Microbe Based Technologies Developed by ICAR

भाकृअनुप
ICAR
Indian Council of Agricultural Research
Krishi Bhawan, New Delhi 110 001

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FOREWORD

Sustainable agriculture is worldwide recognized agricultural practice in the 21st century, in which microorganisms in soil take a decisive role. The role they play in biogeochemical cycles has been the key to the sustenance of life in this planet. They are involved in plethora of ecosystem services in the soil ranging for nutrient solubilization, mineralization, mobilization, recycling of organic wastes, bioremediation, and soil formation. The continuous decline in soil organic matter levels due to continuous cropping without recycling enough crop or animal residues, and insufficient application of nutrients has led to serious nutrient imbalances, impaired soil health and declined factor productivity. The microbe mediated organic matter recycling can be an excellent sustainable option to increase the crop yield. The microbe based technologies are the only low cost and eco-friendly way of improving nutrient supply and improving soil health in the short and medium run.

Indian Council of Agricultural Research has been the pioneer in India for research, development and application of microbial technologies in agriculture. Since last 50 years, various ICAR institutes have developed a number of microbe-based technologies related to biofertilizer, biopesticides, composting and many of them are being used by farmers throughout the country. Looking at the declining soil health and other ecological challenges, it is high time to maximize the popularization of microbe based technologies for a cleaner and healthier future. NITI Ayog has also emphasized to encourage and popularize use of biofertilizers, biopesticides and organics amendments to maintain the soil health. In 2014, the Govt. of India initiated National Mission on Sustainable Agriculture (NMSA) where Integrated Nutrient Management (INM) using judicious application of chemical fertilizers along with biofertilizers and composts is being promoted to improve soil health.

This bulletin entitled, ***"Microbe based technologies developed by ICAR"*** is a compilation of validated microbial technologies developed by various ICAR Institutes to improve nutrient uptake efficiency; biocontrol of fungal pathogens and insect pests and for organic matter recycling. I am hopeful that this publication would be useful for researchers, scientists, students and other stakeholders interested in this area.

Dated: 9th July 2020 **(T. Mohapatra)**
New Delhi

भारतीय कृषि अनुसंधान परिषद
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डॉ. तिलक राज शर्मा
उप महानिदेशक (फसल विज्ञान)

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FNA, FNAAS, FNASc, JC Bose national Fellow
Deputy Director General (Crop Science)

MESSAGE

Since its inception Indian Council of Agricultural Research (ICAR) has been spearheading agricultural research in India and has been instrumental in developing farmer friendly technologies to enhance the crop productivity. The technology-led and innovation-driven Indian agriculture has successfully achieved increase in production of different crops and commodities to match the demand of growing population. The changes in agricultural practices have obviously driven the production in a forward direction, but at the same time we have been paying the price with declining soil nutrient availability, eroding biodiversity, poor water quality and changing climate.

Soil health is the key to agricultural production. Soils are natural habitat for billions of diverse microorganisms which serve as the ecological engineers to make soil as a "living" system. Healthy soils generally have balanced nutrient levels and sufficient biological activity especially of microorganisms. However, intensive cultivation with modern practices including application of agrochemicals have led to increased nutrient loss from the soil and disturbed the soil biological equilibrium leading to deteriorated soil health. This has eventually made our soils "sick" which will ultimately lead to reduced fertility.

Application of microorganisms in agriculture is well known. The microorganisms like *Rhizobium, Azospirillum Azotobacter, Trichoderma, Bacillus thuringiensis,* blue green algae and arbuscular mycorrhizae have significant impacts in crop production and protection. As deteriorating soil health, changing climate, new emerging diseases have become serious threats to agriculture, there is a need to look beyond the routine chemical intensive agriculture and go for using green technologies. The global reports suggest that microorganisms can play an important role in restoring soil health, combating biotic and abiotic stresses under changing climate scenario.

Indian Council of Agricultural Research (ICAR) has been instrumental in research and development of microbe based technologies since 1960s. Constituent institutes of ICAR have developed a number of microbe based technologies like biofertilizers, biopesticides, and compost inoculants which have been quite popular in many parts of the country. Since last few decades govt. of India has taken many initiatives to encourage use of biofertilizers and composts through financial assistance in setting up production units in different states.

This bulletin on ***'Microbe based technologies developed by ICAR'*** prepared by ICAR-National Bureau of Agriculturally Important Microorganisms (NBAIM) was much needed at the present scenario as it is imperative that microbes will be playing a vital role in shaping the future of agriculture. As an intensive compilation, it well reflects the great efforts made by the scientists across various institutes to develop the technologies. I strongly believe this compilation will definitely help us to step further towards shaping Indian agriculture in more sustainable manner. My heartiest congratulations to all the developers of these technologies and authors of this bulletin.

(T.R. Sharma)

INTRODUCTION

Microorganisms have played a key role to shape this living planet. They have been the major factors for biogeochemical cycling of nutrients and soil fertility which ultimately govern the production of majority of the staple foods around the globe. Microorganisms present in the soil play an important role in nutrient solubilisation, mobilization and recycling. They have very wide potential as they control soil-borne pathogens, stimulate plant growth, increase nutrients availability and accelerate decomposition of organic materials, and are anticipated to increase crop production as well as maintain sound environments for crop production. As more than 50% of Indian population are engaged in farming for their livelihood, utilization of local microbial diversity for various commercial and farming applications can generate additional income for them or can reduce the initial farming investments. ICAR has taken a lead in developing technologies based on microbes. These technologies are in different stages of validation and commercialization. The present bulletin is an attempt to make a comprehensive compilation of the technologies developed by different ICAR institutes.

Bio NPK Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

Bio NPK Liquid Biofertilizer is a unique kind of bioformulation comprising nitrogen (N_2) fixing (*Azotobacter chroococum*), P-solubilizing (*Paenibacillus tylopili*) and K-solubilizing (*Bacillus decolorationis*) bacteria. It has a longer shelf life (12–24 months) without loss of microbial populations and properties upon exposure to high temperature.

2. **Target crops and delivery system**: Bio NPK can be used for cereals, millets, pulses, vegetables and oil producing commercial crops. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree plants.

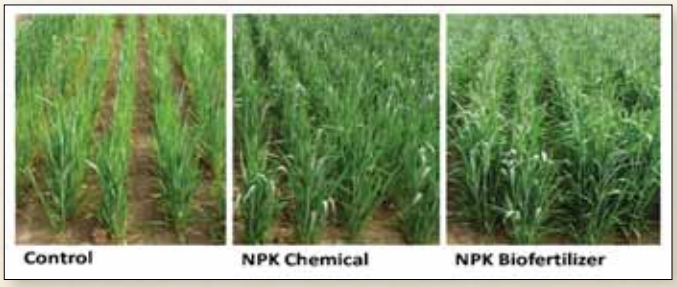
3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** The technology has been validated for Maize at multiple locations under AICRP, for fodder crops at ICAR-IGFRI, Jhansi; for groundnut at multiple locations under AICRP (groundnut); for Wheat at ICAR- IARI and ICAR-NBAIM, Mau and under farmers' fields for rice and wheat. In addition, the technology has given good results in citrus orchards (in Punjab), papaya (Begusarai, Bihar), ginger and turmeric (Anand, Gujarat).

5. **Whether licensed to private companies, If yes, details thereof**: A patent application (CBR Number: 23706; patent numbered 3364/DEL/2015; dt 19.10.2015) has been filed for 'A Microbial Consortium'. The technology has been licensed to:

   - M/s Monal Potteries and Ceramics Pvt Ltd., Himachal Pradesh
   - Prathista Industries Ltd., Secundrabad

6. **Benefits:** Bio NPK has shown remarkable response in the farmers' fields with respect to crop growth and yield. It could save the usage of chemical fertilizers from 25 to 50% of the recommended dose without compromising yield and growth of the plants. Application of Bio NPK biofertilizer with 50% recommended dose of fertilizer resulted in at par yield in wheat and 22% increase in maize as compared to recommended dose of fertilizers (RDF). It has shown a saving of chemical fertilizers up to 25-30 kg of Nitrogen, 10-15 kg of Phosphorus and 2–5 kg Potassium with increase in grain yield in crops like rice, wheat and maize. Its application can result in a net saving of Rs. 2500 per hectare.



7. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

BIOGROW Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

BIOGROW has been developed using consortium of different bacterial species "*viz., Bacillus* sp. BC39, *Bacillus* sp. RC25, *Pseudomonas* sp. K30 and *Pseudomonas* sp. K31," endowed with phosphorus solubilization, IAA and siderophore production attributes.

2. **Target crops and delivery system**: BIOGROW can be used for vegetable crops particularly solanaceous crops like tomato, brinjal, potato and for floriculture crops.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** Validated on tomato, potato and marigold at different locations in Mau and Varanasi. The technology is commercialized and is on the website of Agrinnovate India Ltd.

5. **Benefits:** Application of BIOGROW increased the yield of tomato by 25- 30% at different locations in Mau, Varanasi. Moreover, there was a significant improvement in nutritional quality of the produce as evident from enhanced content of lycopene and β-carotene in inoculated treatment as compared to control.

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Bio Phos and Bio Phos+ Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

Bio Phos and Bio Phos+ are liquid formulations of P-solubilizing bacteria containing *Kluyvera cryocrescens* and *Paenibacillus tylopili* respectively. It has a longer shelf life (12 months) without loss of microbial populations and properties upon exposure to high temperature.

2. **Target crops and delivery system**: Bio Phos and Bio Phos+ can be used for cereals, millets, pulses, vegetables and oil producing commercial crops. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree plants.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** The formulations have been validated on maize under AICRP on maize at 22 locations; at UAS, Shimoga besides its validation at ICAR- NBAIM. The technology is commercialized and is on the website of Agrinnovate India Ltd.

5. **Benefits:** Inoculation of Bio Phos and Bio Phos+ helps to augment 15 to 20 kg P_2O_5 ha^{-1}. Both the formulations along with 30 kg P /ha when inoculated to maize produced yield equivalent to 60 kg P/ha and hence can reduce the application of Phosphatic fertilizer @ 30 kg/ha. As compared to RDF, both the formulations along with 30 kg P /ha, produced ~7% more yield. In wheat, application of both the formulations with 50% P and full dose of N & K could produce almost equal yield as recommended dose of fertilizer and thereby could reduce 50% of P fertilizer application. It can save 30 kg P_2O_5/ha and enhances grain (7-11%) and stover yield (5-8%) in maize.

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Bio Zn Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

Bio Zn: A liquid formulation containing highly efficient Zinc solubilizing bacteria (*Bacillus endophyticus*) that can be used in different types of soils. It has a longer shelf life (12 – 24 months) without loss of microbial populations and properties upon exposure to high temperature.

2. **Target crops and delivery system**: Bio Zn can be used for cereals, millets, pulses, vegetables and oil producing commercial crops. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree plants.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** The technology has been validated for wheat at ICAR- IARI and ICAR-NBAIM, Mau and at farmers' fields in Azamgarh district, and on soybean at ICAR- IARI. The technology is commercialized and is on the website of Agrinnovate India Ltd.
5. **Whether licensed to private companies, If yes, details thereof**: The technology has been licensed to:
   - M/s Kirti International, New Delhi
6. **Benefits:** Bio Zn enhances uptake of Zn in soybean and wheat and its application can save 2 – 5 kg zinc sulfate per ha. It also improves yields of wheat and soybean by 5-10%.

7. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Bio Potash Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

Bio Potash: A liquid formulation having highly efficient K-solubilizing bacterium *Bacillus decolorationis* that can be used in different types of soils.

2. **Target crops and delivery system**: Bio Potash can be used for maize, wheat, mustard and potato. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree plants.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** The technology has been validated for wheat and maize at ICAR- IARI and ICAR-NBAIM, Mau. The technology is commercialized and is on the website of Agrinnovate India Ltd.

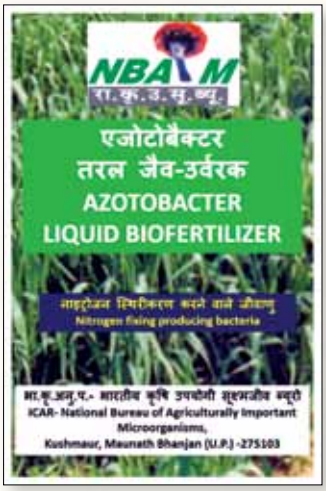
5. **Benefits:** Bio Potash helps plant to utilize K fixed in soil. Inoculation of K-solubilizer helps to augment 10-15 kg K ha^{-1}.

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Bio-Bacter Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

Bio-Bacter: A liquid formulation having highly efficient nitrogen fixing *Azotobacter chroococcum* that can be used in different types of soils.



2. **Target crops and delivery system**: Bio-Bacter is a multipurpose formulation that shows no specificity to the crop plants. It can be used for all plants to supply biologically fixed nitrogen. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree plants.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** The technology has been validated for wheat, mustard, maize and chickpea at ICAR-NBAIM, Mau. The technology is commercialized and is on the website of Agrinnovate India Ltd.
5. **Benefits:** Bio-Bacter when applied as seed inoculant can save 20-25 kg N/ha. It enhances the yield of wheat and maize by 5-7% as compared to uninoculated control.
6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

RhizoNBAIM Liquid Formulation

1. Name of the technology and its microbial constituent (Genus/ species):

RhizoNBAIM: A liquid formulation having highly efficient nitrogen fixing rhizobial strains specific to chickpea, pigeonpea, mungbean, urdbean, groundnut, pea and lentil.

2. **Target crops and delivery system**: Rhizobia are specific for leguminous crops. Rhizobia specific to chickpea, pigeonpea, mungbean, urdbean, groundnut, pea and lentil have been developed for seed inoculation.
3. **Target agroecological zones (if any)**): All
4. **Validation and commercialization:** The technology has been validated for pigeonpea, chickpea, mungbean, pea and lentil at ICAR- NBAIM experimental fields. The technology is commercialized and is on the website of Agrinnovate India Ltd.
5. **Benefits:** RhizoNBAIM when applied as seed inoculant can save 25-30 kg N/ha and enhance the yield by 7-10% over uninoculated control.

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

ZincFort

1. Name of the technology and its microbial constituent (Genus/ species):

ZincFort is a bacterial bioformulation containing an endophytic *Arthrobacter* sp. It has a longer shelf life (12 – 24 months) without loss of microbial populations and properties upon exposure to high temperature.

2. **Target crops and delivery system**: This bioformulation can be used for wheat. Inoculation can be done through seed treatment.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** The technology has been tested at farms of ICAR-IARI, New Delhi, ICAR-NBAIM, Mau and three centres of Punjab Agriculture University, Ludhiana.
5. **Benefits:** This formulation has shown remarkable response in improving the Zn content in wheat grains without compromising the yield. Inoculation can result in ~35-40% increase in Zn content (~45-50 ppm) in grains. Besides, this formulation significantly improves root architecture which can also improve other nutrient and water use efficiency.
6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

IronFort

1. Name of the technology and its microbial constituent (Genus/ species):

IronFort is a bacterial liquid formulation containing an endophytic *Arthrobacter sulfonivorans*. It has a longer shelf life (12 – 24 months) without loss of microbial populations and properties upon exposure to high temperature.

2. **Target crops and delivery system**: This bioformulation can be used for wheat. Inoculation can be done through seed treatment.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** The technology has been tested at farms of ICAR-IARI, New Delhi, ICAR-NBAIM, Mau and three centres of Punjab Agriculture University, Ludhiana.

