# ICAR TECHNOLOGIES

# BIOFERTILIZERS

## FOR SUSTAINABLE CROP PRODUCTION

Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001

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त्रिलोचन महापात्र, पीएच.डी.
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SECRETARY & DIRECTOR GENERAL

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# FOREWORD

Soil is a dynamic living entity wherein several self regulatory mechanisms are operated through the constituent living organisms. Microorganisms play a major role in keeping soils live through its ecosystem services like solubilization of minerals, recycling of organic matter, bioremediation and soil formation. Post green revolution, self sufficiency in food grain production was achieved through the use of high yielding varieties responsive to chemical fertilizers. However, indiscriminate use of chemical fertilizers has resulted in deterioration of soil health leading to shift in emphasis towards sustainable agriculture. Use of biofertilizers for nutrient management is an integral component of sustainable agriculture.

Biofertilizers contain different plant associated microorganisms that enhance plant growth and improve yield and quality of the produce through supply of adequate nutrients. Nitrogen fixers, P-solubilizers and mobilizers are the traditionally known biofertilizers. With the advancement of science, new groups of biofertilizers kept on adding to the list, a few to name are K-solubilizers, Zn-solubilizers and consortia supplying different nutrients. In addition to supply of nutrients to crop plants, many of these microbes help the plants to tolerate abiotic stresses.

Indian Council of Agricultural Research recognized the importance of Biofertilizers and started AICRP on Biological Nitrogen fixation in 1976, which was renamed as All India Network Project on Soil Biodiversity-Biofertilizers in 2008. These coordinated projects and the constituent institutes of ICAR have developed a large number of biofertilizers for different field and horticultural crops. In 2014, the Govt. of India initiated National Mission on Sustainable Agriculture (NMSA) where use of biofertilizers is being promoted to improve soil health. Though a lot of efforts have been made on the development

and popularization of biofertilizers, the usage of biofertilizers is not at the expected level. The distribution of production and usage across the country is also skewed with south zone dominating both in terms of production and consumption of biofertilizers. Popularization of biofertilizers developed by ICAR is the immediate concern.

This compendium entitled "***ICAR Technologies: Biofertilizers for Sustainable Crop Production***" is a compilation of validated biofertilizers developed by constituent ICAR institutes over the decades. I am hopeful that this publication would be useful for researchers, scientists, students and other stakeholders interested in this area. It would also help to popularize the biofertilizer technologies developed by ICAR.

**Dated: 30th July, 2021** **(T. Mohapatra)**
**New Delhi**

# PREFACE

Indian Council of Agricultural Research is the leader of agricultural research in India developing a large number of technologies adopted by farmers and other stakeholders. This has led to increased crop productivity in almost all the crops so that demands of a growing population are met adequately. The growth in agricultural production in the last few decades has been accompanied by a sharp increase in the use of chemical fertilizers, causing serious concern. Foremost among these concerns is the effect of excessive fertilizers on the quality of soil and ground water. As a consequence the soil health is compromised for productivity and over a period our soils are made sick with reduced fertility and eroded biodiversity.

The use of environmental friendly biofertilizers can cut down the use of chemical fertilizers. Biofetilizers are the products containing living cells of different types of microorganisms that enrich the nutrient quality of soil. Bacteria, fungi and cyanobacteria (blue green algae) are considered as the potential candidates to be used as biofertilizers. Most biofertilizers belong to one of the following categories: nitrogen fixing; phosphate, potash and zinc solubilizing and mobilizing, and plant growth promoting rhizobacteria. The Gazette of India in its notification in April, 2014 also made provision for the production of microbial consortium. It is economical to use biofertilizers as they are a cheap source of nutrients when compared to chemical fertilizers. Biofertilizers in addition to different nutrients also provide certain growth promoting substances like hormones, vitamins, and amino acids that improve the plant health and vigour.

Keeping pace with the biofertilizer industry, several Institutes of ICAR have developed biofertilizer technologies which have been validated under on-farm or multi-location trials. This compendium ***"ICAR Technologies: Biofertilizers for Sustainable Crop Production"*** is an intensive compilation and reflects the great efforts made by the scientists across various institutes to develop the technologies.

With great pleasure I extend my sincere thanks to Dr. T. Mohapatra, Hon'ble Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR, for insight, guidance and support in preparation of this compendium. I also thank the developers of biofertilizer technologies for their innovations and contributions. My appreciations are due to my colleagues at the Council and ICAR-NBAIM for bringing out this compendium which will help in shaping Indian Agriculture more sustainable.

**(T.R. Sharma)**
Deputy Director General (Crop Science)
Indian Council of Agricultural Research

# CONTENTS

## INTRODUCTION

Microorganisms, as an important driver of biogeochemical cycles, play a key role in soil fertility and nutrient uptake by plants. Biofertilizers include nitrogen fixing, phosphate, potassium and zinc solubilising; nutrient mobilizing microorganisms used for application to seed or soil. The manipulation of rhizosphere of plants leads to increase in numbers of such microorganisms and thereby accelerate the microbial processes which augment the availability of nutrients that can be assimilated by plants. Biofertilizers are economical and ecofriendly alternative of chemical fertilizers. Integrated nutrient management (INM) considers biofertilizers as an important component and advocates judicious application of fertilizers along with organic manures and biofertilizers which is imperative to sustain crop production and maintenance of soil health in the long term.

Rhizosphere bacteria that favourably influence plant growth and yield of crop plants are designated as plant growth promoting rhizobacteria (PGPR). They not only influence plant growth but also help the plants to overcome abiotic and biotic stresses.

In India, biofertilizer industry has developed over years and many significant changes have taken place. The shift from carrier based to liquid formulations, inclusion of microbial consortium in Fertilizer Control Order (FCO), increase in numbers of efficient strains have led to the surge in production of biofertilizers. ICAR is continuously striving to develop quality assured biofertilizers using efficient and competitive strains. This bulletin is a compilation of **41 biofertilizer technologies** developed by ICAR that are at different stages of commercialization.

# Abbreviations

| | |
|---|---|
| AICRP | All India Coordinated Research Project |
| ATARI | Agricultural Technology Application Research Institute |
| CAZRI | Central Arid Zone Research Institute |
| CCARI | Central Coastal Agricultural Research Institute |
| CCC | Cyanobacterial Culture Collection |
| CCSRI | C C Shroff Research Institute |
| cfu | Colony Forming Unit |
| CIARI | Central Island Agricultural Research Institute |
| CICR | Central Institute for Cotton Research |
| CPCRI | Central Plantation Crops Research Institute |
| CRIDA | Central Research Institute for Dryland Agriculture |
| DARE | Department of Agricultural Research and Education |
| DGR | Directorate of Groundnut Research |
| FFP | Farmers First Program |
| FLD | Frontline Demonstration |
| FYM | Farmyard Manure |
| IARI | Indian Agricultural Research Institute |
| ICAR | Indian Council of Agricultural Research |
| IGFRI | Indian Grassland and Fodder Research Institute |
| IIHR | Indian Institute of Horticultural Research |
| IIPR | Indian Institute of Pulses Research |
| IISR | Indian Institute of Soybean Research |
| KVK | Krishi Vigyan Kendra |
| MCC | Microbial Culture Collection (now National Centre for Microbial Resource) |
| MTCC | Microbial Type Culture Collection |
| MULLaRP | Mungbean, Urdbean, Lentil, Lathyrus, Rajmash and Pea |
| NAIMCC | National Agriculturally Important Microbial Culture Collection |
| NBAIM | National Bureau of Agriculturally Important Microorganisms |
| NBAIR | National Bureau of Agricultural Insect Resources |
| NCIM | National Collection of Industrial Microorganisms |
| NEH | North Eastern Hills |
| NIASM | National Institute of Abiotic Stress Management |
| NMSA | National Mission on Sustainable Agriculture |
| NRRI | National Rice Research Institute |
| NSP | National Seed Project |
| OFT | On Farm Trial |
| PGPR | Plant Growth Promoting Rhizobacteria |
| PSB | Phosphate Solubilizing Bacteria |
| RDF | Recommended Dose of Fertilizers |
| RRS | Regional Research Station |
| UAS | University of Agricultural Sciences |

