# The Expanding Role of Microbial Technologies Internationally

## Some facts about Biologics in India

Sandeepa Kanitkar – CMD

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Smart - Bio Platform

# Microbials for Indian Agriculture
# Kan biosys – founded in 2005 * Technologies used in 5 countries
# First Patent for Liquid Biofertilizers – dormant forms

| Application | |
|---|---|
| Nutrient Management | *Azotobacter chroococcum*<br>*Bradyrhizobium japoinicum*<br>*Bacillus polymyxa*<br>*Bacillus licheniformis*<br>*Acinetobacter calcoaceticus* |
| Pest and Disease Management | *Bacillus subtilis*<br>*Pseudomonas flourescens*<br>*Beauveria bassiana*<br>*Metarrhizium anisopliae*<br>*Verticillium leacanii*<br>*Trichoderma viride*<br>*T harzianum* |
| Soil Health Managment | *Trichoderma viride*<br>*Chaetomium globosum*<br>*Streptomyces sp* |

# Some facts about India

- India holds 2nd largest agricultural land in the world [ 154m ha]. Population of 1.34 billion which is 17% of world population.

- USA has around 174.45 m ha of arable land. Number 1 in the world. Population of 319 million which accounts for only 4.4% of the world population.

- With limited scope of increasing the arable area India needs to produce its food sustainably if it needs to be self –sufficient.

# India – Scope of agriculture

- 15 major climates in the world exist in India .
- 46 of the 60 soil types in the world.
- Self-sufficient in food grains with 277 m tons. There is lot of scope to increase the per acre productivity and that too sustainably.
- India is the largest producer of spices, jute, milk, tea, cashew nut. Second largest producer of wheat, rice, fruits & vegetables, sugarcane, cotton and oil-seeds.
- Agricultural exports are at 32 billion USD. Major exports are tea, basmati and non-basmati rice, fruits. Target exports in 2019- 2020 – 45Billion USD.
- Mission Mode in agriculture to DOUBLE INCOME OF FARMERS.

## Farmer centric technologies

- Reduce Costs
- Optimize yields
- Reduce residues to get access to high value markets
- Tackling water stress and climate change
- Sustainability – reducing ecological foot print for getting consistent yields year after year

## Consumer centric technologies

- Low Costs
- Safe food
- Nutritious food
- Sustainability – reducing ecological foot print for bettering quality of life

MICROBIOME / Microbial technologies offer promise-

- Microbiome offers possibility of discovery for new solutions to the present challenges, mass production
- Microbial technologies are not disruptive as they supplement the existing agro-ecosystem to increase efficiency.
- In organic systems they provide solutions to many issues which lead to increasing yields

## Why do we need microbial technologies?

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Partners of farmers in agriculture

Whole new world out there……

India has many biodiversity HOT SPOTS or the tropical diversity in soil and foliar MICROBIOME

# Partners of farmers in agriculture

Most of life on Earth is microbes. We have only just scratched the surface of the microbial realm. Probably less than 1% of microbes have been cultures or had their genes sequenced. So really microbial realm is a mystery.

- Paul Davis

- As per The American Society of Microbiologists (ASM) farmers will need to produce 70 to 100 percent more food to feed the projected 9 billion humans that will inhabit the earth by 2050.

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# 4 success stories of microbial inoculants in India

- Functional Seed dressing /Soil broadcasting by nitrogen fixing and PGPR - bacteria like *Azotobacter, Bacillus polymxa, Bacillus licheniformis, Acinetobacter calcoaceticus* in all crops

- Biofungicides based on *Bacillus subtilis* and *Pseudomonas flourescens*
- Bioinsecticide based on *Beauveria bassiana* for managing sugarcane soil grubs and grape mealy bug

- Imparting sustainability to rice ecosystem by *in situ* utilization of rice straw

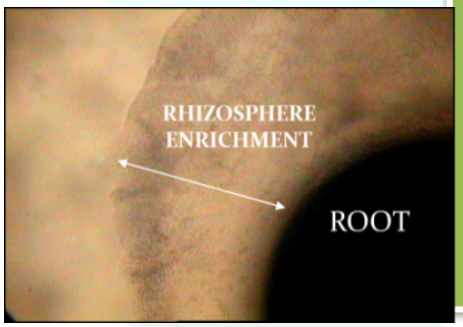
Some functional examples of microbials 2/3rd of 3 billion $ market world wide

# Next generation microbial seed dressing products

## Well begun is half the battle won

- Market - Seed protection Industry will be 9.8 billion US $ by 2021 - In 1997 it was 700 million US $.
- Key growth drivers - Farmers keen interest to protect, insure and maximize his seed investment
  - Advancement of seed dressing technologies which make it a possibility

1. More choices on what you can put on the seed. Fungicide-Insecticide-Nematicide-Microbe.
2. Protectionist approach – Nutritional approach- Functional seed dressing – growing at a rapid pace.
3. Single biologicals versus complex microbiome inoculants. Mycorrhiza, PSB, NFB, PGPR
4. Compatibility with chemicals and other microbes
5. Survival strategies where by spores of PSB and PGPR bacteria are used which can survive for more than 2 years on seeds. So precoated seeds are a possibility versus the on-farm seed treatment. Premier MNC and largest seed company in India is working with Kan biosys on this. Released pilot quantities of 2 tons from 2015 for corn. Tests are underway for soybean and cotton.
6. Dedicated team working on biologicals in many seed – CP – biotech companies
7. ROI is lucrative and often justified




Microbial Seed dressing

- On-farm
  - WP formulation
  - Dry seed dressing after chemical dressing
    - NFB- *Azotobacter chroococcum* KBPL 446
    - PSB - *Bacillus polymyxa* KBPL 451
    - NFB - *Bradyrhizobium japonicum* KBPL 120
    - Mycorrhiza - *Glomus spp.*
- Pre-coated
  - AS formulation to be used with chemical slurries for coating seeds
    - PSB + PGP - *Bacillus licheniformis* KBPL 306
      *Bacillus polymyxa* KBPL 451

