DEVELOPMENT OF NANO FERTILIZERS AS SLOW RELEASE FERTILIZERS

W. P. S. L. Wijesinghe[1] and A. M. C. P. Weerasinghe[2]

[1]*Board of Study in Chemical Sciences*

[2]*Department of Botany, Faculty of Science*

Adequate soil Nitrogen is essential in agricultural soils to increase the crop productivity. There are vast varieties of Nitrogen fertilizers to fulfil the Nitrogen requirement for crop plants, which are commonly available in the market and most commonly they come in solid forms. These fertilizers can release nitrogen as readily water-soluble, inorganic forms, such as NO_3^- and NH_4^+, which can readily be utilized by plants. Therefore, modern farmers tend to use high dosages of commercially available synthetic fertilizers to increase their crop productivity rather than using natural fertilizers such as organic fertilizers [1].

However, heavy usage of commercially-available, synthetic Nitrogen fertilizers has been now created many problems which may override their advantages associated with improved crop productivity. For instance, they could alter the natural equilibrium and the biodiversity of agricultural lands. Urea is one of the commercially-available, fast-release Nitrogen fertilizers, which is easy to use in agricultural fields. After adding urea to agricultural lands, addition of sufficient amount of water is essential for the solubilization and the absorption of Nitrogen as NH_4^+ and NO_3^-, by plants. Urea can dissolve in water within 48 hours after addition of a sufficient amount of water and is then converted to ammonium bicarbonate in the soil through the natural process carried out by the urease enzyme present in the soil, which is released by vast arrays of soil microbes [2].

$$\mathrm{(NH_2)_2CO + H_2O \xrightarrow{urease} 2NH_3 + CO_2}$$

In acidic soils, ammonia gas produced will be in its ammonium form while in basic soils, ammonia exists as ammonia molecules. As such, in soils of pH 7 to 8, part of this gas will be released to the atmosphere, if it is not protected, causing the so called green house effect. As such, added urea on the soil surface will lose 50% - 90% of its initial amount of Nitrogen within few hours of addition rather than being absorbed by plants, if it is not protected. In addition, the urea has a greater ability to move down along the soil profile and can directly runoff to natural water bodies. It also can create eutrophication of surface of water bodies, by increasing the growth of planktonic autotrophs which may be able to produce toxins (algal blooms- bloom forming cyanobacteria), changing the diversity of vascular plants, biomass and productivity of plants and water bodies, changing the water quality parameters which is unfavorable for consumers. This polluted water will also increase possible health risks during consumption of water and also it will decrease the aesthetic value of such whole aquatic ecosystems [3].

Therefore, the use of urea as a synthetic Nitrogen fertilizer will create more adverse effects than its advantages associated with the growth of plants; the disadvantages include the alteration of the natural Nitrogen cycle, soil health and soil microbial density, increasing the possibility for the green house effect. In order to overcome those difficulties, the soil incorporation of urea is essential for its use as a slow-release fertilizer, for the crop growth improvements [1]. At present, a mixed fertilizer has been developed, which includes urea along with the other fertilizers, as a combination of few essential elements, such as Phosphorous (P) and Potassium (K), as solid pills, to suppress its rapid release when it is used in its pure urea form. Modern technologies have been developed to create slow-release fertilizers, with the aid of the development of nanotechnology. The conventional Nitrogen fertilizers contain particles of size exceeding 100 nm making them to be difficult to be absorbed by the plants, resulting low Nitrogen utilization efficiency (NUE) by plants. Hence, greater numbers of researchers have attempted to create urea-based, Nitrogen fertilizers to increase the NUE by plants. Then the nanotechnology has found a new configuration of fertilizers, known as nano-fertilizers, to increase the NUE several times over the synthetic polymer-coated, conventional slow-release fertilizers. In this sense, Kottegoda *et al.,* (2011) have developed a new fertilizer of urea modified with hydroxyapatite (HA) nanoparticales, which are encapsulated into the soft wood of *Gliricidia sepium.* Instead of urea along, when it is used in combination with HA nanopartials, $[(Ca_{10}(PO_4)_6(OH)_2)]$, it is then known as a compound fertilizer, which can fulfil dual roles as slow release Nitrogen and Phosphrous fertilizers [4].

Most important characters of the HA are Calcium (Ca) ions in the HA which has a greater potential to be replaced with the other positive ions of heavy metals such as Cadmium (Cd), Led (Pb) and Silver (Ag) available in the soil which accumulated along with the commercially available inorganic fertilizers due to the greater application during agricultural and mining activities. In similar manner, negatively charged phosphate groups available in the HA complex have an ability to be replaced by the other heavy metals which are available in their negatively charged anionic form such as arsenate (AsO_4^{-3}) due to formation of more stable complexes between HA and most of the heavy metals.[5] Then it prevents the leakage of heavy metals along the water table in to the ground water and runoff to the natural water bodies along with the rain water due to the accumulation of above mentioned complexes in the soil for a long time. Therefore, the encapsulation of N fertilizer with the HA nano perticales may influence the prevention of accumulation and the pollution of water bodies and the ground water table from heavy metals [5]. HA can combine with natural polymers and synthetic polymers or any other compound, such as poly (methyl methycrylate), poly (acrylic acid) (synthetic) and cellulose, chitin (natural). It is important to make soil colloids along with the soil particles and humus particles which are important during the nutrient adsorptions which may increase the water holding capacity and the cation exchange capacity [6].

References

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