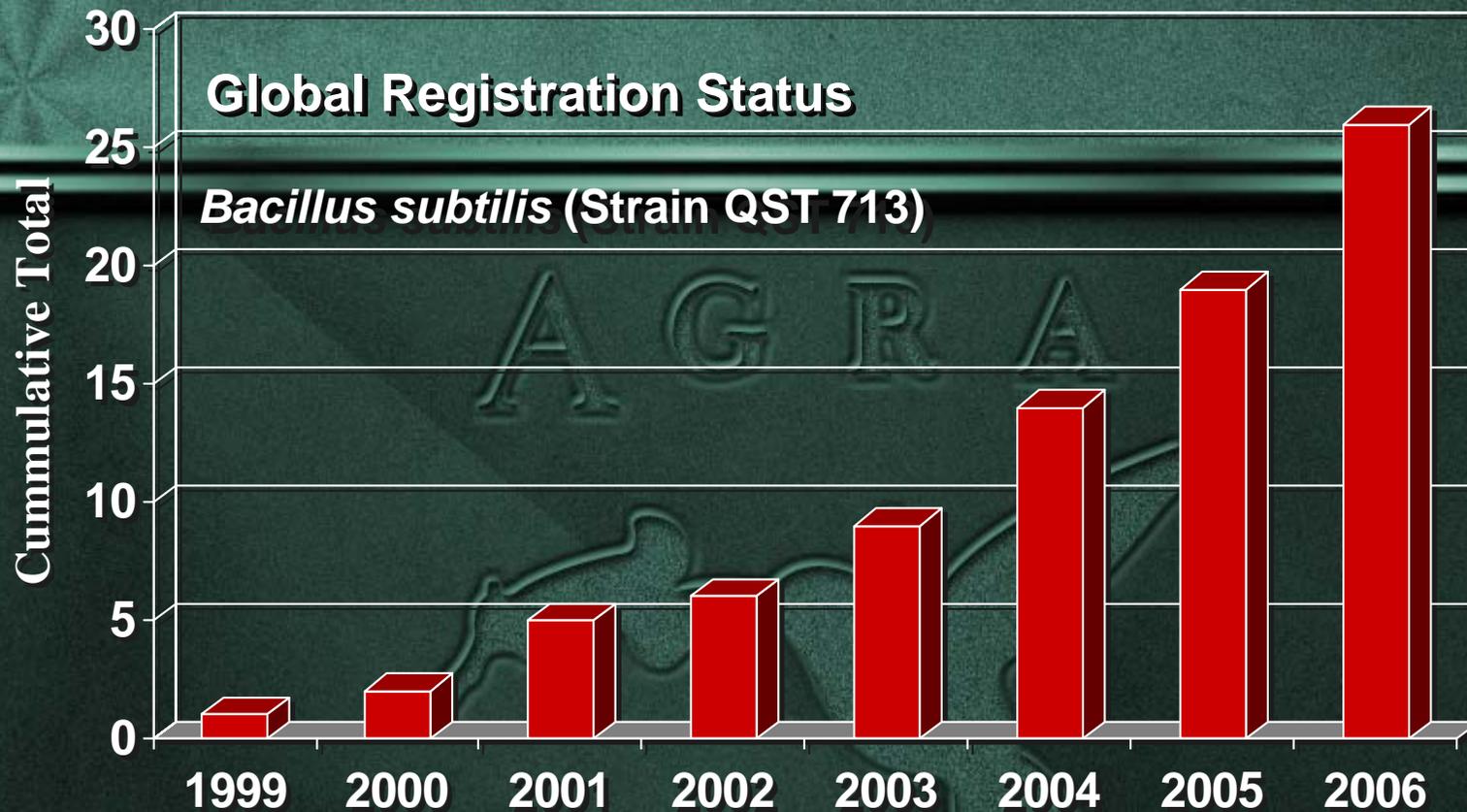
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# *Bacillus subtilis*, Strain QST 713

