Comparative Evaluation of Controlled-Release Urea Fertilizers and Application Methods on Nitrogen Agronomic Efficiency Indicator of Rice Plant

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Abstract:

Rice is a vital global staple crop, and nitrogen (N) is the most limiting nutrient for its growth. Urea, containing 46% N, is the predominant solid N fertilizer used worldwide. However, its excessive use and high solubility increase costs and environmental concerns. Slow-release N fertilizers and split application methods, though effective, often face high costs and implementation challenges. This study explores the potential of emerging technologies and materials to address these issues. A greenhouse experiment was conducted on a calcareous soil and rice plant cv. 'Gohar' with a completely randomized design, including 31 treatments and three replications. The treatments comprised control (without urea application), urea alone, co-application of urea and amendments (rice straw, hydrochar, biochar, and zeolite) with two application methods (split and single), as well as five slow-release fertilizers including urea-impregnated zeolite (UZ), urea-impregnated biochar (UB), urea-impregnated hydrochar (UH), sulfur-coated urea (SCU), and urea-hydroxyapatite nanohybrids (U-HAP). The treatments included urea, urea applied at 435 and 870 mg kg^{-1} rates, while the amendments were used at 10 g kg^{-1} of soil. Results demonstrated that UB, UZ, U-HAP, and SCU at 435 mg urea kg^{-1} soil achieved the highest apparent recovery and agronomic efficiency of N. These slow-release fertilizers enabled about a 50% reduction in urea consumption and eliminated urea distribution costs. Further greenhouse, field, and lysimeter studies are recommended to optimize these fertilizers' effects on various plants and improve their seed and shoot compositions while reducing N losses.