## Functional Seed Dresser – Main benefits

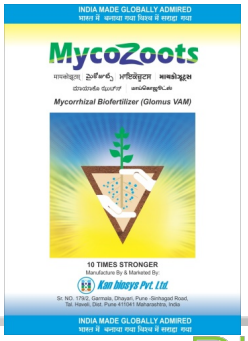
- Early seed germination
- Improved seedling vigor through secretion of PGPS
- Spontaneous uptake of nutrients
- Good plant stand and establishment
- Protection against root pathogens through competitive exclusion
- Microbes coated on seeds continue to colonize growing root surfaces. Provide benefits which are long lasting.
- Conventional seed treatment with fungicide/insecticide : broad spectrum Protection for limited period
- Combined microbial + chemical seed treatment : Double benefits for farmers possible with use of pesticide compatible microbes

# Compatibility check with Chemical pesticides**

| Carbendazim (50% w/w) | Mancozeb (75% WP) | Penconazole 10% EC | Flusiconazole 40 EC | Dimethomorph 50% WP | Mandipropamide 23.4%SC | Captan 50% WP | Iprovalicarb 5.5% + Propineb 61.25% WP | Imidacloprid (17.8% m/m) |
|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |

Bseepel [R]– Registered trademark of Kan biosys
Mycozoots [TM] – Registered trademark of Kan biosys
** - As assessed by Poison Food technique and Germination trials







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# Plant Nutrient Mobilizing Microbes

**Main Customer Benefits**

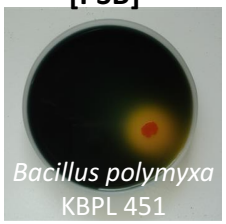
- Increase in Fertilizer use efficiency
- Sustainable supply of nutrients (N, P, K, Zn)
- Increase in quality & quantity of Yield
- Compatible with chemical intensive practices as well as Organic farming practices
- Low grade ores can be used as source of fertilizers

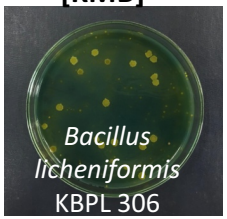
## Asymbiotic/ Symbiotic Nitrogen Fixing Bacteria [NFBs]

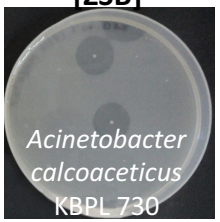



NFBs fix atmospheric nitrogen into amino acids.
Secrete PGPS: plant hormones [IAA/GA], vitamins, etc.

## Phosphate Solubilizing, Potash Mobilizing, Zinc Solubilizing Bacteria [PSB] [KMB] [ZSB]



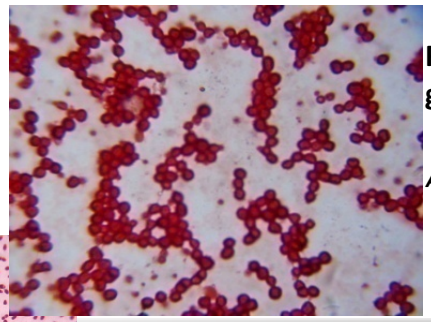




PSB/KMB/ZSB: secrete organic acids to solubilize insoluble forms of P, K and Zn in soil, Secrete PGPS: plant hormones, enzymes

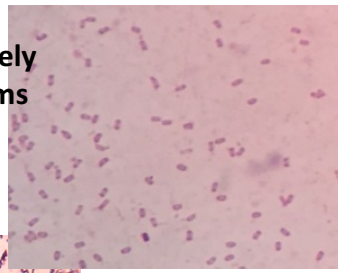
## Use of Dormant forms of Microbes

1. Development of A.S./W.P./W.D.G. formulations
2. Better Shelf-Life [1-2 yrs]
3. No Microbial interaction in consortia formulations
4. Tank mix compatibility with soluble fertilizers
5. Foliar bacterization added benefits



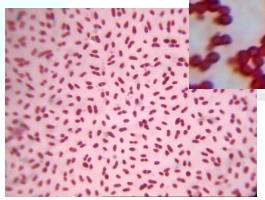
Reversible transition in Actively growing cells & dormant forms

***Azotobacter* cysts**

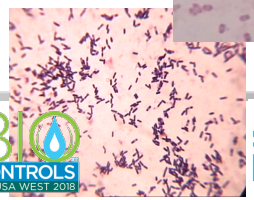


***Bacillus* spores**

***Azotobacter* cells**



***Bacillus* cells**



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# Success achieved in targeted crops

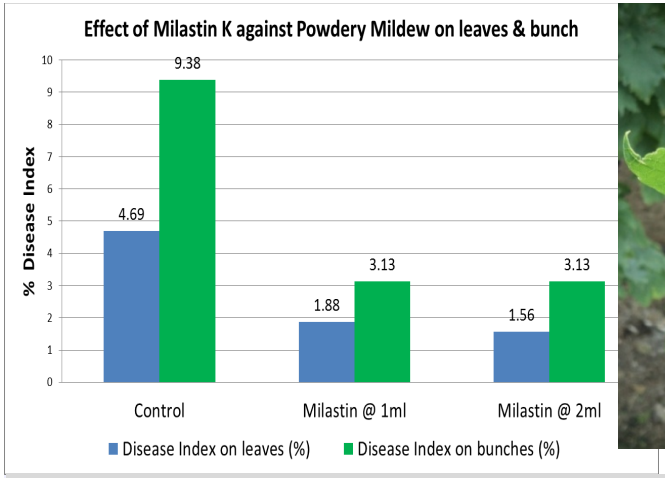
- Foliar nitrogen fixing bacteria as AS formulation in rice-wheat-grapes and vegetables – foliar spray
- PSB bacteria as AS formulation before flowering in high value crops like grapes, pomegranate, watermelon – root zone drenching
- NFB, PSB, Mycorrhiza and ZSB as Granules to inoculate total field in all crops. Major success in sugarcane, rice, wheat, cotton and corn. Applied with basal dose of chemical fertilizers.

