



Government of India  
Bhabha Atomic Research Centre  
**Nuclear Agriculture & Biotechnology Division**  
Trombay, Mumbai, Maharashtra 400 085, India

## Compendium of Technologies Available for Transfer



2022

## PREFACE

Bhabha Atomic Research Centre (BARC) is a multidisciplinary research organization under the Department of Atomic Energy, Govt. of India, specializing in various fields of nuclear research like, power, reactor design, fuels, health, food and agriculture. In the field of agriculture, BARC is well known for its mutation breeding programme which has resulted in the release and notification of 55 high yielding varieties mostly in cereals, pulses and oilseeds, some of which are very popular among the growers.

In addition to crop improvement, BARC's contributions in development of crop production and crop protection technologies are noteworthy. These include technologies related to soil and water management, novel fertilizer formulations, biodegradable waste management, botanical and microbe-based pesticides, plant growth regulators and pesticide residue detection kits. In addition, several biotechnological tools have been developed for tissue-culture based propagation of uniform, easy-to-transport and disease-free planting materials. This Compendium is a compilation of agro-technologies that have been developed at BARC and transferred to different private parties for further commercialization.

Some of the technologies described here have been developed in collaboration with Agricultural Universities/ other Institutes, and we place on record our gratitude for their continued support.



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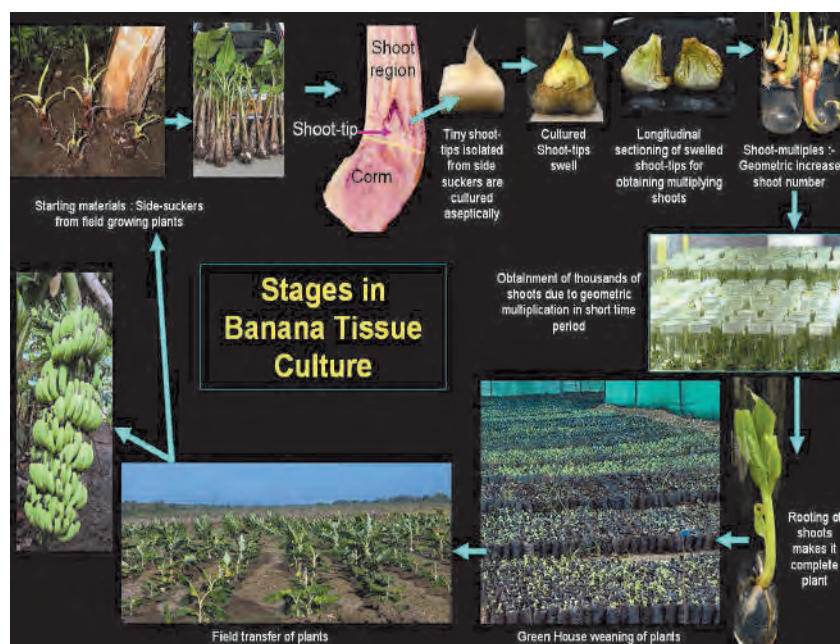
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# Micropropagation technology for banana

## Introduction

- Banana is a globally important fruit crop and ranks second in importance next to mango.
- Banana tissue culture based propagation technology developed at BARC offers several advantages.
- Large number of plantlets can be generated in a short time-span and hence, the problem of planting material shortage is overcome.
- Round the year planting is possible.
- Pathogen (disease) and insect free plantlets
- Uniformity in age of plants shortens harvesting time period.
- Of immense value in biodiversity conservation because different banana varieties can be introduced/imported quickly and multiplied in a short duration.



## APPLICATIONS

- Agriculture sector
- Biotechnology companies
- Plant nurseries

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# A rapid, reproducible and sustainable micropropagation protocol for turmeric (*Curcuma longa* L.) and ginger (*Zingiber officinale* L.)

## Introduction

- Turmeric (*Curcuma longa* L.) is a valuable spice and medicinal plant known for its aromatic, anticancer, stimulant, carminative, antiseptic and anthelmintic properties.
- BARC has developed a technology for micropropagation of turmeric.
  - It offers a continuous source of numerous uniform size plantlets.
  - It provides disease free good quality planting material throughout the year.
  - It enhances potential productivity of this crop.
  - This technology can also be used in germplasm conservation.



## Introduction

- Ginger (*Zingiber officinale* Linn.) is world's most consumed dietary condiment, primarily due to the presence of ketones, especially the gingerols.
- It is valuable not only as a spice but also as a herbal medicine.
- BARC has developed a technology for micropropagation of ginger which offers a continuous source of numerous uniform size and disease-free plantlets throughout the year.

## ADVANTAGES

- Disease-free good quality planting material throughout the year.
- Used in germplasm conservation.



