Biofertilizers are seen as an important alternative technology, since the negative externalities of chemical fertilizers have become well known. The use of the latter has led to considerable environmental cost. Biofertilizers do not pollute the soil and do not disrupt the ecological balance, and hence are environment friendly. An increasing number of farmers are using biofertilizers, and the numbers of biofertilizer manufacturing units have also grown considerably. Organic farming system in India is not new and is being followed from ancient time. It is a method of farming system which primarily aimed at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco friendly pollution free environment. Organic farming has emerged as an important priority area globally in view of the growing demand for safe and healthy food and long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals.

Going organic may be a clear way of getting back to basics and getting away from the havoc chemicals can wreak on our health and our environment but the basics themselves may not be so clear. This book provides the view of immense potential of biofertilizers as a supplementary nutrient source for the crops and covers all major types of bacterial fertilizers.

The major contents of this book is crop response to biofertilizers, nitrogen fixation, phosphate solubilising microorganisms, application and evaluation techniques, Bio Gas production, pest and disease management system in agriculture, production, promotion, quality control, marketing, future research planning, photographs and details of machineries, list of manufacturers and suppliers of biofertilizers and organic farming in directory section.

This book will be of use and interest to consultants, researchers, libraries, entrepreneurs, manufacturers of biofertilizer and for those who wants to venture in to this field.

**Contents**

1. **INTRODUCTION TO BIOFERTILIZERS**
   Concept of IPNM
   Integrated Plant Nutrient Management (IPNM)
   Biofertilizer Development
Materials of Biological Origin
Biofertilizers
Classification
Potential of Biofertilizers in Crop Production in Indian Agriculture
Chemically fixed Nitrogen versus Biologically fixed Nitrogen
Synergistic interaction between Biofertilizing Agents
Biofertilizing agents and Plant Disease Control
Brief account of beneficial Microorganisms
Rhizobium
Azotobacter and Azospirillum
Phosphate Solubilizing Microorganisms
Vesicular Arbuscular Mycorrhizae (VAM)
Azolla
Blue Green Algae
Plant Growth Promoting Rhizobacteria (PGPR)
Status of Biofertilizer in India
Thrust in Research and Development

2. NITROGEN FIXATION
Biochemistry
Historical Review
Molecular Properties of Nitrogenase
Dinitrogenase
FeMo cofactor
Dinitrogenase Reductase
Substrates
Energy Requirements
Electron Donors
Catalytic Mechanism
Inhibitors
Classical Inhibitors
Regulatory Inhibitors
Ammonia Assimilation
Genetics
Introduction
Approaches and Techniques Available
nif Genes in Klebsiella pneumoniae
Regulation of nif
Azotobacter Species
Cyanobacteria
Photosynthetic Bacteria
Rhizobium Species
Fast growing Species
Slow growing Species
Regulation
Applications
Physiology of Organisms
Aerobes
Facultative anaerobes
Anaerobes
Symbionts
Agronomic Applications
3. NITROGEN FIXING MICRO-ORGANISMS : SYMBIOTIC

Biological Nitrogen Fixation
Types of Biological Nitrogen Fixation
Factors Affecting Nitrogen Fixation
Genus: Rhizobium
Rhizobia
Rhizobium/legume Symbiosis
Methods for study of legume root nodulation
Isolation
Differentiation of Rhizobium from its common associate
Agrobacterium
Tests for nodulation
Infection test
Tissue and cell cultures
Acetylene reduction assays
Use of 15N to measure Biological Nitrogen Fixation
Multiplication of rhizobia: Root hair curling
Formation of infection threads
Nodule formation
Cross Inoculation Group
Fungicide Enhancement of Nitrogen Fixation

Stem Nodules
Genus: Frankia
Biofertiliser Role
Genus: Azolla
Introduction
Morphology and taxonomy
Role of Azolla
Inoculum Production of Azolla
Factors Affecting Successful Azolla Production
Azolla Nursery
Constraints
Conclusions and Future Outlook
Integrated Approach for Increasing Microbial Inputs
Economics of Biofertiliser Use