## Biofungicides

### *Bacillus subtilis* **KTSB 1015 1.5% A.S.**

### *Pseudomonas flourescens* **KBPL 2059 0.5% W.P.**

- Hi-value commercial horticultural crops like Pomegranate and Grapes and Chilli as root zone drenching by drip [ Fusarium wilt, damping off ***Pythium aphanidermatum*** **]**
- Foliar application during pre-harvest interval for control of Downey (*Plasmopara viticola* (Berk. & Curt.) Berl. & de Toni & Powdery mildew in grapes *Uncinula necator* (Schw.) Burr.
- Foliar application with compatible fungicides for reducing the impact of residues in final produce.
- Control of Powdery Mildew [***Leveillula taurica***] **Anthracnose[** ***Collectotrichum capsica*** **] in Chilli.**




Mode of Action of Milastin** - ***Bacillus subtilis* KTSB 1015 1.5% A.S.**

1. Inhibition of fungal spore germination by secretion of antifungal metabolites
2. Competitive exclusion by rapid proliferation of surfaces
3. Imparting Induced Systemic Resistance – ISR

**- Trademark of Kan biosys

## Trial for 2 years at National Research Centre for Grapes at Pune 2014 to 2016

- Zero pre-harvest interval
- Compatible with recommended fungicides in grapes grown in hot and humid conditions in India.
- 59 to 66% reduction in disease index on leaves and 66% on bunches together with 15% increase in yield of grapes.
- Rapid adaptation by export growers for residue free production [ 1,00,000 ha ]

1. Root zone drenching of *Bacillus subtilis* KTSB 1015 1.5% A.S and *Pseudomonas flourescens* KBPL 2059 0.5% W.P. gave superior performance against soil borne fungi.
1. Formulation worked at wider temperatures [ 5 to 40°C]
2. ISR activity was prominent

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# Compatibility check with Chemical pesticides**

| | Triadimefon | Penconazole | Flusiconazole | Dimethomorph | Manoipropamide | Mancozeb | Iprovalicarb + Propineb |
|---|---|---|---|---|---|---|---|
| *Bacillus subtilis KTSB 1015* | ✓ | ✓ | ✓ | ✓ | ✓ | X | X |
| *Pseudomonas fluorescens KBPL 2059* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

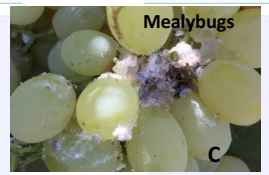
! Milastin – Registered trademark of Kan biosys
# Sudo – Registered trademark of Kan biosys
** - Tank mix Concentrations


# Bio-insecticide based on *Beauveria bassiana* 1.15% W.P.

## Main Customer Benefits

- Bio-insecticide for management of soil & foliar sucking insect pests
- Non-toxic
- Residue free
- Zero Pre-harvest Interval [PHI]
- Tank Mix compatibility with Chemical insecticides
- Organic certified

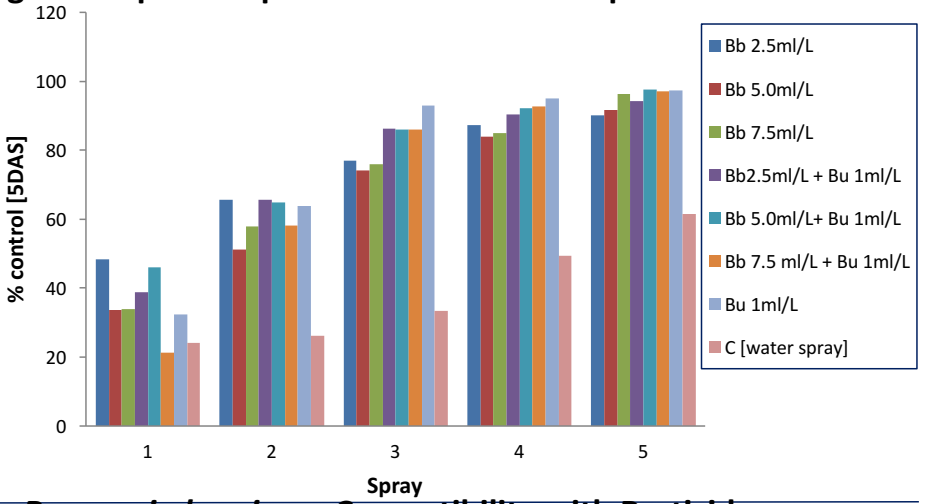
## *Beauveria bassiana* Success Story: Control of Mealy bugs in Grapes comparable to that with Buprofezin






### Field results

1. Mealy bug control 90%, 94% & 97% with Bb 2.5 /5.0 / 7.5 ml/L, resp.
2. Mealybug control with 5 sprays of Bb 7.5ml/L comparable with 5 sprays of Bu 1ml/L [ > 96% control].
3. Tank mix compatibility of Bb with Bu, Mealybug control 96% with Bb 2.5 ml/L + Bu 1ml/L
4. Bb protection against mealybug until harvesting because of Zero PHI as against Buprofezin that has 14d PHI.