# 1. Bio NPK


- **Microbial Constituents:** *Azotobacter chroococcum* W5 (NAIMCC-B-00061/MTCC 25045), *Paenibacillus tylopili* (NAIMCC-B-01548) and *Bacillus decolorationis* (MTCC 25044)
- **Type:** Liquid formulation; $2 \times 10^8$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat, rice, maize, chickpea, soybean, papaya, fodder oat and berseem
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre); root dip for seedlings (500 mL formulation diluted to 2.5 L with water for seedlings to be planted in one acre) and soil application for tree plants (10 mL/tree)
- **Target agroecological zones/states**: Delhi, Punjab, Haryana, Uttar Pradesh, Gujarat, Bihar and Manipur
- **Validation:** AICRPs on Maize and Groundnut for two years; at ICAR-IGFRI, Jhansi on fodder oats and berseem for two years; AICRP on NSP (Crops) for two years; Two years on-farm trials with rice and wheat in Uttar Pradesh and Punjab; One year on papaya in Bihar, on chickpea and soybean in Uttar Pradesh
- **Commercialization:** Commercialized in 2017; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Saves chemical fertilizers up to 25-30 kg N, 10-15 kg P and 2-5 kg K/ha
  - 5-10% increase in grain yield in rice, wheat and maize
  - Net saving of ₹ 1000-3000/ha in target crops
- **Cost:** ₹ 50/- per 100 mL

Control Treated

Effect of BioNPK on wheat var. HD2967 at ICAR-NBAIM, Mau during 2016-17

***Contact:***
Director, ICAR-National Bureau of Agriculturally Important Microorganisms, Mau- 275103; e-Mail: director.nbaim@icar.gov.in

# 2. Bio Grow


- **Microbial Constituents:** *Bacillus* sp. BC39 (NAIMCC-B-02720), *B. subtilis* RC25 (NAIMCC-B-02721), *Pseudomonas fluorescens* KC30 (NAIMCC-B-02722) and *Pseudomonas* sp. KC31 (NAIMCC-B-02723)
- **Type:** Liquid formulation; $2 \times 10^7$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Tomato, chilli, egg plant, marigold and tuberose
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre)
- **Target agroecological zones/states**: Uttar Pradesh and Haryana
- **Validation:** On-farm trials at ICAR-NBAIM, Mau on tomato and chilli; farmers' fields on tomato, potato and marigold in Mau and Varanasi; UAS, Shivamogga on chilli for two years
- **Commercialization:** Commercialized in 2017; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - 25-30% increase in yield of tomato
  - Enhanced content of lycopene and β-carotene
  - Prolonged growth of marigold with two additional pickings of flower
- **Cost:** ₹ 50/- per 100 mL

Control Treated

Effect of Bio Grow on tomato var. Dev-Daksh at ICAR-NBAIM, Mau during 2015-16

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# 3. Bio Phos and Bio Phos+



- **Microbial Constituent:** *Kluyvera cryocrescens* (Bio Phos; NAIMCC-B-02041) and *Paenibacillus tylopili* (Bio Phos+; NAIMCC-B-01548)
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat, maize, rice, mustard and chickpea
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre)
- **Target agroecological zones/states**: Delhi, Punjab, Haryana, Uttar Pradesh, Gujarat, Bihar, Manipur and Karnataka
- **Validation:** AICRP on Maize at 22 locations for two years; OFT at ICAR-NBAIM, Mau on wheat, maize, rice and mustard for two years; farmers' fields in Uttar Pradesh, Bihar and Punjab on wheat and maize; UAS, Shivamogga on chickpea for two years
- **Commercialization:** Commercialized in 2017; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Save chemical fertilizers up to 25-30 kg P/ha
  - 7-11% increase in grain yield of maize, wheat, rice and mustard
- **Cost:** ₹ 50/- per 100 mL


Control


Treated

Evaluation of Bio Phos on maize var. Bio 9637 at ICAR-NBAIM, Mau during 2017-18

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Director, ICAR-National Bureau of Agriculturally Important Microorganisms, Mau- 275103; e-Mail: director.nbaim@icar.gov.in

# 4. Bio Zn


- **Microbial constituent:** *Bacillus endophyticus* (NAIMCC-B-01543)
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat, maize and soybean
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre); root dip for seedlings (500 mL formulation diluted to 2.5 L with water for seedlings to be planted in one acre)
- **Target agroecological zones/states**: Delhi, Punjab and Uttar Pradesh
- **Validation:** ICAR-NBAIM, Mau on wheat and maize; farmers' fields in Mau and Azamgarh on wheat, ICAR-IARI, New Delhi on soybean
- **Commercialization:** Commercialized in 2017; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Saves chemical fertilizer up to 2-5 kg Zn/ha
  - 5-10% increase in grain yield
  - Improves uptake of Zn in seeds
- **Cost:** ₹ 50/- per 100 mL

Control

Treated

Effect of Bio Zn inoculation on accummulation of Zn in maize roots visualized through Dithiozone staining

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# 5. Bio Potash


- **Microbial Constituent:** *Bacillus decolorationis* (MTCC 25044)
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Maize, wheat, mustard and potato
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre)
- **Target agroecological zones/states**: Delhi, Punjab, Uttar Pradesh and Uttarakhand
- **Validation:** In wheat, mustard and maize at ICAR-NBAIM, Mau; on potato in farmers' fields at Dehradun
- **Commercialization:** Commercialized in 2017; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Augments 10-15 kg K/ha
  - 2-5% increase in yield
- **Cost:** ₹ 50/- per 100 mL

Control

Treated

Evaluation of Bio Potash on maize var. Bio 9637 at ICAR-NBAIM, Mau during 2017-18

***Contact:***
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# 6. Bio Bacter


- **Microbial Constituent:** *Azotobacter chroococcum* (NAIMCC-B-00061/MTCC 25045)
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat, rice and maize
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre); root dip for seedlings (500 mL formulation diluted to 2.5 L with water for seedlings to be planted in one acre)
- **Target agroecological zones/states**: Delhi, Punjab and Uttar Pradesh
- **Validation:** ICAR-NBAIM, Mau on wheat, rice and maize; farmers' fields in Mau and Varanasi on wheat
- **Commercialization:** Commercialized in 2017; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Saves 20-25 kg N/ha
  - Increases yield by 5-7%
- **Cost:** ₹ 50/- per 100 mL


Control


Treated

Effect of Bio Bacter on wheat var. HD2967 at ICAR-NBAIM, Mau during 2017-18

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# 7. RhizoNBAIM


- **Microbial Constituent:** Nitrogen fixing rhizobial strains specific to chickpea, pigeon pea, black gram, pea and lentil
  - Chickpea: *Mesorhizobium ciceri* Ca7 (NAIMCC-B-02476)
  - Pigeon pea: *Bradyrhizobium yuanmingense* APP151 (NAIMCC-B-02407)
  - Green gram: *Bradyrhizobium yuanmingense* MV3 ((NAIMCC-B-02475)
  - Pea: *Rhizobium multihospitium* P15 (NAIMCC-B-02717)
  - Lentil: *Rhizobium lentis* LTL3 (NAIMCC-B-02478)
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Specific rhizobia for each of the pulse crops *viz*., chickpea, pigeon pea, green gram, pea and lentil
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre)
- **Target agroecological zones/states**: Uttar Pradesh
- **Validation:** ICAR-NBAIM, Mau on chickpea, pigeon pea, green gram and lentil; farmers' fields on chickpea at Mau
- **Commercialization:** Commercialized in 2018; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Saves 25-30 kg N/ha
  - Increases yield by 7-10%
- **Cost:** ₹ 50/- per 100 mL

Control

Treated

Effect of RhizoNBAIM on chickpea var. Pusa 362 at ICAR-NBAIM, Mau during 2019-20

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Director, ICAR-National Bureau of Agriculturally Important Microorganisms,
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# 8. PUSA Algal Biofertilizer


