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Exploring Shrimp-Derived Chitin Nanofiber as a Sustainable Alternative to Urea for Rice (*Oryza sativa* cv. BRRI dhan67) Cultivation

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Abstract: Rice is a staple food for nearly half the world population. Rice cultivation relies heavily on urea fertilization. However, the use of urea is prone to significant losses and contributes to environmental pollution. This study was aimed at fabricating nitrogen-rich chitin nanomaterials and assessing their effects on the growth and yield of rice. Chitin nanofibers (ChNF), with widths ranging from 10 to 30 nm, were successfully isolated from shrimp shells by chemical pretreatment and mechanical fibrillation. Pot-grown rice plants were treated with various concentrations of ChNF and urea in a completely randomized design with five replicates. ChNF treatment resulted in plant height (97.33 ± 1.53 cm), tiller number (17.67 ± 1.15 hill^{-1}), straw yield (30.40 ± 1.93 g hill^{-1}), and harvest indexes comparable to those achieved with urea treatment at harvest (97.33 ± 1.53 cm, 17.00 ± 1.73 hill^{-1}, 26.47 ± 2.39 g hill^{-1} and 44.12%, respectively). The grain yield using urea (22.70 g hill^{-1}) was almost identical to that achieved with 0.01% ChNF (22.22 g hill^{-1}), which may be attributable to the increased nitrate-nitrogen (N) and ammonium-N availability, reduced nitrogen loss, and enhanced microbial activity associated with 0.01% ChNF. The study findings indicate that shrimp-derived ChNF is a promising functional nanomaterial for rice cultivation, with potential as a partial or full replacement for urea in sustainable rice production.

Keywords: urea; growth; yield; nitrate nitrogen; ammonium nitrogen

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1. Introduction

Rice (*Oryza sativa* L.) is a crucial crop in developing countries and a staple for approximately half the world population. The consumption of rice increased from 437.18 million metric tons in 2008–2009 to 520.4 million metric tons in 2022–2023 [1]. As the global population increases, the demand for rice continues to increase and is expected to reach 584 million tons by 2050. Efforts have been made to enhance rice production using high-yield varieties, appropriate inputs, and management practices.

The use of chemical fertilizers significantly increases rice production. Urea, a nitrogenous fertilizer, has been used extensively and has greatly contributed to higher rice yields. However, the nitrogen use efficiency (NUE) of urea fertilizer is very low (30–35%) and the