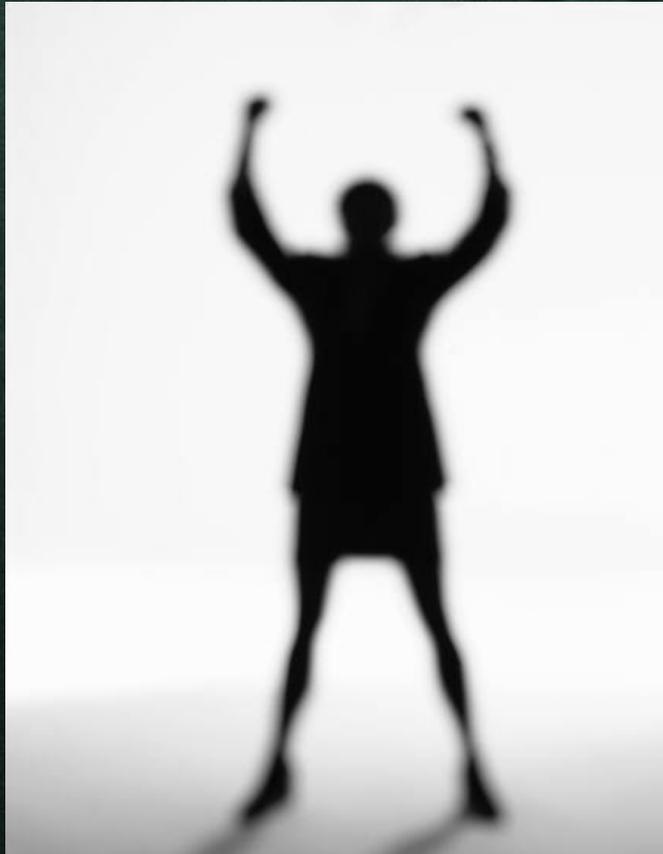
- **Isolated from Soil – CA Organic Peach Orchard**  
**Rod-shaped, Gram Positive, Aerobic, Motile Bacterium**  
**Naturally Occurring, No Genetic Modifications**  
**Unique – Patented *Bacillus* Strain**  
**Distinguished by Previously Unknown Metabolites**
- **US - EPA Registration – July 2000**  
**First “Effective” Broad Spectrum Bio-fungicide**  
**Presidential Green Chemistry Award – 2003**  
**World Technology Award for Environment - 2004**
- **Now Registered Globally – Trade Name Serenade®**



<i>Chile</i>	<i>U.S.</i>	<i>Mexico</i> <i>N.Z.</i> <i>P.Rico</i>	<i>C.Rica</i>	<i>Japan</i> <i>Israel</i> <i>Philip.</i>	<i>Guat.</i> <i>Hond.</i> <i>Switz.</i> <i>Turkey</i> <i>Argen.</i>	<b>France</b> <b>Italy</b> <b>Korea</b> <b>Ecuador</b> Columbia	Germany Spain Greece Australia Canada Peru Thailand China UK
<b>Bold = Currently registered</b>							

# *Bacillus subtilis*, Strain QST 713

## Registration Milestone



### EU Annex 1 Inclusion

*Bacillus subtilis* strain QST 713, the active ingredient of biofungicide product Serenade® was voted for inclusion into Annex 1 of Directive 91/414/EEC at the EU Standing Committee on the Food Chain and Animal Health meeting on July 14, 2006.



# *Bacillus subtilis*, Strain QST 713

## Major Global Crops / Diseases

- Grapes
  - Gray Mold (*Botrytis cinerea*)
  - Powdery mildew (*Uncinula necator*)
- Bananas
  - Black Sigatoka (*Mycosphaerella fijiensis*)
  - Yellow Sigatoka (*Mycosphaerella musicola*)
- Tomato / Pepper
  - Bacterial Leaf Spot (*Xanthomonas spp.*)
  - Early Blight (*Alternaria solani*)
  - P.Mildew (*Leveillula taurica*)
- Cucurbits
  - P.Mildew (*Erysiphe / Sphaerotheca spp.*)
- Lettuce
  - Leaf Drop (*Sclerotinia spp.*)
- Pome Fruit
  - Fire Blight (*Erwinia amylovora*)
  - Scab (*Venturia inaequalis*)
- Mango
  - Anthracnose (*Colletotrichum gloeosporioides*)
- Beans
  - White Mold (*Sclerotinia sclerotiorum*)

