ABSTRACT

Control release urea fertilizers play an important role in reducing urea usage and saving agricultural environment from being contaminated with nitrogen (N) derivatives. The major challenges in control release urea (CRU) fertilizer research include to understand N-release and movement of its transformations in irrigated soils using simulation models and to formulate cost-effective CRUs using locally available low-cost materials. The existing mathematical models are not capable in simulating both water and N-transport in paddy soils treated with CRUs. Urea coated with sulphur and polymers are costly and leave undesired residue of coating materials in the soil environment. In this study a conceptual model (CRUF) was developed by integrating paddy water and N-balance models with an N-release model for simulating water and N-transport in CRU treated paddy fields. CRUF model uncertainty and performance were studied using field (*Kharif* and *Rabi* seasons) and literature data. CRUF model was tested for coated urea, uncoated urea and their mixture. Furthermore, low-cost CRUs were fabricated in the laboratory using urea as base material, zeolite as coating material and white cement, corn starch, potato starch, and acrylic polymer as binding materials. The fabricated CRUs were characterized and used to study N-release and N-movement. The CRUF model performance was tested for the fabricated CRUs using laboratory soil column studies. The optimal coating thickness and radius of urea granules were determined using Response Surface Methodology (RSM) by maximising nitrogen-release time and minimising CRU production cost.

The CRUF model was able to simulate water flow, nitrogen movement in paddy soils treated with uncoated and coated urea, and their mixture. Relative uncertainty in water balance components of CRUF can be minimised by taking extra precision on field measurements during *Rabi* season. The CRU formulated with 50% urea, 33% zeolite, 6% bentonite, 6% white cement and 5% acrylic polymer, was found to be the best and structurally stable. The production cost of the best CRU was 1.5 and 2 times lower and saved ₹ 1000 and ₹ 800 per hectare when compared to polymer and sulphur based CRUs, respectively. The best CRU can control nitrogen release by 54% compared to other fabricated CRUs and 65% lower N-loss through leachate when compared to uncoated urea and neem based CRU. The optimum coating thickness and radius of urea were found to be 0.08 cm and 0.3 cm, respectively for which the maximum nitrogen release time the minimum production cost were found to be 44 days and of ₹ 56/kg, respectively.

Keywords: *Paddy water balance, control release urea fertilizer model, uncertainty analysis, fertilizer granulation, response surface method*