## *Beauveria bassiana*: Control of Sugarcane Grub

Sugarcane grub

Mycosed grub

Field studies in Process: Control of sugarcane grubs [***Holotrichia consanguinea***] with soil application of Bb + FYM

## *Beauveria bassiana*: Compatibility with Pesticides

Compatibility of Bb with Insecticides: Buprofezin, Phorate, Chlorpyriphos, Chlorantraniliprole, Methyl Parathion

Compatibility of Bb with Fungicides: Penconazole, Mandipropamid, Flusilazole, Dimethomorph

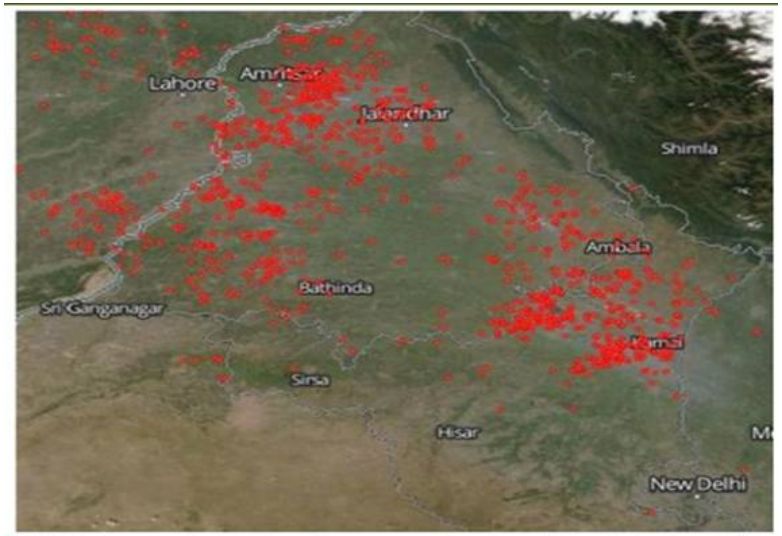
Non-compatibility of Bb with Fungicides: Mancozeb, **Iprovalicarb + Propineb**

# Burning Issue

• Punjab and Haryana : Rice straw over 4.28 m ha burnt every year.

•Ill effects : Reducing yields, increasing costs, eroded soils with organic matter < 0.1%, receding water table, contaminated water and smog over north India in harvesting months of Oct-Nov.

•Farmers burn rice straw (4-5T/ha) as no technology is available for its utilization within 15 days window period between rice harvesting & wheat sowing




NASA image depicting fires on agricultural lands in Punjab and Haryana on October 11, 2016

•Picture released by **NASA** – which significantly reflects fire in North India and adjoining area.

• Severe health issues like asthma attacks and respiratory problems are on rise in this region.

# Imparting sustainability to rice ecosystem by in-situ utilization of rice straw: Soil Carbon Project

## Main Customer Benefits

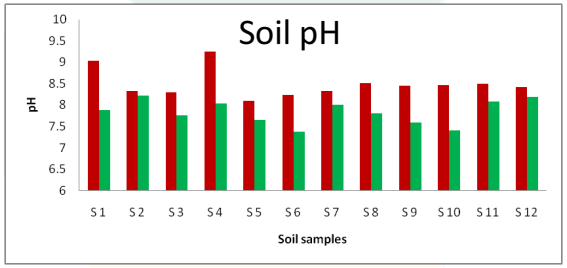
Improving water and fertilizer use efficiency | Reducing human health hazards

Reducing Environmental Pollution | Improving Soil Organic Carbon / Fertility | Soil health is improved because of the PGP activities of beneficial microbes | Deterrent to climate change

| | |
|---|---|
| *Chaetomium, Trichoderma, Bacillus* | Cellulose degradation |
| *Chaetomium, Trichoderma, Bacillus* | Hemi-cellulose degradation |
| *Bacillus* | Starch degradation |
| *Trichoderma, Bacillus* | Chitin degradation |
| *Bacillus licheniformis & Bacillus polymyxa* | Protein degradation |
| *Azotobacter* | Nitrogen enrichment |
| *Azotobacter, Bacillus & Trichoderma* | PSB & KMB solubilization |

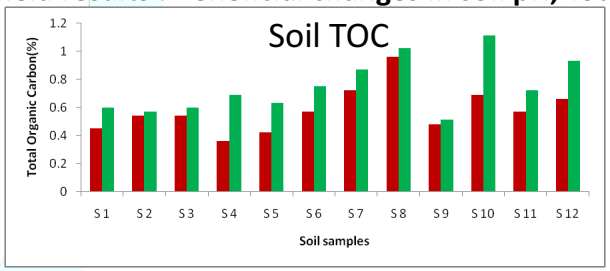
### In-situ rice straw utilization process- Success story implemented on 10,000 ha in Punjab & Haryana , India


### In-situ rice straw utilization field results : Beneficial changes in soil pH, Total Organic Carbon (TOC),



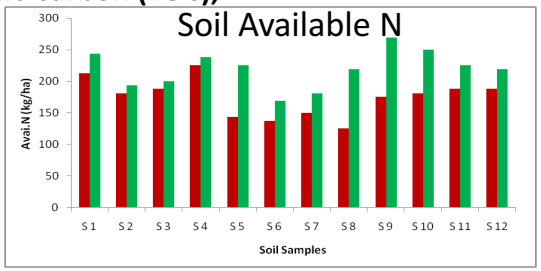

**Conclusion**

- Optimum soil pH for better nutrient availability 6.5 to 7.5
- pH range in Haryana soil samples: Highly alkaline 8.1-9.25
- pH range in treated plots: 7.3 - 8.7
- Reduction in soil pH 0.3- 0.8 units in treated plots over control




**Conclusion**

- Optimum Total organic content (TOC) of soil : 0.40-0.60%
- TOC in Haryana Soil samples : 0.42-0.96%
- TOC in treated soil : 0.51-1.11%
- Mean % increase in TOC is 29.3% in treated plots over control




**Conclusion**

- Medium range of available nitrogen (N) in soil : 281-420 kg/ha
- N content Haryana Soil samples : 125-225 Kg/ha
- N content in treated Haryana Soil samples :169-269 kg/ha
- Mean % increase in N content is 25.1% in treated plots over control

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# Extent of vision

- Product positioning – High value crops-pre harvest interval for residue correction or removal- commercial crops-areas where chemicals are not functioning well. Seed dressing –Pre-coated seeds. Organic farming systems they have already positioned well.[ Cumin-Chilli-Basmati Rice]
- Product requirements- Best strain and Formulation is the key-patented consortia might help scale-up innovation
- Reference point of chemicals – Work closely with them to bring up the technology standards to the level of multiplicity or large scale-up
- CAGR can be increased from 10 to 15% to almost 20% in the next decade. 5 years microbial market can double or infact triple with the speed of technology adoption.

