Plant Growth Promoting Rhizobacteria Pseudomonas A Review

In the context of increasing concern for food and environmental quality, use of Plant Growth-Promoting Rhizobacteria (PGPR) for reducing chemical inputs in agriculture is a potentially important issue. This book provides an update by renowned international experts on the most recent advances in the ecology of these important bacteria, the application of innovative methodologies for their study, their interaction with the host plant, and their potential application in agriculture.

Increasing agro productivity to feed a growing global population under the present climate scenario requires optimizing the use of resources and adopting sustainable agricultural production. This can be achieved by using plant beneficial bacteria, i.e., those bacteria that enhance plant growth under abiotic stress conditions, and more specifically, microorganisms such as plant growth promoting rhizobacteria (PGPR), which are the most promising candidates in this regard. Attaining sustainable agricultural production while preserving environmental quality, agro-ecosystem functions and biodiversity represents a major challenge for current agricultural practices; further, the traditional use of chemical inputs (fertilizers, pesticides, nutrients etc.) poses serious threats to crop productivity, soil fertility and the nutritional value of farm produce. Given these risks, managing pests and diseases, maintaining agro-ecosystem health, and avoiding health issues for humans and animals have now become key priorities. The use of PGPR as biofertilizers, plant growth promoters, biopesticides, and soil and plant health managers has attracted considerable attention among researchers, agriculturists, farmers, policymakers and consumers alike. Using PGPR can help meet the expected demand for global agricultural productivity to feed the world's booming population, which is predicted to reach roughly 9 billion by 2050. However, to do so, PGPR strains must be safe for the environment, offer considerable plant growth promotion and biocontrol potential, be compatible with useful soil rhizobacteria, and be able to withstand various biotic and abiotic stresses. Accordingly, the book also highlights the need for better strains of PGPR to complement increasing agro-productivity.

To meet the food security needs of the 21st century, this book focuses on ecofriendly and sustainable production technologies based on plant growth promoting rhizobacteria (PGPR). It is estimated that the global population could increase to 9 billion by 2050. Further, the amount of land devoted to farming has decreased. Soil is a living entity, and is not only a valuable natural resource for agricultural and food security, but also for the preservation of all life processes. Agricultural productivity rests on the foundation of microbial diversity in the soil, and in recent years, PGPR have emerged as an important and promising tool for sustainable agriculture. The injudicious use of agrochemicals by farmers has created a range of negative impacts, not only threatening the environment, but also destroying useful microorganisms in the soil. The efficient use of PGPR reduces the need for these chemicals while simultaneously lowering production costs. In turn, increased yields could provide a more favourable environment and encourage sustainability. This book assesses the impacts of PGPR on crops, environmental and socio-economic sustainability, and demonstrates these ecofriendly technologies' three critical advantages, namely (a) enhanced crop productivity, (b) reduced application of agrochemicals, and (c) increased incomes for farmers. Besides offering an economically attractive and ecologically sound means of augmenting the nutrient supply and combatting soil-borne pathogens, PGPR play an important part in boosting soil fertility, bioremediation and stress management for the development of ecofriendly and sustainable agriculture.

The inflorescence of the monoecious maize plant is unique among the Gramineae in the sharp separation of the male and female structures. The male tassel at the terminus of the plant most often sheds pollen before the visual appearance of the receptive silks of th the female ear at a lateral bud, normally at the 10 leaf [l]. Earlier studies examined the ontogeny of the growing tissues beginning with the embryo in the kernel through to the obvious protuberances of the growing point as the kernel germinates. The differentiated developing soon-to-become tassel and the lateral bulges that develop into the ears on the lateral buds become apparent very early in the germinating kernel [2, 3, 46]. A certain number of cells are destined for tassel and ear development [8]. As the plant develops, there is a phase transition [\3, 16] from the vegetative lateral buds to the reproductive lateral buds. This change in phase has been ascribed to genotypic control as evidenced in the differences among different genotypes in the initiation of the reproductive [l]. The genetic control of tassel and ear initiation has been gleaned from anatomical observations. Lejeune and Bernier [l2] found that maize plants terminate the initiation of additional axillary meristems at the time of tassel initiation. This would indicate that the top-most ear shoot is initiated on the same day as the initiation of tassel development and this event signals the end of the undifferentiated growing point.