# *Bacillus subtilis*, Strain QST 713

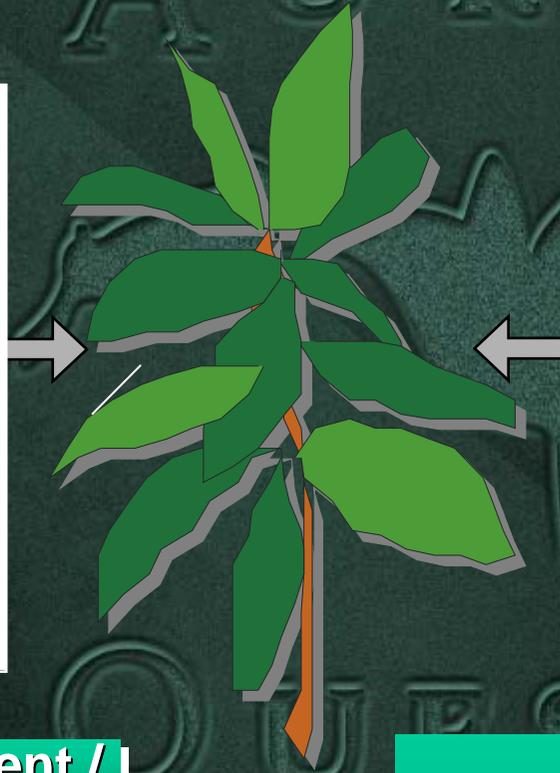
- **Formulations: (AS) Aqueous Suspension (WP) Wettable Powder**
- **Active Ingredients Spec. = Minimum  $1 \times 10^9$  cfu / gram**
- **Organic Formulations (OMRI, IMO, BCS, JAS)**
- **> Two Year Storage Stability**
- **Excellent Suspensibility**
- **Physical / Biological Tank Mix Compatibility with standard fungicides**

# *Bacillus subtilis*, Strain QST 713

Applied Just Like  
Other Products



No Special Equipment /  
Handling or Storage



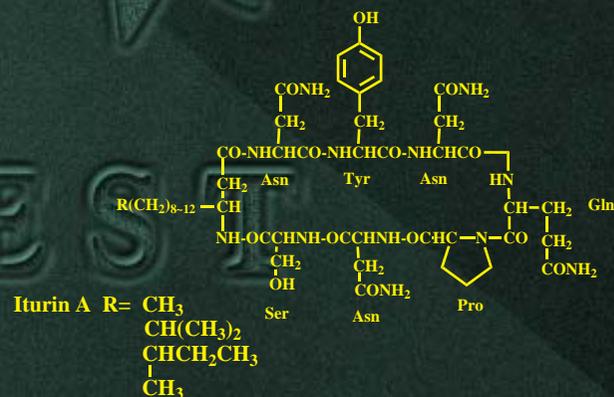
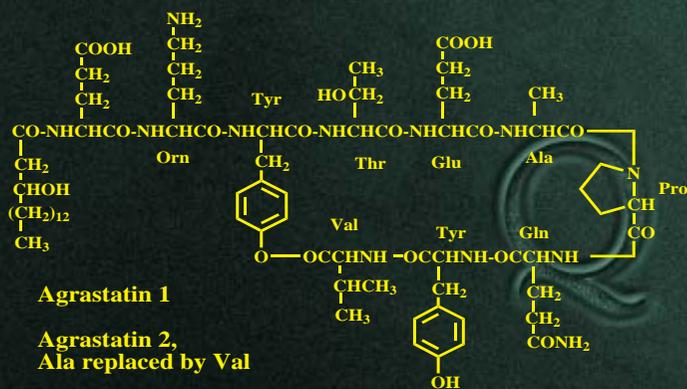
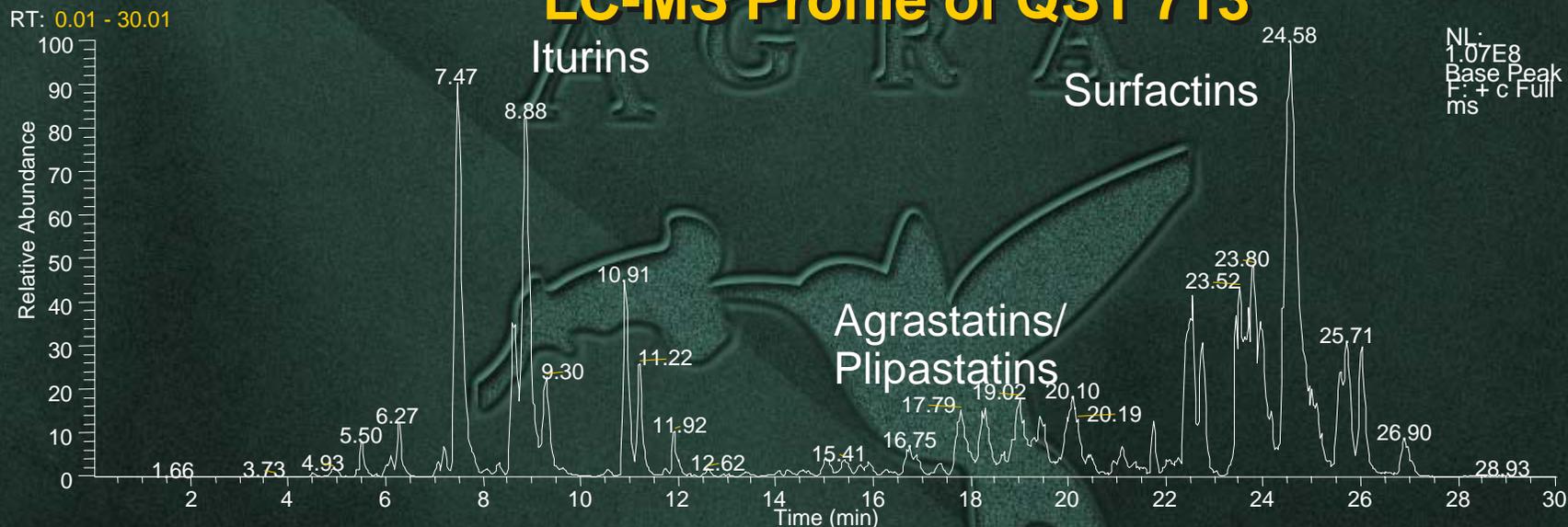
Novel Modes of Action