4. NITROGEN FIXING MICRO-ORGANISMS : ASYMBIOTIC

Genus: Azospirillum
Introduction
Taxonomy
Isolation, Maintenance and Cultivation
Physiology
Genus Azotobacter
Introduction
Distribution
Classification
Morphology and Taxonomy
Isolation
Crop Responses
Blue Green Algae
Introduction
Morphology
Constraints

5. PHOSPHATE SOLUBILIZING MICROORGANISMS: FUNGI AND BACTERIA
Problems in Phosphorus Uptake
Phosphate Fixation in Different Soils
Historical Developments
Phosphate Solubilization
Factors Affecting Phosphate Solubilization
Isolation
Mechanisms of Action
Role of acids
Other Mechanisms
Effect on Crop Yield

6. PHOSPHATE SOLUBILIZING MICRO-ORGANISM: MYCORRHIZAE
Comparison of Ectomorphic and Vesicular-Arbuscular Mycorrhizae
Ectomorphic Mycorrhizae
Systematics of Ectomorphic Fungi and their Hosts
Morphology and Development of Ectomorphic Mycorrhizae
Sources of Ectomorphic Inoculum
Natural airborne spore inoculum
Soil already colonized by an EM fungus or fungi
The introduction of seedling with established mycorrhizae
The deliberate introduction of spores, sporocarps or sclerotia
Mycelial inoculum derived from pure cultures of known mycobionts
Evaluation and Selection of Ectomorphic Fungi
Rapidity and extent of mycorrhization
Host response
Inorganic nutrient uptake
Water relations
Temperature tolerance
pH tolerance
Tolerance to soil toxicity
Stability of the partnership
Disease resistance
Strand formation
Ease of pure culture formation
Ease and rapidity of production
Edibility of the fruit bodies
Natural inoculum: airborne spores
Soil colonized by EM fungi
Seedlings colonized by EM fungi
Fungal sporomata or sclerotia
Mycelial inoculum
Endomycorrhizae (Vesicular-Arbuscular Mycorrhizae)
Systematics of Vesicular-Arbuscular Mycorrhizal Fungi and their Host
Morphology and Development of Vesicular-Arbuscular Mycorrhizae
Sources of VAM Inoculum
Evaluation and Selection of VAM fungi
Laboratory experiments
Greenhouse crops
Field-sown crops
Prospects

7. APPLICATION AND EVALUATION TECHNIQUES
Different Methods for Biofertilizer Inoculation
Seed inoculation
Top dressing of Biofertilizers
Granular biofertilizers:
Solarisation of FYM/Compost
Granular biofertilizer mixed with seed
Broadcasting of granular biofertilizers
Frequency of inoculation
Liquid inoculation of Biofertilizers
Methods of application of liquid inoculation
Drenching by Sprayers
Application in root zone
Culture pellet
Methods of Application of Other Biofertilizers
Blue Green Algae
Azolla
As green manuring
Azolla dual cropping
Azotobacter
Preparation and use of Azotobacter inoculant
Application
Azospirillum
Mycorrhizae
Endomycorrhizae
Ectomycorrhizae
Techniques for Isolation of Vesicular Arbuscular Mycorrhizal Fungi (VAMF) from soil in Laboratory :
Method for examination of mycorrhizal infection in root samples :
Foliar Biofertilizer
Humar
Humic Acid
Introduction
Application
Soil
Foliar
Seed treatment
Soil Benefit
Different Media Used to Study Biofertilizer

I. Growth Media for Rhizobium
1. Yeast Extract Mannitol Agar
2. Congo-red Medium
3. Hoferâ€™s Alkaline Medium
4. Glucose peptone Agar
5. Bergersenâ€™s Synthetic Medium