Iron, Siderophores, and Plant Diseases

Papers presented at a Symposium held May 8 – 11, 1989, at the Beltsville Agricultural Research Center (BARC), Beltsville, Maryland

Volume 2: Rhizobacteria in Biotic Stress Management

Plant Growth Promoting Rhizobacteria and Chili Cultivation

Proceedings of the Third International Workshop on Plant Growth-Promoting Rhizobacteria : Adelaide, South Australia, March 7-11, 1994

Abstract: The ability of three rifampicin-resistant strains of Bacillus spp. (B. subtilis MI600, B. subtilis GBO3 and B. amyloliquefaciens IN937) to improve fresh market tomato growth and productivity and reduce the intensity of diseases caused by Xanthomonas euvesicatoria, Alternaria solani, Septoria lycopersici and Pseudomonas cichorii was evaluated under greenhouse, field, and controlled environmental conditions. Rifampicin-resistant mutants of each strain were generated and used to monitor colonization of tomato roots. There were no differences in colony morphology, endospore production or ERIC fingerprint pattern between wild-type and rifampicin resistant mutants of MBI600 and IN937. The rifampicin-resistant mutant of GBO3 had the same colony morphology and ERIC-fingerprint pattern as the wild-type, but produced significantly fewer endospores. Under greenhouse conditions, no growth increase or bacterial leaf spot (X. euvesicatoria) suppression was observed in tomato plants inoculated with any of the Bacillus spp. evaluated in this study. Under field conditions, MBI600 and GB03+IN937 were integrated in an intensive tomato management program that included mulch, drip irrigation and a forecasted fungicide spray program. Bacillus spp. population densities were 10 4 - 10 6 CFU g -1 during the seedling stage and dropped to less than 10 3 CFU g -1 during the flowering and fruiting stages. Significant increases in plant height were observed in all Bacillus -inoculated tomato plants, however, foliar diseases incited by A. solani and S. lycopersici were not reduced. GBO3+IN937-inoculated plants were more susceptible to bacterial stem rot caused by Pseudomonas cichorii than those inoculated with MBI600 or non-inoculated control plants. In controlled environmental studies, Bacillus spp. population densities ranged from 10 1 -10 5 CFU g -1 tomato root. Neither nitrogen concentration in the nutrient solution nor activation of the systemic acquired resistance defense mechanism had a significant effect on population density of MBI600, GBO3 or IN937. In a separate experiment under controlled environmental conditions, Bacillus spp. strains MBI600, and GBO3+IN937 did not increase nitrogen concentration in tomato leaves. Lesions induced by Pseudomonas cichorii on tomato stems tended to be longer in GBO3+IN937 inoculated plants than those inoculated with MBI600 or a water-treated control.

This book provides a comprehensive information on basic and applied concepts of microbesial strategies adopted for the improvement of vegetables grown in various production systems. The beneficial role of soil microbes including plant growth promoting rhizobacteria (PGPR), nitrogen fixers, and phosphate-solubilizing bacteria in the improvement of vegetables grown both in normal and contaminated soils is discussed. The role of PGPR in tomato production is dealt separately. The impact of heavy metals on different vegetables and abatement of metal toxicity following metal tolerant PGPR and their consequential impact on vegetables grown in metal polluted soil is discussed. Moreover, recent advances in the management of vegetable diseases employing PGPR are addressed. This volume is therefore of special interest to both academics, professionals and practitioners working in the field of vegetable farming/horticulture, microbiology and plant protection sciences.

The future of agriculture greatly depends on our ability to enhance productivity without sacrificing long-term production potential. The application of microorganisms, such as the diverse bacterial species of plant growth promoting rhizobacteria (PGPR), represents an ecologically and economically sustainable strategy. The use of these bio-resources for the enhancement of crop productivity is gaining importance worldwide. Bacteria in Agrobiology: Crop Productivity focus on the role of beneficial bacteria in crop growth, increased nutrient uptake and mobilization, and defense against phytopathogens. Diverse group of agricultural crops and medicinal plants are described as well as PGPR-mediated bioremediation leading to food security.

PGPR have gained world wide importance and acceptance for agricultural benefits. These microorganisms are the potential tools for sustainable agriculture and the trend for the future. Scientific researches involve multidisciplinary approaches to understand adaptation of PGPR to the rhizosphere, mechanisms of root colonization, effects on plant physiology and growth, biofertilization, induced systemic resistance, biocontrol of plant pathogens, production of determinants etc. Biodiversity of PGPR and mechanisms of action for the different groups: diazotrophs, bacilli, pseudomonads, and rhizobia are shown. Effects of physical, chemical and biological factors on root colonization and the proteomics perspective on biocontrol and plant defence mechanism is discussed. Visualization of interactions of pathogens and biocontrol agents on plant roots using autofluorescent protein markers has provided more understanding of biocontrol process. Commercial formulations and field applications of PGPR are detailed.

Bacteria in Agrobiology: Crop Productivity

Phosphorus Recovery and Recycling

Plant-Associated Bacteria

Plant Microbes Symbiosis: Applied Facets

Improving Plant Productivity with Rhizosphere Bacteria

Extensive use of chemical agricultural inputs, pesticides and unwise and frequent adaptation of various agricultural practices have brought undesirable changes in cultivation and microbial activity.Use of naturally occurring beneficial rhizobacteria, which can protect and promote plant growth by colonizing and multiplying along the root surface/root cortex of the introduced plant is found to be a safe and alternative method. Plant growth promotion by these rhizobacteria, collectively referred as Plant Growth Promoting Rhizobacteria(PGPR), can result physiological and chemical stimulation of plant root, resulting more rapid emergence, higher chlorophyll levels, and enhanced stature. Growth promotion can also depend on suppression of either deleterious microorganisms of the soil, that reduce plant growth and development, and /or of soil borne pathogens that cause diseases such as damping off, rot, wilts. Among the PGPR strains, Pseudomonas spp has received much attention . The mechanism involved are competition for nutrients, particularly iron, antibiosis and secretion of lytic enzymes.