## APPLICATIONS

- Agriculture sector
- Biotechnology and pharmaceutical companies
- Plant nurseries

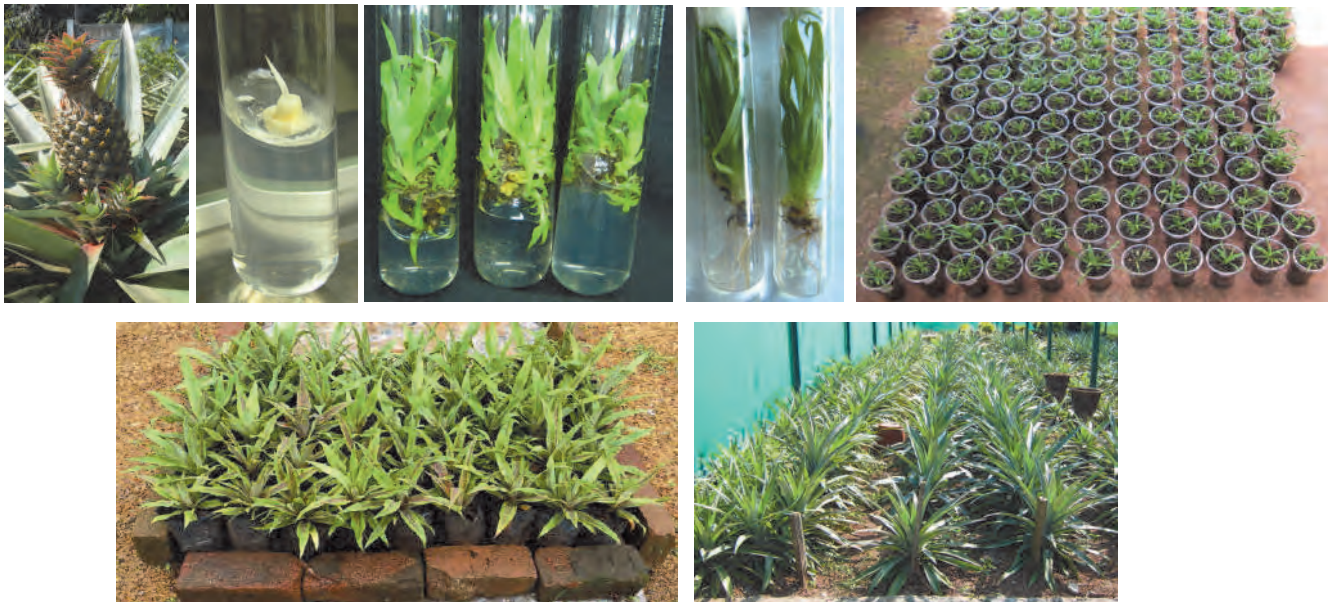
THESE TECHNOLOGIES ARE AVAILABLE FOR TRANSFER THROUGH TTCD (AB40NABTD & AB49NABTD; [www.barc.gov.in](http://www.barc.gov.in))



# Technology for micropropagation of pineapple (*Ananas comosus* L. Merr.)

## Introduction

- Pineapple (*Ananas comosus* L. Merr.) belongs to Bromeliaceae family and is one of the important fruit crops in India.
- Pineapple is propagated vegetatively through suckers and slips. Conventionally the average production is 4-5 propagules per year and it takes considerable time to produce enough planting material.
- BARC has developed a micropropagation protocol for pineapple:-
  - It ensures continuous production of numerous disease-free, uniform plantlets throughout the year. Such materials when planted in the field would eliminate or at least minimize the incidence of diseases, thus stabilizing the yields and reducing the cost of production.
  - The technology has potential to provide thousands of uniform plants in short duration of time (approximately 3 months) which can circumvent the low availability of planting material.



## APPLICATIONS

- Agriculture sector
- Biotechnology
- Plant nurseries

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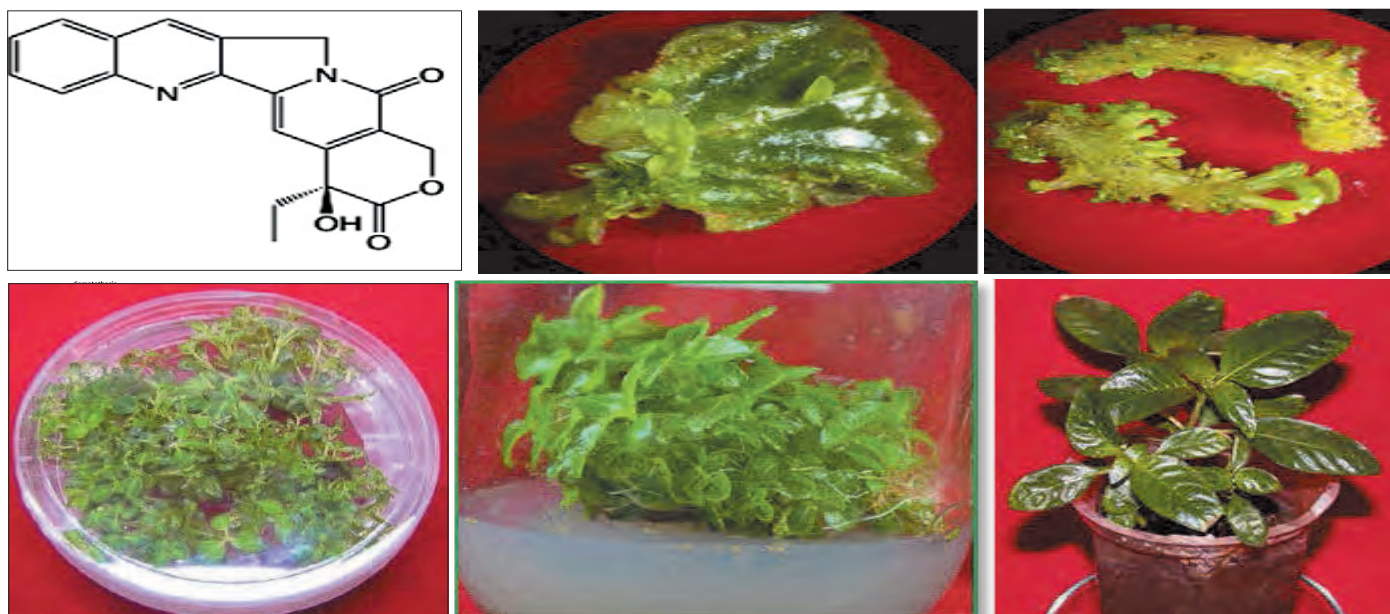




