

Smart fertilizers

for efficient nutrient management

Bisworanjita Biswal, Suryakanta Kashyap, Hardev Ram* and Rakesh Kumar

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001

Application of smart fertilizers based on slow-/controlled-release and/or carrier delivery systems along with smart fertilization techniques has the potential to achieve efficient nutrient management to meet the target productivity, reduce environmental stress and attain sustainable development goals. Zeolites, polymers and agricultural wastes that act as carrier for nutrients and biofertiliser can be suitable material for smart fertilizer production. The main hindrance in expansion of smart fertilizer is low-installed production capacity. Future research should explore its suitability, feasibility and user friendly aspect of smart fertilizers. Innovative fertilizers from naturally available materials would ensure sustainability of agricultural production system.

Keywords: Bioformulation, CRFs, Nanofertilizers, SRFs

FOOD security is limited to that 40-50% of earth's land surface that includes entire agricultural land system cropland, grassland and agro-forestry. Heavy fertilization to achieve maximum yield has serious issue of resource depletion, air, soil and water pollution, greenhouse gas (GHG) emission, climate variability. Excessive use of primary fertilizers without due importance to synchronization of crop demand leads to serious imbalance between plant requirement and availability. This leads to low nutrient use efficiency and loss of nutrients by volatilization, leaching, runoff, fixation, chemical and microbial decomposition. Moreover, the present Indian scenario of nutrient use efficiency suggests that under farmers practice nitrogen use efficiency is 20-30% in dryland or rainfed situation, 30-40% under irrigated situation in different cropping systems.

Development of innovations to increase nutrient use efficiency, ensure food security and environmental health for overwhelming population is the need of hour. New types of smart fertilizers formulated based on

use of microorganisms and/or nanomaterials. USA, Canada, Europe, China and Japan are currently using smart fertilizer and by far China is the largest producer and consumer amounting to one-third of global smart fertilizer. Nanotechnology haven been less ventured could be promising to revolutionize food systems. Nanotechnology based smart fertilizers development with an emphasis on controlled-release and/or carrier/delivery systems will synchronize nutrient availability with the plant demands thereby reducing nutrient losses. Increased nutrient use efficiency reduced dose of phosphate by half to one fourth and increased yields by 10%. For smart micronutrients the reduction in dose was up to 90%. Due to less investment farmers income can be raised by 15-20%.

TYPES OF SMART FERTILIZERS

Slow-/Controlled-Release Fertilizers

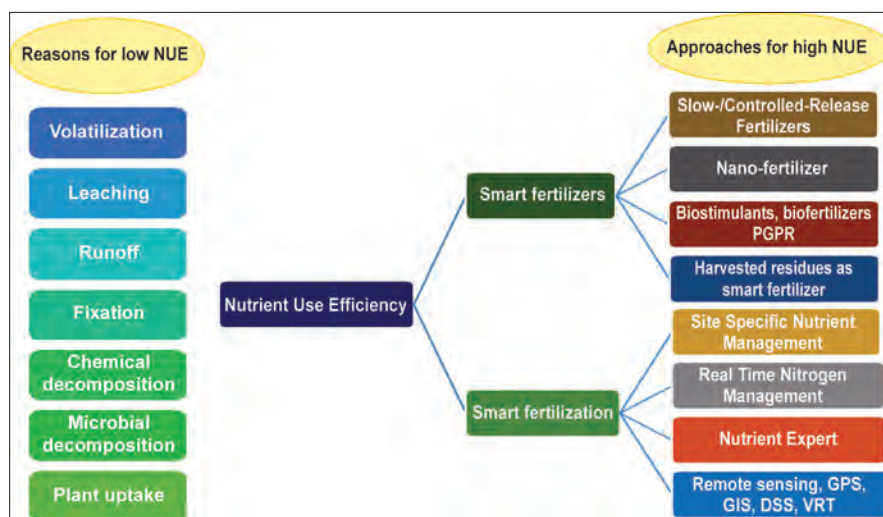
These fertilizers either delays the nutrient availability for plant uptake or makes the nutrients available to

plants for a significantly longer time. There is no basic differentiation between slow-release fertilizers and controlled-release fertilizers, but to say microbially decomposed N products, like urea-formaldehyde, urea-isobutyraldehyde, urea-acetaldehyde, sulfonyl urea, methylene urea, etc. are referred to as slow-release fertilizers (SRFs), and coated or encapsulated products like sulphur coated, polymer coated, etc. as controlled-release fertilizers (CRFs). Semipermeable coatings can serve for delayed availability or consistent supply of nutrients over certain time. These materials respond to temperature, pH, electric and magnetic fields. Natural materials like clay (zeolite) and nanoclays (allophane), biodegradable polymers and nondegradable (polysulfone) can be used as slow release of nutrients. These can be expensive and the polymer coated fertilizers are toxic which are not eco-friendly. Alternatively, natural polymeric carbohydrates are slow release, biodegradable and low cost. Modifying the hydrophilic property and weak coating barrier can make

