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Sustainable agriculture with nano-fertilisers

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As India gears up to ramp up production of nano-fertilisers, questions arise regarding the technical feasibility and logistical implications of transition

Recently, the Union Minister for Chemicals and Fertilisers Mansukh Mandaviya stated "Consumption of urea this fiscal is likely to be 8 percent less than in FY 2022-23 due to the use of its liquid nano variant. Because of this and higher domestic production, import of urea, the soil nutrient that accounts for 70 per cent of the fertiliser subsidy bill, declined more than a fifth on year in 2023. Further spread of nano urea consumption and the start of a new large urea plant (Talcher in Odisha) by September 2023 would lead to elimination of imports in two-three years".

The Minister's statement points towards unprecedented possibilities offered by nano-fertilisers (apart from nano-urea, the industry has also launched nano-DAP; besides other fertiliser types in nano form such as nano-potash, nano-zinc, nano-boron, etc are being developed) in terms of not just a substantial reduction in fertiliser subsidy but also reducing imbalance in fertiliser use, preventing deterioration in soil health and help achieve the environment-related goals. Additional benefits will accrue by way of savings in foreign exchange outgo, reduction in current account deficit (CAD) and reduced stress on the logistics chain, particularly the transport and storage infrastructure. Nano-urea is urea in the form of a nanoparticle containing nitrogen particles of 20-50 nanometres (nm) in size. Likewise, nano-DAP consists of particles of polymer-encapsulated DAP that are less than 100 nm. Nano-urea provides nitrogen or 'N' to plants in liquid form as an alternative to conventional urea which is mostly supplied as prill (it is a small diameter, spherical white solid). Likewise, nano-DAP supplies both 'N' and phosphate or 'P' nutrients to plants in liquid form as an alternative to conventional DAP.

The beauty of nano-fertiliser lies in its ultra-small size and high surface area (10,000 times over 1 mm urea prill), which enable easy absorption by plant leaves. These particles enter the plant through cuticular pores, or stomata, and then penetrate the cell membranes through endocytosis. Once inside the cell, these release nutrients slowly and ensure full absorption by eliminating waste that normally happens with conventional means.

The innovator namely the Nano Biotechnology Research Centre (NBRC) of the Indian Farmers Fertiliser Cooperative (IFFCO) claims the efficiency of nano urea (a measure of how much of the 'N' supplied from it is absorbed by the plant) is over 80 per cent against around 40 per cent for conventional stuff. Furthermore, nano urea increases crop yield by 3-16 percent. Likewise, nano-DAP can deliver gains in efficiency of use and increase in yield.

Furthermore, unlike the use of conventional urea which raises environmental concerns, including nitrate leaching, global warming, ozone layer depletion, and groundwater pollution, the use of nano-urea causes less soil, water and air pollution. According to a study, two foliar sprays of nano-urea curtailed nitrogen load by 25 per cent, besides reducing the greenhouse gas (GHG) emission from 164.2 to 416.5 kg CO_2-eq ha-1 under different crops.

A more startling claim made by IFFCO/NBRC is that a 500-ml bottle of nano-urea is equivalent to a 45-kg bag of conventional urea. The latter contains 46 per cent N nutrient, or 20 kg (45×0.46) whereas the former contains

4 per cent N, or 20 grammes (500x.04). Yet, the two are considered to be equivalent by the innovator. Put simply, this means that urea in nano-form with a mere 20 grammes can achieve what conventional urea does with 20 kg-a gap of 1000 times in efficiency.

It is this monumental difference in efficiency that enables IFFCO to deliver a 500-ml bottle of nano-urea to farmers for Rs 240 without any subsidy support. In contrast, the cost of supplying equivalent conventional urea in a 45 kg bag, is over eleven times at around Rs 2650 (while, this figure is for imported urea, even for urea produced domestically, the cost is substantially higher and varies from unit to unit), the Government has to give a subsidy of Rs 2410 to make available to the farmer at the same price of Rs 240.

In the case of DAP, IFFCO/NBRC claims, a 500-ml bottle of nano-DAP is equivalent to a 50-kg bag of conventional DAP. While the former can be delivered to farmers for Rs 600 without any subsidy support, the cost of supplying the latter is nearly seven times at Rs 4000. With a subsidy of Rs 2,650, the price of conventional DAP to the farmer comes to Rs 1,350 which is more than double the price of an equivalent 500-ml bottle of nano-DAP.

According to Mansukh Mandaviya, India will produce about 55 million bottles of nano-urea during FY 2023-24 thus replacing 2.5 million tons of conventional urea. At one level, it will help in trimming excess consumption of urea thereby reducing the imbalance in fertiliser use (currently, the NPK use ratio is 6.7:2.4:1 against the desired 4:2:1) thereby improving soil health, at another, it will bring about a drastic reduction in subsidy @ Rs 2410 per 45 kg bag, the subsidy on import of a ton of conventional urea comes to Rs 53,550 (2410x22.22 being the number of bags in a ton). On 2.5 million tons, it would have been around Rs 13,400 crore. Since this has been replaced by nano-urea which doesn't require any subsidy support, the entire amount of Rs 13,400 crore is saved. Likewise, there would be savings in subsidy to the extent conventional DAP is replaced by nano-DAP.

Meanwhile, the Government has plans to boost production of nano urea to around 440 million bottles during 2024-25. This is equivalent to 20 million tonnes of conventional urea or around 60 per cent of its total current consumption (2023-24). One wonders whether substitution to that extent is technically feasible. Normally, urea is applied in two dosages: one, basal application being even spreading of solid fertilisers over the entire field before or at sowing or planting; two, top dressing which involves applying fertiliser directly to the leaves as opposed to in the soil. Nano-urea is meant to replace conventional urea only in top dressing even as basal application is entirely in solid form.

Scientists recommend that 50 percent of the application or around 16.5 million tonnes, come from nano-urea. Even at this level, urea import (currently estimated at 6.4 million tonnes during 2023-24) would be eliminated. Not just that, for the balance of 10 million tons coming from nano-urea, the requirement of natural gas or NG - the raw material for urea production - will be 'drastically' pruned.

Taking around 600 cubic metres of NG needed for a tonne of urea, if 10 million tonnes come from conventional stuff, the NG requirement would be 6000 million cubic metres (600x10). If, instead it comes from nano-urea, given the efficiency difference of 1000 times, the requirement will be a mere 6 million cubic meters. This would lead to huge savings in the import of gas (currently, India imports 50 per cent of its NG needs; even for domestic urea production, one-third of the total requirement is met from imported LNG).

Drastic reduction in load on infrastructure will be a bonus. Imagine the impact of handling, moving, storing and delivering a 500- ml bottle of nano-urea vis-à-vis a bag of conventional urea containing 45,000 grammes of material. Ditto the impact of carrying a 500-ml bottle of nano-DAP vis-à-vis a bag of conventional DAP containing 50,000 grammes of material.

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