# Technology for rapid, continuous and renewable multiplication of *Ophiorrhiza rugosa* as a source of anti-cancer drug camptothecin

## Introduction

Camptothecin (CPT) is fourth prominent anticancer compound with global demand > 4 billion USD (2018). It is purified commercially from *Camptotheca acuminata*, *Nothapodytes foetida* and *Ophiorrhiza sp.*



Micropropagation protocol for *Ophiorrhiza rugosa*

## ADVANTAGE

- The technology offers a continuous and sustainable method for the multiplication of numerous plantlets of *Ophiorrhiza*, as a source of camptothecin throughout the year.

## APPLICATIONS

- Agriculture sector
- Biotechnology and pharmaceutical companies
- Plant nurseries

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# Soil organic carbon detection kit

## Introduction

Organic carbon is an indicator element of soil fertility. Within different types of soil, positive correlation between carbon content and crop yield has been observed all over world. Regular monitoring of soil organic carbon is a prerequisite for getting desired yield from crops. With this soil organic carbon detection kit, farmers can analyse carbon content of the soil in his field and take quick decisions about the required manure doses. The method is affordable, simple, fast and reliable.



## ADVANTAGES

- User-friendly
- Economical
- Quick and reliable results
- Gives idea of amount of organic manure.

The technology has been transferred to many industries and also been selected by CIFAL, a UN based NGO in Sweden, for imparting training to farmers from African countries. Panni Foundation is using the technology for soil health improvement programme in Maharashtra. IAEA has also appreciated the simplicity of technology.

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## IAEA International Atomic Energy Agency

### Living in Harmony with Mother Earth: User-Friendly Instant Tool Kit Helps Indian Farmers Determine Soil Organic Carbon

22 Apr 2021  
Carley Willis, IAEA Office of Public Information and Communication



([https://www.iaea.org/sites/default/files/styles/original\\_image\\_size/public/soil-india-1140x640.jpg?itok=1S3cDvtj](https://www.iaea.org/sites/default/files/styles/original_image_size/public/soil-india-1140x640.jpg?itok=1S3cDvtj))

Carbon-rich minerals, organic materials and living organisms – these various components of soil are necessary to absorb water and breakdown pollutants. Having the right balance of organic matter and living organisms, nutrients are released in the soil, allowing healthy crops to grow. (Photo: S. Mehetre/Bhabha Atomic Research Centre)

“To be a successful farmer, one must first know the nature of soil,” ancient Greek



Department of Atomic Energy  
Bhabha Atomic Research Centre

# Nisargruna biogas plant for processing biodegradable waste

## Introduction

- Nisargruna biogas plant for processing different biodegradable waste like kitchen waste, abattoir waste, grass, cow dung etc.
- This plant offers “Zero waste and Zero effluent” processing and provides high quality manure and methane gas.
- This technology of biphasic biomethanation has high potential of solving the solid waste management problems of the urban areas.



## SALIENT FEATURES

- This plant is used for processing different types of biodegradable waste including kitchen waste, cow dung, abattoir waste etc.
- There is a great potential for energy generation in this plant.
- Manure has high nitrogen contents that acts as an excellent soil conditioner and improves soil fertility.

## ADVANTAGES

- This process helps in achieving aim of zero waste.
- The process helps for maintaining resource recycling in equilibrium
- Decentralized waste processing reduces transport cost.
- Biogas use helps in replacing fossil fuels and reduces methane emission from dumping grounds.
- Biogas can be used for generation of electricity.

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# Compact “Biodegradable waste” converter: SHESHA

## Introduction

For processing waste generated in smaller housing societies and restaurants, a novel, compact helical shaped waste converter has been developed. A patent has been filed and technology transferred to the industry.