Plant-Associated BacteriaSpringer Science & Business Media

This book focuses on the engineering aspects of phosphorus (P) recovery and recycling, presenting recent research advances and applications of technologies in this important and challenging area of engineering. It highlights full-scale applications to illustrate the performance and effectiveness of the new technologies. As an essential element for all living organisms, P cannot be replaced by any other element in biochemical processes, humans ultimately rely its availability. Today, P is mostly obtained from mined rock phosphate (Pi). However, natural reserves of high-grade rock Pi are limited and dwindling on a global scale. As such, there have been increased efforts to recycle P from secondary sources, including sewage sludge, animal manure, food waste, and steelmaking slag, and so close the anthropogenic P cycle. In addition to various aspects of phosphorus covered by other literature, including chemistry, biochemistry, ecology, soil-plant systems and sustainable management, this book is a valuable and comprehensive source of information on the rapidly evolving field of P recovery and recycling engineering for students, researchers, and professionals responsible for sustainable use of phosphorus.

This volume is envisioned as a resource for researchers working with beneficial and harmful groups of bacteria associated with crop plants. The book is divided into two parts, with Part I on beneficial bacteria including chapters on symbiotic nitrogen fixers and rhizosphere bacteria. The second part consists of detailed descriptions of 8 genera of plant pathogenic bacteria, including Agrobacterium and Herbaspirillum. Each chapter covers terminology, molecular phylogeny and more. soft-rot, Pseudomonas, Xanthomonas, Ralstonia, Burkholderia and Acidovorax There is an opening chapter on the plant-associated bacteria survey, molecular phylogeny, genomics and recent advances. And each chapter includes terminology/definitions, molecular phylogeny, methods that can be used (both traditional and latest molecular tools) and applications

Antinemic activity of Plant Growth Promoting Rhizobacteria, Pseudomonas fluorescens against root knot nematode, Meloidogyne incognita infesting tomato, Lycopersicon esculentum Mill.

Bioformulations: for Sustainable Agriculture

The Effect of the Plant Growth Promoting Rhizobacteria (PGPR) on Nicotiana Benthamiana Viral Susceptibility

Plant Growth and Health Promoting Bacteria

Bacteria in Agrobiology: Crop Ecosystems

Doctoral Thesis / Dissertation from the year 2010 in the subject Biology - Genetics / Gene Technology, grade: 94.30, Tamil Nadu Agricultural University, course: Plant Nematology, language: English, abstract: Tomatoes (Lycopersicon esculentum) are origin of South America and were first used as food in Southern Mexico. Since the fruit has seeds and grows from flowering plant, botanically it is classified under fruits. It is the state vegetable of New Jersey and official state fruit of Ohio and its juice is the official beverage of Ohio.The fruit is rich in lycopene which is an antioxidant found to be good for the heart and effective against certain cancer diseases. Also the fruits are rich in vitamin A and C, calcium and potassium. The best sources of lycopene are found in processed tomato products. Eighty per cent of the tomatoes harvested are industrially processed. Increase in demand of the processed products of tomato in domestic and international markets make an upward trend in the cultivation of this crop. Now days, tomatoes are important ingredient in pizza and pasta sauces. High acidic content in the fruit makes it a prime candidate in the canning industries.The factors that are attributed for the reduction of fruit yield of the crop include both biotic and abiotic stresses. Among the biotic stresses, plant parasitic nematodes play a major role in reducing the crop yield as tomatoes are excellent host for the nematodes. In general, Crop loss due to these nematodes worldwide was estimated to be greater than 11 per cent and among vegetables, infestation of root knot nematode contributes major loss for the crops (Ayyar, 1926). Annual yield loss of crops due to plant parasitic nematodes have been estimated about dollar 78 billion worldwide and dollar 8 billion for US growers. In Tamil Nadu, the loss incurred was estimated about Rs. 200 crores (Jonathan et al., 2005).Generally, nematode management success over a long term requires several alternatives and integration of approaches which should be economically feasible. This is especially true for horticultural crops. Therefore, safe and alternative methods for managing plant parasitic nematodes in horticultural crops are critically needed for the development of sustainable cropping systems. A promising alternative is the use of microbial antagonists against plant parasitic nematodes which are ecofriendly and economically feasible and it does not allow the nematodes to develop into new races or biotypes.In addition to that, they are easily amenable for mass production, formulation technology and easy to deliver in the field.