# Hurdles in maximizing potential of microbial products

- Shelf life
- Stability at different temperatures, pH and EC
- Retention of bio-efficacy characteristics during mass production
- Formulation and method / site of application
- Compatibility with prevalent POP's
- Quantifiable short time benefits  VS long term benefits
- Cost Benefit ratios
- Impact of depleting agro ecosystems

# Markets in India# ** - potential of almost 1 billion USD by 2025

| Microbials | Current | Potential |
|---|---|---|
| Seed coating<br>1.Pre-coated seeds<br>2.On-farm seed coating | 1.Corn – 2000 tons per year – 3 years<br>2.5000 acres for over 10 years<br>Vegetables- soybean, cotton, Onion, wheat | 5 m ha<br>10 m ha |
| 3.Nutrient Management | Foliar PGPR on grapes, wheat, rice | 10 m ha |
| 4.Biopesticides | 1.Powdery and downy mildew in grapes 75000 acres in 5 years<br>2.Grape mealy bug management – 25000 acres 3 years | 0.25 m ha |
| 5.Residue Management | 10,000 acres of rice in 2 years | 4.18 m ha |
| | | |

# How will the microbial inoculant industry be in 10 years in India

- Compatible consortia – nutrient management as well as in biological control
- Compatible strains with chemicals/biochemicals which can impact dose and effect
- Stress tolerant strains or mutants
- Tapping the potential of low grade fertilizer ores
- New microbes have novel mode of action
- Formulation- stability-shelf life
- Application
- IPR after the potential of Microbiome starts being functionally utilized

# Stop Burning – Start building Soil Carbon
# Instrument for sustainable increase in farm yields




In Japan, people celebrate the rice harvesting season, which takes place in September and October. One of the festivals that honors this harvest is the Wara Art Festival, which has happened for the past decade in Niigata City. The art on display is awesome, especially some surprising (and giant!) straw creatures that look like they'd be right at home in any Fall display……

SIMPLY SUSTAINABLE. ALWAYS EFFECTIVE.

# BPIA Spring 2018 Meeting
# March 07, 2018

**Vijay K. Choppakatla**
**Plant Pathologist**

BioSafe Systems
Simply Sustainable. Always Effective.

SIMPLY SUSTAINABLE. ALWAYS EFFECTIVE.

- *A family-owned manufacturer of biodegradable and reduced risk crop protection products.*
- *Headquartered in East Hartford, CT-USA*
- *Biochemical (Peracetic Acid Based) and Microbial based EPA registered Biopesticides for organic and conventional Agriculture and Horticulture markets.*
- *Currently have 2 EPA registered microbial pesticides for disease and insect control (Pvent and BioCeres WP) and 1 Beneficial soil inoculant (TerraGrow)*
- *Products registered in US, Canada and Mexico.*

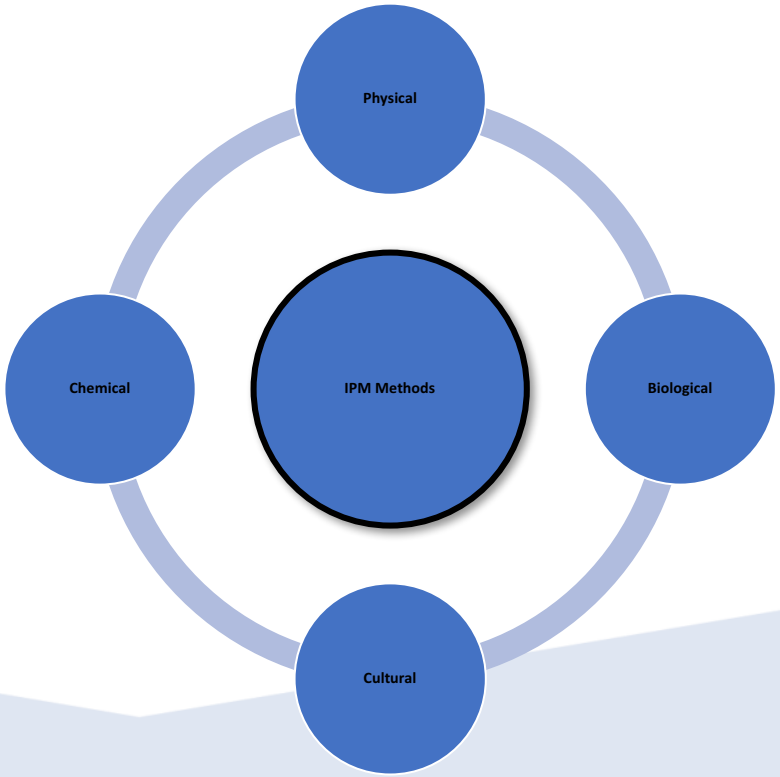
SIMPLY SUSTAINABLE. ALWAYS EFFECTIVE.

# Crop IPM

Integrated Pest Management-Integration of methods for successful management of plant diseases and Insect Pests.

