Overview of R&D activities of Division of Plant-Microbe Interactions

1. **Objectives:**
   - Develop efficient assays for root colonization capability of the native microbial population in host plant rhizosphere.
   - Explore, exploite and characterize stress-tolerant plant growth promoting microbes for biotechnological prospects.
   - Elucidate role of introduced beneficial microbe on plant productivity, microbial community structure and improved soil fertility.
   - Metagenomics of soil from different agro- climatic regions of India.
   - Develop stress tolerant transgenic microbes and plants for enhancing plant growth in degraded ecosystems.
   - Identify root-specific traits for root development, architecture, sensing of edaphic stress, and root-to-shoot communication, for enhancing plant growth under low nutrient and water stress conditions.

2. **Goals:**

   To pursue excellence in innovative plant sciences research that encompasses strategies of rhizosphere microbial management in enhancing plant growth, nutrient and water use efficiency.

3. **Competencies:**

   The plant-microbial interactions group has expertise in the area of interactions between plants and plant growth promoting microbes, ecology of soil microbial communities, and development of high throughput screening media and bioinoculants. The group's focus is on plant-related microbiology through interdisciplinary and collaborative research. The transfer of laboratory technology to the field, and ultimately new products, we encourage interactions between basic and applied scientists.

4. **Facilities:**

   The lab possesses all the necessary state-of-the-art equipments and lab facilities for basic and applied microbiology and interaction between microbes and plants.

5. **Highlights of Current Research:**

   The plant-microbial interactions group is working out the complexity of interaction between microbes and plants. Under the present scenario, microbes will probably assume an increasingly prominent role as we look forward to new responsible technologies. The research is aimed at enhancing yield of economically important crops using native plant growth promoting rhizobacteria and developing stress tolerant transgenic bacteria and plants. Colonization of the plant root system is very important in nearly all interactions between plants and soil borne microbes. Selection and improvement of rhizosphere competent

bacteria to encourage preferential colonization of desired bacteria can, therefore, be expected to modify plant health.

Understanding the population genetics and functional dynamics of soil-borne bacteria is anticipated to increase our predictive capacity, providing insights for developing targeted management strategies for soil. Using Eco-genomics approaches for enhancing crop yield and crop protection, plant associated bacteria have been commercial exploited for products and technology development. The other specific research activities include:

- Develop a novel throughput method for identifying and isolating high antifungal producing rhizosphere competent bacterial strains. This methodology enables fast screening of a large number of soil samples for detecting beneficial rhizosphere competent bacterial strains. ***The work has been patented and published.***
- Develop a novel method for screening phosphate-solubilizing and accumulating microorganisms using NBRIPB and PAM media. The methodology significantly reduces the screening time for phosphate-solubilizing microorganisms. ***The work has been patented and published.***
- Our group is studying PGPR as potential plant growth promoting and biological control agents. After screening several bacterial species, several efficient rhizosphere competent abiotic stress tolerant *Azotobacter, Pseudomonas,* and *Rhizobium* strains were isolated and characterized. This technology implemented through the Department of Agriculture, U. P.
- Three novel *Bacillus* strains NRRL B-30486, NRRL B-30487 and NRRL B-30488 were isolated. These isolates, when used individually or as a novel blend of consortium, provides a unique synergism with the ability to control phytopathogenic fungi and promote plant growth. ***The work has been patented, published and technology has been transferred to industries***.
- A novel synergistic bioinoculant, comprising of *Trichoderma harzianum* isolates of accession Nos. NRRL 30595, NRRL 30596, and NRRL 30597 showed phytopathogenic fungi controlling activity, abiotic stress tolerating capability, ability to stimulate plant growth, and induce systemic resistance in plants to diseases caused by phytopathogenic organisms. ***The highly efficient root colonization capacity and long shelf life was developed, published and patented***. The technology has been transferred to industries.
- Characterize microbial community structure, diversity and bacterial phylogeny from soils of different amendment such as, organic manure using state of the art technologies, community level physiological profiling (CLPP) and 454 pyrosequencing.
- Whole genome sequencing and analysis of potential PGPR isolates using the emerging next-generation sequencing technique (454 sequencing), for better understanding of their metabolic characteristics at systems level.
- Metagenomes from several different soils that are collected across a range of habitats for determining which microorganisms and functional processes predominate in different soil ecosystems.

- Develop methods for the identification of plant genotypes with root characteristics contributing to efficient nutrient acquisition from low fertility soils.