The future of agriculture strongly depends on our ability to enhance productivity without sacrificing long-term production potential. An ecologically and economically sustainable strategy is the application of microorganisms, such as the diverse bacterial species of plant growth promoting bacteria (PGPB). The use of these bio-resources for the enhancement of crop productivity is gaining worldwide importance. Bacteria in Agrobiology: Crop Ecosystems describes the beneficial role of plant growth promoting bacteria with special emphasis on oil yielding crops, cereals, fruits and vegetables. Chapters present studies on various aspects of bacteria-plant interactions, soil-borne and seed-borne diseases associated with food crops such as rice, sesame, peanuts, and horticultural crops. Further reviews describe technologies to produce inoculants, the biocontrol of post harvest pathogens as a suitable alternative to agrochemicals, and the restoration of degraded soils.

Rhizosphere biology is approaching a century of investigations wherein growth-promoting rhizomicroorganisms (PGPR) have attracted special attention for their ability to enhance productivity, profitability and sustainability at a time when food security and rural livelihood are a key priority. Bio-inputs - either directly in the form of microbes or their by-products - are gaining tremendous momentum and harnessing the potential of agriculturally important microorganisms could help in providing low-cost and environmentally safe technologies to farmers. One approach to such biologically-based strategies is the use of naturally occurring products such as PGPR. Written by an international team of experts, this book considers new concepts and global issues in biopesticide research and evaluates the implications for sustainable productivity. It is an invaluable resource for researchers in applied agricultural biotechnology, microbiology and soil science, and also for industry personnel in these areas.

There has been a resurgence of interest in environmental friendly, sustainable and organic cultural practices that warrants high yield and quality in agricultural crops. To enhance sustainable agricultural production and alleviate food scarcity, spoor of majority of microorganisms, especially plant growth and health promoting bacteria of eminent characteristics that allow them for exploitation in agro-ecosystem. Plant growth promoting rhizobacteria are the soil bacteria inhabiting around/on the root surface and are directly or indirectly involved in promoting plant growth and development via production and secretion of various regulatory chemicals in the vicinity of rhizosphere. Among various beneficial bacteria mediated mechanisms include direct production of phytohormones and biosurfactants experiencing quest of research and concept up gradation that can built emerging paradigm (agriculture model). Research on bacteria-mediated phytohormones is crucially important, provides key understanding of the plant growth and development. Various genera including PGPR group of bacteria are potential source of plant growth regulators. Application of such organism allow plants to survive under abiotic and biotic stress conditions besides govern phytohormone mediated immune response and manage to regulate hormones. Such group of bacteria also produce another important metabolite i.e. biosurfacatants which are involved in many important functions to bacteria itself as we ll as for the plants and their ecosystem. Biosurfactants may alter nutrient availability, endogenous metabolites such as antibiotics production, root colonization imparting protection from phytopathogens besides eradicating soil contaminants and other pollutants. The role and activities of surfactants produced by bacteria are multifarious in nature. Thus, bacterial phytohormones and biosurfactants are identified as effector molecules in plant- microbe interactions, in pathogenesis and phyto-stimulation which can either be beneficial for the bacteria itself or for the crops. This book highlights current applications and research on bacterial hormones and surfactants to provide a timely overview. The chapters have been contributed by subject experts from around the world and include topics of varied importance which include phytohormones production by rhizospheric and endophytic bacteria, their role in rhizosphere competence, plant growth regulation, bioremediation, biosurfactants as antibiofilm agents and other aspects. This major new work represents a valuable source of information to all those scientists interested in microbial technology with respect to the microbial innovative products and applications towards sustainable agroecosystem.

PGPR: Biocontrol and Biofertilization

Microbial Strategies for Vegetable Production

Applications of Microbial Engineering

Plant Growth

Technical Issues and Protocols

The functional analysis of plant-microbe interactions has re-emerged in the past 10 years due to spectacular advances in integrative study models. This book summarizes basic and technical information related to the plant growth promoting rhizobacteria (PGPR) belonging to the genus Azospirillum, considered to be one of the most representative PGPR last 40 years. We include exhaustive information about the general microbiology of genus Azospirillum, their identification strategies; the evaluation of plant growth promoting mechanisms, inoculants technology and agronomic use of these bacteria and some special references to the genetic technology and use.

In the present study, soil samples were collected from ten different locations and the physico chemical properties & microbial population of the soil samples were analyzed. The PGPR organisms viz., Azospirillum, Pseudomonas, Azotobacter and Bacillus were isolated from ten different soil samples purified and maintained for further studies. The PGPR isolates of Pseudomonas, Azospirillum, Azotobacter and Bacillus were screened for there efficiency by determining the ability to produce phytohormone IAA, N fixation and phosphorus solubilization. The selected PGPR isolates viz., Azs-2, Ps-2 and Azo-4 were inoculated either individually and along with Bacillus BS-2 and the interaction effect on chilli var. K-l was studied under pot culture experiment. All the inoculation of PGPR organisms increased the growth and yield parameters of chilli when compared to uninoculated control.