## ADVANTAGES

- Helical shaped compact digester made from low cost PVC pipes.
- Saving major cost of construction of civil structures and MS dome required in conventional designs.
- Suitable for skid mounting, useful for processing waste from smaller societies/residential complexes.
- Has in-built capacity of biogas recycling for methane enrichment.
- Suitable for online monitoring of process parameters.
- The technology transferred to many industries and many installations are in working conditions.

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# A rapid composting technology for decomposition of dry leaves, kitchen-waste & temple-waste

## Introduction

- Management of different types of biodegradable waste has become major challenge during recent times.
- Rapid composting technology has been developed for faster degradation of dry leaves, kitchen waste and temple waste.
- The technology is based on use of single microbe (fungus) i.e. *Trichoderma koningiopsis* isolated from tree bark.
- The fungus enhances the degradation process.



## ADVANTAGES

- Single microbe multiplied easily using a low cost substrate.
- Simple, rapid and odourless process.
- Eco-friendly alternative to waste dumping.
- Compost generated is a good soil conditioner.
- Natural cycles sustained.

## APPLICATIONS

- Municipalities, housing societies, institutional gardens
- Nurseries, orchards, farms etc.
- Biotechnology companies
- 45 licensees and 8 products in market till August 2022

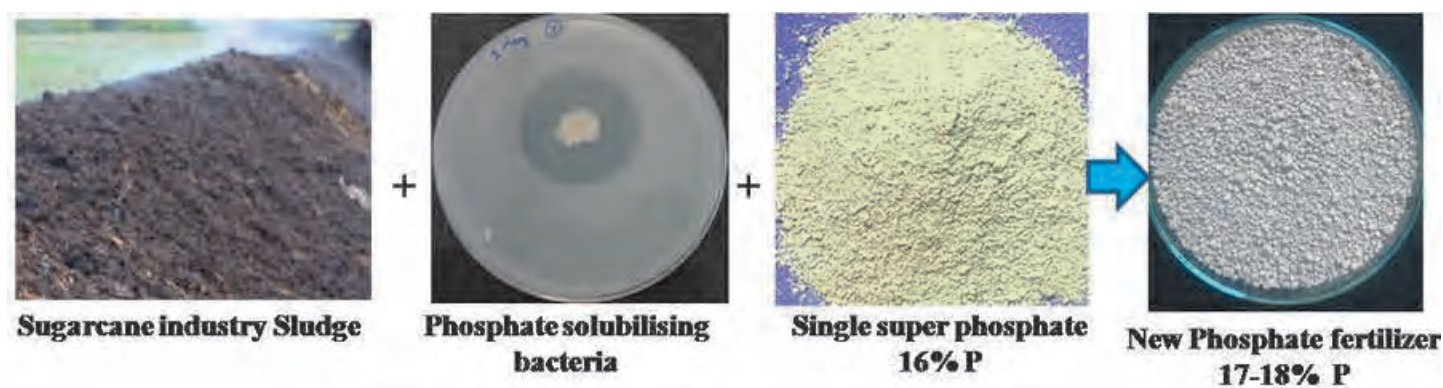
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# Improved phosphorus (P) fertilizer formulation from biosludge

## Introduction

- Phosphatic fertilizer from biosludge obtained from distillery waste has been developed and the process is patented (No.758/MUM/2007 Dated 19.04.2007, Indian Patent No. 238485).
- This fertilizer contains more available phosphorus and is more efficient than conventional single super phosphate (SSP) fertilizer. By keeping the application rate 25% less than SSP in terms of the absolute  $P_2O_5$  level, the new modified P fertilizer produces equivalent yield and ensures better availability of residual fertilizer to the next crop as well.



## ADVANTAGES

- Improved availability of phosphorus which is an important nutrient for the plant
- There is an increase in the yield for next-season crop.
- Phosphorus is made available through the use of phosphate solubilizing bacteria.
- Availability of phosphorus is enhanced due to the combination of organic and inorganic forms, required for the growth of plants.

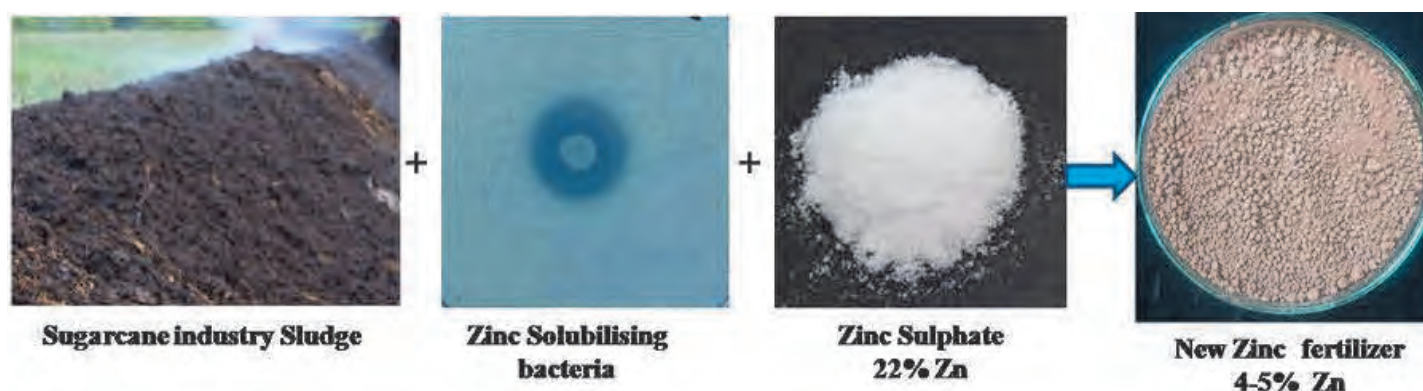
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# Improved zinc (Zn) fertilizer formulation from biosludge