- *B. subtilis* spores cover leaf surface & prevent fungal spores from penetrating and infecting the plant.
- Lipopeptide metabolites break down pathogen cell membranes, causing pathogen to collapse & die.
- Lipopeptides prevent pathogens from multiplying.

SAR - Role in MOA  
Academic or Significant  
Contribution?

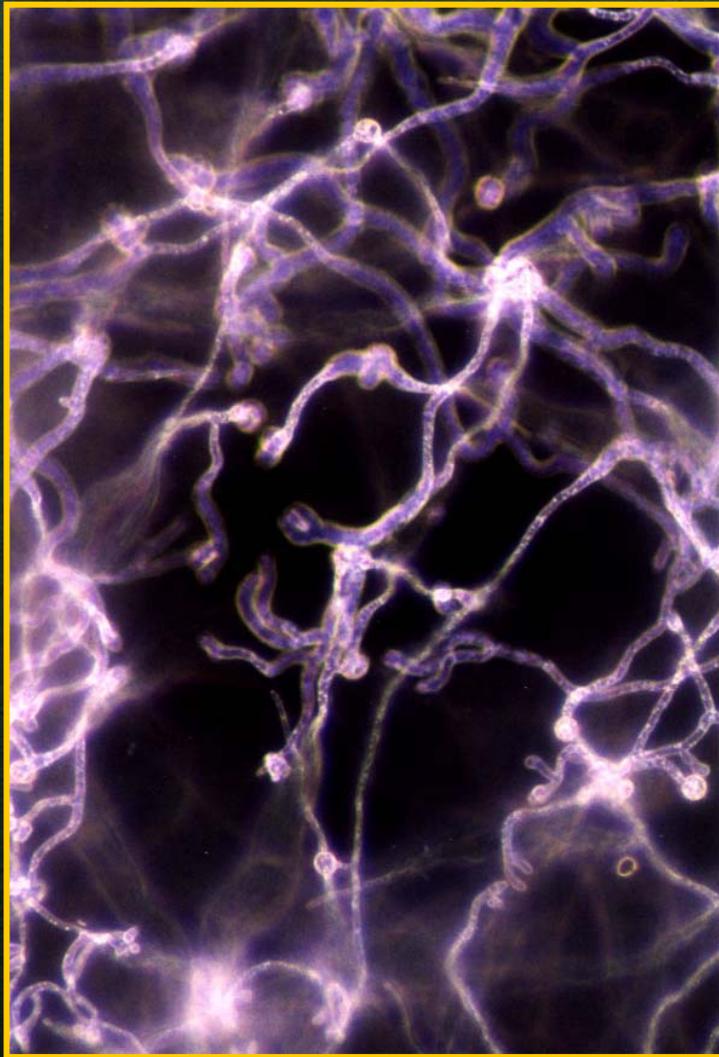
# Profile of *B. subtilis*, QST 713 Metabolites