"*Beneficial free-swimming planktonic plant growth promoting rhizobacteria (PGPR) have long been used as biofertilizer and biocontrol agents. However, their effects in the field are inconsistent, which has limited commercial application. This is probably caused by the inoculants' inability to compete with existing endogenous microbial communities (Gupta et al, 2015). To overcome this issue, the use of biofilms is being investigated as potential PGPR inoculants. Biofilms are defined as dense colonies of single or multi-species of microbial cells, adherent to either a biotic or abiotic surface, encased in a self-produced matrix composed of extracellular polymeric substances (Davey et al., 2000). The formation of biofilms not only enhances the survival of bacteria but also allows them to continue plant growth promotion in ways similar to that of planktonic PGPR. Moreover, biofilms withstand a wide range of physical conditions including extreme temperatures, salt levels and pH as well as the presence of commonly used antibiotics (Baty et al., 2000 Todar, 2008) making the use of biofilm-PGPR (B-PGPR) a promising prospect. The objective of this study was to develop and elucidate the potential use of novel Pseudomonas sp. and Bacillus sp. mono- and dual-species biofilm inoculants. To address this issue, optimization experiments for bacterial inoculants were conducted to standardize cell density (colony forming units) levels of each treatment in order to compare and contrast B-PGPR traits against their planktonic counterparts. Results indicate that mono- and dual-species biofilms exhibited enhanced values for various biochemical attributes, compared to their planktonic counterparts. These include phosphorus solubilisation as well as the production of indole-3-acetic acid (IAA) and siderophores. Moreover, greenhouse trials with tomato plants reinforced our in-vitro findings, suggesting that B-PGPRs are more effective inoculants than their planktonic equivalents. Results, therefore, suggested that the use of innovative B-PGPR technologies could prove extremely advantageous as biocontrol and biofertilizer agents, thus potentially alleviating some of the dependence on agro-chemicals for effective crop production. " --*

Soilborne diseases result in tremendous economic losses of agricultural production and many of the diseases cannot be controlled effectively by presently accepted chemical prevention practices. Hence, scientific research is required to achieve alternatives to chemical methods. Biocontrol strategies including the application of plant growth-promoting rhizobacteria (PGPR) could be a promising alternative. Arbuscular mycorrhizal fungi (AMF) are regarded as an important factor for the uptake of phosphorus (P) and other relatively immobile nutrients particularly in low input systems. Furthermore, AMF support healthy growth of plants and are involved in the resistance against toxic elements and in suppression of pathogens. However, mycorrhization with AMF is

frequently very limited. Large scale soil inoculation with appropriate AMF is usually not practicable. The application of beneficial PGPRs to improve root infection with indigenous, site adapted AMF might be a promising alternative.
Use of Plant Growth-Promoting Rhizobacteria (PGPR) to Improve Mycorrhization, Nutrient acquisition and Growth of Vegetable Plants Affected by Soilborne Pathogens
The Rhizosphere and Plant Growth
Plant-Growth-Promoting Rhizobacteria (PGPR) and Medicinal Plants
Bacterial Metabolites in Sustainable Agroecosystem
Plant Growth Promoting Rhizobacteria for Sustainable Stress Management
To cope with the increasing problems created by agrochemicals such as plant fertilizers, pesticides and other plant protection agents, biological alternatives have been developed over the past years. These include biopesticides, such as bacteria for the control of plant diseases, and biofertilizer to improve crop productivity and quality. Especially plant growth promoting rhizobacteria (PGPR) are as effective as pure chemicals in terms of plant growth enhancement and disease control, in addition to their ability to manage abiotic and other stresses in plants. The various facets of these groups of bacteria are treated in this Microbiology Monograph, with emphasis on their emergence in agriculture. Further topics are Bacillus species that excrete peptides and lipopeptides with antifungal, antibacterial and surfactant activity, plant-bacteria-environment interactions, mineral-nutrient exchange, nitrogen assimilation, biofilm formation and cold-tolerant microorganisms.
Tomato cultivation is a major economic activity in many countries of the world. Thus, strategic efforts should be directed towards mitigating production constraints that limit overall yields and quality. In addressing some of these constraints, researchers are developing and using varieties of modern and innovative techniques to improve local tomato germplasm, make rapid genetic gains, and breed for varieties with resistance to biotic and abiotic stress. This book focuses on recent advances in genomics and genetic improvement of the tomato crop, and production systems, and center around the following themes: (i) disease and pest management in tomato production, and (ii) breeding tools and improvement of the tomato.
Papers Presented at a Symposium held May 8--11, 1989, at the Beltsville Agricultural Research Center (BARC), Beltsville, Maryland, U.S.A.
This book compiles various methodologies used in understanding interactions within the rhizosphere. An in-depth understanding of the rhizosphere is essential to developing successful strategies for future sustainable agriculture. The book summarizes methods and techniques used to study the mechanisms involved in mutualistic symbioses and pathogenic interactions of plants with various microbial organisms including fungi, bacteria, and oomycetes. Each chapter discusses different methodologies used in rhizosphere biology, while also providing real-world experimental data and trouble-shooting tips. Interested researchers will also find a wealth of literature references for further research. As the first comprehensive manual and compilation of methods and techniques used in rhizosphere biology, the book represents an essential resource for all researchers who are newcomers to soil microbiology experimentation.
Effect of Herbicides on Growth of Plant Growth Promoting Rhizobacteria (PGPR) PSB-16, Pseudomonas Sp., and SB-16
Microbial Biotechnology
Investigating the Role of Pseudomonas Sp. and Bacillus Sp. Biofilms as Plant Growth Promoting Inoculants
Plant Growth Promoting Rhizobacteria (PGPR): Prospects for Sustainable Agriculture
Role of Plant Growth-Promoting Rhizobacteria in Integrated Disease Management and Productivity of Tomato