5. **Benefits:** This formulation has shown remarkable response in improving the Fe content in wheat grains without compromising the yield. Inoculation can result in ~40-45% increase in Fe content (~55-65 ppm) in grains. Besides, this formulation significantly improves root architecture which can also improve other nutrient and water use efficiency.

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Drought alleviating microbial formulation

1. Name of the technology and its microbial constituent (Genus/ species):

This is a unique kind of liquid bioformulation containing an archaea. It has a longer shelf life (12 – 24 months) without loss of microbial populations and properties upon exposure to high temperature.

2. **Target crops and delivery system**: This bioformulation can be used for wheat, maize and mustard. Inoculation can be done through seed treatment.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** The technology has been tested at farms of ICAR-NBAIM, Mau and under testing in twenty different centres of AICRP-NSP since last two years.
5. **Benefits:** This unique formulation can save 2-3 irrigations for the target crops. It helps to sustain the plant growth even in case of extreme water deficit and allow the farmers to attain some yield instead of complete crop failure

Inoculated with Archaea | Un-inoculated

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Eco-Pesticide

1. Name of the technology and its microbial constituent (Genus/ species):

Eco-Pesticide is a unique kind of talc-based bioformulation consisting of *Pseudomonas fluorescens,* a free-living bacterium and establishes robust and long-lasting colonisation on root surfaces and penetrates into the epidermis and a few cells below this level. It has a longer shelf life (12 – 18 months) under ambient room temperature.

2. **Target crops and delivery system**: Eco-Pesticide can be used for cereals, millets, pulses, vegetables and commercial plantation crops. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree plants.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** The technology has been validated at ICAR-NBAIM, Mau in tomato, maize, rice, and wheat under nethouse and field conditions, KVK Ghazipur in chickpea, KVK Azamgarh in direct seeded rice, ICAR-IISS Mau in wheat and under farmers' fields in vegetables, onion, chickpea and wheat.
5. **Whether licensed to private companies, If yes, details thereof**: Nil
6. **Benefits:** Eco-Pesticide has shown remarkable response in the experimental fields of ICAR-IISS, Mau with respect to crop establishment and protection from spot blotch disease of wheat, at ICAR-NBAIM on sheath blight in rice, and wilt of tomato (45-55%) as well as at the farmers' fields with respect to crop growth and yield. It could save the usage of chemical pesticides from 15 to 25% without compromising yield and growth of the plants. It is found to be effective against a number of soil and seed borne pathogens like *Rhizoctonia, Sclerotium, Sclerotinia, Fusarium, Pythium, Ralstonia, Macrophomina, Bipolaris, Phoma,* etc. Root colonization by *Pseudomonas fluorescens* frequently enhances root growth and development, crop productivity, resistance to biotic and abiotic stresses and the uptake, use and translocation of essential plant nutrients from soil.
7. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

Bio-Pulse

1. Name of the technology and its microbial constituent (Genus/ species):

Bio-Pulse is talc based bioformulation of *Trichoderma harzianum* and *Bacillus amyloliquefaciens* and has biocontrol; plant growth promotion; nutrient mobilization and root colonization properties. It has a longer shelf life of 12 – 18 months).

2. **Target crops and delivery system**: Bio-Pulse can be used for cereals, millets, pulses, vegetables, plantation crops, etc. Inoculation can be done through seed treatment, root dip for seedlings and soil application for tree and plantation crops.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** The technology has been validated against seed and soil borne disease of chickpea at multiple locations of Bundelkhand region such as KVK Hamirpur, KVK Tikamgarh, KVK Chhattarpur, KVK Panna, KVK Ghazipur, and ICAR-IARI, for rice at KVK Azamgarh; for Tomato, Wheat and Maize at ICAR-NBAIM, Mau and under farmers' fields for chickpea, pea, lentil, vegetables, and wheat. In addition the technology has given good results in papaya (Begusarai, Hazaribagh and Bhabhua, Bihar).
5. **Benefits:** Bio-Pulse has shown remarkable response in the ICAR-NBAIM and KVK farms as well as farmers' field with respect to disease control, crop growth and yield. It is effective against a number of soil and seed borne pathogens like *Rhizoctonia, Sclerotium, Sclerotinia, Fusarium, Pythium, Ralstonia, Macrophomina, Bipolaris, Phoma, Xanthomonas* etc. It could save the usage of chemical pesticides. Application of Bio-Pulse could reduce the wilt incidence by 40-75% in chickpea, 30-55% in lentil, 45-60% in pea, 25-40% in pigeonpea, and 60-75% damping off/seedling mortality in papaya under different agroclimatic condition depending upon soil type and crop species. Application of Bio-Pulse as seed biopriming with recommended dose of fertilizer resulted in yield increase in chickpea (15-25%), pea (20-30%), lentil (10-20%) and papaya (25-42%) under different pathogenic stress as compared to pathogen challenged condition.
6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

BioCompost Technology

1. Name of technology and its microbial constituent (Genus/species):

BioCompost is a carrier based formulation of consortium of four lignocellulolytic fungi namely *Phanerochaete chrysosporium*, *Trichoderma viride, Aspergillus awamori* and *Pleurotus florida*.

2. **Target crops and delivery system:** Agricultural residue of almost all field crops like wheat, rice, mustard, maize, and soybean can be converted into mature compost within 65- 70 days by pit or windrow methods. Each windrow is prepared using straw mix (substrates for composting) + Cow dung + good quality soil + old compost in the ratio of 8 : 1 : 0.5 : 0.5 (For preparing 1 ton of compost: 800 kg substrate + 100 kg fresh cowdung or poultry droppings + 50 kg soil + 50 kg old compost has to be mixed). In case, P enriched compost is to be prepared, Rock phosphate @1% is also added as a source of insoluble P. At all times, 65 -70 % moisture is maintained in the biomass. The piles containing raw material needs to be turned after every 15 days. By this process N (1-1.5%) and P (0.3-0.5%) enriched compost can be prepared from diverse crop residues within 70-75 days.

3. **Target agroecological zones (if any)**: For plains.

4. **Validation and commercialization**: Eight villages were covered in the districts of Mau and Azamgarh of Eastern Uttar Pradesh since the technology underwent spread under Rashtriya Krishi Vikas Yojna project sponsored by Govt. of Uttar Pradesh. The windrow composting technology has been disseminated among more than 1000 farmers in >24 villages of Mau and Azamgarh districts.

5. **Benefits:** The application of nutrient enriched compost in soil leads to a significant increase in the soil fertility status, in terms of microbial biomass, N and available P, enhancing the overall physical, chemical and biological health of soil. The Cost: Benefit ratio is 1:3 taking Rs 6/ per kg as the minimum sale price. The technology is very much suitable for the Swachh Bharat Abhiyan and will help to improve rural sanitation.

6. **Contact:** Director, ICAR- National Bureau of Agriculturally Important Microorganisms, Mau- 275103

IARI-PUSA-Biofertilizer Technologies

1. Name of the technology and its microbial constituent (Genus/ species):

A. Carrier Based inoculants:

Rhizobium | Azotobacter | P solubilizer | Azospirillum | Cyanobacteria | Mycorrhiza

Nitrogen Fixers

- BGA(Blue Green Algae) Consortium: Rice
- *Azotobacter chroococcum*: Cereals, vegetables
- *Azospirillum brasilense*: Cereals
- *Rhizobium* (different strain for different legumes) : Legumes

P-solubilizers

- *Pseudomonas* sp.: All crops
- *Lactobacillus* sp. :All crops
- *Bacillus* sp. :All crops

P-mobilizers

- Vesicular Arbuscular Mycorrhizae *:* All crops & protected cultivation

K and Zn

- *Pseudomonas* and *Bacillus* sp.: Cereals

Agriresidue degradation (Ex-situ)

- Fungal+Bacterial consortium paddy, wheat & corn residues
- Kitchen waste, horticultural waste, leaf litter

B. Liquid Based (for nutrients: N, P, K, Zn)

- N, K, P, Zn (individually) N-all crops; K, P, Zn: selected crops
- NPK consortium: all crops
- Compost consortium agriresidue waste, kitchen waste, horticultural waste

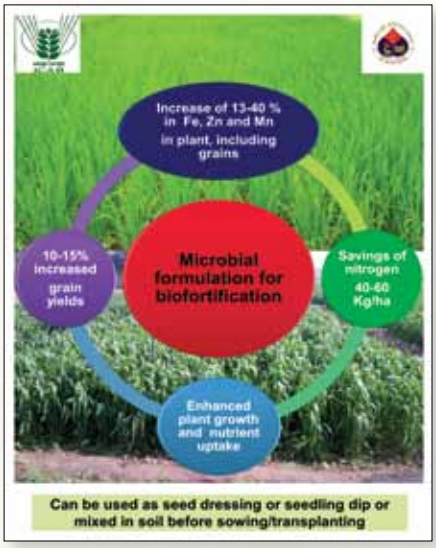
2. **Delivery system:**
   - Seed coating for all carrier based & liquid Biofertilizer
   - Placement in furrows: VAM
   - Machine spray: Liquid PUSA-compost
   - Broadcast in rice fields: BGA
3. **Target agroecological zones (if any):** All
4. **Validation and commercialization**: All technologies mentioned have been successfully validated in IARI and farmers' fields, and also under AICRP trials under different agroecological regions.They have been commercialized and licensed to private companies through IARI-ZTM Unit.
5. **Benefits:** PUSA-Biofertilizers have covered > than 10,000 ha of cultivated land for nutrient management. The Benefits of the PUSA Biofertilizer technologies has been very good both in terms of savings of chemical nitrogen, P, K as well as increase in crop yields besides improving soil health in a sustainable manner. Of all the field trials conducted over last ten years, it has been found to contribute 20-30 kg N/ha/season with increase in productivity of different crops by 8-25%. Similarly the P uptake has improved and saving of 20- 25 kg P_2O_5/ha has been recorded. The K augmentation have been observed to be 10-15 kg/ha and Zn about 5-7kg/ha. PUSA biofertilizer technology improves soil health by releasing growth promoting substances and maintains a continuous supply of nutrients to the crop. BGA biofertilizer technology led to enhanced yield and higher income for farmers. PUSA-Compost technology has become popular with the RWA coming forward to use it at individual and community levels.
6. **Contact:** Director, ICAR-Indian Agricultural Research Institute, New Delhi-110012

BioFort

1. Name of technology and its microbial constituent (Genus/species):

BioFort -Microbial formulation for effective micronutrient mobilization to wheat and rice grains

Two formulations, each containing a consortium of three plant growth promoting rhizobacteria were developed - (*Bacillus pumilus* PW1 + *Providencia* sp. PW5 + *Brevundimonas diminuta* PW7) for wheat and (*Providencia* sp. PR3 + *B. diminuta* PR7 + *Ochrobactrum anthropi* PR10) for rice**.** Field trials have proved that these inoculants can be used interchangeably in both crops



2. **Target crops and delivery system:** These microbial formulations (using compost: vermiculite, 1:1 as carrier) can enhance plant growth, improves N and P nutrient availability/ uptake and significant micronutrient enrichment of grains in rice and wheat. Shelf life tested for six months with no significant loss of activity, if stored in shade below 25 ^{o}C
3. **Target agroecological zones:** Indo-Gangetic plains
4. **Validation and commercialization**: Validated at IARI fields. Already registered at Zonal Technology Management & Business Planning and Development Unit , ICAR-IARI, New Delhi
5. **Benefits:** Application rate is 300 g /acre. Effective micronutrient mobilization to grains, with 13 – 40% increase in Fe, Zn and Mn concentrations. 40-60 kg N savings/ha/season/crop. 10-15% increase in yields
6. **Contact:** Director, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012

Cyanobiocon (A & C)

1. Name of technology and its microbial constituent (Genus/species):

Cyanobiocon A & C - Two formulations, each containing a native cyanobacterial strain - *Anabaena laxa (A) or Calothrix elenkinii (C)*, which exhibit fungicidal activity activity against phytopathogenic fungi (*Fusarium oxysporum / F. solani*, *Rhizoctonia solani, Macrophomina phaseolina, Magnaporthe oryzae* and *Pythium aphanidermatum / P. debaryanum).*

2. **Target crops and delivery system:** Nursery grown vegetables, cotton and rice. The formulations are not crop-specific and can be promising biocontrol formulations for use in integrated practices for the management of fungal diseases in a wide range of crops, particularly against soil-borne diseases, highly problematic nursery grown crops. Shelf life: Six months, if stored in shade below 25 °C. Using compost: vermiculite, 1:1 as carrier, these formulations can be used as seed dressing or seedling dip or mixed in soil before sowing; also being developed as soil drench and potting mix supplements.
3. **Target agroecological zones (if any):** Irrespective of zones/soil types/agroecologies
4. **Validation and commercialization**: Validated in IARI field, already registered at Zonal Technology Management & Business Planning and Development Unit , ICAR-IARI, New Delhi.
5. **Benefits:** Effective in vegetable crops (including tomato, pea - challenged by soil borne phytopathogenic fungi) and in "sick/diseased" plots of cotton and cucumber, leading to 10-40% reduction in disease severity and mortality, along with 12-30% increase in N and P uptake and yields.
6. **Contact:** Director, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012

Cyanonutricon

1. Name of technology and its microbial constituent (Genus/species):

Cyanonutricon- Plant growth promoting cyanobacterial formulation containing four cyanobacterial strains (*Anabaena torulosa* BF1, *Nostoc carneum* BF2, *Nostoc piscinale* BF3 *and Anabaena doliolum* BF4) promising for enriching macro and micronutrients and improving their availability in soil.