Media for Testing Nodulating Ability of Rhizobium

II. Isolation of Frankia

Media Used

III. Selective Media for Blue Green Algae

IV. Selective Media for Azotobacter

V. Selective Media for Azospirillum

VI. Selective Media for Phosphate Solubilizing Organisms

VII. Selective Medium for isolation of Pseudomonas fluorescens, a biocontrol agent

VIII. Selective medium for isolation of Trichoderma an antagonistic fungus

Precautions in handling

8. CROP RESPONSE TO BIOFERTILIZERS

Symbiotic Nitrogen Fixation:

Rhizobium
Irrigated Crops
Dry land Crops
Dryland Legumes
Fodder Crops

Nonsymbiotic Nitrogen Fixation

Blue Green Algae (BGA)
Irrigated Crops
Azotobacter
Irrigated Crops
Dry land crops
Azospirillum
Irrigated Crops
Dryland Crops
Fodder Crops
Phosphate Solubilizers and Fixers

Mycorrhiza
Irrigated Crops
Dryland Crops
Fodder Crops

Factors Affecting Crop Response to Biofertilizers

Interaction effect of microbial strains
Effect of nutrient interactions

Phosphate Solubilizing Microorganisms

Irrigated Crops
Dryland Crops
Fodder Crops
Methods of Inoculation
Other Factors
Host Response to Biofertilizers
Interaction of Inoculants with other Nutrients
Multi-Microbial Inoculation
Compatibility Between Biofertilizers and Chemical Fertilizers
Adaptive Trials

9. SIMPLIFIED ANAEROBIC DIGESTERS FOR BIOFERTILIZER
Abstract
Foreword
Batch Digester Plant
Results
Plug Flow Digester Plant
Results
Covered Lagoon Biogas System
Results
Continuous Expansion Digester
Tests on a Small Electric Generator set Fuelled by Biogas
Results
An Economic Evaluation of the Plants
Conclusions

10. MODIFIED ANAEROBIC FERMENTER FOR BIOFERTILIZER
Abstract
Introduction
Apparatus
Choice of a Laboratory Fermenter
The Proposed Impeller Design
Three-phase Fluidized Bed
Experimental Technique
Results and Discussions
Effect of using the 3-phase Fluidisation Technique
Effect of the Modified Paddle Mixer
Effect of Type and Duration of Mixing
Effect of Temperature
Conclusions and Recommendations

11. OPERATING CONDITIONS FOR ANAEROBIC DIGESTION OF BIOFERTILIZER
Abstract
Introduction
Design of the Experiment
Results and Discussion
1. Effect of the initial total solids (TS) concentration on
   A. TVS reduction
   B. Biogas and methane
2. Effect of hydraulic retention time (0) on
   A. TVS reduction
   B. Biogas and methane
3. Effect of temperature on:
   A. TVS reduction
   B. Biogas and methane
4. Effect of mode of operation on:
A. TVS reduction
B. Biogas and methane

12. BIOGAS PRODUCTION FROM ORGANIC BIOFERTILIZER
Abstract
Introduction
Materials and Methods
Organic Wastes
Starter
Digestion Apparatus
Analytical procedures
Experimental
Results and Discussion
Biogas Production from Geranium Flour (GF)
Biogas Production from Akalona (AK)
Biogas Production from Watermelon Residue (WR)

13. BIOGAS FROM LIQUID BIOFERTILIZER DERIVED FROM BANANA AND COFFEE PROCESSING
Abstract
Introduction
Results

14. ORGANIC FARMING
Pollution Problems with Fertilizers
Water Pollution
Atmospheric pollution
Damage to crops and soils
Heavy Metal Contamination
Environment Restoration with Fertiliser
Organic Matter
Chemical nature of organic matter
Organic Manures
Organic residues
Cow dung manure
Live stock wastes
Green Manure
Importance of green manure
Green manure crops
Turning of green manure crops

Biological cont

NIIR Project Consultancy Services (NPCS) 8/12
Specific Objectives
Philosophy or Concepts of IPDMS
Component of IPDMS
Cultural Control
Mechanical and physical control
Biological Control
Conservation of Natural enemies
Release of Parasites
Use of Microbial Agents
Use of Predators
Cultivated crops
Varietal resistance
Pest Surveillance Methodology
Forecasting Pest Attack
Use of Selective Pesticide
Need-based Application of pesticides
Other pest Control Methods
Limitations of IPDMS
Demonstrations
Role of government and private sectors in the promotion of IPDMS