- **Microbial Constituents:** *Anabaena variabilis* (CCC 421), *Nostoc muscorum* (CCC 442), *Aulosira fertilissima* (CCC 444) and *Tolypothrix tenuis* (CCC 443)
- **Type:** Multani Mitti based formulation; $10^4$ propagules/g
- **Shelf life:** 03 months at 25°C to 35°C
- **Target crop:** Rice
- **Method of application:** Soil application (500 g/acre)
- **Target agroecological zones/states**: Punjab, Delhi, Uttar Pradesh, Haryana and Bihar
- **Validation:** Multilocational trials on rice for 20 years
- **Commercialization:** On sale counters in the Division of Microbiology, ICAR-IARI, New Delhi since 1970s; Commercialized in 2010; Licensed to three entrepreneurs
  - Sai Bio Organics, Moga, Punjab
  - Ecological Products Industries, New Delhi
  - Forex Fastners (P) Ltd., Punjab
- **Benefits:**
  - Saves 20-30 kg N/ha
  - Induces early grain setting
- **Cost:** ₹ 50/- per 500 g

Treated Control

Evaluation of Pusa Algal Biofertilizer on rice var. Pusa Sugandh 5 at ICAR-IARI, New Delhi during 2007

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# 9. IARI Azotobacter



- **Microbial Constituent:** *Azotobacter chroococcum* W5 (NAIMCC-B-00061)
- **Type:** Carrier based; $1 \times 10^8$ cfu/g; Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 03 months for carrier based formulation; 36 months for liquid formulation at 25°C to 35°C
- **Target crops:** Cotton, wheat, maize, potato, brinjal, pearl millet, mustard and onion
- **Method of application:** Seed treatment (50 mL formulation diluted to one litre with water for seeds to be sown in one acre; or 200 g for coating seeds for one acre)
- **Target agroecological zones/states**: All states
- **Validation:** Multilocational trials on different crops for 30 years
- **Commercialization:** On sale counters in the Division of Microbiology, ICAR-IARI, New Delhi since 1976; Commercialized in 2010; Licensed to four companies
  - Sai Bio Organics, Moga, Punjab
  - Eco Inputs, Ludhiana
  - HBPL, East Champaran, Bihar
  - Department of Horticulture, Hoshiarpur, Punjab
- **Benefits:**
  - Saves 15-20 kg N/ha
  - 10-35% increase in grain yield
- **Cost:** ₹ 50/- per 200 g; ₹ 75/- per 50 mL

Control

Treated

Effect of IARI Azotobacter on brinjal at ICAR-IARI, New Delhi during 2002-03

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e-Mail: director@iari.res.in

# 10. PUSA Azospirillum

- **Microbial Constituent:** *Azospirillum brasilense*
- **Type:** Carrier based formulation; $1 \times 10^8$ cfu/g
- **Shelf life:** 03 months at 25°C to 35°C
- **Target crops:** Sorghum, pearl millet, finger millet, Italian millet, kodo millet, barn yard millet, small millet, oats, rice and sugarcane
- **Method of application:** Seed treatment (200 g for coating seeds for one acre)
- **Target agroecological zones/states**: All states
- **Validation:** Multilocational trials on target crops for 30 years
- **Commercialization:** On sale counters in the Division of Microbiology, ICAR-IARI, New Delhi since 1982; Registered at Zonal Technology Management & Business Planning and Development Unit, ICAR-IARI, New Delhi
- **Benefits:**
  - Saves 15-20 kg N/ha
  - 10-35% increase in grain yield
- **Cost:** ₹ 50/- per 200 g


Control Treated

Effect of PUSA Azospirillum on sorghum at ICAR-IARI, New Delhi during 2002-03

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e-Mail: director@iari.res.in

# 11. PUSA Rhizobium


- **Microbial Constituent:** Rhizobial strains specific to different pulse crops- chickpea (*Mesorhizobium ciceri*), pigeon pea (*Bradyrhizobium yuanmingense*), black gram and cowpea [*Bradyrhizobium* sp. (*Vigna*)], pea and lentil (*Rhizobium leguminosarum* bv. *viceae*), groundnut [*Bradyrhizobium* sp. (*Arachis*)], berseem (*Rhizobium leguminosarum* bv. *trifolii*), lucerne (*Rhizobium meliloti*), dhaincha (*Azorhizobium caulinodans*) and sunhemp [*Bradyrhizobium* sp. (*Crotolaria*)]
- **Type:** Carrier based formulation; $1 \times 10^8$ cfu/g
- **Shelf life:** 03 months at 25°C to 35°C
- **Target crops:** Chickpea, pigeon pea, black gram, pea, lentil, groundnut, cowpea, berseem, lucerne, dhaincha and sunhemp
- **Method of application:** Seed treatment (200 g for coating seeds for one acre)
- **Target agroecological zones/states**: All states – Pulse growing areas
- **Validation:** AICRPs on MULLaRP, Chickpea and Soybean; Multilocational trials for more than 30 years
- **Commercialization:** On sale counters in the Division of Microbiology, ICAR-IARI, New Delhi since 1970s; Licensed to one entrepreneur
  - Sai Bio Organics, Moga, Punjab
- **Benefits:**
  - Saves 15-25 kg N/ha
  - Increases yield by 30-60% in target crops
- **Cost:** ₹ 50/- per 200 g


Control Treated

Effect of PUSA Rhizobium on Chickpea at ICAR-IARI, New Delhi during 2014

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e-Mail: director@iari.res.in

# 12. PUSA BIOPHOS

- **Microbial Constituent:** *Lactococcus lactis* PHM5-37
- **Type:** Carrier based; $1 \times 10^8$ cfu/g; Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 03 months for carrier based and 12 months for liquid formulation at 25°C to 35°C
- **Target crops:** Wheat, rice, cowpea, soybean, lentil, gram and potato
- **Method of application:** Seed treatment (50 mL formulation diluted to one litre with water for seeds to be sown in one acre; or 200 g for coating seeds for one acre)
- **Target agroecological zones/states**: All states
- **Validation:** ICAR-IARI, New Delhi on wheat, rice, cowpea, soybean, lentil and gram for four years
- **Commercialization:** Licensed to Department of Horticulture, Hoshiarpur, Punjab
- **Benefits:**
  - Saves 10-15 kg P/ha
  - Increases yield by 15-20%
- **Cost:** ₹ 50/- per 200 g; ₹ 75/- per 50 mL


Control Treated

Effect of PUSA BioPhos on Lentil var. L4076 at ICAR-IARI, New Delhi during 2017-18

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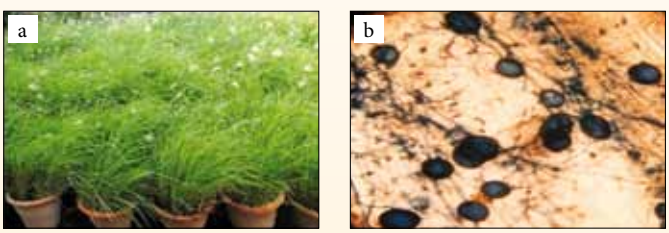
e-Mail: director@iari.res.in

# 13. PUSA Mycorrhiza

- **Microbial Constituents:** *Funneliformis mosseae* (=*Glomus mosseae*), *Rhizophagus intraradices* (=*G. intraradices*) and *Scutellospora* sp.
- **Type:** Soil based formulation; 100 infective propagules/g soil
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Nursery raised crops, crops grown under protected cultivation; useful in tissue culture crops where it helps in hardening the roots before transplanting
- **Method of application:** Soil application (5 kg/acre)
- **Target agroecological zones/states**: All states
- **Validation:** Multilocational trials on different crops for 20 years
- **Commercialization:** Commercialized in 1985; Licensed to twenty five entrepreneurs. Few are listed here
  - Patanjali, Haridwar, Uttrakhand
  - Bharat Agro Molecules Ltd., Meerut, Uttar pradesh
  - Pratishtha Industries Ltd., Secunderabad, Uttar pradesh
  - Vaishnavi Biotech Ltd., Secunderabad, Uttar pradesh
  - Prabhat Fertilizer and Chemical Works, Karnal, Haryana
- **Benefits:**
  - Improves crop yield by 15-25%
  - Improves P-uptake in crops under P-deficient soil conditions
  - Sustains the crop under water stress conditions and improves soil aggregation
  - Enhances microbial population near the roots and enhances uptake of micro- (Zn, B, Cu, Fe etc.) and macro-nutrients like N & P
- **Cost:** ₹ 50/- per kg