2. **Target crops and delivery system:** Formulation for rice, wheat, maize, cotton, vegetables and flowers. Developed using compost: vermiculite, 1:1 as carrier. Found to be promising under SRI/SWI, DSR/ZT and conventional mode of rice/wheat cultivation. Can be used as seedling dip or broadcast in fields before sowing/transplanting or as dried algal flakes for soil application in pots and fields; also suitable as seed dressing/potting mix supplements for nurseries of vegetable/flower crops. Shelf life tested for six months, if stored in shade below 25 °C.
3. **Target agroecological zones (if any):** Irrigated regions growing rice-wheat
4. **Validation and commercialization**: Validated in IARI field in various crops, and in flowers/ vegetables grown in the Centre for Protected Cultivation (CPCT, IARI). Already registered at Zonal Technology Management & Business Planning and Development Unit, ICAR-IARI, New Delhi.
5. **Whether licenced to private companies, if yes, details thereof:** In the process of licensing to various companies
6. **Benefits**: Can provide 20-25 kg N savings/ha/season; enhanced N, P availability and uptake by plant. Yield enhancement of 15-20% over RDF was recorded. Enrich carbon status of soil
7. **Contact:** Director, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012

IARI Compost Inoculant Technology

1. Name of technology and its microbial constituent (Genus/species):

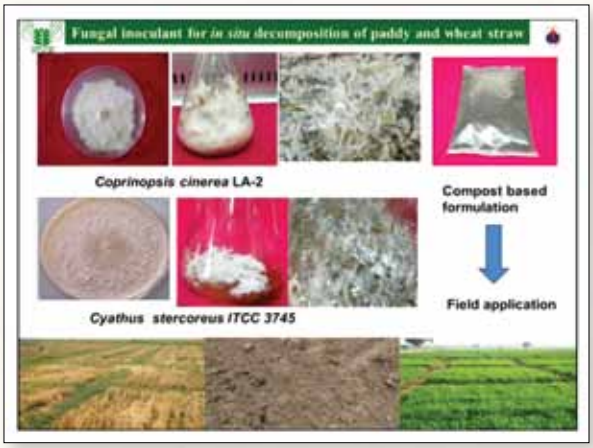
Compost inoculant consisting of a consortium of four promising lignocellulolytic fungi namely *Aspergillus nidulans*, *Trichoderma viride*, *Phanerochatae chrysosporium* and *Aspergillus awamori.*

2. **Target crops and delivery system:** The consortium can be used for composting of diverse agricultural wastes such as paddy straw, soybean trash, pearl millet, maize residues and mustard stover effectively. The C:N ratio of crop residues may be adjusted to 50 :1 by the addition of poultry droppings/cowdung by mixing in 8:1 ratio. A packet of 500g is enough to decompose 1 t of crop residue within 60-75 days.
3. **Target agroecological zones (if any)**: All ecological regions except cold climate
4. **Validation and commercialization**: Validated at IARI farm and farmers field. Carrier based 500g inoculant is sufficient for preparing compost of 1-ton of wastes (crop residues, paddy straw, animal manure, garden weeds and litter, grass, hedge cuttings, and garbage).
5. **Benefits:** By this process, N (1-1.5%) and P (0.3-0.5%) enriched compost can be prepared from diverse crop residues within 70-75 days. Its application in soil leads to significant increase in the soil fertility status, in terms of microbial biomass, N and available P. Application of 10 t of compost provides 120 kg N, 40 kg P_2O_5 and 30 kg K_2O, thus leading to saving of chemical fertilizers.
6. **Contact:** Director, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012

IARI Microbial Inoculant for in situ Degradation of Crop Residue

1. Name of technology and its microbial constituent (Genus/species):

A consortium of efficient lignocellulolytic fungi *Coprinopsis cinerea* and *Cyathus stercoreus* for in-situ degradation of paddy/ wheat stubbles.



2. **Target crops and delivery system**: The inoculant is designed for in situ degradation of wheat/paddy stubbles remaining after mechanical harvesting of wheat and paddy. The microbial inoculant @ 3 Kg/ha along with a basal dose of urea @ 30 Kg/ha can be applied directly on the paddy or wheat stubbles left in field. Field can be prepared with rotavator for next crop. A window of 15- 25 days is sufficient to degrade the paddy residue and no harmful effect was observed on yield of next crop.
3. **Target agroecological zones (if any):** North western region of India
4. **Validation and commercialization**: Technology is validated at ICAR-IARI field but not commercialized yet.
5. **Benefits:** The inoculant will help to reduce the paddy straw burning in fields, thereby minimizing air pollution and leading to environment-friendly in situ management of crop residues.
6. **Contact:** Director, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012

Low Temperature Composting Consortium

1. **Name of technology and its microbial constituent (Genus/species):**

   Low temperature composting consortium of *Penicillium ubiquetum*, *Penicillium rubens* and *Mucor plumbeus*

2. **Target crops and delivery system:** Composting of agri residues of all kinds at low temperature below 15 °C

3. **Target agroecological zones (if any)**: Hilly areas, cold deserts

4. **Validation and commercialization:** Validated at DIHAR (DRDO), Leh for 2 years and at IIWBR, Karnal for the composting of rice straw, wheat straw and leaf litter

5. **Benefits**: Degradation of paddy straw at low temperature in 45 to 60 days can help in managing the rice straw burning. Significant reduction in time of decomposition of agri-residues in hilly cold regions from more than 90 days to less than 50 days.

6. **Contact:** Director, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012

CRIDA Mixed Inoculum-I

1. **Name of the technology and its microbial constituent (Genus/ species):**

   CRIDA Mixed Inoculum-I: For drought stress management

   Pseudomonas putida P7 + *Paenibacillus favisporus* strain B30

2. **Target crops and delivery system:** Sorghum, Seed treatment
3. **Target agroecological zones (if any):** Telāngana
4. **Validation and commercialization:** Under evaluation at different rain-fed regions of the country.
5. **Benefits**: An increase of 12-20% in grain yield was observed due to inoculation along with 100% RDF under rainfed conditions in field experiments with sorghum compared to uninoculated control. The inoculum was also tested as seed inoculant in sorghum crop (Rabi season, ~3 ha) at farmers' fields (village: Utkur, Mahabubnagar Dist.).

6. **Contact:** Director, ICAR-Central Research Institute for Dryland Agriculture, Rajendranagar, Hyderabad- 500030

CRIDA Mixed Inoculum-II

1. **Name of the technology and its microbial constituent (Genus/ species):**

   CRIDA Mixed Inoculum-II: For drought stress management

   Pseudomonas putida P45 + *Bacillus amyloliquefaciens* B17

2. **Target crops and delivery system**: Sorghum and sunflower, Seed treatment
3. **Target agroecological zones (if any):** Telāngana
4. **Validation and commercialization:** Under evaluation at different rain-fed regions of the country
5. **Benefits:** Use of this consortium increased the yield of sunflower and sorghum upto 15-20 % under rain fed conditions.

6. **Contact:** Director, ICAR-Central Research Institute for Dryland Agriculture, Rajendranagar, Hyderabad- 500030

Biofort

1. Name of the technology and its microbial constituent (Genus/ species):

Bacillus aryabhattai MDSR14: A potential rhizobacteria for scavenging native phosphorus and zinc from soil for improved biofortification in Soybean and Wheat Grown in Vertisols

2. **Target crops and delivery system**: Soybean, Wheat
3. **Target agroecological zones (if any):** Central Zone or regions with vertisols
4. **Validation and commercialization :** It has been validated under field conditions on soybean and wheat crops at IISR farm.
5. **Benefits:** Inoculation of *B. aryabhattai* strain MDSR14 significantly increases seed yield by 30.7% and 48.0 %, in soybean and wheat crop respectively over un-inoculated control. Similarly, there was an increase of 21.4 % and 36.2 % in shoot Zn content and 37.5 and 42.7 % in seed Zn content, respectively in soybean and wheat crops. The inoculation with this strain increased Zn concentration in wheat up to 60.5 mg kg^{-1} as against 42.4 mg kg^{-1} in un-inoculated control hence the strain has a potential to be promoted as bio-inoculants to mitigate P, Zn and Fe deficiency in soils.
6. **Contact:** Director, ICAR-Indian Institute of Soybean Research, Near IT Park, Khandwa Road, Indore-452001

On-Farm Production Technology for AM Fungal Biofertilizer

1. **Name of the technology and its microbial constituent (Genus/ species):**
   AMF consortium of *Glomus mosseae, Glomus intraradices* and *Glomus* sp.
2. **Target crops and delivery system:** Soybean, Wheat
3. **Target agroecological zones (if any):** Central Zone or regions with vertisols
4. **Validation and commercialization:** AMF production under on-farm system can be achieved up to 25 IP/g soil (from less than 1 IP/g soil) after three years involving multiple consecutive multiplicative cycles consisting annual/seasonal trap plants. Sufficient number of propagules can be produced on 10 m^2 area which can meet the requirement of 25 acre field.
5. **Benefits:** AMF application can save upto 25% of external P fertilizers. The on-farm production of local strains of AMF is suitable for marginal farmers and also suitable for small medium size enterprise. Less expensive since the system can also be used for production of transplant seedlings. Enhanced shelf life (up to 50 °Celsius at 5-8% moisture).
6. **Contact:** Director, ICAR-Indian Institute of Soybean Research, Near IT Park, Khandwa Road, Indore-452001

Biocapsules

1. **Name of the technology and its microbial constituent (Genus/ species):**
   Biocapsules; encompasses any bacterial or fungal or actinobacterial strain

2. **Target crops and delivery system:** All crops, delivery by encapsulation
3. **Target agroecological zones (if any):** For all agro-ecological zones
4. **Validation and commercialization:** Validated in multi-location trials and commercialized
5. **Whether licensed to private companies, If yes, details thereof:** Licensed to two companies:
   - M/s Codagu Agritech
     Kudlur, PB No.58, Kushalnagar – 571234, Karnataka
   - M/s SRT Agro Science Pvt. Ltd.
     Vill: Funda, Tah: Patan, Durg-491111, Chhattisgarh
6. **Benefits:** This technology has now covered 5% of cropped area in states of Tamil Nadu, Karnataka, Kerala, Telengana, AP, Maharashtra, Gujarat and NE regions like Tripura, Assam and Nagaland; expected to cover at least 20% of the area across India in the next five years.

Trichoderma and *Bacillus amyloliquefaciens* capsules commercialized

Rhizobium and Azotobacter capsules commercialized by M/s SRT Agro Science Pvt. Ltd, Chhattisgarh

7. **Contact:** Director, ICAR-Indian Institute of Spices Research, Marikunnu PO, Kozhikode-673012

Arka Microbial Consortium

1. Name of the technology and its microbial constituent (Genus/ species):

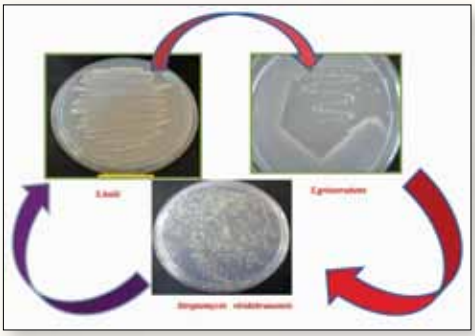
Arka Microbial Consortium comprise of the N fixing *Azotobacter tropicalis* strain PAN MC 1, P and Zn solubilizing *Bacillus aryabhattai* strain Bel 6, K mobilizing and plant growth promoting *Pseudomonas taiwanensis* strain Mpf2.

2. **Target crops and delivery system:** All horticultural crops. Available as a solid carrier and liquid inoculum.
3. **Target agroecological zones (if any):** Used widely across horticultural crops and field crops alike in the state of Karnataka
4. **Validation and commercialization:** Approved for commercial use by the Varietal and Technology Identification Committee of ICAR-IIHR, Bengaluru during 2011.
5. **Whether licensed to private companies, If yes, details thereof:** Yes. Licensed to thirteen entrepreneurs/KVK's and State departments.
   i. M/s Bloom Biotech, Chikkamagalur – 50 tonnes / year
   ii. M/s Gayatri Hasiru Uddime , Ramnagara District – 50 tonnes / year
   iii. ICAR-KVK, Hirehalli , Tumakuru District, Karnataka - 10 tonnes/ year
   iv. Department of Horticulture , GoK, Bengaluru- 200 tonnes / year
   v. M/s Phalada Organics, Bengaluru - 50 tonnes / year
   vi. ICAR- KVK, Gonikoppal , Kodagu District, Karnataka- 10 tonnes / year
   vii. M/s Natura Crop Care, Bengaluru- 50 tonnes / year
   viii. M/s Janardhana Bengaluru – 10 tonnes / year
   ix. M/s Bhavani Biochemicals – 50 tonnes / year
   x. M/s ESAF Swarasya Farmers Producers Organization, Palakkad - 50 tonnes / year
   xi. M/s ESAF Swarasya Farmers Producers Organization, Palakkad
   xii. M/s Ganpath Products, Madurai, Tamil Nadu
   xiii. M/s JSS Krishi Vigyan Kendra, Mysuru
   xiv. State Parasite Breeding Farm, Kasaragod, Kerala
6. **Benefits:** The licensees put together have an installed capacity of 1000 t/annum which is sufficient to cater to the needs of 2 lakh acres of land. Yield increases of 6-16 % recorded in various horticultural crops. Its application can reduce 25 % of N&P fertilizer application.
7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Hassaraghatta Lake Post, Bengaluru-560089

Arka Actino-Plus

1. Name of the technology and its microbial constituent (Genus/ species):

Arka Actino-Plus is an exclusive Actinobacterial formulation for plant health management. It comprises of the Actinobacterial strains viz., *Streptomyces viridobrunneus* strain Pan Act1, *Streptomyces bullii* strain Pan Act2 and *Streptomyces griseorubens* strain Pan Act3.



2. **Target crops and delivery system:** All horticultural crops. Available as a solid carrier and liquid inoculum.
3. **Target agroecological zones (if any)**: Karnataka
4. **Validation and commercialization:** Approved for commercial use by the Varietal and Technology Identification Committee of ICAR-IIHR, Bengaluru during 2015.
5. **Whether licensed to private companies, If yes, details thereof:** Yes. Licensed to.
   - M/s Bloom Biotech, Chikkamagalur
6. **Benefits:** The technology is being widely adopted in various crops. A unique feature of the technology is its ability to enhance the rhizospheric availability of the applied organic matter. It helps in the recovery of guava plants showing bronzing symptoms.

Weak Plant with bronzing symptoms

Recovered plants (after 5 months)

7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Hassaraghatta Lake Post, Bengaluru-560089

Arka Fermented Cocopeat

1. Name of the technology and its microbial constituent (Genus/ species):

Arka Fermented Cocopeat is produced by the bioconversion of raw coirpith by the tannase producing fungal consortium of *Aspergillus heteromorphus* strain PATHLF-1 and *Aspergillus herteromorphus* strain HSGLF-1. It is subsequently enriched with the Arka Microbial Consortium

Raw Coir Pith Fermented Cocopeat

2. **Target crops and delivery system**: Suitable as a nursery substrate for all horticultural crops and nursery raised crops and field crops like sugarcane.
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** Approved for commercial use by the Varietal and Technology Identification Committee of ICAR-IIHR, Bengaluru during 2011.
5. **Whether licensed to private companies, If yes, details thereof**: Yes. Licensed to five entrepreneurs.
   i. M/s Chennakeshava Swamy Industries, Doddaballapur Bangalore
   ii. M/s Bloom Biotech, Chikkamagalur (50 tonnes / year)
   iii. M/s Natura Crop Care, Bengaluru (50 tonnes / year)
   iv. M/s Janardhana , Bengaluru (10 tonnes / year)
   v. M/s Sneha Eco -Solutions, Kollegal, Karnataka (10 tonnes/year)
6. **Benefits:** The technology has been widely adopted by nurserymen since it reduces the cost of cocopeat by almost Rs. 2 per kg, besides giving rise to healthy and vigorous seedlings.