This edited book, is a collection of 20 articles describing the recent advancements in the application of microbial technology for sustainable development of agriculture and environment. This book covers many aspects like agricultural nanotechnology, promising applications of biofuels production by algae, advancements and application of microbial keratinase, biocontrol agents, plant growth promoting rhizobacteria, bacterial siderophore, use of microbes in detoxifying organophosphate pesticides, bio-surfactants, biofilms, bioremediation degradation of phenol and phenolic compounds and bioprospecting of endophytes. This book intends to bring the latest research advancements and technologies in the area of microbial technology in one platform, providing the readers an up-to-date view on the area. This book would serve as an excellent reference book for researchers and students in the agricultural, environmental and microbiology fields.

This book describes the various applications of microorganisms in improving plant growth, health and the efficiency of phytochemical production. The chapters trace topics such as the role of PGPRs in improving salt stress and heavy metal tolerance in plants; the prevention and control of plant diseases; boosting soil fertility and agriculture productivity; the induction of secondary metabolite biosynthesis in medicinal and aromatic plants; the enhancement of phytochemical levels, and the action mechanisms, diversity and characterization of PGPRs. The reviews will be of interest for scientists in the fields of agriculture, microbiology, soil biology, plant breeding and herbal medicinal products.

How to achieve sustainable agricultural production without compromising environmental quality, agro-ecosystem function and biodiversity is a serious consideration in current agricultural practices. Farming systems' growing dependency on chemical inputs (fertilizers, pesticides, nutrients etc.) poses serious threats with regard to crop productivity, soil fertility, the nutritional value of farm produce, management of pests and diseases, agro-ecosystem well-being, and health issues for humans and animals. At the same time, microbial inoculants in the form of biofertilizers, plant growth promoters, biopesticides, soil health managers, etc. have gained considerable attention among researchers, agriculturists, farmers and policy makers. The first volume of the book Microbial Inoculants in Sustainable Agricultural Productivity - Research Perspectives highlights the efforts of global experts with regard to various aspects of microbial inoculants. Emphasis is placed on recent advances in microbiological techniques for the isolation, characterization, identification and evaluation of functional properties using biochemical and molecular tools. The taxonomic characterization of agriculturally important microorganisms is documented, along with their applications in field conditions. The book exploresthe identification, characterization and diversity analysis of endophytic microorganisms in various crops including legumes/ non-legumes, as well as the assessment of their beneficial impacts in the context of promotingplant growth. Moreover, it provides essential updates onthe diversity and role of plant growth promoting rhizobacteria (PGPR) and arbuscular mycorrhizal mycorrhizal fungi (AMF). Further chaptersexamine in detailbiopesticides, thehigh-density cultivation of bioinoculants in submerged culture, seed biopriming strategies for abiotic and biotic stress tolerance, andPGPR as abio-control agent. Given its content,the book offers a valuable resource for researchers involved in research and development concerningPGPR, biopesticides and microbial inoculants.

Sustainable increase in agricultural production while keeping the environmental quality, agro-ecosystem function and biodiversity is a real challenge in current agricultural practices. Application of PGPR can help in meeting the expected demand for increasing agricultural productivity to feed the world's booming population. Global concern over the demerits of chemicals in agriculture has diverted the attention of researchers towards sustainable agriculture by utilizing the potential of Plant Growth Promoting Rhizobacteria (PGPR). Use of PGPR as biofertilizers, biopesticides, soil, and plant health managers has gained considerable agricultural and commercial significance. The book Plant Growth Promoting Rhizobacteria (PGPR): Prospects for Sustainable Agriculture has contributions in the form of book chapter from 25 eminent global researchers, that discusses about the PGPRs and their role in growth promotion of various crop plants, suppression of wide range of phytopathogens, their formulation, effect of various factors on growth and performance of PGPR, assessment of diversity of PGPR through microsatellites and role of PGPR in mitigating biotic and abiotic stress.This book will be helpful for students, teachers, researchers, and entrepreneurs involved in PGPR and allied fields. The book will be highly useful to researchers, teachers, students, entrepreneurs, and policymakers.