Production of AM fungi using (a) *Cenchrus ciliaris* as host and (b) root colonization by AM fungi

***Contact:***
Director, ICAR-Indian Agricultural Research Institute, New Delhi-110012;
e-Mail: director@iari.res.in

# 14. PUSA BIOPOTASH


- **Microbial Constituent:** *Bacillus* sp.
- **Type:** Liquid formulation; $1 \times 10^7$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Maize, wheat, rice and pearl millet
- **Method of application:** Seed treatment (50 mL formulation diluted to one litre with water for seeds to be sown in one acre)
- **Target agroecological zones/states**: Delhi, Punjab, Bihar, Jharkhand, West Bengal, Odisha, Chhattisgarh, Madhya Pradesh and Rajasthan
- **Validation:** In wheat and maize at ICAR-IARI, New Delhi for two years; Three years on rice, wheat and pearl millet in collaboration with KVKs of target states
- **Commercialization:** Licensed to Department of Horticulture, Hoshiarpur, Punjab
- **Benefits:**
  - Augments 10-15 kg K/ha
  - 2-5% increase in yield
- **Cost:** ₹ 75/- per 50 mL

Control Treated

Evaluation of PUSA BIOPOTASH on wheat var. HD2967 at ICAR-IARI, New Delhi during 2016

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# 15. PUSA BioZinc


- **Microbial Constituent:** *Bacillus* sp.
- **Type:** Liquid formulation; $1 \times 10^8$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat, soybean, rice and pearl millet
- **Method of application:** Seed treatment (50 mL formulation diluted to one litre with water for seeds to be sown in one acre)
- **Target agroecological zones/states**: Delhi, Punjab, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Chhattisgarh, Madhya Pradesh, Rajasthan, Gujarat, Uttarakhand and Haryana
- **Validation:** ICAR-IARI, New Delh on soybean and wheat for two years; Three years on rice, wheat and pearl millet in collaboration with KVKs of target states
- **Commercialization:** Commercialized in 2013; Licensed to M/s Kirti International, Ludhiana, Punjab
- **Benefits:**
  - Augments 2 to 5 kg Zn/ha
- **Cost:** ₹ 75/- per 50 mL

Control

Treated

Evaluation of PUSA BioZinc on wheat var. HD2967 at ICAR-IARI, New Delhi during 2013-14

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# 16. NPK Biofertilizer


- **Microbial Constituents:** *Azotobacter chroococcum* (MTCC 25045), *Burkholderia cepacia* (MTCC 25043) and *Bacillus decolorationis* (MTCC 25044)
- **Type:** Liquid formulation; $2 \times 10^8$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat, rice, citrus, turmeric and garlic
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre); root dip for seedlings (500 mL formulation diluted to 2.5 L with water for seedlings to be planted in one acre) and soil application for tree plants (10 mL/tree)
- **Target agroecological zones/states**: Bihar, Jharkhand, West Bengal, Odisha, Chhattisgarh, Madhya Pradesh, Punjab, Rajasthan, Gujarat, Delhi, Uttarakhand and Haryana
- **Validation:** Two years on-farm trials at ICAR-IARI, New Delhi and farmers' fields at Punjab with rice and wheat; One year on citrus in Punjab, on garlic and turmeric in Gujarat; Three years on rice, wheat and pearl millet in collaboration with KVKs of target states
- **Commercialization:** Commercialized in 2015; Licensed to two entrepreneurs
  - M/s Monal Potteries and Ceramics Ltd., Una, Himachal Pradesh
  - Pratishtha Industries Ltd., Secunderabad, Telangana
- **Benefits:**
  - Saves chemical fertilizers up to 25-30 kg N, 10-15 kg P and 2-5 kg K/ha
  - 5-10% increase in grain yield in rice and wheat
- **Cost:** ₹ 125/- per 100 mL

Control


Treated

Evaluation of NPK Biofertilizer on rice at ICAR-IARI, New Delhi during 2013-14

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# 17. PUSA SAMPOORN


- **Microbial Constituents:** *Azotobacter chroococcum* W5 (MTCC 25045), *Pseudomonas psychrophila* and *Bacillus decolorationis*
- **Type:** Liquid formulation; $2 \times 10^8$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Wheat and rice
- **Method of application:** Seed treatment (100 mL formulation diluted to one litre with water for seeds to be sown in one acre); root dip for seedlings (500 mL formulation diluted to 2.5 L with water for seedlings to be planted in one acre)
- **Target agroecological zones/states**: Delhi, Punjab and Haryana
- **Validation:** Four years on-farm trials at ICAR-IARI, New Delhi with rice and wheat
- **Commercialization:** Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Saves chemical fertilizers up to 25-30 kg N, 10-15 kg P and 2-5 kg K/ha
  - 5-10% increase in grain yield in rice and wheat
- **Cost:** ₹ 100/- per 100 mL

Control Treated

Evaluation of PUSA SAMPOORN on wheat var. HD2967 at ICAR-IARI, New Delhi during 2017-18

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Director, ICAR-Indian Agricultural Research Institute, New Delhi-110012;
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# 18. Biofort IARI

- **Microbial Constituents:** Biofort (W)-*Bacillus pumilus* PW1 (NAIMCC-B-00550) + *Providencia* sp. PW5 (NAIMCC-B-00557) + *Brevundimonas diminuta* PW7 (NAIMCC-B-00559); Biofort (R)-*Providencia* sp. PR3 (NAIMCC-B-00563)+ *B. diminuta* PR7 (NAIMCC-B-00566)+ *Ochrobactrum anthropi* PR10 (NAIMCC-B-00568)
- **Type:** Carrier based formulation; $3 \times 10^9$ cfu/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Biofort (W) for wheat and Biofort (R) for rice
- **Method of application:** Seed coating; soil application or seedling dip (500 g/acre)
- **Target agroecological zones/states**: Delhi, Punjab, Haryana and Andhra Pradesh
- **Validation:** Five years in rice-wheat cropping system at ICAR-IARI, New Delhi; On-farm trials at KVKs of Andhra Pradesh with rice; Ambala District, Haryana with rice for one year
- **Commercialization:** Commercialized in 2015; Registered at Zonal Technology Management & Business Planning and Development Unit, ICAR-IARI, New Delhi
- **Benefits:**
  - Effective micronutrient mobilization to grains, with 13–40% increase in Fe, Zn and Mn concentrations
  - Saves chemical fertilizers up to 30-50 kg N/ha
  - 10-15% increase in yield in target crops

a. Control-100% NPK (RDF) b. 50% N + Full dose of P & K + Biofort IARI

Influence of Biofort IARI application in wheat var. HD 2967at ICAR-IARI, New Delhi during 2017-18