Seedlings raised on Arka Fermented Cocopeat

7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Hassaraghatta Lake Post, Bengaluru-560089

Soilless Arbuscular Mycorrhizal Fungal Inoculum

1. **Name of the technology and its microbial constituent (Genus/ species):**

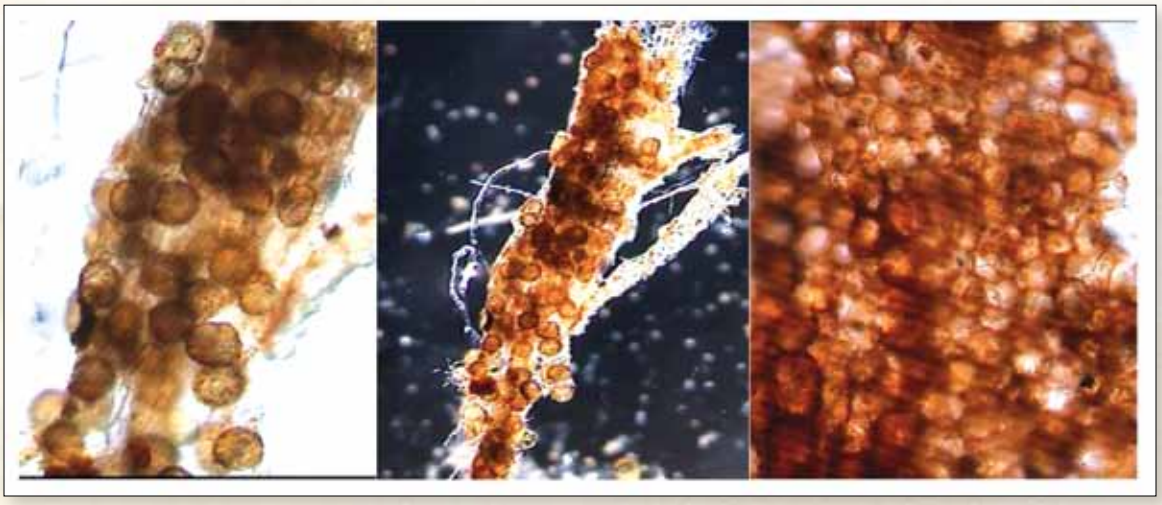
   Soilless Arbuscular Mycorrhizal Fungal Inoculum. The technology provides a method for soilless production of AM fungal inoculum by utilizing sterile Arka Fermented Cocopeat as the sole substrate for host plant growth with the intervention of a mycorrhizal helper bacterium (*Pseudomonas taiwanensis*)

2. **Target crops and delivery system**: Substrate for all horticultural crops with the exception of non-mycorrhizal crops belonging to families Brassicaceae and Chenopodiaceae.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** Approved for commercial use by the Varietal and Technology Identification Committee of ICAR-IIHR, Bengaluru during 2016.

5. **Benefits:**The benefits that accrue from this technology include increased propagule density per gram of inoculum, freedom from nematodes and pathogens, reduced inoculum dosage.



spores within host roots grown on Arka Fermented Cocopeat

6. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Hassaraghatta Lake Post, Bengaluru-560089

KeraProbio™

1. Name of the technology and its microbial constituent (Genus/ species):

KeraProbio™: Talc based multifunctional PGPR (*Bacillus megaterium*) for raising healthy coconut seedlings. The PGPR possess multiple plant growth promotion properties including hormone production and pathogen suppression activities.

2. **Target crops and delivery system:** Coconut; The bioinoculant is effective for vegetables such as tomato, brinjal and chilli grown as intercrops in coconut garden.
3. **Target agroecological zones (if any)**: Kerala
4. **Validation and commercialization:** Validated under AICRP- Palms and farmers' fields
5. **Whether licensed to private companies, If yes, details thereof**: The product has been commercialized to an entrepreneur group of Farmers First Program (FFP) in Pathiyoor panchayath of Aleppey District. The group has launched the product as Kalpakam Kera Probio. The FFP group has applied for obtaining license for their product with Kerala Government through Agriculture Department.
6. **Benefits:** The main Benefits of application of KeraProbio to coconut seedlings are:
   i. improved root growth and establishment,
   ii. better nutrition uptake even from nutrient-poor soils,
   iii. quicker growth compared to conventionally raised seedlings resulting in development of healthy and robust seedlings.
   iv. An yield enhancement of 10 -12% nuts/palm/yr when included in organic farming or INM based farming could fetch an additional remuneration to the tune of Rs. 20,000/ha/yr to coconut farmer and if vegetable is cultivated as intercrop, then about Rs. 30-40,000/ha/yr (depending upon the prevailing price).
7. **Contact:** Director, ICAR-Central Plantation Crops Research Institute, Kudlu PO Kasaragod-671124

CocoaProbio™

1. **Name of the technology and its microbial constituent (Genus/ species):**

   CocoaProbio™: A talc based multifunctional PGPR (*Pseudomonas putida*) for raising healthy cocoa seedlings.

2. **Target crops and delivery system:** Cocoa
3. **Target agroecological zones (if any)**: South India
4. **Validation and commercialization:** Evaluated at different cocoa growing places in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana.
5. **Benefits:** The application of bioinoculant showed an increase of 56% dry matter contents in cocoa seedlings. The translation of this growth promotion in terms of yield is being evaluated at different cocoa growing places.
6. **Contact:** Director, ICAR-Central Plantation Crops Research Institute, Kudlu PO Kasaragod-671124

KerAM™

1. **Name of the technology and its microbial constituent (Genus/ species):**

   KerAM™ : A soil based mycorrhiza (*Claroideoglomus etunicatum*) for raising healthy coconut seedlings.

2. **Target crops and delivery system:** Coconut
3. **Target agroecological zones (if any)**: South India
4. **Validation and commercialization:** Evaluated at different coconut growing places in Kerala.
5. **Benefits:** *Claroideoglomus etunicatum* is one of the dominant AM species isolated from coconut agro-ecosystem with high potential to increase the growth parameters of coconut seedlings.
6. **Contact:** Director, ICAR-Central Plantation Crops Research Institute, Kudlu PO Kasaragod-671124

Kalpa Organic Gold

1. Name of the technology and its microbial constituent (Genus/ species):

Kalpa Organic Gold : Vermicompost prepared from coconut leaves mixed with cow dung and using local isolate of *Eudrilus* earthworm obtained from CPCRI

2. **Target crops and delivery system:** Coconut leaves
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** Evaluated at different coconut growing places in Kerala. The technology has been commercialized to several farmers/ entrepreneurs as well as corporate house like SPIC.
5. **Whether licensed to private companies, If yes, details thereof:** Biotech Division, SPIC, Coimbatore
6. **Benefits:** About 4 to 4.5 tonnes of fresh vermicompost can be produced from coconut leaves which can meet 25 % of the nitrogen requirement of coconut palms of 1 ha area. The yield improvement of 24% (approx 11 nuts/palm) with 50% chemical N replacement adds to the reduction in the expenditures on chemical fertilizer. A coverage of 25,000 ha coconut area under vermicompost improves the economic returns close to Rs. 64 crores each year. In addition the ecosystem services improved by the addition of vermicompost in terms of organic carbon and beneficial microbiota added to soil makes the crop sustainable. The vermicompost is an ideal input for agri-horti industries for use as soilless medium.
7. **Contact:** Director, ICAR-Central Plantation Crops Research Institute, Kudlu PO Kasaragod-671124

Kalpa Soil Care

1. **Name of the technology and its microbial constituent (Genus/ species):**

   Kalpa Soil Care: Urea free coir-pith compost

2. **Target crops and delivery system:** Coir-pith
3. **Target agroecological zones (if any)**: All
4. **Validation and commercialization:** Evaluated at different coconut growing places in Kerala. The technology has been commercialized to several farmers/entrepreneurs as well as corporate house like SPIC.
5. **Whether licensed to private companies, if yes, details thereof**-"Biotech Division, SPIC, Combatore; Cladis Pvt. Ltd., Calicut; Chooral Coir Unit, Payyanur, Kerala; Banana Biotech Pvt. Ltd., Andhra Pradesh
6. **Benefits:** A simple farmer-friendly technology to compost the lignin rich coir-pith within 60 days using poultry manure, lime and rock phosphate. The coir pith compost has 1.3-1.4 %N, 0.9- 1.2% P and 1.3 to 1.6 % K and its application can curtail the use of chemical fertilizers. Very high organic carbon content of 28-30% improves the soil organic matter content in a sustainable manner. Highly beneficial for improving soil physical and biological properties. Improves the water holding capacity of soils significantly. It is an ideal input for agri-horti industries for use as soilless medium.
7. **Contact:** Director, ICAR-Central Plantation Crops Research Institute, Kudlu PO Kasaragod-671124

NutBoost

1. Name of the technology and its microbial constituent (Genus/ species):

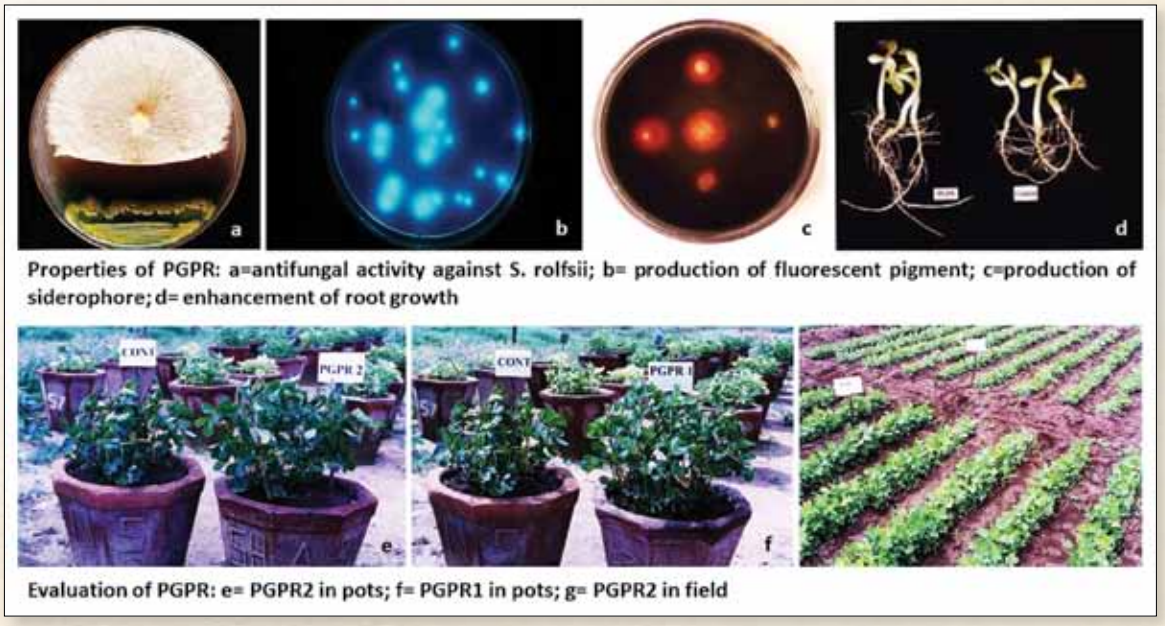
NutBoost: A formulation of consortium of PGPRs (P, K, and Zn solubilizer) comprising of *Pseudomonas gessardii* BHU1(PGPR1), *Pseudomonas putida* S1(6) (PGPR2) and *Pseudomonas aeruginosa* BM6 (PGPR4) isolated at Junagadh from groundnut rhizosphere.

2. **Target crops and delivery system**: Groundnut; NutBoost can be applied after dilution through irrigation water or through FYM after multiplication in FYM or through drip or as seed treatment.

3. **Target agro-ecological zones (if any)**: All groundnut growing areas

4. **Validation and commercialization:** The technology has been validated at DGR and farmers' fields, Junagadh; multilocations in India through AICRP(G) centres for three years and demonstration through FLDs.

5. **Benefits:** Seed inoculations can enhance pod yields by 16.5 to 18.1 % over the un-inoculated control. These PGPR isolates have been recommended for irrigated and rainfed groundnut cultivation in India on the basis of the performance. The FLDs conducted in India with groundnut showed yield response of 18% with B:C ratio of 2.46 (ICBR:6.4). The formulation has shelf-life >1yr at room temperature. Application of NutBoost can save 30-40% of externally applied phosphatic and 25% of potassium fertilizers



Properties of PGPR: a=antifungal activity against S. rolfsii; b= production of fluorescent pigment; c=production of siderophore; d= enhancement of root growth

Evaluation of PGPR: e= PGPR2 in pots; f= PGPR1 in pots; g= PGPR2 in field

6. **Contact:** Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001

NutMagic

1. Name of the technology and its microbial constituent (Genus/ species):

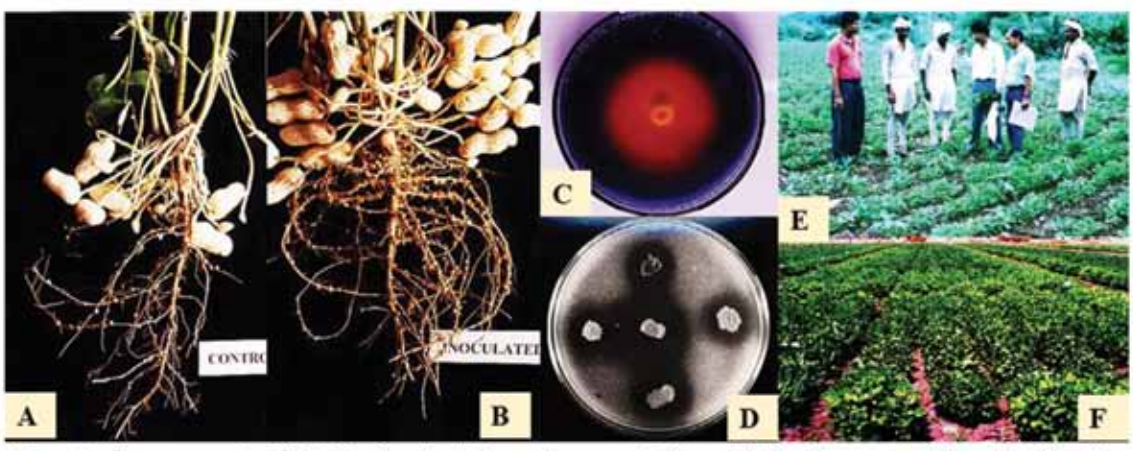
NutMagic: A formulation of consortium of PGPR (*Pseudomonas gessardii* BHU1, *Pseudomonas putida* S1(6)); PSB (*Enterobacter cloacae* BM8; *Bacillus polymyxa*) and rhizobia (*Sinorhizobium americanum* NRCG4 and *Rhizobium* sp. NRCG9).

2. **Target crops and delivery system**: Groundnut; NutMagic can be applied after dilution through irrigation water or through FYM after multiplication in FYM or through drip or as seed treatment

3. **Target agroecological zones (if any)**: All groundnut growing areas

4. **Validation and commercialization:** The technology has been validated at DGR and farmers' fields, Junagadh; multilocations in India through AICRP(G) centres for three years and demonstration through FLDs.