## LC-MS Profile of QST 713



*Botrytis* 0% inhibition  
Iturins 10ppm or  
Agrastatins 50ppm

*Botrytis* 90% inhibition  
Iturins 10ppm + Agrastatins 2.5ppm  
Synergistic Action of Metabolites



# *Bacillus subtilis*, Strain QST 713

## *Novel / Multiple Modes of Action*

- *B.s.* spores – Colonize and Out-compete Pathogen
- Fungicidal Metabolites – Lipopeptides  
Present in Formulation / Produced by Colonizing *B.s.*  
Destroy Pathogen Spore & Mycelium Membranes  
Provide Barrier to Infection by Pathogen  
Optimal Use = Preventative Control Program
- New / Unique Resistance Management Tool

*Bacillus subtilis*, Strain QST 713

*Use in Integrated Programs  
with Conventional  
Fungicides*



# *Bacillus subtilis*, Strain QST 713

## Use in Integrated Disease Control Program - Japan

### IPM Program for Cucurbit Powdery Mildew (*Sphaerotheca fuliginea*)

#### 50% Reduction in Chemical Fungicide

	0 Day	7 Day	13 Day	20 Day	% Control
<b>Untreated</b>	Water	Water	Water	Water	---
<b>Chemical Repeating</b>	Std Fungicide	Std Fungicide	Std Fungicide	Std Fungicide	98.8
<b>Biological Repeating</b>	QST 713	QST 713	QST 713	QST 713	86.9
<b>Chemical + Biological</b>	Std Fungicide	QST 713	Std Fungicide	QST 713	98.6
<b>Chemical + Biological</b>	QST 713	Std Fungicide	QST 713	Std Fungicide	98.4

Chemical standard fungicide = Quinomethionate

# *Bacillus subtilis*, Strain QST 713

## Cucurbit Powdery Mildew (*Sphaerotheca fuliginea*) - USA

Treatment (Amt/100 gal/acre)*	% Powdery Mildew			% Control	
	6/14	6/20	6/25	6/20	6/25
Chlorothalonil (2.25 lbs ai) alt with Azoxystrobin (0.25 lb ai)	2	4	4	89	96
QST 713 at 4 lbs (5 applns); followed by Azoxystrobin at 0.15 lb ai (3 applns)	1	5	10	87	89
QST 713 at 4 lbs	5	10	66	74	30
Untreated control	17	38	94	---	---

\*Applied weekly on 5/3, 5/8, 5/15, 5/22, 5/30, 6/6, 6/13, and 6/19

***Bacillus subtilis* Strain QST 713 - Bananas**  
**Black Sigatoka (*Mycosphaerella fijiensis*)**



**Requirement = 6 Functional Leaves at Harvest**

# *Bacillus subtilis*, Strain QST 713 – “Sustainable” Black Sigatoka (*Mycosphaerella fijiensis*) Control Program in Bananas

Mindanao – The Philippines (March to August 2003)  
Small Plot / RCB Trial

Treatment (rate / hectare)	Visible Streaks On Leaves	Functional Leaves At Harvest
<i>B.subtilis</i> 2 liters	3.9 a	7.8 a
<i>B.subtilis</i> + mancozeb 2 + 0.9 liters	3.9 a	7.4 a
Standard Program Mancozeb – 1.8 liters	4.1 a	8.5 a
Untreated	3.4 b	4.9 b

# *Bacillus subtilis*, Strain QST 713

## ***Product Positioning – Features***

- Effective “Non-Chemical” Option for Disease Control Programs
- Broad Spectrum Disease Control – Fungal and Bacterial Pathogens
- Tank mix and Rotation with Protectants / Systemics in Programs
- MRL Management / Sustainable / Organic Production Tool
- Resistance Management
  - Single Site Compounds – e.g., Strobilurin and Triazole Fungicides
- Exempt From Tolerance / 0-Day PHI / No CODEX
  - Late Season, Pre-Harvest Option / No Residues
- Integrated Pest Management
  - Not toxic to Non-target Organisms -  
*Honeybees, Lady Beetles, Lacewings, Parasitic Wasps, and Earthworms*
- Safe to Workers / Environment