Bacteria in Agrobiology: Plant Probiotics
Screening of exogenous IAA producing plant growth promoting Rhizobacteria from agriculture soil
Rhizosphere Fluorescent Pseudomonas - a New Perspective

Recent Advances in Tomato Breeding and Production

Plants form mutualistic association with various microorganisms, particularly in the rhizosphere region. The association benefits both the partners in a number of ways. A single plant can support the growth of diverse microbes and in reciprocation these microbes help the plant in several ways. A great deal of knowledge is now available on the mechanisms of action of plant growth promoting microbes in forming association with their partner plant and benefitting it. With ever increasing population and to achieve food security it has become utmost necessary to utilize these friendly microbes to enhance the crop yield and quality in an ecofriendly and sustainable manner. We already know about the huge negative impact of chemicals used in agriculture on the humans and the ecosystems as whole. 'Plant Microbes Symbiosis – Applied Facets' provides a comprehensive knowledge on practical, functional and purposeful utility of plant-microbe interactions. The book reviews the utilization of beneficial microbes for crop yield enhancement and protection against diseases caused by phytopathogens and nutrient deficiencies. The tome also reviews the utility of plant growth promoting microbes in helping the plants to deal with abiotic stresses imposed by climate change and anthropogenic activities. The book showcases how plant-microbe interactions are or can be utilized for reclamation of stressed soils and degradation of pollutants in a most effective and environment friendly manner. It also ascertains the reasons for the below par performance of the microbial based inoculants. The utilization of biotechnological tools for development of next generation bioformulations to combat the new challenges and overcome past hurdles has been discussed. This wonderful association between plants and microbes if used properly will not only enhance the crop yields and reclaim barren lands but also make our planet a better place to live on for all of its habitants.
Attaining sustainable agricultural production while preserving environmental quality, agro-ecosystem functions and biodiversity represents a major challenge for current agricultural practices; further, the traditional use of chemical inputs (fertilizers, pesticides, nutrients etc.) poses serious threats to crop productivity, soil fertility and the nutritional value of farm produce. Given these risks, managing pests and diseases, maintaining agro-ecosystem health, and avoiding health issues for humans and animals have now become key priorities. The use of PGPR as biofertilizers, plant growth promoters, biopesticides, and soil and plant health managers has attracted considerable attention among researchers, agriculturists, farmers, policymakers and consumers alike. Using PGPR as bioinoculants can help meet the expected demand for global agricultural productivity to feed the world's booming population, which is predicted to reach roughly 9 billion by 2050. However, to provide effective bioinoculants, PGPR strains must be safe for the environment, offer considerable plant growth promotion and biocontrol potential, be compatible with useful soil rhizobacteria, and be able to withstand various biotic and abiotic stresses. Accordingly, the book also highlights the need for better strains of PGPR to complement increasing agro-productivity.
Phytohormones (plant hormones) are chemical messengers that affect a plant's ability to respond to its environment. There are five major classes of plant hormones: auxin, gibberellin, cytokinin, ethylene and abscisic acid. These hormones can work together or independently to influence plant growth. Of these five hormones, auxin is the most important one. The most important member of auxin family is indole-3-acetic acid (IAA), which generates the majority of auxin effects in intact plants, and is the most potent native auxin. The indole acetic acid (IAA) production is a major property of rhizosphere bacteria that stimulate and facilitate plant growth. Plant growth promoting rhizobacteria (PGPR) are commonly used as inoculants for improving the growth and yield of agricultural crops, however screening for the selection of PGPR strains is very critical. This study focuses on the screening of effective PGPR strains on the basis of their potential for invitro auxin production. Soil samples were subjected to serial dilution and suitable dilution was poured on nutrient agar medium. Isolated colonies were subjected to invitro screening using Salkowski reagent which results in pink coloration. Appearance of pink colour indicates the presence of IAA producers. After morphological and biochemical test this isolated organism were subjected for DNA isolation. Isolated DNA was amplified using 16S PCR. The amplified products were sequenced and analysed using BLAST and the organism was identified as Rhizobium oryziradicis. Auxin production capability of Rhizobium oryziradicis is higher when compared to other strains. Plant growth promoting rhizobacteria (PGPR) have gained worldwide importance and acceptance for agricultural benefits. This is due to the emerging demand for dependence diminishing of synthetic chemical products, to the growing necessity of sustainable agriculture within a holistic vision of development and to focalize environmental protection.
More than a century has passed since the first bioformulations were introduced to the market. But there is still much to be done, explored and developed. Though bioformulations offer green alternatives and are important for sustainable agriculture, they make up only a small fraction of the total additions used to enhance crop yields or protect them from pests. There is a great need to develop bioformulations that can promote confidence among end users; accordingly, it is imperative that bioformulations to replace chemicals be reliable and overcome the shortcomings of the past. Bioformulations: for Sustainable Agriculture discusses all the issues related to the current limitations and future development of bioformulations. It examines in detail those bioformulations that include biofertilizers and biopesticides (also commonly known as bioinoculants), presenting a global picture of their development. Further chapters address diverse microbes that are already being or could be used as bioformulations. The book also discusses the techniques, tools and other additions required to establish bioformulations as trustworthy and global solutions. It assesses the types of bioformulations currently available on the market, while also considering the future roles of bioformulations, including the reclamation of marginal and polluted soils. Further, it discusses the current legislation and much-needed amendments. Overall the book provides a comprehensive outlook on the status quo of bioformulations and the future approaches needed to improve them and achieve sustainable agriculture and food security without sacrificing the quality of soils. This will be extremely important in offering chemical-free foods and a better future for generations to come.
Methods in Rhizosphere Biology Research
Volume 1. Applications in Agriculture and Environment
New Perspectives and Approaches in Plant Growth-Promoting Rhizobacteria Research
Microbial Inoculants in Sustainable Agricultural Productivity
Plant Growth Promoting Rhizobacteria for Agricultural Sustainability