5. **Benefits:** Improvement in nutrient mobilization and uptake like P, K, N, Fe, Zn, Mn etc. Enhancement in biological nitrogen fixation by 25-30%. Compatible with seed treating chemicals like Bavistin (Carbendazime)/Thiram. Yield advantage can be upto 20% and formulation has shelf life >1 yr at room temperature. Application of NutMagic can save 25-30% of nitrogenous, 30-40% of phosphatic and 25% of potassic fertilizers

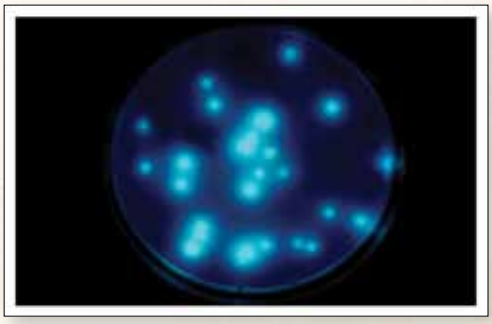


Impact of components of NutMagic: A & B= enhancement in nodulation by competitive rhizobia; C= production of siderophore by PGPR strain; D= phosphate solubilisation by PSB; E = demonstration of the effect of rhizobia in farmers field; F= evaluation trial of PGPR at DGR research farm

6. **Contact:** Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001

NutGrow

1. Name of the technology and its microbial constituent (Genus/ species):



NutGrow: Diacetyl-fluoroglucinol producing multiple plant growth phloroglucinol fluorescent pseudomonads (*Pseudomonas putida* DAPG2, *P. putida* DAPG4, *P. fluorescens* FP98 and *Pseudomonas putida* FP86)

2. **Target crops and delivery system**: Groundnut for stimulation of plant growth, solubilisation and mobilization of nutrients besides suppressing soil-borne fungal pathogens like *Sclerotium rolfsii*, *Aspergillus niger* and *Aspergillus flavus* and nematodes. NutGrow can be applied after dilution through irrigation water or through FYM after multiplication in FYM or through drip or as seed treatment or as soil drenching
3. **Target agroecological zones (if any)**: All groundnut growing areas
4. **Validation and commercialization:** The technology has been validated at DGR and at farmers' fields, Junagadh; multilocations in India through AICRP(G) centres and demonstration through FLDs. The strains were recommended for cultivation of both summer and kharif groundnut in 2017.
5. **Benefits:** NutGrow application reduces the mortality of the groundnut seedlings from 73-82% in pathogen control to 21-42% in different treatments inoculated with the inoculant strains against natural death of 5-9% in field conditions with susceptible cultivar GG20. Improves the yield of cultivar GG20 by 13-21% over the years over un-inoculated control. Reduces incidence of collar and stem rot by 40-60%. Improves availability of macro- and micro-nutrients (P, K, Mn, Fe, Zn, etc.) by 20-25%. Controls nematodes in soil. Save upto 30% of externally applied fertilizers like P, K, Zn, Fe, etc.
6. **Contact:** Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001

DroughtGuard

1. **Name of the technology and its microbial constituent (Genus/ species):**
   Formulation of Endophytic bacteria: *Bacillus firmus* J22
2. **Target crops and delivery system**: For alleviation of drought stress in groundnut, soybean and pigeonpea. DroughtGuard can be applied as seed treatment, after dilution through irrigation water or through FYM after multiplication or through drip.
3. **Target agroecological zones (if any)**: All groundnut growing areas strictly under rainfed situation. Life saving irrigation is not required.
4. **Validation and commercialization:** The technology has been validated at DGR and farmers' fields, Junagadh with cultivar TG37A; farmers' fields at Anantapur and Kalyandurga district of Andhra Pradesh with cultivar Kadiri 9 as OFTs; farmers' fields at Hiriyur, Karnataka
5. **Benefits:** Water saving: Summer groundnut is raised with the application of 10-12 irrigations depending upon soil type. But with the application of drought-stress alleviating endophytic bacteria, at least 3-4 irrigations can be saved without much reduction in yield. Horizontal expansion in area: the saved water can be utilized for horizontal expansion of irrigated area and thus total production can be improved substantially. Economic benefit: As application of three protective irrigations after emergence with *Bacillus firmus* J22 gave 2260-2309 kg/ha of pod yield equivalent to that obtained with 10 irrigations after emergence (2233-2483 kg/ha), doubling the area with same available water can double the production and income. Benefits in farmers' field: Demonstration in the farmers' field at Anantapur District of Andhra Pradesh with cultivar Kadiri 9 and 180 mm rainfall and two protective irrigations gave 32% yield improvement with *Bacillus firmus* J22 over untreated control. Benefits to other crops: *Bacillus firmus* J22 could alleviate drought stress in Soybean and pigeonpea and could prevent yield loss by 20%.

6. **Contact:** Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001

SalGuard

1. **Name of the technology and its microbial constituent (Genus/ species):**
   Formulation of Endophytic bacteria: *Bacillus firmus* J22 and *Bacillus subtilis* REN51
2. **Target crops and delivery system**: Groundnut; seed treatment or through drip or through irrigation water after dilution
3. **Target agroecological zones (if any)**: Groundnut growing areas affected by salinity (particularly Kachchh, Porbandar, Junagadh, Dwarka, Gir-Somnath and Surendranagar districts of Gujarat)
4. **Validation and commercialization:** The technology has been validated at experimental and farmers' fields as OFTs, Bhuj with cultivar TG37A and EC of 5-6
5. **Benefits:** Application of *Bacillus firmus* J22 and *Bacillus subtilis* REN51 can prevent yield losses upto 20% over uninoculated control. Inculation results in average increase in pod yield of 17.9% over control. The haulm yield increased by 6% due to seed treatment over the control. The bacterial seed treatment was economically beneficial as a net return of Rs 79,320/ha along with BCR of 2.37 was recorded under treated plot as against Rs 63,895/ha with BCR of 2.15 in control. Application of endophytes is beneficial for groundnut cultivation in salinity affected areas and more salinity affected areas can be brought under cultivation with the help of endophytes in future.
6. **Contact:** Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001

Microbial biopolymer for smart farming

1. Name of the technology and its microbial constituent (Genus/ species):

Microbially derived biopolymer is a metabolic product of a *Rhizobium* sp. associated with halophytic weed *Psoralea corylifolia* L. The product is a carbohydrate-rich polymer, having excellent gelability, heat stability, and has diversity of reactive functional groups that can interact with variety of metal ions including micronutrients. Further the product has unique ability to induce microbial colonization, which is an important aspect for sound crop performance and soil health. The product is completely green in nature, and undergoes microbial decomposition in soil environment.

2. **Target crops and delivery system**:

   The biopolymer is suitable for use in variety of crops including cereals, millets, legumes, vegetables, spices, and oilseed crops. Application of the biopolymer can be done through foliar spray, drip-irrigation system, seed-treatment, root-dipping for seedlings.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:** The technology has been validated for sorghum, soybean, maize, brinjal, onion, fenugreek, at ICAR-NIASM headquarters.

5. **Whether licensed to private companies, If yes, details thereof**: A patent application (3127/ MUM/2015) has been filed for 'Development of a Microbially Derived Polymeric Product for Gel formation, Microbial Colonization, and Metals Binding'. The technology is yet to be transferred to the interested companies.

6. **Benefits:**The biopolymer has shown promising response in different crops under drought conditions. Further, it has demonstrated significant capacity to induce rhizosphere colonization by different beneficial microbes such as nitrogen fixers, siderophore producers, and exopolysaccharides producers. The product has promoted nodule formation in soybean. Overall, the biopolymer has great applicability under drought conditions where moisture is critical factor for survival of the plants. Additionally, the biopolymer has shown significant influence on soil microbiota, which is a critical factor for maintaining soil health in long term.

7. **Contact:** Director, ICAR- National Institute of Abiotic Stress Management, Malegaon (kh) Baramati –413115, Pune, Mahrarashtra, India.

Goa Bio-1

1. Name of the technology and its microbial constituent (Genus/ species):

Goa Bio-1 is a bioformulation containing a salt tolerant plant growth promoting bacterium (*Bacillus methylotrophicus* strain STC-4). The talc formulation has a longer shelf life of more than 24 months. The bioformulation can be stored under ambient temperature.

2. **Target crops and delivery system:** Goa Bio-1 can be used in paddy (under saline and non-saline soils), vegetable crops (brinjal, tomato, chilli and cucumber), black pepper, fruit and plantation crop nurseries. Application of talc formulation is through seed treatment, soil application in nursery and main field.

3. **Target agroecological zones (if any):** All

4. **Validation and commercialization:** The technology has been validated at ICAR- CCARI, Goa and under farmers' field in rice, vegetable crops and black pepper. Large scale demonstration and validation was done in farmers' fields through tribal sub plan and SCSP programmes.

5. **Benefits:** Benefits of using Goa Bio-1 include, better nutrient mineralization; alleviation of salinity stress; better crop establishment; improved plant growth parameters, yield and soil biological activity. In paddy, application of bioformulation with NPK and bioformulation with organic manure recorded higher growth parameters when grown under saline conditions. In Korgut local land race, higher grain yield was recorded in bioformulation with NPK (1.31 t ha^{-1}) followed by NPK (1.28 t ha^{-1}) and bioformulation with OM (1.25 t ha^{-1}). Application of bioformulation in nursery (1.19 t ha^{-1}) and in field also increased the grain yield (1.17 t ha^{-1}) compared to control. In field demonstrations, 12.0% increase in grain yield was recorded. Application of talc formulation reduced the incidence of soil borne diseases in vegetable crops (40-60%) and foot rot in black pepper (70-80%).

Rice Black Pepper

Application of Goa Bio-1 to rice, black pepper plantation and chilli

6. **Contact:** Director, ICAR- Central Coastal Agricultural Research Institute, Old Goa 403 402 Goa.

Goa Bio-2

1. Name of the technology and its microbial constituent (Genus/ species):

Goa Bio-2 is a bioformulation containing a plant growth promoting antagonistic bacterium (*Bacillus methylotrophicus* RCh6-2b). The talc formulation has a longer shelf life of more than 24 months without any loss of bacterial populations(8 log CFU g^{-1}). The bioformulation can be stored under ambient temperature.

2. **Target crops and delivery system:** Goa Bio-2 can be used in vegetable crops (brinjal, tomato, chilli and cucumber), black pepper, fruit and plantation crop nurseries. Application of talc formulation is through seed treatment, soil application in nursery and main field.

3. **Target agroecological zones (if any):** All

4. **Validation and commercialization:** The technology has been validated at ICAR- CCARI, Goa and under farmers' fields in vegetable crops and black pepper. Large scale demonstration and validation was done in farmers' fields through tribal sub plan and SCSP programmes.

5. **Benefits:** Benefits of using Goa Bio-2 include, improved plant growth parameters, plant health and yield; reduced soil borne diseases incidence in brinjal (70-80% bacterial wilt), chilli(40-60% wilt and root rot) and black pepper (70-80% foot rot); important component in IPM strategy and eco-friendly hence fits in organic farming concept. The results of various studies conducted clearly showed that soil borne disease incidence was significantly lower and growth is improved in Goa Bio-2 treated plants .

Goa Bio-2 treated chilli fields and black pepper plantation

6. **Contact:** Director, ICAR- Central Coastal Agricultural Research Institute, Old Goa 403 402, Goa.

Liquid Bioinoculant of Endophytic Nitrogen Fixing Bacteria for Rice Crop

1. Name of the technology and its microbial constituent (Genus/ species):

Liquid bioinoculant of endophytic nitrogen fixing bacteria is a quality bioformulation particularly for rice crop, comprising with nitrogen (N_2) fixing (*Azotobacter chroococcum Avi2*) bacteria. It has a longer shelf life (more than 12 months) without loss of microbial populations and properties.

2. **Target crops and delivery system**: Liquid bioinoculant of endophytic nitrogen fixing bacteria *A. chroococcum Avi2* is suitable for rice crop. Inoculation can be done through seed treatment, and root dip for seedlings.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated at multiple locations of farmers' field (30 villages of Cuttack & Puri district) of Odisha and also given very encouraging results at NRRI field.
5. **Benefits:** Liquid bioinoculant of endophytic nitrogen fixing bacteria for rice crop has shown remarkable response in the farmers' field with respect to crop growth and yield. It could save the usage of chemical fertilizers by 25% of the recommended dose without compromising yield and growth of the plants. Application of this biofertilizer with 75% recommended dose of fertilizer resulted in at par yield in rice with 100 % RDF.
6. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack – 753006.

Liquid Bioinoculant of Rhizospheric Nitrogen Fixing Bacteria for Rice Crop

1. Name of the technology and its microbial constituent (Genus/ species):

Liquid bioinoculant of rhizospheric nitrogen fixing bacteria is a quality bioformulation particularly for rice crop, comprising with nitrogen (N_2) fixing (*Azotobacter vinelandii* SRIAz3) bacteria. It has a longer shelf life (more than 12 months) without loss of microbial populations and properties.

2. **Target crops and delivery system**: Liquid bioinoculant of rhizospheric nitrogen fixing bacteria (*A. vinelandii* SRIAz3) can be used for rice crop. Inoculation can be done through seed treatment, and root dip for seedlings.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated at multiple locations of farmers' fields (30 villages of Cuttack & Puri district) and also given very encouraging results at NRRI field.
5. **Benefits:** Liquid bioinoculant of rhizospheric nitrogen fixing bacteria for rice crop has shown the remarkable response in the farmers' field with respect to crop growth and yield. It could save the usage of chemical fertilizers upto 15-25% of the recommended dose without compromising yield and growth of the plants. Application of this biofertilizer with 75% recommended dose of fertilizer resulted in at par yield in rice with 100 % RDF.
6. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Talc-Based Formulation Of Metarhizium For Managing Rice Leaf Folder

1. Name of the technology and its microbial constituent (Genus/ species):

Talc-based formulation of *Metarhizium anisopliae* TF19 is a unique biopesticide particularly for managing rice leaf folder. It has a longer shelf life (more than 6 months) without loss of microbial populations and properties.

2. **Target crops and delivery system:** Talc-based formulation of *M. anisopliae* TF19 can be used for managing rice leaf folder. Inoculation can be done through spraying.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated in farmers' fields of Mahanga, Nischinticuil & Santpur villages of Odisha and also experimental field of NRRI, Cuttack, Odisha for four consecutive seasons.
5. **Whether licensed to private companies, if yes, details there of**: A patent application (patent numbered 265/ KOL/2015 dated 10.03.2015) has been filed.
6. **Benefits:** Talc-based formulation of *M. anisopliae* TF19 for managing rice folder has shown the remarkable response in the farmers' fields with leaf folder mortality of 76.83%. It could save the harmful effect of chemical pesticides in soil and human health.
7. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Talc-Based Formulation of Baeuveria for Managing Rice Leaf Folder

1. Name of the technology and its microbial constituent (Genus/ species):

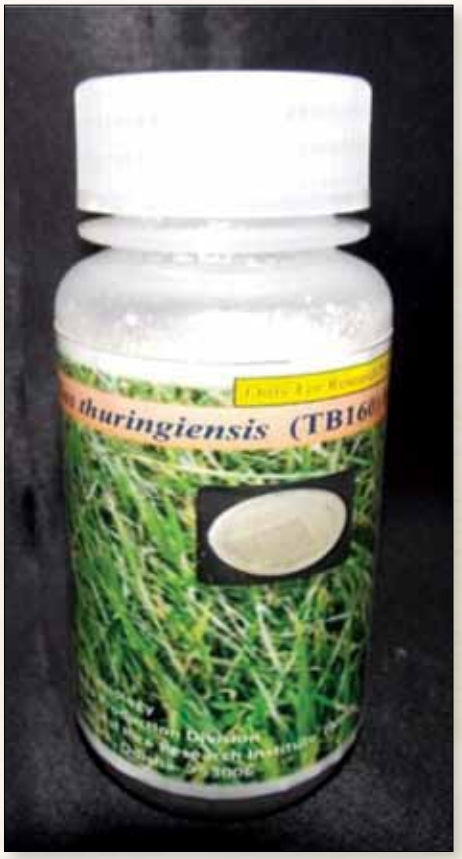
Talc-based formulation of *Baeuveria bassiana* TF6 is a unique biopesticide particularly for managing rice leaf folder. It has a longer shelf life (more than 8 months) without loss of microbial populations and properties.