***Contact:***
Director, ICAR-Indian Agricultural Research Institute, New Delhi-110012;
e-Mail: director@iari.res.in

# 19. Cyanobiocon

- **Microbial Constituents:** *Anabaena laxa/Calothrix elenkinii*
- **Type:** Carrier based formulation; 2-5 µg Chlorophyll/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Tomato, cucumber, capsicum, cotton, rice, chickpea and chrysanthemum
- **Method of application:** Seed coating (1.25 kg/ha); soil application (1.25 kg suspended in 500 L water for one ha) or seedling dip (1.25 kg suspended in 25 L water for one ha)
- **Target agroecological zones/states**: Delhi, Punjab, Haryana, Himachal Pradesh, Uttarakhand, Rajasthan, Madhya Pradesh and Maharashtra
- **Validation:** Five years under Centre for Protected Cultivation Technology in vegetables and flower crops at ICAR-IARI, New Delhi; Three years field trials in cotton, at ICAR-Central Institute for Cotton Research, Sirsa and Nagpur; Two years with capsicum and tomato, at ICAR-IARI Regional station, Katrain; okra and cucumber at ICAR-Indian Institute of Vegetable Research, Varanasi Uttar Pradesh; Two years in chrysanthemum and tomato at ICAR-IARI, New Delhi; One year with rice in Ambala District, Haryana
- **Commercialization:** Commercialized in 2015; Registered at Zonal Technology Management & Business Planning and Development Unit, ICAR-IARI, New Delhi
- **Benefits:**
  - Significant enhancement of plant growth, N and P uptake
  - Elicits immunity against soil borne fungal diseases
  - Saves chemical fertilizers up to 30-50 kg N/ha
  - 10-12% increase in yields

Influence of Cyanobiocon application in chickpea var. Pusa 1103 at ICAR-IARI, New Delhi during 2013-14

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# 20. Cyanonutricon


- **Microbial constituents:** *Anabaena torulosa* BF1 (NAIMCC-C-00344), *Nostoc carneum* BF2 (NAIMCC-C-00345), *Nostoc piscinale* BF3 (NAIMCC-C-00346) and *Anabaena doliolum* BF4 (NAIMCC-C-00347)
- **Type:** Carrier based formulation; 2-5 µg Chlorophyll/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Rice, wheat, maize, cotton, vegetables and flower crops
- **Method of Application along with dose**: Seed coating (1.25 kg/ha), soil application (1.25 kg suspended in 500 L water for one ha) or seedling dip (1.25 kg suspended in 25 L water for one ha)
- **Target agroecological zones/states**: Delhi, Punjab, Haryana, Andhra Pradesh, Telangana and Maharashtra
- **Validation**: Five years in rice-wheat cropping system at ICAR-IARI, New Delhi; Two years under Centre for Protected Cultivation Technology in vegetables and flower crops at ICAR-IARI, New Delhi; On-farm trials at KVKs of Andhra Pradesh and Telangana in rice; Ambala District, Haryana in rice for two years; One year with cotton at ICAR-Central Institute for Cotton Research, Nagpur
- **Commercialization:** Commercialized in 2015; Registered at Zonal Technology Management & Business Planning and Development Unit, ICAR-IARI, New Delhi
- **Benefits:**
  - 10–20% increase in grain micronutrients
  - Saves 30-50 kg N/ha
  - 10-15% increase in yields
  - Enrichment of soil carbon

Control- 100% NPK (RDF) 50% N+ 100% P & K + Cyanonutricon

Influence of Cyanonutricon on rice var. Pusa Basmati 1509 at ICAR-IARI New Delhi during 2019

***Contact:***
Director, ICAR-Indian Agricultural Research Institute, New Delhi-110012;
e-Mail: director@iari.res.in

# 21. CRIDA Resilia-I


- **Microbial Constituents:** *Pseudomonas putida* P7 (NAIMCC-B-00922) and *Paenibacillus favisporus* B30 (NAIMCC-B-01801)
- **Type:** Carrier based formulation; $1 \times 10^8$ cfu/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Maize and rabi sorghum
- **Method of application:** Seed treatment 30 g/kg seeds; soil application 2.5 kg/ha (Mix with 50 kg of well decomposed FYM and apply to one hectare)
- **Target agroecological zones/states**: Punjab, Karnataka and Telangana
- **Validation:** On-farm trials at ICAR-CRIDA, Hyderabad with maize and sorghum for three years; AICRP on Dryland Agriculture at Ballowal Saunkhri, Punjab for three years
- **Commercialization:** Available for licensing
- **Benefits:**
  - 20-30% increase in yield of maize and rabi sorghum

Control

Treated

Response of maize var. PMH-1 at Ballowal Saunkhri, Punjab during 2019-20

***Contact:***
Director, ICAR-Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500 059; e-Mail: director.crida@icar.gov.in

# 22. CRIDA Resilia-II


- **Microbial Constituents:** *Pseudomonas putida* P45 (NAIMCC-B-00923) and *Bacillus amyloliquefaciens* B17 (NAIMCC-B-00921)
- **Type:** Carrier based formulation; $1 \times 10^8$ cfu/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crop:** Sorghum
- **Method of application:** Seed treatment 30 g/kg seeds + soil application 2.5 kg/ha (Mix with 50 kg of well decomposed FYM and apply to one hectare)
- **Target agroecological zones/states**: Maharashtra and Telangana
- **Validation:** On-farm trials at ICAR-CRIDA, Hyderabad with sorghum for three years; AICRP on Dryland Agriculture at Parbhani, Maharashtra for three years
- **Commercialization:** Available for licensing
- **Benefits:**
  - 15-20% increase in yield of sorghum


Control Treated

Response of sorghum var. CSV-27 at Parbhani, Maharashtra during 2019-20

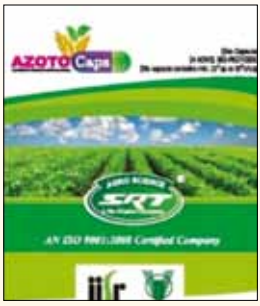
***Contact:***
Director, ICAR-Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500 059; e-Mail: director.crida@icar.gov.in

# 23. Biocapsules

- **Microbial Constituents:** Capsule can act as a carrier for any bacterial/fungal strain (*Rhizobium*, *Azotobacter, Pseudomonas fluorescens, Bacillus, Burkholderia* and *Trichoderma*)
- **Type:** Capsules; $1 \times 10^{12}$ cfu/capsule
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** All plantation and horticultural crops
- **Method of application:** Soil drenching using 8-10 capsules per acre; one capsule suspended in 1000 mL water and finally diluted to 100 L
- **Target agroecological zones/states**: All
- **Validation:** Farmers' fields at Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat, Uttar Pradesh and Himachal Pradesh
- **Commercialization:** Commercialized in 2016; Licensed to two companies
  - M/s Codagu Agritech, Kudulur, PB No. 58, Kushalnagar-571234, Karnataka
  - M/s SRT Agro Science Pvt. Ltd. Vill: Funda, Tah: Patan, Durg-491111, Chhattisgarh
- **Benefits:**
  - Enhances root production, nutrient mobilization and use efficiency, crop growth and yield
  - Protect crops against soil borne pathogens



*Trichoderma* sp. and *Bacillus amyloliquefaciens* capsules


*Rhizobium* and *Azotobacter* capsules

***Contact:***
Director, ICAR-Indian Institute of Spices Research, Marikunnu PO, Kozhikode-673012;
e-Mail: director.spices@icar.gov.in

# 24. Arka Microbial Consortium


- **Microbial Constituents:** *Azotobacter tropicalis* PAN MC1 (NAIMCC-B-01336) (Nitrogen fixer), *Bacillus aryabhattai* Bel 6 (NAIMCC-B-01335) (P & Zn solubilizer) and *Pseudomonas taiwanensis* Mpf2 (NAIMCC-B-01337) (K-solubilizer and PGPR)
- **Type:** Carrier based formulation; 1 × $10^8$ cfu/g of each; Liquid formulation; 1x $10^9$ cfu/mL of each
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** All annual and perennial horticultural and plantation crops.
- **Method of application:** Seed treatment; biofertigation through drip lines, soil drenching (3 L/acre or 5 kg/acre)
- **Target agroecological zones/states**: Karnataka, Tamil Nadu, Kerala, Telangana, Andhra Pradesh and Maharashtra
- **Validation:** AICRP on Fruits with guava and papaya for two years; ATARI, Zone VIII for two years on a variety of vegetables; on different horticultural crops at ICAR-IIHR, Bengaluru for three years
- **Commercialization:** Commercialized in 2013; Licensed to 13 entrepreneurs/ KVKs/State departments
  - M/s Bloom Biotech, Chikkamagaluru, Karnataka
  - M/s Gayatri Hasiru Uddime , Ramnagara District, Karnataka
  - ICAR-KVK, Hirehalli , Tumakuru District, Karnataka
  - Department of Horticulture, Bengaluru, Karnataka
  - M/s Phalada Organics, Bengaluru, Karnataka
  - ICAR- KVK, Gonikoppal , Kodagu District, Karnataka
  - M/s Natura Crop Care, Bengaluru, Karnataka
  - M/s Janardhana, Bengaluru, Karnataka
  - M/s Bhavani Biochemicals, Koppal, Karnataka
  - M/s ESAF Swarasya Farmers Producers Organization, Palakkad, Kerala
  - M/s Ganpath Products, Madurai, Tamil Nadu
  - M/s JSS Krishi Vigyan Kendra, Mysuru, Karnataka
  - State Parasite Breeding Farm , Kasaragod , Kerala
- **Benefits:**
  - Saves 25% of N and P fertilizers
  - Enhances yield by 10 to 15% in target crops
  - Net savings of ₹ 1000-3000/ha in target crops
- **Cost:** ₹ 147/- per kg and ₹ 263/- per litre

