

*This small piece of work is dedicated to the beloved  
memory of  
my former supervisor*

***Late Dr. Palash Mandal***

*and*

*my father*

***Late Taurit Husain***

*Sir you were more than a mentor to me – you were a guiding light, a source of inspiration, and a true friend, philosopher and guide. Your sudden departure left a void that words can hardly express. I am reminded of the countless hours we spent discussing ideas, overcoming challenges, and celebrating small victories. You possessed a rare combination of wisdom, kindness, and unwavering support. You taught me to experiment with courage, analyze challenges with resilience, and draw conclusions with wisdom. Though you may not be physically present, your spirit resonates in the corridors of academia, reminding me to strive for excellence. Sir you will always be remembered not only for your scholarly achievements but for the indelible mark you left on the hearts and minds of those fortunate enough to know you. Your legacy lives on in the pages of my thesis, and I am forever grateful for the privilege of having had you as my mentor, my guide, and my friend.*

*.....Solmon (the pronunciation you used to call me)*

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*.....Your Son*

# DECLARATION

*I, Mr. Md Salman Haydar, hereby declare that the research work presented in my thesis, entitled “APPLICATION OF ESSENTIAL CATIONIC MICRONUTRIENTS AS NANO-FERTILIZER ON VEGETATIVE PROPAGATION AND GROWTH OF MULBERRY,” has been carried out by me under the supervision of Dr. Swarnendu Roy, Assistant Professor, Department of Botany, University of North Bengal, for the award of the **Doctor of Philosophy (Ph.D.) in Science (Botany)**. I also declare that this thesis or any part of this thesis has not been submitted for any other degree/diploma either to this or other Universities.*

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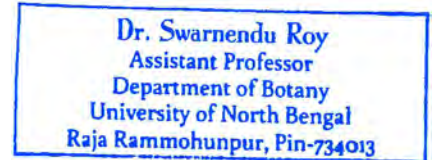
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# PREFACE

In the pursuit of sustainable agriculture and enhanced crop productivity, the realm of nanotechnology has emerged as a promising frontier, offering innovative solutions to address the challenges faced by the global agricultural community. This doctoral thesis represents a dedicated exploration into the application of micronutrient nano-fertilizers and their impact on the vegetative propagation and growth of mulberry plants.

Mulberry, an important plant in sericulture, serves as the lifeblood of the silk industry, supporting a substantial portion of global silk production. In the context of India, the second-largest silk producer globally, the economic significance of mulberry cultivation is undeniable, contributing significantly to the nation's GDP, exports, and employment. However, the cultivation of this vital plant faces challenges, including limited cultivable land, water scarcity, and inefficient nutrient management. The conventional methods of nutrient management have proven to be insufficient and environmentally detrimental.

In response, this research delves into the innovative realm of nanotechnology, specifically focusing on the green synthesis of iron, zinc, manganese, and copper nanoparticles using the pruning litter from tea plants, a by-product abundantly available in North East and South Eastern India. The precised synthesis process, coupled with the utilization of waste materials, exemplifies the commitment to sustainability inherent in this research.

Through meticulous experimentation and systematic analysis, this study explores the efficacy of micronutrient nano-fertilizers in enhancing the vegetative propagation process of mulberry plants. Furthermore, the study examines the phytotoxicity of nanoparticle treatments, ensuring the safety of both plants and the environment. Beyond vegetative propagation, this thesis investigates the impact of micronutrient nano-fertilizers on mulberry growth under drought conditions and their subsequent effects on silkworm rearing. The findings highlight the potential of nanotechnology to mitigate the adverse effects of drought stress and enhance the nutritional quality of mulberry leaves.

The exploration doesn't stop here. The thesis delves into the realm of slow release nano-fertilizers (SRNFs), offering a solution to nutrient leaching issues associated with traditional fertilizers. This innovative approach significantly contributes to improving mulberry growth, propagation, and internal health, as evidenced by morpho-biochemical analyses.

As the findings unravel, the thesis emphasizes the importance of precision in micronutrient management for mulberry, acknowledging the role of nanotechnology in shaping the future of sustainable agriculture. However, it also calls attention to the need for a comprehensive understanding of the long-term effects of nano-based fertilizers on soil microbiome, human health, and the ecosystem.

As we embark on this academic journey, it is imperative to acknowledge the collaborative efforts and invaluable support of mentors, colleagues, and research collaborators who have contributed to the completion of this thesis. In essence, this thesis represents a journey of scientific rigor, environmental management, and a commitment to advancing agricultural practices for a sustainable and resilient future. May the insights gleaned from these pages serve as a catalyst for continued exploration and innovation in the empire of nanotechnology for agriculture.

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