Abstract of the Problem:

Indian agriculture is undergoing a critical transition driven by declining soil fertility, rising input costs, climate variability, and increasing pressure to reduce dependence on chemical fertilizers. In Tamil Nadu, intensive cropping systems, phosphorus fixation in soils, micronutrient deficiencies, and prolonged imbalance in fertilizer use have resulted in reduced nutrient-use efficiency and deterioration of soil biological health. These challenges threaten long-term agricultural productivity and sustainability, underscoring the need for effective biological interventions that can complement conventional nutrient management practices.

Arbuscular Mycorrhizal Fungi (AMF) are among the most important soil microorganisms supporting sustainable agriculture. By forming obligate symbiotic associations with the roots of most agricultural crops, AMF significantly enhance phosphorus and micronutrient uptake, improve water-use efficiency, increase tolerance to abiotic stresses, and contribute to soil structure and microbial diversity. In Tamil Nadu, AMF are particularly relevant for major crops such as paddy, sugarcane, pulses, millets, vegetables, and horticultural systems. Consequently, AMF-based biofertilizers are increasingly recognized as strategic inputs aligned with national and state priorities on sustainable and climate-resilient agriculture.

Despite strong scientific evidence and growing market demand, the commercial AMF biofertilizer sector in India faces persistent technological and quality-related limitations. Most commercially available AMF products are produced using substrate-based or pot culture methods that are low-yielding, space-intensive, contamination-prone, and difficult to standardize. These production systems often result in inconsistent propagule density, variable infectivity, and poor batch-to-batch reproducibility. Additionally, market products are frequently limited to single species or poorly characterized strains, lacking robust quality benchmarks

and performance validation. This has led to inconsistent field outcomes and limited confidence among farmers and agri-input stakeholders.

Root Organ Culture (RoC) technology represents a scientifically validated approach for axenic and controlled multiplication of AMF, enabling higher propagule density, improved infectivity, and enhanced quality control compared to conventional methods. RoC-based AMF production has demonstrated technical feasibility at laboratory scale and holds significant potential for development into high-quality biofertilizer inputs. However, in India—and particularly in Tamil Nadu—the technology remains largely confined to research environments. The absence of standardized protocols, pilot-scale validation, and reproducible production workflows has limited its translation into commercially viable products.

A critical gap therefore exists between laboratory-scale RoC research and industry-ready AMF inoculum production systems. Fertilizer manufacturers and agri-input companies currently lack access to validated RoC platforms that demonstrate scalability, process stability, and consistent biological performance under pilot-scale conditions. This gap has constrained broader adoption of AMF technology and slowed the development of next-generation biofertilizers capable of delivering predictable agronomic benefits.

Addressing this problem requires focused translational research to systematically advance AMF Root Organ Culture technology from early-stage validation toward pilot-scale readiness. Such efforts must establish standardized operating protocols, define quality benchmarks, evaluate batch-to-batch reproducibility, and generate biological performance data relevant to industry requirements. Strengthening this translational link will enable development of scalable, contamination-free AMF inoculum production systems and support integration of advanced mycorrhizal technologies into mainstream agricultural input supply chains.

Successful resolution of these challenges will not only improve the reliability and adoption of AMF-based biofertilizers but also contribute to sustainable soil management, reduced chemical fertilizer dependency, and the positioning of Tamil Nadu as a centre for agricultural biotechnology innovation and bio-input development.

Project Objective:

The objective of this project is to further develop and validate an AMF Root Organ Culture (RoC) technology currently positioned within the TRL 3–4 range, and to advance it through systematic process optimization, pilot-scale demonstration, and performance validation toward TRL 6 readiness. The project aims to establish a scalable, standardized, and contamination-free RoC platform suitable for pilot-scale inoculum production, with a clearly defined pathway for progression toward TRL 7 through subsequent industry-led scale-up and technology transfer to fertilizer manufacturing companies.

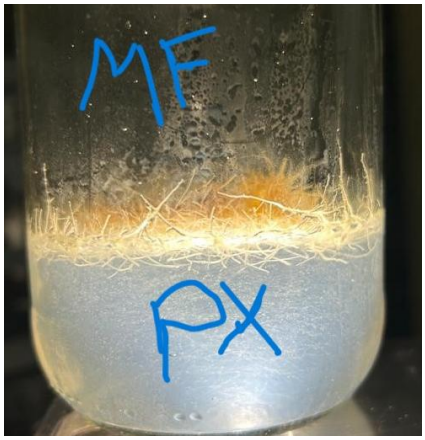

Figure 1. Overview of in vitro Root Organ Culture (RoC) system for AMF inoculum production.