2. **Target crops and delivery system:** Talc-based formulation of *Baeuveria* can be used for managing rice leaf folder. Inoculation can be done through spraying.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated in farmers' fields of Mahanga, Nischinticuil & Santpur villages of Odisha and also experimental fields of NRRI, Cuttack, Odisha for four consecutive seasons.
5. **Whether licensed to private companies, if yes, details there of**: A patent application (patent numbered 260/ KOL/2015 dated 10.03.2015) has been filed.
6. **Benefits:** Talc-based formulation of *Baeuveria bassiana* TF6 for managing rice folder has shown the remarkable response in the farmers' field with leaf folder mortality of 74.00%. It could save the harmful effect of chemical pesticides in soil and human health.
7. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Bentonite-Based Formulation of Bt (TB160) for Managing Rice Leaf Folder

1. Name of the technology and its microbial constituent (Genus/ species):

Bentonite-based formulation of *Bacillus thuringiensis* (TB160) is a unique biopesticide particularly for managing rice leaf folder. It has a longer shelf life (more than 8 months) without loss of microbial populations and properties.



2. **Target crops and delivery system:** Bentonite-based formulation of Bt (TB160) can be used for managing Rice leaf folder. Inoculation can be done through spraying.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated in farmers' fields of Mahanga, Nischinticuil & Santpur villages of Odisha and also experimental fields of NRRI, Cuttack, Odisha for four consecutive seasons.
5. **Whether licensed to private companies, if yes, details there of**: A patent application (patent numbered 264/ KOL/2015 dt. 10.03.2015) has been filed.
6. **Benefits:** Bentonite-based formulation of *B. thuringiensis* (TB 161) for managing rice folder has shown the remarkable response in the farmers' field with leaf folder mortality of 82.34%. It could save from harmful effects of chemical pesticides on soil and human health.
7. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Bentonite-Based Formulation of Bt (TB161) for Managing Rice Leaf Folder

1. Name of the technology and its microbial constituent (Genus/ species):

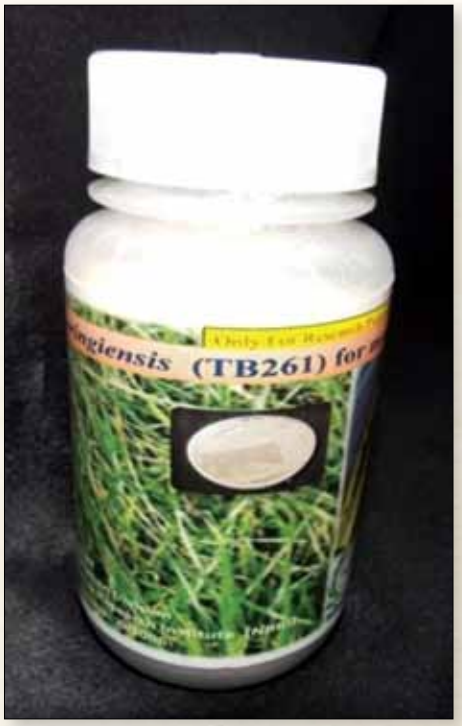
Bentonite-based formulation of *Bacillus thuringiensis* (TB161) is a unique biopesticide particularly for managing rice leaf folder. It has a longer shelf life (more than 8 months) without loss of microbial populations and properties.

2. **Target crops and delivery system**: Bentonite-based formulation of Bt (TB161) for managing rice can be used for managing rice leaf folder. Inoculation can be done through spraying.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated in farmers' fields of Mahanga, Nischinticuil & Santpur villages of Odisha and also experimental fields of NRRI, Cuttack, Odisha for four consecutive seasons.
5. **Whether licensed to private companies, if yes, details there of**: A patent application (patent numbered 263/ KOL/2015 dated 10.03.2015) has been filed.
6. **Benefits:** Bentonite-based formulation of *B. thuringiensis* (TB 161) for managing rice folder has shown the remarkable response in the farmers' field with leaf folder mortality of 79.29%. It could save from harmful effects of chemical pesticides on soil and human health.
7. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Bentonite-Based Formulation of Bt (TB261) for Managing Rice Leaf Folder

1. Name of the technology and its microbial constituent (Genus/ species):

Bentonite-based formulation of *Bacillus thuringiensis* (TB261) is a unique biopesticide particularly for managing rice leaf folder. It has a longer shelf life (more than 8 months) without loss of microbial populations and properties.



2. **Target crops and delivery system**: Bentonite-based formulation of Bt (TB261) for managing rice can be used for managing rice leaf folder. Inoculation can be done through spraying.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated in farmers' fields of Mahanga, Nischinticuil & Santpur villages of Odisha and also experimental fields of NRRI, Cuttack, Odisha for four consecutive seasons.
5. **Whether licensed to private companies, if yes, details there of**: A patent application (patent numbered 261/ KOL/2015 dt. 10.03.2015) has been filed.
6. **Benefits:** Bentonite-based formulation of *B. thuringiensis* (TB 261) for managing rice folder has shown the remarkable response in the farmers' field with leaf folder mortality of 76.11%. It could save from harmful effects of chemical pesticides on soil and human health.
7. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Bentonite-Based Formulation of Bt (TB263) for Managing Rice Leaf Folder

1. Name of the technology and its microbial constituent (Genus/ species):

Bentonite-based formulation of *Bacillus thuringiensis* (TB 263) is a unique biopesticide particularly for managing rice leaf folder. It has a longer shelf life (more than 12 months) without loss of microbial populations and properties.

2. **Target crops and delivery system**: Bentonite-based formulation of Bt (TB263) for managing rice can be used for managing rice leaf folder. Inoculation can be done through spraying.
3. **Target agroecological zones (if any)**: Eastern region of India
4. **Validation and commercialization:** The technology has been validated in farmers' fields of Mahanga, Nischinticuil & Santpur villages of Odisha and also experimental fields of NRRI, Cuttack, Odisha for four consecutive seasons.
5. **Whether licensed to private companies, if yes, details there of**: A patent application (patent numbered 263/ KOL/2015 dt. 10.03.2015) has been filed.
6. **Benefits:** Bentonite-based formulation of *B. thuringiensis* Bt (TB 263) for managing rice folder has shown the remarkable response in the farmers' field with leaf folder mortality of 73.24%. It could save from harmful effects of chemical pesticides on soil and human health.
7. **Contact:** Director, ICAR-National Rice Research Institute, Cuttack-753006

Suspension Concentrate (SC) formulation of DOR Bt-127

1. Name of the technology and its microbial constituent (Genus/ species)

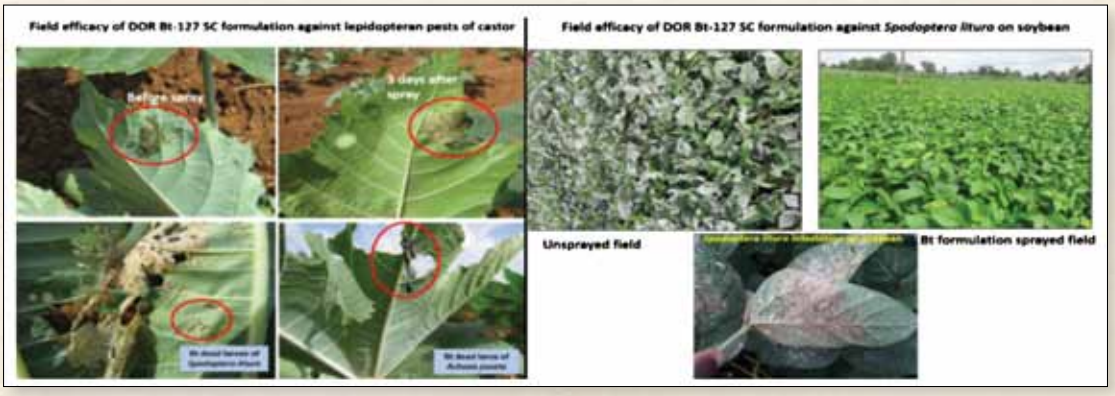
Suspension Concentrate (SC) formulation of *Bacillus thuringiensis* var. *kurstaki* strain DOR Bt-127 (MTCC 5976/NAIMCC-B-01463); 37% Suspension Concentrate formulation with mineral oil as carrier

2. **Target pests and delivery system**: *Spodoptera litura*, *Helicoverpa armigera*, *Thysanoplusia orichalcea*, *Achaea janata*. Can be extended to other lepidopteran pests *viz*., *H. armigera* on pigeon pea, *Cnaphalocrocis medinalis* on rice, *Plutella xylostella* on cauliflower and cabbage etc.

3. **Target agroecological zones (if any)** All soybean growing areas of India

4. **Validation and commercialization:** Studies for determination of potency and safety to natural enemies and phytotoxicity studies completed. Analytical test report for physicochemical and biological parameters generated including endotoxin quantification. Evaluated under AICRP (Soybean) against *Spodoptera litura* and other defoliators for 3 years under AICRP (Soybean) and evaluation completed. Bt-127 SC formulation is in third year of evaluation under AICRP (castor) and AICRP (sunflower) against lepidopteran pests of castor and sunflower respectively. The formulation is being evaluated against lepidopteran pests of cotton and groundnut under the respective AICRPs from 2019.

5. **Benefits:** DOR Bt-127 strain is effective at high temperatures (till 40^{0}C). It was found to have a broad host range with potencies of 34833 IU/mg, 50200 IU/mg, 46205 SU/mg and 71,722 SU/mg against *Helicoverpa armigera*, *Achaea janata*, *Spodoptera* exigua and *S. litura* respectively. It is effective against defoliators in soybean under AICRP and gave good control of *Spodoptera litura, Chrysodeixis acuta, Gesonia gemma* etc.



Field testing of DOR Bt-127 SC formulation

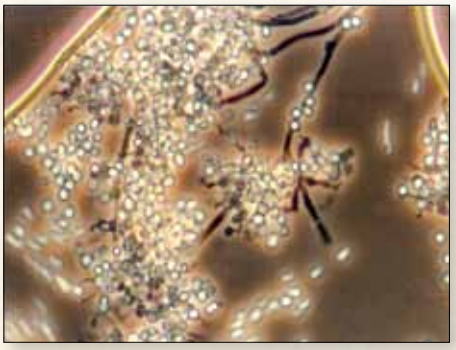
6. **Contact:** Director, ICAR-Indian Institute of Oilseed Research, Rajendranagar, Hyderabad- 500030

Suspension Concentrate (SC) formulation of Beauveria bassiana

1. Name of the technology and its microbial constituent (Genus/ species)

Suspension Concentrate (SC) formulation of *Beauveria bassiana*; 30% Suspension Concentrate formulation with mineral oil as carrier

2. **Target pests and delivery system**: *Helicoverpa armigera* on pigeon pea
3. **Target agroecological zones (if any):** For all pigeon pea growing areas of India.
4. **Validation and commercialization:** Evaluated for efficacy against *H. armigera* and other lepidopteran pests on pigeon pea under AICRP (pigeon pea)
5. **Whether licensed to private companies, If yes, details thereof**: Data for provisional registration under section 9(3b) already completed and technology licensed to four companies till date. Eco-toxicity data needs to be generated as per registration guidelines to enable licensing data for complete registration under section 9(3).
6. **Benefits:** The formulation was also found effective against *H. armigera and T. orichalcea* on sunflower at RARS-Nandyal, Andhra Pradesh and ORS-Latur, Maharashtra.The formulation is not phytotoxic, eco-friendly and safe to non-target organisms and beneficial insects.

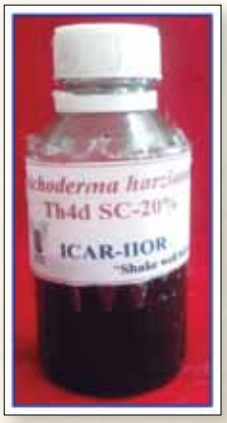


7. **Contact:** Director, ICAR-Indian Institute of Oilseed Research, Rajendranagar, Hyderabad- 500030

Trichoderma harzianum Th4d 20% SC (Suspension Concentrate)

1. Name of the technology and its microbial constituent (Genus/ species):

Suspension Concentrate (SC) formulation of *Trichoderma harzianum* Th4d; shelf life of more than 18 months



2. **Target pests and delivery system:** *Phytophthora* seedling blight, *Macrophomina* root rot and *Fusarium* wilt of safflower and castor Grey mold of castor. *Alternaria* aster leaf blight and powdery mildew of sunflower.
3. **Target agroecological zones (if any):** All
4. **Validation and commercialization:** Multilocation field trials under AICRP carried out.
5. **Whether licensed to private companies, If yes, details thereof**: Licensed to 4 companies
6. **Benefits:** *Trichoderma* formulation has longer shelf life (more than 24 months), dosage required is very low (1 or 2ml/kg seed/L water), the strain is effective against many plant diseases (broad host range), symbiotic root colonizer, induces defense response in plants against pathogen and promotes plant growth. The production process supports high yield and desiccation tolerant viable propagules. *Trichoderma harzianum* Th4d SC liquid formulation can be produced at a low cost.
7. **Contact:** Director, ICAR-Indian Institute of Oilseed Research, Rajendranagar, Hyderabad- 500030

Trichoderma harzianum Th4d 1.5% WP (Wettable powder)

1. **Name of the technology and its microbial constituent (Genus/ species):**

   Wettable powder (WP) formulation of *Trichoderma harzianum* Th4d; shelf life of more than 18 months

2. **Target pests and delivery system:** *Phytophthora* seedling blight, *Macrophomina* root rot and *Fusarium* wilt of safflower and Fusarium wilt of castor

3. **Target agroecological zones (if any):** All

4. **Validation and commercialization:** Multilocation field trials under AICRP carried out. More than 1000kg produced every year for supply to farmers, FLDs and treating seeds produced by IIOR

5. **Whether licensed to private companies, If yes, details thereof:** Technology ready for transfer with complete data required as per CIB &RC and Letter of Intent (LOI) obtained from 2 private firms

6. **Benefits:** *Trichoderma* WP formulation has longer shelf life (more than 18 months), effective against many plant diseases (broad host range), *Trichoderma* strain is a symbiotic root colonizer, induces defense response in plants against pathogen and promotes plant growth. The production process supports high yield and desiccation tolerant viable propagules. *Trichoderma harzianum* Th4d WP formulation can be produced at a low cost

7. **Contact:** Director, ICAR-Indian Institute of Oilseed Research, Rajendranagar, Hyderabad- 500030

Trichoderma asperellum Ta DOR 7316 5% WP

1. **Name of the technology and its microbial constituent (Genus/ species):**
   Trichoderma asperellum Ta DOR 7316 5% WP; shelf life of more than 18 months
2. **Target pests and delivery system:** *Phytophthora* seedling blight, *Macrophomina* root rot and *Fusarium* wilt of safflower and castor
3. **Target agroecological zones (if any):** All
4. **Validation and commercialization:** Multi-locational field trials are being conducted at AICRP centres of Safflower and Castor
5. **Whether licensed to private companies, If yes, details thereof**: Technology ready for transfer; complete data required as per CIB &RC generated, patent filed
6. **Benefits :** The wettable powder of thermo-tolerant strain of *Trichoderma asperellum* TaDOR7316 when applied as seed treatment in safflower under drought condition is able to control soil borne diseases in safflower and gave high seed yield.
7. **Contact:** Director, ICAR-Indian Institute of Oilseed Research, Rajendranagar, Hyderabad- 500030

Metarhizium anisopliae ICAR-NBAIR Ma 4

1. Name of the technology and its microbial constituent (Genus/ species):

Metarhizium anisopliae ICAR-NBAIR Ma 4 strain has been identified as a promising microbial biocontrol agent for management of white grubs (*Holotrichia serrata* & *Holotrichea Consanguinea*) in sugarcane. Talc formulation (2% W. P) has been developed with shelf life of 12 months. It is ecologically safe and do not have any deleterious effects on non-target organisms, other living organisms in the environment, unlike chemical insecticides.