***Contact:***
Director, ICAR- Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bengaluru-560089; e-Mail: director.iihr@icar.gov.in

# 25. Arka Actino Plus


- **Microbial Constituents:** *Streptomyces viridobrunneus* Pan Act1 (MTCC 11933), *S. bullii* Pan Act2 (MTCC 11934) and *S. griseorubens* Pan Act3 (MTCC 11935)
- **Type:** Carrier based; $1 \times 10^6$ cfu/g of each
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** All annual and perennial horticultural and plantation crops.
- **Method of application:** Seed treatment, soil drenching, enrichment of FYM and cocopeat used for raising nurseries and applied at 5 kg/acre. For annual crops it can be applied once during the crop cultivation period, preferably within 10 days of transplantation/sowing. For perennial crops, it can be applied at four monthly intervals with the first application commencing in the month of June/July
- **Target agroecological zones/states**: Karnataka, Tamil Nadu, Kerala, Telangana, Andhra Pradesh and Maharashtra
- **Validation:** Validated through extensive institutional trials at ICAR-IIHR, Bengaluru on a variety of horticultural crops and through the ATARI of Zone VIII in different vegetable crops
- **Commercialization:** Commercialized in 2015; Licensed to two entrepreneurs
  - M/s Bloom Biotech, Chikkamagaluru, Karnataka
  - M/s Natura Crop Care, Bengaluru, Karnataka
- **Benefits:**
  - Saves 25% of P fertilizers
  - Improves overall plant health
- **Cost:** ₹ 140/kg

Control

Treated

Effect of Arka Actino Plus on vegetable Cowpea (Arka Garima) at ICAR-IIHR, Bengaluru during 2020-21

***Contact:***
Director, ICAR- Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bengaluru-560089; e-Mail: director.iihr@icar.gov.in

# 26. Kera Probio™


- **Microbial Constituent:** *Bacillus megaterium* (NAIMCC-B-02718)
- **Type:** Carrier based formulation; $10^7$-$10^9$ cfu/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Coconut, tomato, brinjal and chilli
- **Method of application:** Seedling dip (mix 500 g in 5 L of water and dip the coconut seedlings for 8-10 hrs); soil application (25 g per plant); for transplanted seedlings booster dose can be given at 50 g per plant; for vegetable crops at 2 kg/acre
- **Target agroecological zones/states**: Kerala
- **Validation:** AICRP on Palms with coconut for 3 years; On-farm trials at ICAR-CPCRI, Kasaragod and farmers' fields, Kasaragod for one year
- **Commercialization:** Commercialized in 2018; Licensed to entrepreneur group of Farmers First Program (FFP) in Pathiyoor Panchayat of Alappuzha district, Kerala
- **Benefits:**
  - Yield enhancement of 10-12% nuts/palm/year
  - Incorporation in INM based farming could fetch additional remuneration of ₹ 20000/ha and ₹ 30000-40000/ha if vegetables are taken as intercrop
- **Cost:** ₹ 100/- per kg

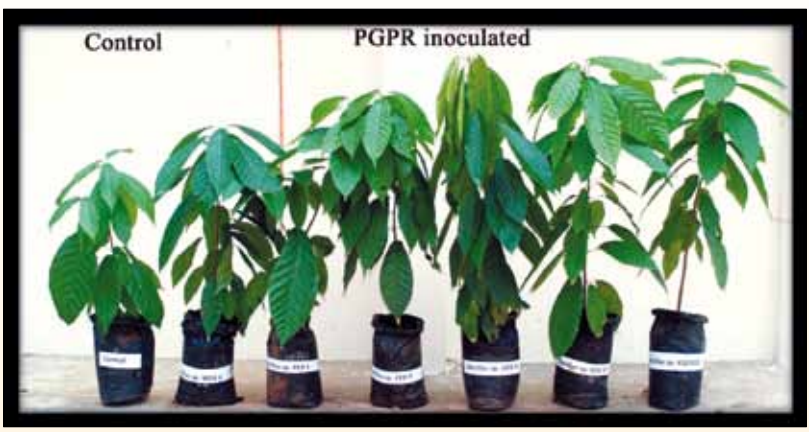
Control Treated

Kera Probio treatment effect on coconut seedlings

***Contact:***
Director, ICAR-Central Plantation Crops Research Institute, P.O Kudlu, Kasaragod-671124; e-Mail: director.cpcri@icar.gov.in

# 27. Cocoa Probio™


- **Microbial Constituent:** *Pseudomonas putida* (NAIMCC-B-02719)
- **Type:** Carrier based formulation; $10^7$-$10^9$ cfu/g
- **Shelf life:** 06 months at 25°C to 35°C
- **Target crops:** Cocoa and Vegetable crops
- **Method of application:** Soil application (25 g per plant); for transplanted seedlings booster dose can be given at 100 g per plant; for vegetable crops at 2 kg/acre
- **Target agroecological zones/states**: Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana
- **Validation:** ICAR-CPCRI farms and farmers' fields of different cocoa growing areas of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana for two years
- **Commercialization:** Available for licensing
- **Benefits:**
  - 50-60% increase in dry matter in seedlings
- **Cost:** ₹ 100/- per kg




Trials with cocoa var. forastero at ICAR-CPCRI, Kasaragod during 2013-14

***Contact:***
Director, ICAR-Central Plantation Crops Research Institute, P.O Kudlu, Kasaragod-671124;
e-Mail: director.cpcri@icar.gov.in

# 28. KerAM™


- **Microbial Constituent:** *Claroideoglomus etunicatum*
- **Type:** Carrier based formulation; 100 infective propagules/g
- **Shelf life:** 04 months at 25°C to 35°C
- **Target crops:** Coconut
- **Method of application:** Soil application (50 g/ plant)
- **Target agroecological zones/states**: Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana
- **Validation:** ICAR-CPCRI farms and farmers' fields in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana
- **Commercialization:** Available for licensing
- **Benefits:**
  - Improves overall plant growth
  - Better nutrient uptake

Mixing of KerAM with nursery media

KerAM treated coconut seedlings

***Contact:***
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e-Mail: director.cpcri@icar.gov.in

# 29. NutBoost


- **Microbial Constituents:** *Pseudomonas gessardii* BHU1, *Pseudomonas putida* S1(6) and *Pseudomonas aeruginosa* BM6
- **Type:** Carrier based formulation; $1 \times 10^7$ cfu/g of each; Liquid formulation; $1 \times 10^8$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crop:** Groundnut
- **Method of application:** Carrier based: 4 g of formulation to be suspended in 50 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel; Liquid: 10 mL of bioformulation diluted with 40 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel
- **Target agroecological zones/states**: Gujarat, Andhra Pradesh, Karnataka, Maharashtra, Telangana, Tamil Nadu, Rajasthan, Odisha, West Bengal, NEH region, Madhya Pradesh and Uttar Pradesh
- **Validation:** ICAR-DGR, Junagadh and farmers' fields, Junagadh for three years; AICRP on Groundnut centres for three years; FLDs for two years in different states
- **Commercialization:** Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Enhances pod yield in groundnut upto 16 to 18%
  - Saves 30-40% of phosphatic and 25% of potassium fertilizers
  - Saves input cost by ₹ 1000-2000/ha