## Introduction

- Zinc fertilizer from biosludge obtained from distillery waste has been developed and the process is patented (No.757/MUM/2007 Dated 19.04.2007, Indian Patent No. 239929).
- This Zn fertilizer containing 4-5% Zn and is more efficient than conventional Zn fertilizer (Zinc sulphate heptahydrate, 21-22% Zn). Keeping the Zn application rate same (5 kg Zn/ha), the modified Zn fertilizer produces higher yields and ensures better availability of residual fertilizer to the next crop as compared to the conventional zinc sulphate heptahydrate.



## ADVANTAGES

- Improved availability of zinc which is an important nutrient for plants.
- Increase in the yield for second crop.
- Phosphorus is made available through the use of phosphate solubilizing bacteria.
- Availability of zinc is enhanced due to the combination of organic and inorganic forms.

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# Superabsorbent BARC hydrogel for improving water-use efficiency

## Introduction

- Drought is the largest abiotic stress that obstructs the growth of plant and its productivity.
- Superabsorbent polymer (SAP) is considered as a suitable approach for nourishing the soil.
- BARC has developed superabsorbent polymer hydrogel (BARC-Hydrogel) using natural polymer graft-co-polymerized with synthetic precursor by cold ionizing energy, such as gamma-rays.
- BARC-Hydrogel can absorb and retain pure water up to several hundred times (~550 times) of its own weight and supply water upon plant-root demand.
- The use of hydrogel in macro porous medium (sandy soil) is very effective to increase the water holding capacity, which significantly improves plant health and productivity.



## MODE OF APPLICATION



## ADVANTAGES

- Enhances plant productivity, especially in arid areas
- Reduces irrigation frequency
- Improves hydro-physical properties of soil
- Bio-degradable and non-toxic
- Reduces erosion and water runoff

## APPLICATIONS

- Agriculture sector
- Biotechnology
- Plant nurseries and landscape
- Forestry

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# ANU-CHAITANYA

## (A versatile bioregulator for sustainable crop production)

### Introduction

In agriculture, one of the major problems is the loss in crop yield due to different abiotic stresses. Increased episodes of climatic variations and unpredictability have compounding effects. A versatile bioregulator named “ANU-CHAITANYA” has been developed, containing gamma-irradiated chitosan (a linear polysaccharide composed of randomly distributed  $\beta$ -linked D-glucosamine and N-acetyl-D-glucosamine units). ANU-CHAITANYA application not only boosts plant growth but also, activate built-in plant defence to tolerate multiple abiotic/biotic stress conditions.



(Field photo courtesy: VSI, Pune)

### ADVANTAGES

- The raw materials for ANU-CHAITANYA are of low-cost and easily available.
- ANU-CHAITANYA involves radiation treatment of chitosan that improves its bioavailability to plants.
- ANU-CHAITANYA can be stored at room temperature.

### APPLICATIONS

- ANU-CHAITANYA can be applied as a foliar spray, at vegetative maturity and/or active grain filling stage.
- ANU-CHAITANYA can be to be applied on various grain crops, vegetables and flowering plants.

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# Microfine neem powder for insect-pest management

## Introduction

- Microfine neem biopesticide has been developed using a novel technique of making micro-sized powder of whole neem fruits.
- Azadirachtin, the active ingredient in neem, after extraction becomes unstable when sprayed on crops and its insecticidal effect is short-lived. Instead of extraction, this technology utilizes azadirachtin in its original form as in neem fruit. The product is developed as powder formulation. As the particle size is decreased, the efficacy increases substantially. Thus, the insecticidal effect is stronger and long lasting.



## SALIENT FEATURES

- All the goodness of neem are available to crops from this formulation.
- The formulation particles create a sustained release effect since the ingredients are gradually released and thus long term protection from insects is achieved.
- Insecticidal effect can be much stronger and longer lasting.
- Use of other herbs in micro fine powder adds to the effectiveness of the product.