2. **Target crops and delivery system**:

   Sugarcane

   Soil application of *M. anisopliae* (NBAIR Ma-4) enriched Farm Yard Manure.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:**

   - The technology was tested at two AICRP-BioControl centres, UAS-Raichur, Karnataka and RARS, ANGRAU, Anakapalli, Andhra Pradesh for two years.
   - Toxicology data has been generated for CIBRC registration and commercialization.

5. **Whether licensed to private companies, If yes, details thereof**: No

6. **Benefits:** Soil application of 250kg of *M. anisopliae*, (ICAR-NBAIR Ma-4) enriched Farmyard manure per hectare (2.5 x 10^{11} spores/hectare) two times in a year (June/July & July/August) effectively reduced the grub population by 75-96% leading to reduced plant damage and increased yield (33-62%).

NBAIR Ma 4 treated plot | Untreated Control Plot

Effect of NBAIR Ma-4 on white grubs in Sugarcane

7. **Contact:** Director, ICAR- National Bureau of Agricultural Insect Resources, Bangalore-560 024

Metarhizium anisopliae ICAR-NBAIR Ma 35

1. Name of the technology and its microbial constituent (Genus/ species):

Metarhizium anisopliae ICAR-NBAIR Ma 35 strain has been identified as a promising microbial biocontrol agent for management of recent invasive pest, Fall armyworm *Spodoptera frugiperda* in Maize. Talc formulation (2% W. P) and oil formulation have been developed with shelf life of 12 months. It is ecologically safe and do not have any deleterious effects on non-target organisms, other living organisms in the environment, unlike chemical insecticides.

2. **Target crops and delivery system**:

   Maize

   Foliar application of talc/oil Formulations.

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:**

   - The technology was tested at ICAR-NBAIR experimental farm at Yelahanka, Bangalore, Karnataka and AICRP Bio Control center-RARS, ANGRAU, Anakapalli, Andhra Pradesh for two years.
   - Multi-locational testing is under progress.
   - Toxicology data has to be generated for commercialization.

5. **Whether licensed to private companies, If yes, details thereof**: No

6. **Benefits:** Three foliar sprays of *Metarhizium anisopliae* ICAR-NBAIR Ma 35 at the dose of 5g/ml/liter containing 1 x 10^8cfu/ml at 10 days interval after 20, 30 and 40 days after sowing showed 33-76% reduction in plant damage caused by fall armyworm in maize with an increased yield of 38-53%.

7. **Contact:** Director, ICAR- National Bureau of Agricultural Insect Resources, Bangalore-560 024

Isaria fumosorosea ICAR-NBAIR Pfu-5

1. Name of the technology and its microbial constituent (Genus/ species):

Isaria fumosorosea ICAR-NBAIR Pfu-5 strain has been identified as a promising microbial biocontrol agent for management of Rugose Spiralling Whitefly (*Aleurodicus rugioperculatus*) in coconut and oilpalm. Talc formulation (2% W. P), rice grain and oil formulations have been developed with shelf life of 12 months. It is ecologically safe and do not have any deleterious effects on non-target organisms, other living organisms in the environment, unlike chemical insecticides.

2. **Target crops and delivery system**:

   Coconut and Oil Palm

   Foliar application of Talc/rice grain/oil Formulations.

3. **Target agroecological zones (if any)**:

   Different coconut and oil palm growing areas of the country

4. **Validation and commercialization:**

   - The technology was tested in coastal Andhra Pradesh (coconut and oil palm) and in Karnataka (coconut).
   - Multi-locational testing in other coconut and oil palm growing areas are under progress.
   - Toxicology data has to be generated for commercialization.

5. **Whether licensed to private companies, If yes, details thereof**: No

6. **Benefits:** Two foliar sprays of *Isaria fumosorosea* ICAR-NBAIR Pfu-5 at the dose of 5g/ml/liter containing 1 x 10^8cfu/ml at 15 days interval after pest incidence showed 74-75% reduction of Rugose Spiralling Whitefly in coconut and oil palm.

7. **Contact:** Director, ICAR- National Bureau of Agricultural Insect Resources, Bangalore-560 024

Beauveria bassiana ICAR-NBAIR Bb-5a

1. Name of the technology and its microbial constituent (Genus/ species):

Beauveria bassiana ICAR-NBAIR Bb-5a strain has been identified as a promising microbial biocontrol agent for management of aphids in chilli & brinjal (*Aphis gossypii*), cabbage (*Brevicoryne brassicae*) and cowpea (*Aphis craccivora*). Oil formulation has been developed with shelf life of 12 months. It is ecologically safe and do not have any deleterious effects on non-target organisms, other living organisms in the environment, unlike chemical insecticides.

2. Target crops and delivery system:

Chilli, brinjal, cabbage and cowpea

Foliar application of oil formulation.

3. Target agroecological zones (if any): All

4. Validation and commercialization:

- The technology was tested at ICAR-NBAIR experimental farm at Yelahanka, Bangalore for 2 years.
- Multi-location testing at different agro-climatic zones to be conducted.
- Toxicology data has to be generated for commercialization.

5. Whether licensed to private companies, If yes, details thereof: No

6. **Benefits:** Three foliar sprays of *Beauveria bassiana* ICAR-NBAIR Bb-5a at the dose of 5ml/liter containing 1 x 10^8cfu/ml at 15 days interval after pest incidence showed 50-83% reduction of aphids in chilli and brinjal (*Aphis gossypii*), cabbage (*Brevicoryne brassicae*) and cowpea (*Aphis craccivora*) with an increased yield of 20-33%.

Bb-5a isolate | Untreated control | Mycosis of Bb-5a on aphid | Untreated control

Effect of Bb-5a isolate on brinjal aphids

Effect of Bb-5a isolate on cabbage aphids

7. **Contact:** Director, ICAR- National Bureau of Agricultural Insect Resources, Bangalore-560 024

Lecanicillium lecanii ICAR-NBAIR Vl-8

1. Name of the technology and its microbial constituent (Genus/ species):

Lecanicillium lecanii ICAR-NBAIR Vl-8strain has been identified as a promising microbial biocontrol agent for management of aphids in chilli (*Aphis gossypii*) and cowpea (*Aphis craccivora*). Oil formulation has been developed with shelf life of 12 months. It is ecologically safe and do not have any deleterious effects on non-target organisms, other living organisms in the environment, unlike chemical insecticides.

2. **Target crops and delivery system**:

Chilli and cowpea.

Foliar application of oil formulation.

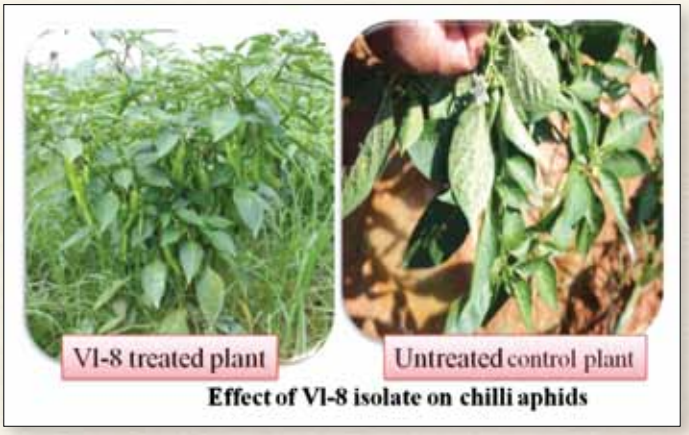
3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:**

- The technology was tested at ICAR-NBAIR experimental farm at Yelahanka, Bangalore for 2 years.
- Multi-location testing at different agro-climatic zones to be conducted.
- Toxicology data has to be generated for commercialization.

5. **Whether licensed to private companies, If yes, details thereof**: No

6. **Benefits:** Three foliar sprays of *Lecanicillium lecanii* ICAR-NBAIR Vl-8at the dose of 5ml/liter containing 1 x 10^8cfu/ml at 15 days interval after pest incidence showed 77-78% reduction of aphids in chilli (*Aphis gossypii*) and cowpea (*Aphis craccivora*) with an increased yield of 24-27%.



Effect of Vl-8 isolate on chilli aphids

7. **Contact:** Director, ICAR- National Bureau of Agricultural Insect Resources, Bangalore-560 024

Plant growth promoting strain of *Bacillus megaterium* NBAII EXB53 for vegetable crops

1. Name of the technology and its microbial constituent (Genus/ species):

Bacillus megaterium NBAII EXB-53 strain has been identified as a plant growth promoter in different vegetable crops like chilli, capsicum, tomato, eggplant, cauliflower and cabbage.Talc and liquid based formulations have been developed with shelf life of 12 months. It is ecofriendly strategy of obtaining healthy and robust vegetable seedlings which can also reduce the use of fungicides for vegetable seed treatment.

2. **Target crops and delivery system**:

Chilli capsicum, tomato, egg plant, cauliflower and cabbage.

Seed treatment

3. **Target agroecological zones (if any)**: All

4. **Validation and commercialization:**

The technology was tested at NBAIR experimental farm, Yelahanka and commercial nurseries in Bangalore.

5. **Whether licensed to private companies, If yes, details thereof**: Yes.

The technology has been transferred to Agribiocare, Kottayam, Kerala

6. **Benefits:**

Talc based or liquid formulation of *B. megaterium* NBAII EXB-53 was used for seed treatment at the rate of 10g or 10ml kg^{-1} of seeds. Seed treatment with talc based formulation of *B. megaterium* NBAII EXB53 increased the seedling vigor index from 20 to 245% in four different chilli varieties (Byadgikaddi, Byadgidabbi, Demon and HPH-12) and other vegetable crops like *Capsicum*- Indra (245%), Cabbage - Summer Queen (81%), Egg plant -Harit (59%), Cauliflower-Tetris (52%) and Tomato - Heem Sohna (25%) compared to untreated control under nursery conditions.

7. **Contact:** Director, ICAR- National Bureau of Agricultural Insect Resources, Bangalore-560 024

Bio formulation for disease management: Maru sena 1

1. Name of the technology and its microbial constituent (Genus/ species):

The bioformulated product coined as Maru sena 1 was developed by a heat tolerant strain of *Trichoderma harzianum* isolated from native soil. Utilizing residues of a locally available weed of the region, a bioformulated product was developed where this bio agent can survive for a period of 120 days even at high temperature (55°C).

2. Target crops and delivery system:

Maru sena 1 can be used for legumes, oil seeds crops, vegetables and seed species specially cumin. Inoculation can be done through seed treatment (4g/kg seed) and soil application 1kg with 50 kg FYM) as well as root dips for vegetable seedlings. *T. harzianum* has separately shown effectiveness in reducing incidence of charcoal rot on rain fed crops like guar, cowpea, sesame, mung bean and moth bean. This strain was also found effective in reducing incidence of wilt caused by *Fusarium oxysporum* f.sp. *cumini* on cumin as seed and soil treatment.

3. Target agroecological zones (if any): Arid and semi arid region

4. Validation and commercialization: The technology has been validated after developing bio-formulated product; their efficacy was demonstrated at growers' field in order to disseminate this eco friendly and easy management strategy in the region. Field demonstrations were carried out at adopted villages of the Institute's KVK and NGOs of the region.

5. Whether licensed to private companies, If yes, details thereof: No

6. Benefits: The expected benefit depends on severity of the disease in a particular field and season. The cost benefit ratio varies from 1:25 to 1:50 with crop and growing season as the severity of charcoal rot is more when crops experience moisture stress. Effectiveness of seed coating with bio formulated product of *T. harzianum* on incidence of dry root rot and seed yield of Guar, moth bean and sesame and on incidence of wilt on cumin were demonstrated at 290 grower's field during 2015 to 2017. The per cent increase in seed yield ranged from 13.3-23.5% in all legumes and oil seed crops. Its application resulted in reduction in incidence of wilt on cumin crop and enhanced yield by14.5-25.8%. .

Control Treated
Effect of Trichoderma application on Cumin crop

7. Contact: Director, ICAR- Central Arid Zone Research Institute, Jodhpur-342003

ICAR-FUSICONT

1. Name of the technology and its microbial constituent (Genus/ species):

ICAR-FUSICONT is a bio-formulation developed using antagonistic fungal isolate CSR-T-3 of *Trichoderma reesei* and a bacterial PGPR isolate CSR-A-11 of *Lysnibacillus fusiforms* in a unique IPR protected media with a dynamic substrate. It has an effective shelf life of 14-18 months when stored at ambient temperature.

2. Target crops and delivery system:

- ICAR- FUSICONT can be applied in the control of wilt diseases in banana, vegetables (tomato, potato, capsicum, chillies) and spices (cumin and fenugreek).
- Can be applied as seed treatment with 1 % solution prepared by dissolving 10 g in 1 litre of water along with 2 g of jaggery.
- Field application through drenching with 3 percent solution at the critical stages of the crop growth.

3. Target agroecological zones (if any): All

4. Validation and commercialization: The technology has been validated in the hot spots of banana wilt affected regions of Uttar Pradesh and Bihar. It is also being validated under AICRP fruits program for the management of banana wilt disease caused by race 1 at Dr. YSR Horticultural University, Andhra Pradesh, TNAU, Coimbatore, Navsari Agricultural University, Gujarat, Assam Agricultural University, Jorhat and ICAR-Central Institute of Sub-tropical Horticulture, RRS, Malda. Validated for control of cumin wilt in Jodhpur region. The formulation has been submitted for approval of CIB&RC.

5. Benefits

It is the only validated effective formulation in the country for the management of devastating outbreak of banana *Fusarium* wilt disease caused by TR-4. Its application could restore 273 acres of wilt affected banana plantations in Uttar Pradesh and Bihar back in to cultivation and restricted the proliferation of the disease to other districts of the country. The technology revived the income of banana growers in the hotspot region to about 16.38 crores through community based intervention along with ICAR-Central Institute of Sub-tropical Horticulture, Lucknow.

6. Contact: Director, ICAR- Central Soil Salinity Research Institute, Karnal-132001.

Arka Krishi Samrakshak

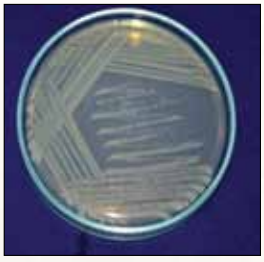
1. Name of the technology and its microbial constituent (Genus/species):

Arka Krishi Samrakshak is a microbial biopesticide containing 1% wettable powder formulation of *Pseudomonas fluorescens* IIHR Pf-2.

2. Target Crops and delivery system:

Arka Krishi Samrakshak effectively controls several soil borne pathogens and nematodes in capsicum, onion, cabbage, cauliflower, crossandra, roses, gerbera, banana, grapes, guava, acid lime, papaya, tomato and egg plant. It can be given as seed treatment, substrate treatment and soil application.

3. Target agro-ecological zones (if any): All



4. Validation and commercialization: The technology has been validated at multiple locations under All India Coordinated Research projects. The product has been tested for its bio-efficacy in three different agro-climatic regions at Karnataka, Odisha and Tamil Nadu for two seasons.

5. Whether licensed to private companies, if yes, details thereof: Yes

The technology has been licensed to 168 industry licensees all over India.