Plant microbe interaction is a complex relationship that can have various beneficial impacts on both the communities. An urgent need of today's world is to get high crop yields in an ecofriendly manner. Utilization of beneficial and multifaceted plant growth promoting (PGP) microorganisms can solve the problem of getting enhanced yields without disturbing the ecosystem thus leading to sustainability. For this to achieve understanding of the intricate details of how the beneficial microbes form associations with the host plant and sustain that for millions of years must be known. A holistic approach is required wherein the diversity of microbes associated with plant and the network of mechanisms by which they benefit the host must be studied and utilized. 'Plant Microbe Symbiosis – Fundamentals and Advances' provides a comprehensive understanding of positive interactions that occur between plant and microorganisms and their utilization in the fields. The book reviews the enormous diversity of plant associated microbes, the dialog between plant-microbes-microbes and mechanisms of action of PGP microbes. Utilization of PGPRs as nutrient providers, in combating phytopathogens and ameliorating the stressed and polluted soils is also explained. Importantly, the book also throws light on the unanswered questions and future direction of research in the field. It illustrates how the basic knowledge can be amalgamated with advanced technology to design the future bioformulations.
Over the last few decades, the prevalence of studies about plant growth has dramatically grown in most regions of the world. Many aspects have been investigated related to this phenomenon. If we can gain understanding of how plants grow, then we may be able to manipulate it to reduce both chemical fertilizer use and its environmental impact without decreasing the yield. This book provides information about the use of bio-agents, plant health, plant pathogen, property of melanin, and the influence of rootstock and root growth. We hope this information will be useful for all the people who work with this hot topic.
The importance of competition for iron in the interactions between saprophytic microorganisms, pathogens and plants has been recognised for almost a decade. This has been reflected i.n an upsurge of publications on the topic over the last five years. Paradoxically, the subject was only touched upon during the International Congress of Plant Pathology held in 1983. In response to this apparent omission, a few of those most closely associated with the topic met one evening during which they resolved to organise a symposium devoted solely to the various aspects of iron uptake and its relation to plant disease. It was my privilege to be asked to undertake the task of convenor. &arly correspondence brought a wealth of positive replies to the proposal, particularly from Bob Schippers in Baarn. With the increasing costs of international symposia the need for a sponsor soon became apparent and an application to NATO was favourabiy received, following helpful advice from Dr. di Lullo, Advanced Research Workshop Programme Director, to whom all the participants in this Workshop owe a debt of gratitude.
The future of agriculture strongly depends on our ability to enhance productivity without sacrificing long-term production potential. An ecologically and economically sustainable strategy is the application of microorganisms, such as the diverse bacterial species of plant growth promoting bacteria (PGPB). The use of these bio-resources for the enhancement of crop productivity is gaining worldwide importance. "Bacteria in Agrobiology: Plant Probiotics" discusses the current trends and future prospects of beneficial microorganisms acting as Probiotics. Topics include the application for the aboveground fitness of plants, in mountain ecosystems, in tropical and Mediterranean forests, and in muga sericulture. Further aspects are Arabidopsis as a model system for the diversity and complexity of plant responses, plant parasitic nematodes, nitrogen fixation and phosphorus nutrition.
Volume 1: Rhizobacteria in Abiotic Stress Management
From Theory to Practices
Advances in PGPR Research
Biology and Biotechnology of the Plant Hormone Ethylene II
Vol. 1: Research Perspectives

The microbial engineering technologies have been identified as an essential and important subject area of engineering and applied biological sciences. A microbial engineer works on the biological, chemical and engineering aspects of biotechnology, manipulating microbes and developing new uses for microbes. In agriculture, bioprocess engineering, in biotechnology, genetic engineering, microbial vaccines, and the development of bionanotechnology, microbial engineering could be recognized as high potential technologies in the current scenario for economic development. Scientists and engineers are motivated for sustainable green technology as a part of an upcoming industrial revolution turning more and more to processes involving microorganisms. Applications of Microbial Engineering provides a better understanding of industrially important genetically manipulated and engineered prokaryotic and eukaryotic cell systems. The content of this book are based on most recent developments in microbial engineering. The contributions by specialists on the respective topics provide a profound scientific basis for further research. It is expected that this book will be a valuable resource for researchers as well as students dealing with microbiology and biotechnology.

Plant Microbe Symbiosis: Fundamentals and Advances
Effects, Characterization, and Formulation of Plant Growth-promoting Rhizobacteria of Apple from New York Soils

Handbook for Azospirillum