Effect of NutBoost on groundnut var. JL24 at ICAR-DGR, Junagadh during 2000-01

***Contact:***
Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001, Gujarat; e-Mail: director.dgr@icar.gov.in

# 30. NutMagic


- **Microbial constituents:** *Pseudomonas gessardii* BHU1 and *Pseudomonas putida* S1(6) (PGPR); *Enterobacter cloacae* BM8 and *Bacillus* sp. (PSB); *Sinorhizobium americanum* NRCG4 and *Rhizobium* sp. NRCG9 (Groundnut nodulating rhizobia)
- **Type:** Carrier based formulation; $1 \times 10^7$ cfu/g of each; Liquid formulation; $1 \times 10^8$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Groundnut
- **Method of application:** Seed treatment; Carrier based: 4 g of formulation to be suspended in 50 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel; Liquid: 10 mL of bioformulation diluted with 40 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel
- **Target agroecological zones/states:** Gujarat, Andhra Pradesh, Karnataka, Maharashtra, Telangana, Tamil Nadu, Rajasthan, Odisha, West Bengal, NEH region, Madhya Pradesh and Uttar Pradesh
- **Validation:** ICAR-DGR, Junagadh and farmers' fields, Junagadh for three years; AICRP on Groundnut centres for three years; FLDs for two years in different states
- **Commercialization:** Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Pod yield enhancement upto 20%
  - Saves 25-30% of nitrogenous, 30-40% of phosphatic and 25% of potassic fertilizers
  - Saves input cost by ₹ 1000-3000/ha

Control

Treated

Effect of NutMagic on groundnut var.TG3A at ICAR-DGR, Junagadh during 2007-08

***Contact:***
Director, ICAR-Directorate of Groundnut Research, Ivnagar Road, PB No. 5, Junagadh-362001, Gujarat; e-Mail: director.dgr@icar.gov.in

# 31. NutGrow


- **Microbial constituents:** *Pseudomonas putida* DAPG2, *Pseudomonas putida* DAPG4, *Pseudomonas putida* FP86 and *Pseudomonas fluorescens* FP98
- **Type:** Carrier based formulation; $1 \times 10^7$ cfu/g of each; Liquid formulation; $1 \times 10^8$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Groundnut
- **Method of application:** Carrier based: 4 g of formulation to be suspended in 50 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel; Liquid: 10 mL of bioformulation diluted with 40 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel
- **Target agroecological zones/states:** Gujarat, Andhra Pradesh, Karnataka, Maharashtra, Telangana, Tamil Nadu, Rajasthan, Odisha, West Bengal, NEH region, Madhya Pradesh and Uttar Pradesh
- **Validation:** ICAR-DGR, Junagadh and farmers' fields, Junagadh for three years; AICRP on Groundnut centres for three years
- **Commercialization:** Available for licensing
- **Benefits:**
  - Improves pod yield of groundnut by 21%
  - Reduces incidence of collar- and stem- rot by 60%
  - Improves availability of macro- and micro-nutrients (P, K, Mn, Fe, Zn, etc.) by 20-25%
  - Controls nematodes in soil
  - Saves upto 30% of P, K, Zn, Fe
  - Saves input cost by ₹ 1500-2500/ha

Control

Treated

Effect of NutGrow on groundnut var. GG20 at ICAR-DGR, Junagadh during 2011

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# 32. DroughtGuard


- **Microbial constituent:** *Bacillus firmus* J22
- **Type:** Carrier based formulation; $1 \times 10^7$ cfu/g; Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 24 months at 25°C to 35°C
- **Target crops:** Groundnut, pigeon pea, cotton and soybean
- **Method of application:** Carrier based: 4 g of formulation to be suspended in 50 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel; Liquid: 10 mL of bioformulation diluted with 40 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel
- **Target agroecological zones/states:** Gujarat, Andhra Pradesh, Karnataka, Maharashtra, Telangana, Tamil Nadu, Rajasthan, Odisha, West Bengal, NEH region, Madhya Pradesh and Uttar Pradesh
- **Validation:** On groundnut at ICAR-DGR, Junagadh and farmers' fields, Junagadh (Gujarat), Anantapur and Kalyandurga (Andhra Pradesh), Hiriyur (Karnataka); on soybean at ICAR-IISR, Indore; on pigeon pea at ICAR-IIPR, Kanpur; on cotton and groundnut at CCSRI, Mandvi, Bhuj; on groundnut under rainfed conditions at AICRP-Groundnut centres for three years
- **Commercialization:** Available for licensing
- **Benefits:**
  - Saves 30-40% irrigation water, can give pod yield of 2200-2300 kg/ha with 3-4 less protective irrigations in summer groundnut
  - Under rainfed condition, alleviates drought stress and improves pod yield upto 32%
  - Alleviates drought stress in soybean and pigeon pea and improves yield upto 20%

Control Treated

Effect of DroughtGuard on groundnut var. TG37A at ICAR-DGR, Junagadh during 2015-16

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# 33. SalGuard


- **Microbial constituents:** *Bacillus firmus* J22N and *Bacillus subtilis* REN51N
- **Type:** Carrier based formulation; $1 \times 10^7$ cfu/g of each; Liquid formulation; $1 \times 10^9$ cfu/mL of each
- **Shelf life:** 24 months at 25°C to 35°C
- **Target crops:** Groundnut
- **Method of application:** Carrier based: 4 g of formulation to be suspended in 50 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel; Liquid: 10 mL of bioformulation diluted with 40 mL of water along with 5 g of sugarcane jaggery and then mixed with one kilogram of groundnut kernel
- **Target agroecological zones/states**: Kachchh, Porbandar, Junagadh, Dwarka, Gir-Somnath and Surendranagar districts of Gujarat
- **Validation:** Experimental and farmers' fields at Bhuj, Gujarat
- **Commercialization:** Available for licensing
- **Benefits :**
  - Alleviates salinity stress and improves pod yield upto 18% and haulm yield upto 6%
  - Increases net return by ₹ 15000-16000/-

Control Treated

Effect of SalGuard on groundnut var. TG37A and GG2 at RRS of ICAR-CAZRI, Kukma, Bhuj during 2014-15

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# 34. Fytoprost

- **Microbial Constituent:** Metabolic product of a *Rhizobium* sp. (NCIM 5599)
- **Type:** Gel based
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Sorghum, soybean, maize, brinjal, onion and fenugreek
- **Method of application:** Foliar spray (50 mL/$m^2$); drip-irrigation system (5-10 kg/ha); seed-treatment/seed-coating (10 g/kg); soil drenching (5-10 kg/ha)
- **Target agroecological zones/states**: Maharashtra
- **Validation:** On sorghum, soybean, maize, brinjal, onion and fenugreek at ICAR-NIASM, Baramati, Maharashtra
- **Commercialization:** Available for licensing
- **Benefits:**
  - Induce rhizosphere colonization by different beneficial microbes such as nitrogen fixers, siderophore producers, and exopolysaccharides producers
  - Promote nodulation in soybean

Control

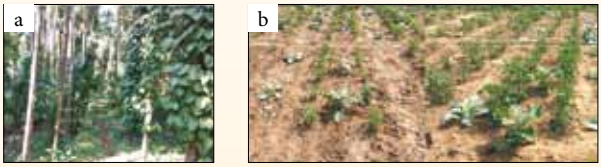
Treated

Effect of Fytoprost on turmeric at ICAR-NIASM, Baramati during 2018-19

***Contact:***
Director, ICAR- National Institute of Abiotic Stress Management, Malegaon, Baramati–413115; e-Mail: director.niasm@icar.gov.in