**IPM methods have to be:**

- Effective
- Economical
- Environmentally Safe



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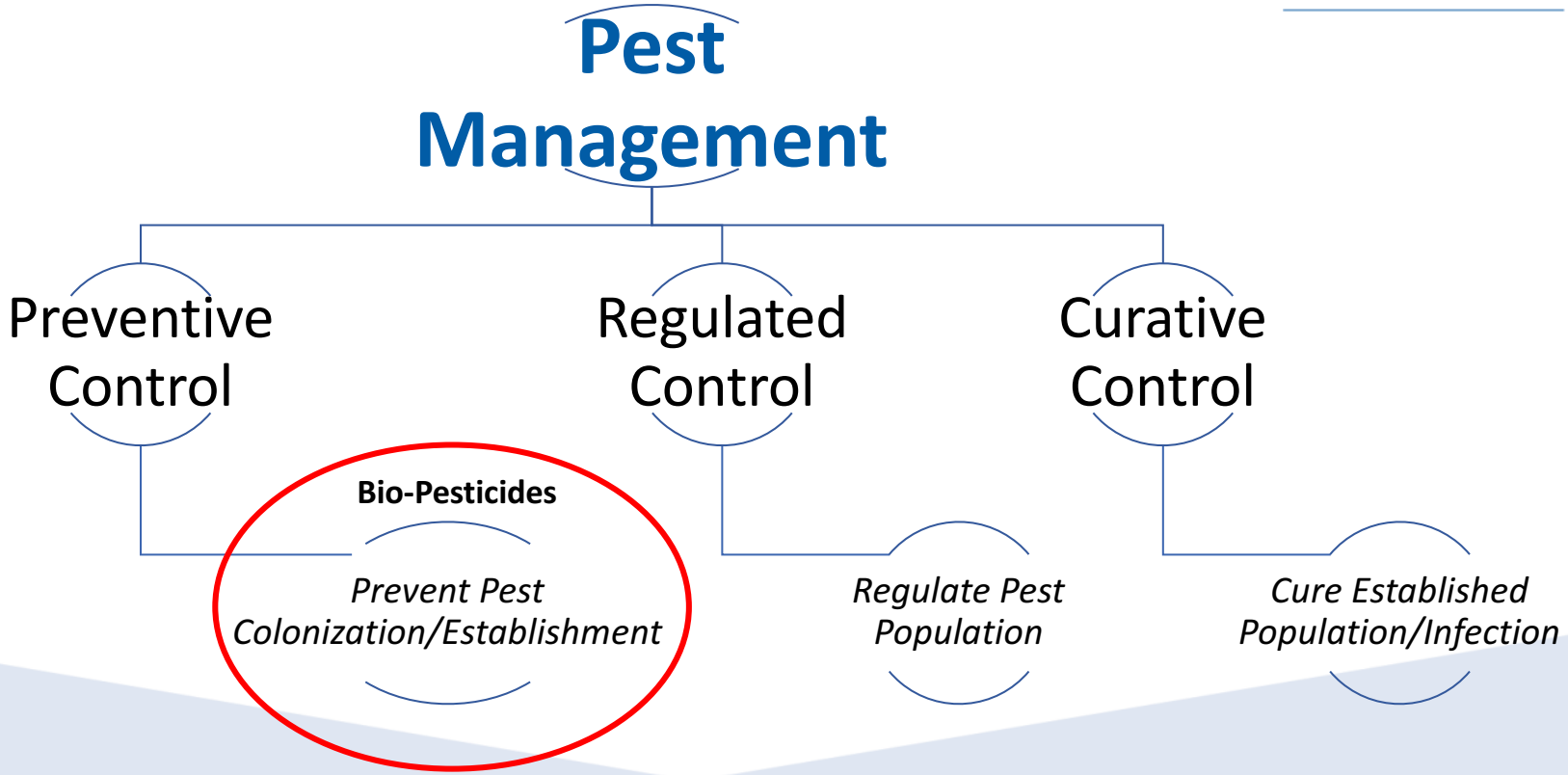
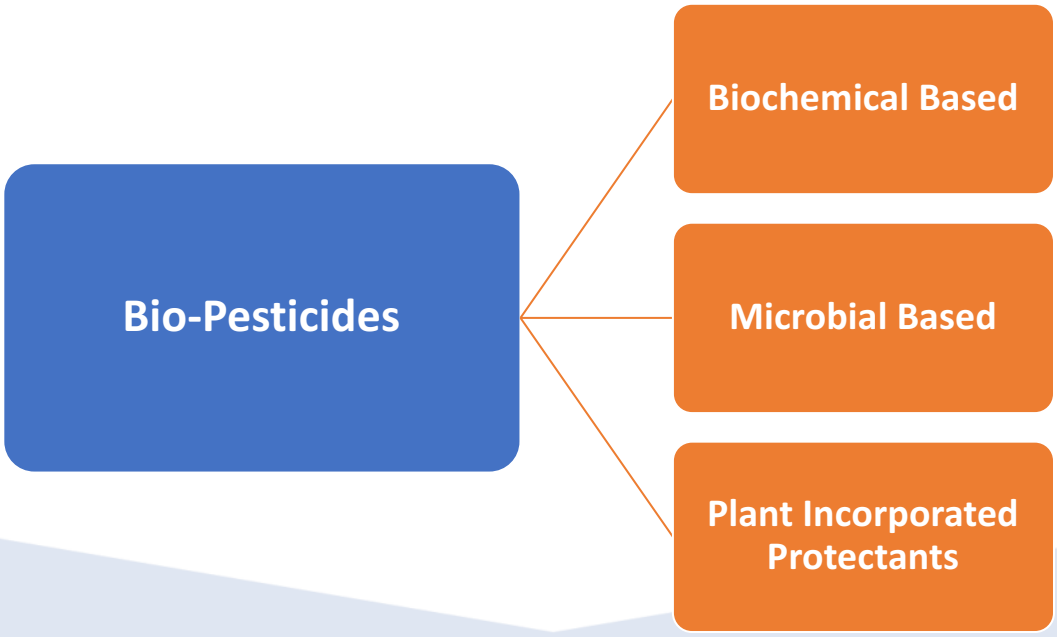
BioSafe Systems



SIMPLY SUSTAINABLE. ALWAYS EFFECTIVE.

BioSafe Systems

*"Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals"-EPA*



SIMPLY SUSTAINABLE. ALWAYS EFFECTIVE.

