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Mechanized Fertilizer Deep Placement: A Transition Towards Climate Smart Agriculture

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Background

Broadcasting fertilizers by hand is a traditional technique in the developing world to deliver plants nutrients in soil. This practice exhibits lower fertilizer use efficiency (FUE) especially of nitrogen (N), ranging 30 to 50% due to the losses from ammonia (NH_3) volatilization, surface runoff, nitrification–denitrification and leaching [1-5]. The fertilizer broadcast not only causes substantial monetary losses to farmers, but also causes a high environmental cost to society [6-8]. Therefore, many strategies have been developed to reduce N losses and increase N use efficiency (NUE) from applied fertilizer through 4R concept of right source, timing, rate, place; integrated nutrient management (INM), slow-release fertilizers etc. [6,9]. However, the response of fertilizer N to these measures varies markedly because of the differences in agro-ecologies, management practices and cultivars. Many researchers reported that point deep placement of N fertilizers can be a promising alternative to broadcast fertilizer [2,6,10-12]. One effective means of reducing the nutrient (particularly N) losses and improve NUE is to adopt the urea deep placement (UDP) technology [13], which was developed by IFDC and collaborators from different countries [14].

Urea Deep Placement Technology

The UDP technology is a simple, farmer-friendly technology with two key elements (i) a large-sized fertilizer particle of 1-3 grams by weight, referred to as a urea super granule (USG) or briquette, and (ii) point placement of the briquette at 7-10cm depth near the root zone [15]. Through the UDP technology, the avenues for N losses are reduced, and improved N uptake by the plant is possible [16-18]. Studies have shown that the UDP technology is a highly effective soil nutrient management strategy, enabling farmers to achieve higher crop yields (25-50%) with lower use of fertilizers (15-25%), reduced greenhouse gas (GHG) emission (30-85%) by inhibiting nitrification up to seven weeks and provides rural employment [19-23]. The UDP technology has been widely tested and promoted in different parts Asia and Africa, more particularly in Bangladesh with adoption in more than 2 million ha. The socio-economic study in Bangladesh revealed improved household income by adopting UDP technology, which helped in better investment towards education (12.9%), improved housing (11.8%), purchases of animals (8.5%), purchases of agricultural equipment (6.5%), purchases of new clothing (5.9%), new or improved small businesses (4.1%), purchases of household appliances (3.3%), and installation of tube wells (3.0%). Despite documented agronomic superiority and socio-economic benefits of UDP, the adoption has been stagnant in the developing countries due to additional field operation to hand-press UDP in soil in absence of suitable machinery for which labor, time and human energy are required. Labor scarcity and cash liquidity are major constraints of the developing world. Secondly, the UDP was managing the single plant nutrient (N), whereas other plant nutrients were still being broadcast on the soil surface [24].

Several attempts have been made in the past to develop suitable UDP applicators [25]. The applicators were found to be labor saving, but having operational problems related to metering, depth of placement and clogging were pertinent [26].

Current Pollution Concern of Fertilizers and UDP

There is an increased concern of soil, air, and water pollution in, which is drawing attention towards regulatory action and a range of policies related to N pollution [27]. Limits on the amount of fertilizer have been implemented in some countries, Europe, for example, has announced plans to cut fertilizer use by a quarter over this decade, as part of a broader effort to make its farms more sustainable, while other jurisdictions rely on voluntary measures as the means to track progress towards environmental goals [28]. The widespread concerns about fertilizer related pollution from agriculture and regulations to reduce it, demands investment in climate smart technologies like UDP. Therefore, IFDC reinvested in the UDP technology during the last decade with a vision to layer it with other climate smart technologies like mechanization for regenerative agriculture. IFDC worked with the public and private sector partners to modify existing zero-till drills (ZT) and paddy transplanter (PT) into a single-operation seed/transplanting and fertilizer deep placement (FDP) system. Also considering imbalanced fertilizer use as the key concern of low efficiency, high losses and GHG emissions, IFDC conducted research to transforming USG into multi-nutrient (NPKZnS) briquette for balanced nutrient application (Singh, personal communication).

Mechanized Fertilizer Deep Placement: Way Forward

IFDC along with the national agriculture research system in India has conducted more than 2000 farmer participatory research trials in different agro-ecologies to evaluate the mechanized FDP in rice, mustard, tomato and brinjal crops, using ZT-FDP and PT-FDP machines. The study revealed that crop productivity increased by 26% in rice using PT-FDP, and 50% in mustard, 26% in tomato, and 21% in brinjal using ZT-FDP. The mechanized FDP (m-FDP) surpassed the existing state average by a range of 33% to 124% across different crops (Saharawat et al., unpublished). The crop yield from one kg NPK application increased from 26kg to 47kg in rice by using PT-FDP, and 50kg to 71kg in brinjal, 42kg to 60kg in tomato and 5kg to 10kg in mustard using ZT-FDP. The m-FDP enhanced the farmers' profitability in range of US$ 305 to 1927 in different crops and agro-ecologies over the traditional broadcasting method (Saharawat et al., unpublished). The studies from similar agro-ecologies of Bangladesh have shown that FDP enhances the soil, environment and human health by reducing the ammonia volatilization (~75-80%), greenhouse gas (GHG) (~28-66%); enhance productivity (~15-45%) and saves fertilizer budgets (~15-25%). Pan et al. (2017) also observed that mechanically deep placement of N fertilizer significantly enhanced NUE and grain yield compared to surface broadcasting. The mechanized FDP has shown potential for scaling-out in different agro-ecologies for enhancing the fertilizer use efficiency, reducing input cost and environmental footprints and enhancing the profitability. An enabling policy environment with an incentive-based system for farmers adopting M-FDP as a climate smart technology and permission for local level blending of fertilizers in some countries will help in faster and large-scale adoption of the technology. There is also a need for dedicated awareness programs for the farmers and other stakeholders on the M-FDP. Overall, the large-scale adoption of M-FDP will help in sustaining agrifood production and contribute the one health by contributing to Sustainability Development Goals (SDGs) #1, #2, #3, #12, #13, and #15 [29-32].

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