6. **Benefits:** Arka Krishi Samrakshak had exhibited excellent antagonistic activity against root-knot nematode, *Meloidogyne incognita* by suppressing the egg hatching and causing juvenile mortality. It successfully inhibited the growth of *Fusarium oxysporum* f.sp. *vasinfectum*, *Ralstonia solanacearum*, *Erwinia caratovora* and *Fusarium solani*. An increase in yield of 13.2 to 21.8% in several horticultural crops is reported. Usage of chemical pesticides can be reduced by 40 to 50% with a net saving of Rs.10000 to Rs.15000 per acre.

7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Bengaluru-560089.

Arka Krishi Veera

1. Name of the technology and its microbial constituent (Genus/species):

Arka Krishi Veera is a microbial biopesticide containing 1.5% wettable powder formulation of *Trichoderma viride* IIHR Tv-5.

2. **Target Crops and delivery system:** Arka Krishi Veera can be delivered as seed treatment, substrate treatment and soil application in capsicum, onion, cabbage, cauliflower, crossandra, roses, gerbera, banana, grapes, guava, acid lime, papaya, tomato and egg plant.
3. **Target agro-ecological zones (if any):** All
4. **Validation and commercialization:** The technology has been validated at multiple locations under All India Coordinated Research projects. The product has been tested for its bio-efficacy in three different agro-climatic regions at Karnataka, Odisha and Tamil Nadu for two seasons.

5. **Whether licensed to private companies, if yes, details thereof:** Yes

   The technology has been licensed to 177 industry licensees all over India
6. **Benefits:** Arka Krishi Veera had exhibited excellent antagonistic activity against root-knot nematode, *Meloidogyne incognita* by suppressing the egg hatching and causing juvenile mortality. It successfully inhibited the growth of *Fusarium oxysporum* f.sp. *vasinfectum*, *Fusarium oxysporum* f.sp. *lycopersici, Sclerotium rolfsii* and *Fusarium solani*. It also exhibited an increase in yield of 12.8 to 16.3% in several horticultural crops. Usage of chemical pesticides can be reduced by 30- 50% with a net saving of Rs.12000 to Rs.15000 per acre. This product serves as a vital component in organic farming systems and integrated nematode/disease management packages.
7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Bengaluru-560089.

Arka Krishi Vriddhi

1. **Name of the technology and its microbial constituent (Genus/species):**

   Arka Krishi Vriddhi is a biopesticide containing 1% wettable powder formulation of *Trichoderma harzianum* IIHR Th-2.

2. **Target crops and delivery system:** It can be delivered as seed treatment, substrate treatment and soil application in capsicum, onion, cabbage, cauliflower, crossandra, roses, gerbera, banana, grapes, guava, acid lime, papaya, tomato and egg plant.
3. **Target agro-ecological zones (if any):** All
4. **Validation and commercialization:** The technology has been validated at multiple locations under All India Coordinated Research projects. The product has been tested for its bio-efficacy in three different agro-climatic regions at Karnataka, Odisha and Tamil Nadu for two seasons.

5. **Whether licensed to private companies, if yes, details thereof:** Yes

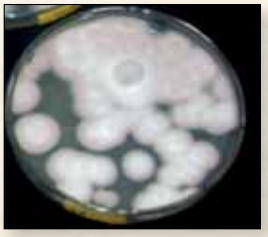
   The technology has been licensed to 110 industrial licensees all over India

6. **Benefits:** Arka Krishi Vriddhi had exhibited excellent ovicidal and larvicidal activity against root-knot nematode, *Meloidogyne* spp. and reniform nematode, *Rotylenchulus reniformis*. It successfully inhibited the growth of *Fusarium oxysporum* f. sp. *vasinfectum*, *Fusarium oxysporum* f. sp. *lycopersici, Sclerotium rolfsii* and *Fusarium solani*. It also exhibited an increase in yield of 14.2 – 19.3% in several horticultural crops. Usage of chemical pesticide can be reduced by 40- 50% with a net saving of Rs.8000 to Rs.12000 per acre. This product serves as a viable option in organic farming systems and integrated nematode/disease management packages.
7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Bengaluru-560089.

Arka Krishi Kawach

1. Name of the technology and its microbial constituent (Genus/species):

Arka Krishi Kawach is a biopesticide containing 1% wettable powder formulation of *Purpureocillium lilcinum* (formerly *Paecilomyces lilacinus*) IIHR Pl-2. It is a nematophagous fungus strongly parasitizing the eggs, egg masses and females of plant parasitic nematodes.



2. **Target Crops and delivery system:** This bioagent can be inoculated as seed treatment, substrate treatment and soil application in all horticultural crops.
3. **Target agro-ecological zones (if any):** All
4. **Validation and commercialization:** The technology has been validated at multiple locations under All India Coordinated Research projects. The product has been tested for its bio-efficacy in three different agro-climatic regions at Karnataka, Odisha and Tamil Nadu for two seasons.
5. **Whether licensed to private companies, if yes, details thereof:** Yes

   The technology has been licensed to 86 industrial licensees
6. **Benefits:** Arka Krishi Rakshak had exhibited strong antagonism against root-knot nematode, *Meloidogyne* sp., reniform nematode, *Rotylenchulus reniformis*, banana nematode *Radopholus similis* and citrus nematode *Tylenchulus semipenetrans*. It also increased the yield by 14.2 to 17.8% in several horticultural crops under field conditions. Usage of chemical nematicides can be reduced by 40 to 50% with a net saving of Rs. 8000 to Rs. 10000 per acre.
7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Bengaluru-560089

Arka Krishi Rakshak

1. Name of the technology and its microbial constituent (Genus/species):

Arka Krishi Rakshak is a biopesticide containing 1% wettable powder formulation of *Pochonia chlamydosporia* (formerly *Verticillium chlamydosporium*) IIHR Vc-3, a promising nematophagus fungus.

2. **Target Crops and delivery system:** This bioagent can be inoculated as seed treatment, substrate treatment and soil application in all horticultural crops.
3. **Target agro-ecological zones (if any):** All
4. **Validation and commercialization:** The technology has been validated at multiple locations under All India Coordinated Research Projects. The product has been tested for its bio-efficacy in three different agro-climatic regions at Karnataka, Odisha and Tamil Nadu for two seasons.

5. **Whether licensed to private companies, if yes, details thereof:** Yes

   The technology has been licensed to 48 industrial licensees.
6. **Benefits:** Arka Krishi Rakshak had exhibited strong antagonism against root-knot nematode (*Meloidogyne* sp.), and cyst nematode (*Heterodera* sp.). It also increased the yield by 14.6 to 20.5% in several horticultural crops under field conditions. Usage of chemical nematicides can be reduced by 30 to 50% with a net saving of Rs.8000 to Rs.10000 per acre.
7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Bengaluru-560089

Arka Krishi All-rounder and Arka Plant Growth Booster

1. **Name of the technology and its microbial constituent (Genus/species):**

   Arka Krishi All-rounder is the talc based and organic formulation of *Pseudomonas fluorescens* and *Trichoderma harzianum*.

   Arka Plant Growth Booster is the liquid based formulation of *Pseudomonas fluorescens* and *Trichoderma harzianum*.

2. **Target Crops and delivery system:** These formulations can be delivered as soil application after enrichment in FYM or through drip application, spraying on the foliage of several horticultural crops *viz.,* tomato, capsicum, okra, brinjal, cabbage, cauliflower, chillies, carrot, onion, tuberose, gerbera, crossandra, gladioli, carnation, banana, papaya, pomegranate, acid lime, citrus, grapes and also on crops grown under protected conditions such as carnations, gerbera, capsicum, tomato, okra, musk melon and water melon. This formulation can also be used for treatment of potting mixture used for producing grafts or hardening tissue culture seedlings of horticultural crops in small polythene bags.

3. **Target agro-ecological zones (if any):** All

4. **Validation and commercialization:** These formulations have been tested under IIHR research fields and farmers' fields in Karnataka.

5. **Whether licensed to private companies, if yes, details thereof:**

   The process for making the products has been granted patents in India (No.250779), US (US 7,923,005 B), Australia (AU 2007216174 B2) and Thailand (No: 7621).

   The technology has been licensed to 1 industry licensee

   - M/s Krishibiosys Pvt Ltd, Bengaluru

6. **Benefits:** The products help in producing vigorous and disease-free seedlings of horticultural crops in nursery stage and boost crop yield. The product can reduce the cost incurred on plant protection measures upto 50% with a net saving of Rs.10000 to Rs.12500 per acre.

7. **Contact:** Director, ICAR-Indian Institute of Horticultural Research, Bengaluru-560089

CIARI-Bioconsortia

1. **Name of the technology and its microbial constitution (Genus/ species):**

   CIARI-Bioconsortia is a talc based biofertilizer cum biocontrol agent with consortia of multipotential *Bacillus* spp.

2. **Target crops and delivery system:** CIARI-Bioconsortia can be used for management of bacterial wilt disease and plant growth promotion in brinjal. It can be applied in soil 20 days after transplantion as bioenriched FYM.

3. **Target agro-ecological zones (if any):** Islands of Andaman-Nicobar and Lakshadweep

4. **Validation and commercialization:** This technology is validated for management of bacterial wilt disease, plant growth promotion and yield enhancement in brinjal at Institute Research Farm, ICAR-CIARI and farmers' fields at multiple locations under Andaman and Nicobar Island conditions.

5. **Weather licensed to private companies, If yes, details thereof:** No

6. **Benefits:** Bacterial wilt disease caused by *Ralstonia solanacearum* is a severe concern for growing solanaceous vegetables and yield loss may accrue 10-50% in these crops under Island conditions. The CIARI-Bioconsortia has shown significant response in the farmers' fields with respect to management of bacterial wilt disease and growth promotion in brinjal crop.

7. **Contact:** Director, ICAR-Central Island Agricultural Research Institute, Port Blair- 744101, Andaman and Nicobar Islands.

CIARI-GroPro

1. **Name of the technology and its microbial constitution (Genus/ species):**

   CIARI-GroPro is a liquid based bio-fertilizer cum biocontrol agent which consists of consortia of multipotential *Bacillus* spp.

2. **Target crops and delivery system:** CIARI-GroPro can be used for management of leaf spot diseases in vegetables and overall growth promotion in vegetable crops. It is used as seed treatment, seedling dip and foliar spray in vegetable crops.

3. **Target agroecological zones (if any):** Islands of Andaman-Nicobar and Lakshadweep

4. **Validation and commercialization:** This technology is validated for management of major plant diseases in solanaceous vegetable crops at farmers' fields at multiple locations under Andaman and Nicobar Island conditions.

5. **Weather licensed to private companies, If yes, details thereof:** No

6. **Benefits:** CIARI-GroPro enhances plant growth by uniform seed germination, high seedling vigor and uniform plant growth. It also acts as effective biocontrol agent against major plant diseases. It is easy to use and have longer shelf life.

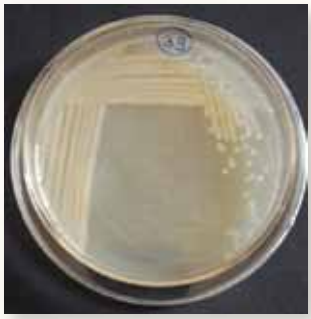
Effect of seed treatment -Treated (left); untreated (right) in Brinjal and tomato

7. **Contact:** Director, ICAR-Central Island Agricultural Research Institute, Port Blair- 744101, Andaman and Nicobar Islands.

Bacillus subtilis strain DR-39 bio formulation

1. Name of the technology and its microbial constituent (Genus/species):

Bacillus subtilis bio formulation contains efficient *Bacillus subtilis* DR-39 strain and having bacterial population of 1X10^9 CFU/g which enhance the degradation of pesticide.



2. **Target crops and delivery system:**

   It is mainly used for grapevine. As it is bio-remediation agent, it can be used for other crops also. Inoculation can be done by foliar spraying.

3. **Target agro-ecological zones:** All

4. **Validation and commercialization:**

   The technology has been validated for Grapes at multiple locations on farmers' fields and vineyard of ICAR- NRC for Grapes, Pune.

5. **Whether licensed to private companies, if yes, details thereof:** No.

   The technology has been developed in collaboration with:

   - Zytex Biotech Pvt. Ltd., Mumbai.

6. **Benefits:**

   Bacillus subtilis DR-39 bio formulation has shown distinct response in the farmer's field with respect to pesticide degradation. Application of *Bacillus subtilis* DR-39 to grapevine enhanced degradation of the 10 studied pesticides by 12.73-65.55% in ICAR-NRCG vineyards. Similar enhanced degradation was observed in farmers' fields at four locations.

7. **Contact:** Director, ICAR – National Research Centre for Grapes, Pune- 413702.

Trichoderma asperelloides strain 5R on liquid and solid medium

1. **Name of the technology and its microbial constituent (Genus/species):**

   Trichoderma asperelloides strain 5R on liquid media and solid organic substrate with spore load of 10^{11} enhances the disease resistance of grapevines to various foliar diseases, especially powdery mildew.

2. **Target crops and delivery system:**

   It is mainly used against the various diseases of grapevine. Inoculation can be done by soil drenching.

3. **Target agro-ecological zones:** All

4. **Validation and commercialization:**

   The technology has been validated for Grapes at multiple locations on farmers' fields and vineyard of ICAR- NRC for Grapes, Pune.

5. **Whether licensed to private companies, if yes, details thereof:** No

6. **Benefits:**

   Soil drenching of *Trichoderma asperelloides* 5R culture in the form of liquid / solid enhances the disease resistance of grapevines to various foliar and soil borne diseases. Its application in alternation with the sulfur remarkably reduces powdery mildew severity in grape vineyards and number of applications of fungicides. *Trichoderma asperelloides* 5R induces systemic resistance in vines and increases its tolerance to various plant pathogens. Long term application of *Trichoderma asperelloides* 5R in liquid / solid form leads to the reduction of overwintering inoculum in vineyards. As number of fungicide applications is minimized, consequently the grapes conform to 'zero' residue levels. Out of the 59 random samples analyzed in 2019-20, 53 conformed to zero residue levels and out of these 36 conformed to the EU standards

7. **Contact:** Director, ICAR – National Research Centre for Grapes, Pune- 413702

Trichoderma afroharzianum (NAIMCC-F-01938) liquid formulation

1. Name of the technology and its microbial constituent (Genus/species):

Trichoderma afroharzianum (NAIMCC-F-01938) liquid formulation is a liquid formulation which contains $5X10^8$ spores/ml. It helps in reducing the disease incidence on grapevines.

2. **Target crops and delivery system:**

   It is mainly used against the various diseases of grapevine. Inoculation can be done by foliar application.

3. **Target agro-ecological zones:** All

4. **Validation and commercialization:**

   The technology has been validated for Grapes at multiple locations on farmers' fields and vineyard of ICAR- NRC for grapes, Pune.

5. **Whether licensed to private companies, if yes, details thereof:** No

6. **Benefits:**

   Foliar spray application of *Trichoderma afroharzianum* liquid formulation enhances the disease control in grapevines to various fungal diseases. Its spray application in alternation with the sulfur remarkably reduces powdery mildew severity in grape vineyards and number of applications of fungicides. Its need based foliar application along with soil drenching of *Trichoderma asperelloides* 5R minimizes the downy mildew incidence in vineyards. As number of fungicide applications is minimized, consequently the grapes conform to 'zero' residue levels. Out of the 59 random samples analyzed in 2019-20, 53 conformed to zero residue levels and out of these 36 conformed to the EU standards.

7. **Contact:** Director, ICAR – National Research Centre for Grapes, Pune- 413702

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