# 35. GoaBio-1


- **Microbial constituent:** *Bacillus methylotrophicus* STC-4 (NAIMCC-B-01890)
- **Type:** Carrier based formulation; $1 \times 10^8$ cfu/g
- **Shelf life:** 24 months at 25°C to 35°C
- **Target crops:** Rice, black pepper, fruits, and plantation crop nurseries
- **Method of application:** Rice: Seed treatment at 40 g/kg seed; Nursery application at 50 g/m$^2$ by pouring the water suspension at 7 and 14 days after sowing; Vegetables: Soil application at 50 g/m$^2$ in nursery and at 1.0 g/plant (suspend 1 kg in 50 L water and pour 50 mL/plant) while planting or within a week of planting; Black pepper: Soil application at 5 g/cutting in nursery and 50 g/plant while planting
- **Target agroecological zones/states**: Goa, Coastal Maharashtra, Coastal Karnataka and Kerala
- **Validation:** On rice, vegetable crops and black pepper at ICAR-CCARI, Goa for three years
- **Commercialization:** Commercialized in 2019; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Cost:** ₹ 300/- per kg
- **Benefits:**
  - Better nutrient mineralization, alleviation of salinity stress, better crop establishment and improved plant growth parameters, yield and soil biological activity
  - 12% increase in grain yield in rice
  - Reduced incidence of soil borne diseases in vegetable crops (40-60%) and foot rot in black pepper (70-80%)




Effect of GoaBio-1 on a) Pepper var. Paniyur-1 at Chorao, Goa b) Chilli var. Nisha at Sangolda, Goa during 2016-17

***Contact:***
Director, ICAR-Central Coastal Agricultural Research Institute, Old Goa-403402, Goa;
e-Mail: director.ccari@icar.gov.in

# 36. GoaBio-2


- **Microbial constituent:** *Bacillus methylotrophicus* RCh6-2b (NAIMCC-B-01889)
- **Type:** Carrier based formulation; $1 \times 10^8$ cfu/g
- **Shelf life:** 24 months at 25°C to 35°C
- **Target crops:** Brinjal, tomato, chilli, cucumber, black pepper, fruit and plantation crops nurseries
- **Method of application:** Vegetables: Soil application at 50 g/m$^2$ in nursery and at 1.0 g/plant (suspend 1 kg in 50 L water and pour 50 mL/plant) while planting or within a week of planting; Black pepper: Soil application at 5 g/cutting in nursery and at 50 g/plant while planting
- **Target agroecological zones/states**: Goa, Coastal Maharashtra, Coastal Karnataka and Kerala
- **Validation:** On brinjal, tomato, chilli and black pepper at ICAR- CCARI, Goa and under farmers' fields at Goa for three years
- **Commercialization:** Commercialized in 2019; Available for licensing through Agrinnovate India Ltd. (www.agrinnovateindia.co.in)
- **Benefits:**
  - Improved plant growth parameters, plant health and yield
  - Reduced soil borne disease incidences in brinjal (70-80% bacterial wilt), chilli (40-60% wilt and root rot) and black pepper (70-80% foot rot)
- **Cost:** ₹ 300/- per kg

Control Treated

Effect of Goa Bio-2 on brinjal var. Agassaim at ICAR-CCARI, Goa during 2016-17

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e-Mail: director.ccari@icar.gov.in

# 37. NRRI-EndoN

- **Microbial Constituent:** *Azotobacter chroococcum* Avi2 (MCC 3432)
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crop:** Rice
- **Method of application:** Seedling root dip treatment at 500 mL/ha
- **Target agroecological zones/states:** Odisha
- **Validation:** ICAR-NRRI, Cuttack experimental farm for six years; at farmers' fields (30 locations) in Odisha
- **Commercialization:** Available for licensing
- **Benefits:**
  - Saves 25% of chemical N-fertilizers


Control

Treated

Effect of NRRI-EndoN on rice var. Naveen at ICAR-NRRI, Cuttack during 2017-18

***Contact:***
Director, ICAR- National Rice Research Institute, Cuttack-753006, Odisha;
e-Mail: director.nrri@icar.gov.in

# 38. NRRI-RhizoN

- **Microbial Constituent:** *Azotobacter vinelandii* SRIAz3
- **Type:** Liquid formulation; $1 \times 10^9$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crop:** Rice
- **Method of application: :** Seedling root dip treatment at 500 mL/ha
- **Target agroecological zones/states**: ICAR-NRRI, Cuttack experimental farm for six years; at farmers' fields (30 locations) in Odisha
- **Commercialization:** Available for licencing
- **Benefits:**
  - Saves 15-25% of chemical N-fertilizers

Control

Treated

Evaluation of NRRI-RhizoN on rice var. Naveen at ICAR-NRRI, Cuttack during 2018-19

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# 39. Shatpada Plant growth Booster

- **Microbial Constituent:** *Bacillus megaterium* NBAII EXB53
- **Type:** Carrier based; 1 × $10^9$ cfu/g; Liquid formulations; 1 × $10^8$ cfu/mL
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Chilli, capsicum, tomato, brinjal, cauliflower and cabbage
- **Method of application:** Seed treatment (10 g/kg of seeds or 10 mL/kg of seeds)
- **Target agroecological zones/states**: Karnataka
- **Validation:** On-farm trials at ICAR-NBAIR, Bengaluru and commercial nurseries, Bengaluru
- **Commercialization:** Commercialized in 2014; Licensed to Agribiocare, Kottayam, Kerala
- **Benefits:**
  - Increased seedling vigor index in chilli, capsicum, cabbage, brinjal, cauliflower and tomato

Control Treated

Effect on chilli var. Bydagi at ICAR-NBAIR, Bengaluru during 2013-14

***Contact:***
Director, ICAR- National Bureau of Agricultural Insect Resources, Bengaluru-560024;
e-Mail: director.nbair@icar.gov.in

# 40. CIARI-Bioconsortia


- **Microbial Constituents:** *Bacillus amyloliquefaciens*, *Lysinibacillus sphaericus* and *Bacillus subtilis*
- **Type:** Carrier based formulation; $1 \times 10^7$ cfu/g of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Solanaceous vegetables and flower crops
- **Method of application:** Soil application as bio-enriched FYM; 1 kg to be mixed with 50 kg matured FYM and allowed to get multiplied for one week under shaded field condition with intermittent mixing once in two days; this bio-enriched FYM can be applied in field at 2.5 tonnes/ha; it can be applied throughout cropping season at 20-30 days interval
- **Target agroecological zones/states:** Andaman and Nicobar Islands
- **Validation:** On brinjal and flower crops at ICAR-CIARI, Port Blair, and farmers' fields at Andaman and Nicobar Islands for three years
- **Commercialization:** Available for licensing
- **Benefits:**
  - Promotes growth and yield of brinjal and flower crops
  - Protects plants from bacterial wilt disease

Treated Control

Effect of CIARI-Bioconsortia on brinjal in Andaman and Nicobar Islands during 2015-16

***Contact:***
Director, ICAR-Central Island Agricultural Research Institute, Port Blair-744101, Andaman and Nicobar Islands; e-Mail: director.ciari@icar.gov.in

# 41. CIARI-GroPro

- **Microbial Constituents:** *Bacillus amyloliquefaciens*, *Lysinibacillus sphaericus* and *Bacillus subtilis*
- **Type:** Liquid formulation; $1 \times 10^7$ cfu/mL of each
- **Shelf life:** 12 months at 25°C to 35°C
- **Target crops:** Vegetable crops
- **Method of application:** Seed treatment at 10 ml/kg seeds; Foliar spray at 5 L/ha at 20-30 days interval
- **Target agroecological zones/states:** Andaman and Nicobar Islands
- **Validation:** On vegetable crops at farmers' fields of Andaman and Nicobar Islands for three years
- **Commercialization:** Available for licensing
- **Benefits:**
  - Enhances plant growth by uniform seed germination, high seedling vigor and uniform plant growth
  - Also acts as effective biocontrol agent against major foliar diseases


Control

Treated

Effect of seed treatment with CIARI-GroPro on brinjal in Andaman and Nicobar Islands during 2015-16

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# Notes

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