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
Rhizobium
Azospirillum
Cyanobacteria
Cyanobacterial Associations
Photosynthetic Bacteria
New Associations
Industrial Applications
Chemical Catalysts
Ammonia Production
Hydrogen Production
Biomass Conversion
Timber Production
Phytochemical Production

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
Inoculam 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
Comparision of Ectorophic and Vesicular-Arbuscular Mycorrhizae
Ectomycorrhizae
Systematics of Ectomycorrhizal Fungi and their Hosts
Morphology and Development of Ectomycorrhizae
Sources of Ectomycorrhizal Inoculum
Natural airbone 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 Ectomycorrhizal 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
Root
Seeds
Plants
Precautions
Different Media Used to Study Biofertilizer
I. Growth Media for Rhizobium
   1. Yeast Extract Mannitol Agar
   2. Congo-red Medium
   3. Hofer’s Alkaline Medium
   4. Glucose peptone Agar
   5. Bergersen’s Synthetic Medium
Media for Testing Nodulating Ability of Rhizobium
II. Isolation of Frankia
Media Used
III. Selective Media for Blue Green Alage
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
   Azolla
   Irrigated crop
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
Phosphate Solubilizing Microorganisms
Irrigated Crops
Factors Affecting Crop Response to Biofertilizers
Interaction effect of microbial strains
Effect of nutrient interactions
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

8/12
and Development Nitrogen Fixation Biochemistry Historical Review Molecular Properties of Nitrogenase Dinitrogenase FeMo cofactor Dinitrogenase Reductase Substrates Energy Requirements Electron Donors Catalytic Mechanism Inhibitors Classical Inhibitors

17. PEST AND DISEASE MANAGEMENT SYSTEM IN AGRICULTURE Pesticide Usage Trend Harmful Effects
Integrated Pest and Disease Management System (IPDMS)
Definition 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 Microbes on Crops
Genetic Diversity
Integrated Nutrient 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
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.

NIIR PROJECT CONSULTANCY SERVICES, 106-E, Kamla Nagar, New Delhi-110007, India. Email: npcs.india@gmail.com Website: NIIR.org