# Microbial Based

BioSafe Systems

-**<u>Beneficial Inoculants/Biofertilizers</u>:**

a. Plant growth promoting.

b. Nitrogen Fixing-*Bradyrhizobium*, *Azospirillum*, *Azotobacter* etc.

c. Phosphate Solubilizing-*Bacillus* sp., *Pseudomonas* sp., *Aspergillus* and *Penicillium.*

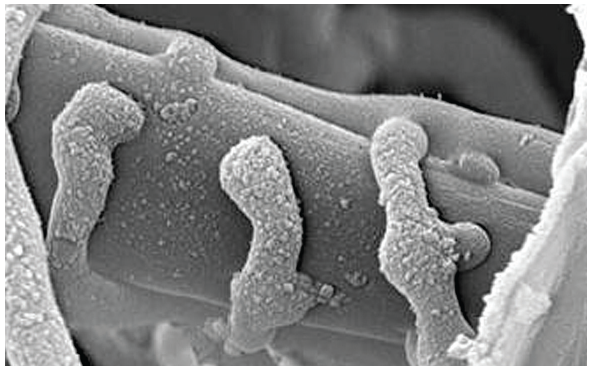
SIMPLY SUSTAINABLE. ALWAYS EFFECTIVE.

# Microbial Based

-**Bio-Controls for Crop Protection:**

a. Active ingredients based on Live micros/Secondary metabolites.

b. Products registered in all 4 crop protection product types for use as a seed treatment, on-farm and post-harvest.



- **Bio-Fungicides**
- **Bio-Insecticides**
- **Bio-Nematicides**
- **Bio-Herbicides**

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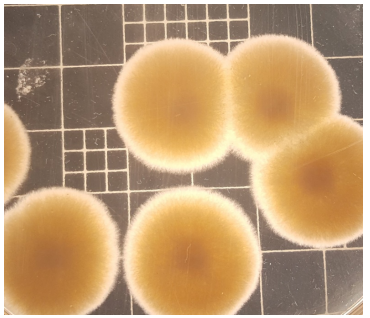
# Bio-Pesticides: Global and US Trends

BioSafe Systems



- ✓About $3 Billion market world wide accounting for about 5% of the total crop protection market (Christos & Spyridon, 2017; Marrone, 2014 and Olson, 2015).
- ✓ Increasing by about 10% every year. (Christos & Spyridon, 2017 ; Kumar & Singh, 2015)
- ✓North America (US, Canada and Mexico) shares >40% of world market in biopesticide usage and sales.
- ✓Close to 300 registered Biopesticide Active Ingredients and 1401 active biopesticide product registrations with US EPA as of 2016.
- ✓Fruits and Vegetables takes major chunk of usage of biologicals among all crop groups both on global scale and US due to demands for safe consumption with less pesticide residues.
- ✓Future usage potentially on par with conventional chemical pesticides.

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# Bio-Pesticides Growth

BioSafe Systems

## Drivers

✓Safer alternative to conventionals- Lesser risk to humans and environment.

✓Pest specific

✓Organic production

✓Non-residual

## Barriers

- Tighter regulations to register actives.
- Efficacy-Lack of adequate research.
- Cost
- Manufacturing infrastructure
- QA/QC

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# Microbial Based Bio-Pesticides: Areas of Interest in AG/Hort. Markets

BioSafe Systems

- ✓ Research Interest on several important crop groups (Both Conventional and Organic) and pests/diseases/weeds

  *Ex. SWD and Whiteflies in fruiting crops; Fire Blight in Organic Pome fruits and Downy Mildew in Organic Spinach etc.*

- ✓ Foliar Bio-Fungicides-As a stand-alone and rotation with other soft chemistries (Biochemicals/Biostimulants).

- ✓ Soil borne pathogens and nematode control as an alternative for conventional fumigants. Includes research on integration with non-fumigant based synthetic and soft chemistries.

- ✓ Bio-herbicides

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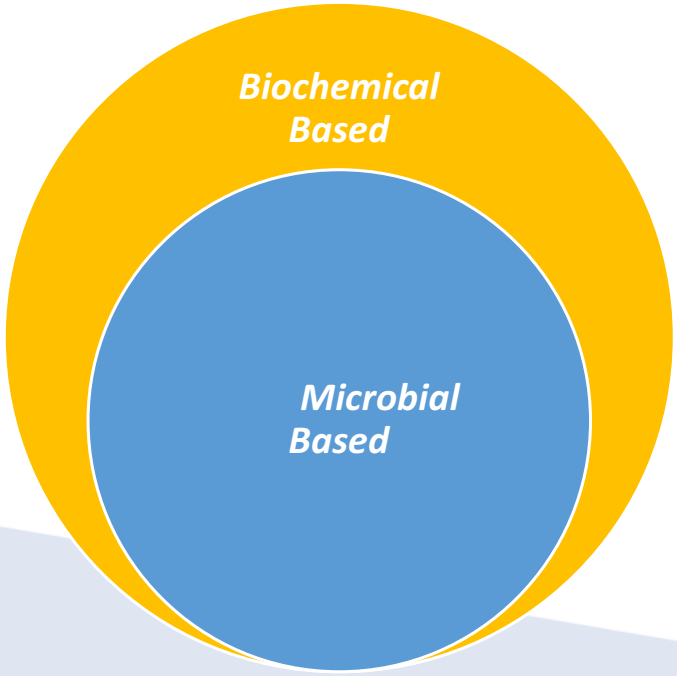
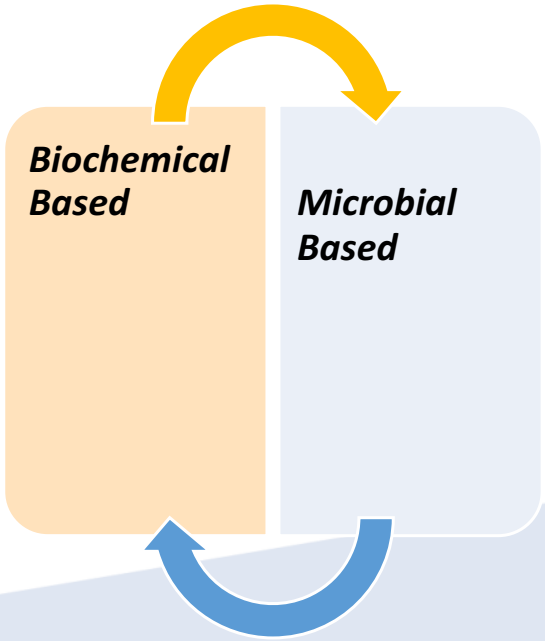
# Integration of Biopesticides for Sustainable and Effective Crop Protection