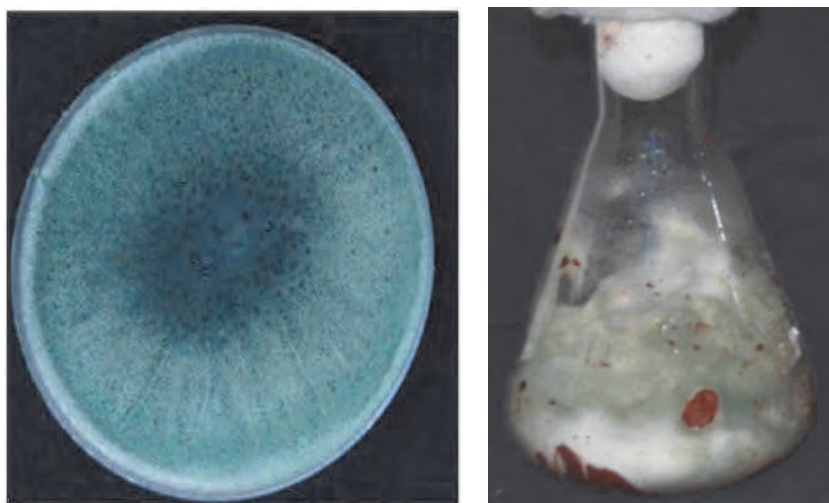
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(AB21NABTD; [www.barc.gov.in](http://www.barc.gov.in))



# A cheap and effective mass multiplication protocol for *Trichoderma*

## Introduction

- The field application of *Trichoderma* requires mass multiplication which is done on solid and liquid state fermentation. In the industrialized nations, liquid fermentation is extensively used, while solid state fermentation is preferred in India due to low initial investment and availability of labour and space.
- Prevailing solid state fermentation technology uses food grains like sorghum and bajra for commercial mass multiplication at industrial scale. However, the food grains are comparatively expensive, have short storage life and may not be available throughout year. In contrast, the present technology uses a cheap locally available substrate for the multiplication of *Trichoderma* biopesticide. .



## ADVANTAGES

- Prolific growth and biomass production.
- Added antimicrobial properties.
- Enhanced induction of plant defense.
- No synthetic sticker needed.

## APPLICATIONS

- A novel and economical formulation, which is suitable for both solid as well as liquid conditions and gives better growth of fungus than the conventional methods.

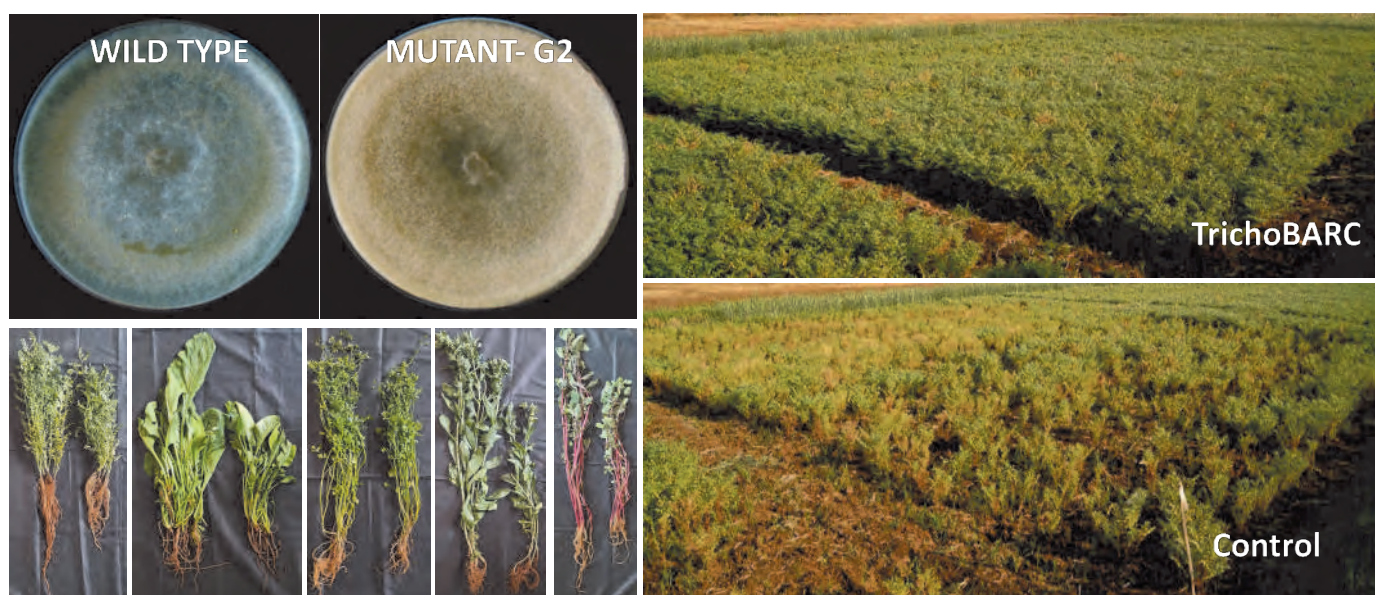
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# *Trichoderma* mutant-based formulation for disease biocontrol and plant growth promotion

## Introduction

- Using gamma radiation, a mutant of *Trichoderma virens*, that produces more bioactive compounds, has been isolated.
- A purely organic, synthetic-sticker-free formulation (TrichoBARC) has been developed.
- The seed treatment formulation is highly effective against diseases of several crops and also promotes plant growth under field conditions.
- Very significant yield enhancement has been observed in many crops over multiple years and locations.