6. List of Current Projects:

Title of the project	Funding Agency	PI	Co-PI
Exploitation of microbial wealth of India	CSIR	Dr. C.S. Nautiyal	Dr. Suchi Srivastava Dr. Poonam C. Singh
Delineation of bioremediation protocol for high phosphate bearing water bodies	CSIR	Dr. C.S. Nautiyal	Dr. Suchi Srivastava
Popularize the use of quality biofertilizers by its pilot scale production and distribution, training and demonstration to farmers	Department of Agriculture, UP	Dr. C.S. Nautiyal	Dr. Suchi Srivastava Dr. Poonam C. Singh
Popularize use of beneficial microorganism enriched organic manure production technology training and demonstration to farmers	Department of Agriculture, UP	Dr. C.S. Nautiyal	Dr. Suchi Srivastava Dr. Poonam C. Singh
Exploration of microbial diversity for useful products	In-House	Dr. C.S. Nautiyal	

7. Group's achievements:

Powerful blend of consortium consisting of novel microbes *(Pseudomonas*, *Rhizobium, Bacillus* and *Trichoderma*) inoculants with synergistic fermented plant growth promoting bio-control composition could be applied to agronomic crops, flowers, vegetables, to digest organic wastes and recover degraded ecosystems. The technologies based on aforesaid developments include:

- ***Pseudomonas* based technology:** The technology was successfully transferred to a leading Biotechnology Company MBI International, USA in 2000. The MBI has successfully utilized it against fish pathogenic fungi
- ***Rhizobium* and phosphate solubilizing bacteria (PSB) based technology and its commercial production:** The bioinoculant technologies was transferred to the **U. P. Government.** Based on our technology, 17 biofertlizer producing laboratories of U. P. are producing quality biofertilizer and biopesticide. ***Bacillus* based technology:** The technology was transferred to Biotech International Ltd. (BIL), New Delhi and Balaji Crop Care Pvt. Ltd., Hyderabad.
- ***Trichoderma* based technology:** It has been transferred to GAPC, a company jointly promoted by Gujarat State Fertilizer and Chemicals Ltd. (GSFC), Gujarat Agro Industries Corporation (GAIC) and Gujarat National Fertilizers Company Limited (GNFC) and by Balaji Crop Care Pvt. Ltd.

8. Recent Publications: (Give latest/best 10 publications)

1. V. Chaudhry and C. S. Nautiyal. 2011. A high throughput method and culture medium for rapid screening of phosphate accumulating microorganisms. *Bioresource Technology.* 102: 8057-8062.
2. H. B. Singh, B. N. Singh, S. P. Singh and C. S. Nautiyal. 2010. Solid-state cultivation of *Trichoderma harzianum* NBRI-1055 for modulating natural antioxidants in soybean seed matrix. *Bioresource Technology.* 101: 6444–6453.
3. C.S. Nautiyal, A. Rehman and P. S. Chauhan. 2010. Environmental *Escherichia coli* occur as natural plant growth-promoting soil bacterium. *Archieves of Microbiology.* 192:185-193.
4. C. S. Nautiyal, R. Govindarajan, M. Lavania and P. Pushpangadan. 2008. Novel mechanism of modulating natural antioxidants in functional foods: Involvement of plant growth promoting rhizobacteria NRRL B-30488. *Journal of Agricultural and Food Chemistry.* 56: 4474-4481.
5. S. Mehta and C. S. Nautiyal. 2001. An efficient method for qualitative screening of phosphate solubilizing bacteria. *Current Microbiology.* 43: 51-56.
6. C. S. Nautiyal, Shipra Bhadauria, Pradeep Kumar, Hind Lal, Rajesh Mondal and Dinesh Verma. 2000. Stress induced phosphate solubilisation in bacteria isolated from alkaline soils. *FEMS Microbiology Letters.* 182: 291-296.

7. C. S. Nautiyal. 1999. An efficient microbiological growth medium for screening phosphate solubilizing microorganisms. *FEMS Microbiology Letters.* 170: 265-270.
8. C. S. Nautiyal. 1997. Rhizosphere competence of *Pseudomonas* sp. NBRI9926 and *Rhizobium* sp. NBRI9513 involved in the suppression of chickpea (*Cicer arietinum* L.) pathogenic fungi. *FEMS Microbiol Ecology.* 23: 145-158.
9. C. S. Nautiyal. 1997. A method for selection and characterisation of rhizosphere competent bacteria of chickpea. *Current Microbiology.* 34: 12-17.
10. C. S. Nautiyal, and P. Dion, 1990. Characterization of the opine-utilizing microflora associated with samples of soil and plants. *Applied and Environmental Microbiology.* 56: 2576-2579.

9. Scientists: (Name and Designation of Scientists working in the Research Area/R& D Groups)

- Dr. C.S.Nautiyal,
  Director CSIR-NBRI;
  Area Coordinator (Division of Plant Microbe Interactions)
- Dr. Suchi Srivastava (Scientist C)
- Dr. Poonam C. Singh (Scientist C)
- Dr. Aradhana Mishra (DST-WOS Scientist)
- Dr. Puneet Singh Chauhan (Scientist Fellow)

10. Technical Staff: (Name and Designation of Technical / Lab Astts./TOs in the Research Area/R& D Groups)

- Mr. Sumit Yadav (TA)

11. Research Fellows/ Project Assistants: (Name and Designation of JRF/SRF/RA/PAs working in the Research Area/R& D Groups)

Vasvi Chaudhry (CSIR-SRF)

Madhuri Kumari (CSIR-JRF)

Pratibha Vajpayee (Project Assistant)

Shashank Mishra (Project Assistant)

Swati Maheshwari (Project Assistant)

Pramila Tripathi (Project Assistant)

Niladri Chaudhry (Project Assistant)