these polymers excellent coating materials. Various degradable materials suitable for development of smart fertilizers can be brown coal, charcoal, biochar, perlite, vermiculite, bentonite, attapulgite, peat, alginate beads, saw dust, wood ashes, humic substances, wheat bran, spent mushroom compost, lingo-cellulosic materials, etc. Few commercial products like Nitroform (UF Formulation), IB Nitrogen (IBDU) are SRFs and Multigreen, multiagro and multicote are CRFs.

Nanofertilizer

The three types of nanofertilizers synthesised nanoparticles called nanoscale fertilizers; bulk products with nanoscale additives called nanoscale additives and products coated with nanopolymer or loaded with nanoparticles called nanoscale coating. Natural clays or zeolites occurring naturally in soils have unique physicochemical properties to stabilize and increase the catalytic activity of enzymes. Natural montmorillonite act as good immobilizer for *Escherichia coli* phytase, stabilizes, enhances specific activity and V_{max} of acid phosphatase (maximum rate of reaction when the enzyme has completely saturated with substrate) in nanoclay-cattle dung-AP complexes. Nano-composites having <10% of nanomaterial as the dispersed phase in the polymeric continuous phase can improve physical and mechanical properties, pH tolerance, stability and durability. Nanocomposites coupled with smart delivery system, release nutrient with crop uptake thereby reducing nutrient leaching and volatilization losses. Synthetic materials or polymers such as polysulfone, PVC, PU, etc had a slower nutrient rate than the biodegradable cellulose acetate-based ones. Triple polymer fertilizers application enhanced the soil water-holding capacity, therefore increasing the availability, uptake and productivity. Surface coating on fertilizers with nanoscale materials, are held strongly due to high surface tensions thereby helps in controlled release. Bioformulations having biodegradable polymers as microbial



Smart fertilizer as an aid to improve nutrient use efficiency.

carriers protect the microbial inoculants from stress and increase its shelf life. For the first time in India IFFCO produced nano nitrogen, nano zinc and nano copper. The products are currently tested on farmers field and is likely to reduce the NPK fertilizer requirement by 50%.

Biostimulants, biofertilizer and Plant Growth Promoting Rhizobacteria (PGPR)

Plant bio-stimulants are substances or materials, with the exception of nutrients and pesticides, which, when applied to plants, seeds or growing substrates in specific formulations, have the capacity to modify physiological processes in plants in a way that provides potential benefits to growth, development, or stress response. Biostimulants have direct hormonal effect on plants that positively affect root growth, root efficiency, nutrient uptake and characters that are beneficial in shifting from chemical to organic fertilization regime.

Major groups of biostimulants are humic substances, protein hydrolysate and amino acid stimulants, seaweed extract and PGPR. Biofertilizer on the other hand have an indirect effect on nutrient availability without itself supplying nutrients. They are live microbial formulations that aid in nutrient availability and uptake. PGPR associated with root helps in production and regulation of phytohormones, slow release of nutrients fixed nutrients, chelating

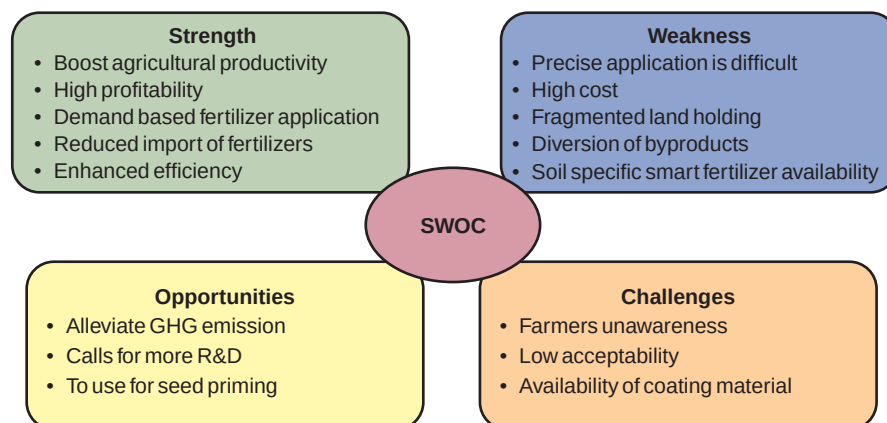
micronutrients (siderophores), produce antibiotics and are anti pathogenic. Bioformulations made with microorganisms encapsulated on carrier materials helps to achieve above benefits along with improved storability and resistance to adverse environmental conditions. Agri Life SOM Phytopharma (India) Limited produces Agri Boom (foliar spray), Aminoacid-Gr, Kohinoor as biostimulants and Fe-sol B, Agri Life Nitrofix as Biofertilizers.