(Field photo courtesy: Prof. Anil Kotasthane, IGKV, Raipur)

## ADVANTAGES

- Higher efficacy, lower cost of production.
- Purely organic formulation, especially suitable for organic/natural farming.
- Suitable for all size packaging.
- The strain has been approved by CIB&RC as a biopesticide.
- High benefit/cost ratio for the growers.

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# Biopesticide based on *Bacillus thuringiensis* subsp. *kenyae* ISPC-1

## Introduction

Biopesticides are important components of integrated pest management (IPM) programme. *Bacillus thuringiensis* subsp. *kenyae* ISPC-1 (Btk) is active against lepidopteran insect pests of field crops. Btk is amenable to large scale mass multiplication in industrial fermenters. Wettable powder (WP) formulation based on Btk is effective against pod borer management on pigeon pea and chickpea.



## ADVANTAGES

Insect pests are the major problems in agriculture and growers still relies on insecticides which are costly and harmful to the environment. Our technology offers environment friendly and effective tool against lepidopteran insect pests, an important tool for IPM.

## APPLICATIONS

- Agriculture sector
- Organic farming

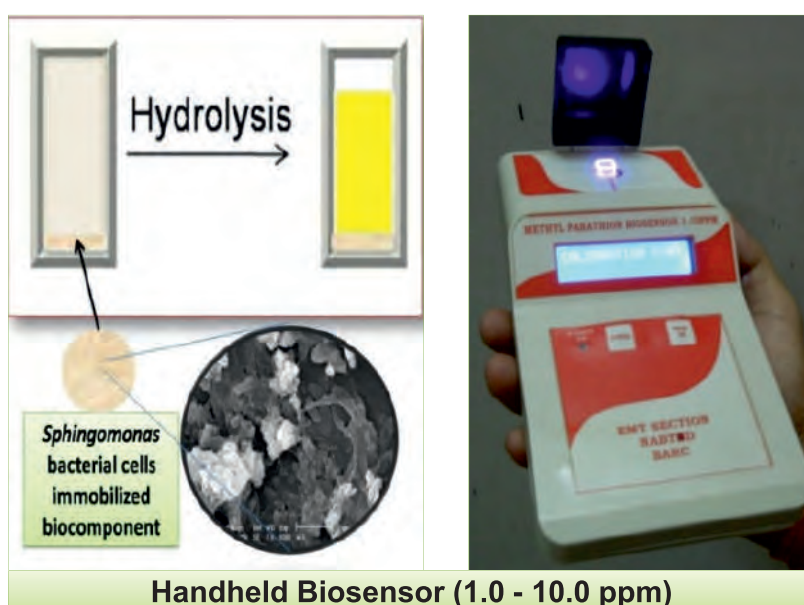
**THE TECHNOLOGY IS AVAILABLE FOR TRANSFER THROUGH TTCD (AB03NABTD; [www.barc.gov.in](http://www.barc.gov.in))**



# Biosensor for methyl parathion, an insecticide

## Introduction

- Methyl parathion was earlier used as restricted-use organophosphate insecticide now banned in India.
- Residual insecticide from excessive use can enter food chain.
- Causes inhibition of acetylcholinesterase enzyme in nervous system (overstimulation of muscle and nerve fibers, uncontrollable twitching, convulsions and breathing difficulty) .
- Biosensor detection is based on enzymatic hydrolysis of methyl parathion into optically detectable product.



Handheld Biosensor (1.0 - 10.0 ppm)

## ADVANTAGES

- This biosensor is specifically useful for detecting methyl parathion pesticide in 10 - 20 min while conventional analytical techniques are not specific and require longer time.
- It can be used for onsite detection of samples in the agriculture field.

## APPLICATIONS

- Agriculture and food sector for detection of banned pesticide methyl parathion

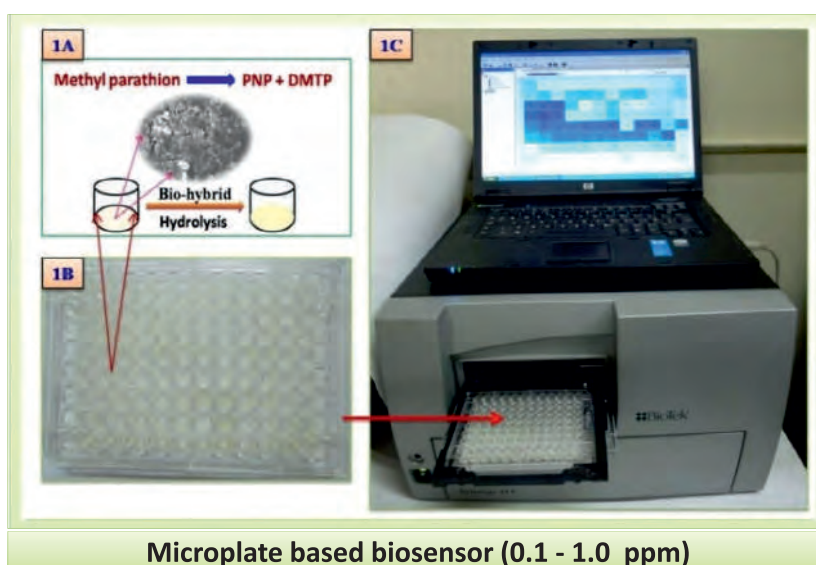
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# Microplate based biosensor for the detection of methyl parathion