BioSafe Systems



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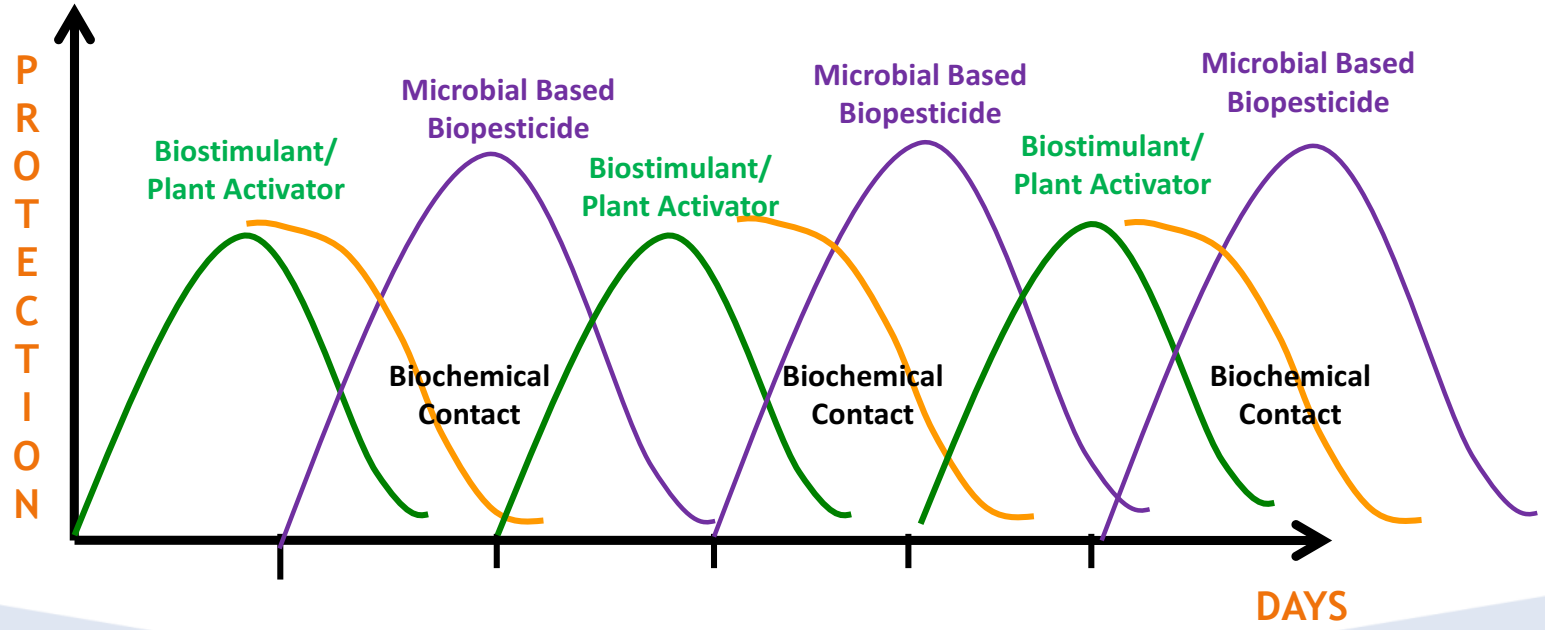
# Rotational Treatment Program with Biopesticides for Foliar Disease Control

BioSafe Systems



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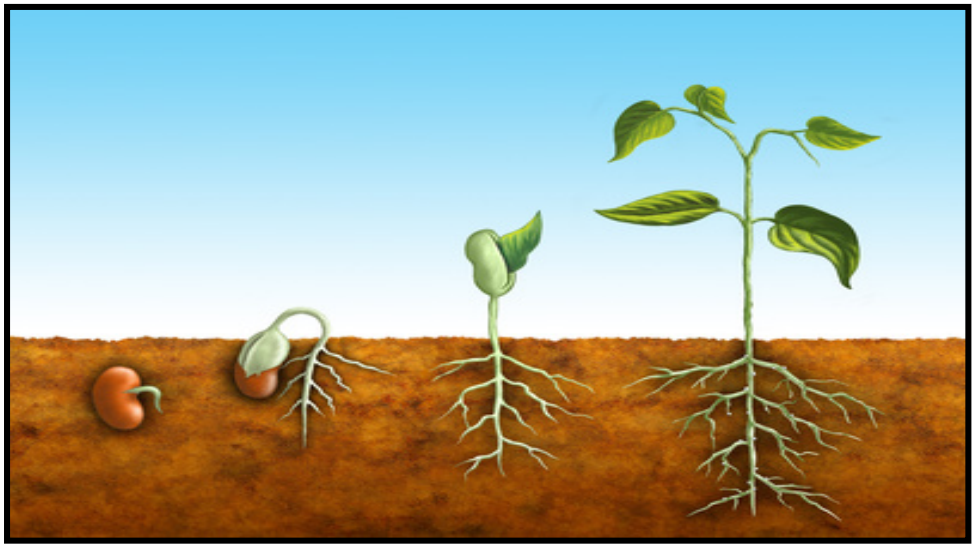
# Sustainable Soil Treatment Program with Biopesticides for SB Plant Disease Control

BioSafe Systems




**Pre-Plant**

**Biochemical Based (Activated Peroxide)**

**At-Plant**

**Microbial Based/Biochemical Based (Activated Peroxide)**

**Post-Plant**

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# Rotational/Tank Mix Treatment Program with Biopesticides for Plant Insect Control

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Microbial Based +/ Biochemical Based (Ex. Plant extract based IGR's)

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# Thank You

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