Harvested residues as smart fertilizer

Low cost residues such as straw is rich in lignin, cellulose and hemicellulose that impart mechanical strength to it. Abundantly available wheat straw has carboxyl, hydroxyl, ether, amino and phosphate groups on surface that makes it an excellent absorbent material to treat waste water and making slow-release fertilizers. These have high adsorption capacity of ammonia and phosphate ion, antifungal and an effective carrier of PGPR strains. However, straw is susceptible to rapid decomposition in soil. A combination of clay or biochar along with wheat straw can act as slow release fertilizers. Heating of biomass at 350-700°C in absence of oxygen produces light-weight, neutral, stable, carbon rich, charcoal called biochar which is a good soil ameliorant. It reduces the native organic matter mineralization, provides microbial habitat, chelates nutrients due to its large surface area and complex pore structure.

Smart fertilization

Smart fertilizer along with smart fertilization can revolutionize agriculture production and help us to achieve food security and environmental security goals. Smart fertilization would mean the techniques of applying smart fertilizer in order to reduce the application losses, further reduce the amount of fertilizer required and accentuate the role of smart fertilizer for synchronising nutrient availability with crop demand. This can be achieved by site specific nutrient management (SSNM), Real time nitrogen management, Nutrient expert system, Precision nutrient application using decision support system (DSS), Variable rate technology (VRT), GIS, GPS and remote sensing and other climate smart cropping practices. SSNM aided with geo-informatics tools arrange for a profitable means of high-resolution real time data through Remote sensing, geo-referencing the ground truth data with GPS, data management and analysis through GIS to supply the crop with nutrients as and when required. To avoid inefficient splitting of N applications that result in lower NUE, Real time nitrogen management serves the purpose. It synchronizes the demand and supply of nitrogen by rapid and periodic assessment of leaf nitrogen content. Leaf nitrogen content is



meticulously associated with plant photosynthetic rate and biomass production, therefore indicates the changes in nitrogen demand of crop during the growing period. Based on the principle of SSNM Nutrient Expert is an interactive computer based decision support tool. It is easy to use and provides recommendations in presence as well as absence of soil testing data. Decision support system is a software that takes various soil, weather, crop and management data as input and gives output report that is actionable. VRT is an automated application of inputs based on information collected by sensors, maps and remote sensing. According to the research at Michigan State University, precision fertilizers and remote sensing technology could save 6.8 million metric tons of carbon dioxide from entering the atmosphere — the equivalent of 1.5 million cars

per year.

How smart is smart fertilizer?

- Reduces application volume by CRF's, saves energy required for fertilizer production.
- Reduces frequency of fertilizer application (once or twice), saves labor, application cost and production cost by 30-50%.
- Increases NUE of controlled release urea fertilizer by 50-100% than conventional urea.
- Improves water holding capacity, SOC content and thereby over all crop productivity.
- Reduces leaching and other losses.
- Combats climate change by reducing CO₂ release during production (20-30%), N₂O release after application.

*Corresponding author e-mail: devagron@gmail.com

Innovative Agri-Solutions During COVID-19

Promoting Nutrition Gardening during Lockdown

Intervention

- Women were guided to take care of intercultural operations in the standing crops in the Nutrition gardens. They were also advised to sow the Kharif vegetables in the Nutrition garden so that they may able to fetch fresh vegetables in the coming months.
- A total 1 lakh seedlings of vegetables, like tomato, brinjal, capsicum, chilli, bottle gourd, sponge gourd, cucumber and pumpkin were provided to farmers.
- Women were also encouraged to grow herbs like tulsi, mint, turmeric and other medicinal plants in their Nutrition garden for the immunity.
- Advisors and messages pertaining to healthy and balanced diet, enriching the diet through sprouting and the available food resource were also sent to the groups via Whatsapp.
- Summer/Kharif vegetables kits were also distributed among women (>5236 families covered in 56 villages).

Contribution: KVK, Kullu and Una, Himachal Pradesh

Source: www.icar.org.in