Redefining Deep Placement Technology for Twenty-First Century Agriculture

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ABSTRACT

Prilled urea (PU) conventionally broadcasted on lowland (flooded) rice (*Oryza sativa* L.) results in inefficient use of nitrogen (N) due to volatilization, nitrification-denitrification and leaching of N to the environment. These losses negatively affect the productivity and sustainability of lowland rain-fed and irrigated rice and reduce farmers' profitability. Alternative N-fertilizer management practices that maximize N use efficiency are needed. Urea super-granule deep placement (UDP) and fertilizer briquette deep placement (FDP) with N, P and K are tested technologies for improving N use efficiency and productivity.

Laboratory, greenhouse and field experiments were conducted to compare UDP and FDP with common farmer practice (FP) of broadcasting PU to: quantify floodwater N and P content; ammonia volatilization and leaching losses; nitrous oxide and nitric oxide (N_2O-NOx) emissions; nitrogen use efficiency (NUE); weed growth; and overall agronomic and economic performance in lowland rice and in upland crops. These trials were conducted by IFDC and partner institutions in Bangladesh, Burkina Faso, India, Madagascar, Niger, Senegal and the USA.

Deep placement resulted in highly significant ($p < 0.001$) reduction in floodwater N and P content and ammonia volatilization loss and overall the N losses from UDP and FDP were similar (non-significant difference) when compared with losses from zero N plots. Floodwater pH was lower with deep placement than with broadcast application of PU, clearly indicating that effective deep placement resulted in reduced algal activity and minimum change in floodwater pH and hence less volatilization loss. The deep-placed plots gave significantly higher rice grain yield (GY) ($p < 0.01$) and N uptake ($p < 0.01$) compared with FP. Yield gains of 15-35% have been obtained across seasons, soil types and varieties in Bangladesh, India and Sub-Saharan Africa. Similar yield gains have been obtained for upland crops including maize and vegetables. The UDP/FDP yield increases were achieved with 20-45% less N use and 45-60% less weed biomass compared with broadcast application of PU.

Overall, the magnitude of rice yield advantage of UDP/FDP over FP is dependent on growing seasons, varieties and soil types. During the dry season (*Boro* rice in Bangladesh) yield advantages of UDP over FP were > 1000 kg ha^{-1} with at least 35% less N use. Soil CEC and clay content were the critical soil characteristics that significantly affected UDP efficiency. Rice yield gains were > 1100 kg ha^{-1} on soils exhibiting CEC of 7.0-8.2 cmol+/kg. Crop response to UDP was strongly correlated with soil clay content. Rice variety trials showed overall yields were significantly ($p < 0.05$) greater for UDP compared with FP. Total rice N uptake, recovery and yield increment differed among varieties for both UDP and FP. Preliminary results have also shown deep placement of N results in reduced N_2O and NOx emissions. Soil analyses from long-term UDP and FP trials in Bangladesh have shown up to 10 tons more soil organic carbon accumulation in UDP fields.

Ongoing research includes improving the handling and application of urea supergranules through the use of manual and mechanized applicators and coating of the granules. Additional focus is on customized preparation of fertilizer briquettes containing limiting secondary and primary nutrients to increase yield and enhance the nutrient content of grains.