## Introduction

- Methyl parathion (MP) was earlier used as restricted-use organophosphate insecticide now banned in India by FSSAI and the MRLs of MP in food commodities is in the range of 0.1-1 ppm.
- Causes inhibition of acetylcholinesterase enzyme in nervous system (overstimulation of muscle and nerve fibers, uncontrollable twitching, convulsions and breathing difficulty) .
- This microplate based optical biosensor detects methyl parathion in solution on 96 wells microplate and it is able to detect methyl parathion pesticide in the range of 0.1- 1.0 ppm (MRL value).



## ADVANTAGES

- This biosensor is specific for detecting methyl parathion pesticide in food sample.
- Simultaneous analysis of multiple samples (96 samples).
- Detection of methyl parathion pesticide in the range of MRL value.
- Less analysis time (5-10 min) than conventional analytical techniques.

## APPLICATIONS

- This biosensor can be used for specifically detecting methyl parathion pesticide in large numbers of samples in the range of MRL value.
- Agriculture and food sector.

**THE TECHNOLOGY IS AVAILABLE FOR TRANSFER THROUGH TTCD (AB35NABTD; [www.barc.gov.in](http://www.barc.gov.in))**



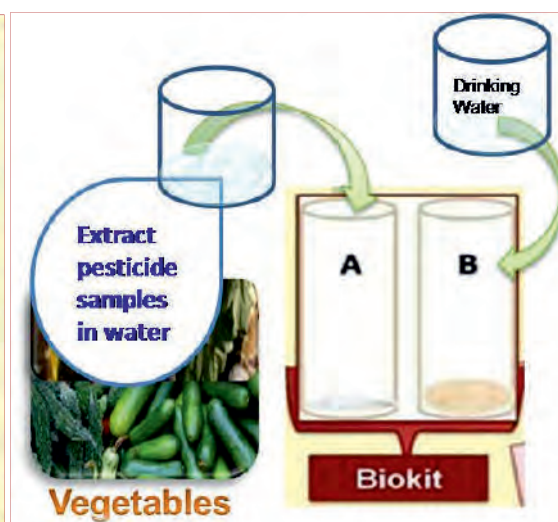
# Biosensor Kit (Biokit)

## Detection of organophosphate and organocarbamate pesticides

### Introduction

- Organophosphate (OP) and organocarbamate (OC) pesticides are most commonly used insecticides in agriculture and domestic sector. Presence of these insecticides is thus expected in food commodities.
- This Biokit is a simple visual colorimetric biosensor for detection of 12 pesticides.
- There is colour code (Blue and Green) which indicate the presence and absence of pesticides (If pesticides concentration is higher as mentioned in table).

BioKit testing 12 pesticides (OP and OC groups):			
Organophosphate (OP)	Conc. (ppm) Where no colour changes	Organocarbamate (OC)	Conc. (ppm) Where no colour changes
Dichlorvos	0.2	Carbaryl	0.05
Methyl Parathion	1.0	Carbofuran	0.01
Monocrotophos	1.0	Carbosulfan	0.01
Chlorpyrifos	2.0	Aldicarb	0.05
Phorate	2.0		
Profenofos	1.0		
Parathion	0.005		
Quinalphos	0.01		

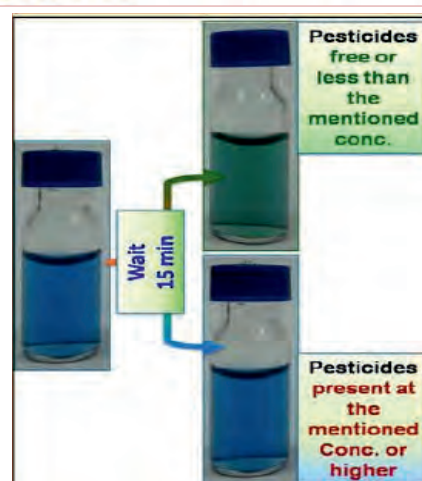


### ADVANTAGES

- This is one unique kit developed for qualitative detection of multiple pesticides.
- Simple visual detection takes 40 min for onsite detection of pesticides in the field.
- Based on colour changes and no instrument is required.
- Chemicals used in the kit are safe to handle.

### APPLICATIONS

- For detection of pesticide residues in farm produce.
- For use in food industry to detect contamination of products delivered prior to export.
- For domestic use after purchase of organic fruits and vegetables.



**THE TECHNOLOGY IS AVAILABLE FOR TRANSFER THROUGH TTCD (AB37NABTD; [www.barc.gov.in](http://www.barc.gov.in))**









**For further queries please contact:**

**Head, Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, Maharashtra, India**

**Email: [panabtd@barc.gov.in](mailto:panabtd@barc.gov.in)**

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