18. BIOPESTICIDES
Discovery
Development
Registration
Biological Control of Insect
Fungal Insecticides
Bacterial Insecticides
Bacillus thuringiensis (BT)
Mode of action
The question of resistance
Commercial Prospects
Improvements in BT through genetic engineering
The BT protein and the efforts on recombinant DNA in this area
Limitations of BT
Safety
Viral Insecticides
Nuclear Polyhedrosis Virus
Protozon Insecticides
Possibilities of field application
Botanical Pesticides
Pheamon trap
Trichocards
Biological control of plant diseases
Soilborne diseases
Methods for biocontrol
Biological Seed Treatment
Foliar Diseases
Introduction
Selection of biocontrol agents
Formulation and delivery system
Improved efficacy
Commercialization
Nematodes as Biological Control Agents
Production and Formulation
Biological Control of Nematodes
Biological Control of Weeds
Role of genetic engineering

19. SUSTAINABLE AGRICULTURE
Definition
Dimensions
Perceptions
Components
Crop Diversification
Crop Rotation
Biological Nitrogen Fixation
Mixed Cropping
Soil Micorbes on Crops
Genetic Diversity
Integrated Nuitent Management (INM)
Integrated Pest Management (IPM)
Sustainable Water Management
Post Harvest Technology
Extension Programmes
Sustainable Agriculture for India
Maintaining quality of the land resource
Indigenous Water Management
Conserving crop diversity
Stable farming systems
Judicious use of inputs
Role of biotechnology
Government support to farmers
Conclusion

20. PRODUCTION : PROMOTION : QUALITY CONTROL AND MARKETING
Diversification
Need for Basic Facilities
Availability of High Standard Raw Materials
Efficient strain
High grade carrier
Suitable nutrient broth
Reliable packing material
Good quality of adhesive
Application of Updated Technology
Conventional method of production
Production of freeze dried culture
Improvement on technological procedures
Production System
Sterile carrier system
Improvement in sterilisation procedure
Fermentation technology
Latest Technology on Inoculant production
Bag and carrier
Rhizobium broth
Quality Control
Isolation and Identification of bacterial strains
Screening of the pure isolated strains
In Vitro
In vivo
Fermentation
Finished Product
Production Constraints
Raw material
Bacterial strain
Economic viability
Production process
Shelf life
Production Technology (Proposed)
Establishment of efficient Culture Bank
Research and Development (R & D)
Mass Production
Promotion
Field Experiments on R & D Farm
Trials on farms
Demonstration on Farmers' Fields
Marketing
Constraints
Pricing policy and packing
Lack of awareness
Inadequate shelf-life
ISI Mark
Outlook

21. FUTURE RESEARCH PLANNINGS
Production
Raw materials
Economics of production
Production of biofertilisers
Miscellaneous
Biological
Technical
Ecological
Inoculum
Establishment
Biological stresses
Abiotic stress
Pesticides
Agronomic
Rainfall
Soil Type
Soil Moisture and temperature
Survival of Rhizobial Populations
Field Level
Method of Application
Marketing
Governments Future Planning for Promotion of Biofertilisers
Future
About NIIR

NIIR PROJECT CONSULTANCY SERVICES (NPCS) is a reliable name in the industrial world for offering integrated technical consultancy services. NPCS is manned by engineers, planners, specialists, financial experts, economic analysts and design specialists with extensive experience in the related industries.


NPCS also publishes varies process technology, technical, reference, self employment and startup books, directory, business and industry database, bankable detailed project report, market research report on various industries, small scale industry and profit making business. Besides being used by manufacturers, industrialists and entrepreneurs, our publications are also used by professionals including project engineers, information services bureau, consultants and project consultancy firms as one of the input in their research.