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Nano-fertiliser - A New Dimension in Mordern Agriculture

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Abstract
In recent years there is mounting interest in management of fertiliser application in soils to obtain higher fertiliser use efficiency. To address the issues relating to increasing fertiliser use efficiency, development of new agricultural technologies will be crucial in meeting the ecological needs and in achieving the anticipated food demands of the growing population in the near future. In this context, nanotechnology in agricultural sector has to be introduced, which is likely to bring a sea change in the production of fertilisers, which are expected to improve agricultural production and productivity. This newly emerging area has assumed greater significance to advance agricultural productivity through genetic improvement of plants, natural resource management, production and smart delivery systems of agrochemicals like fertilisers etc. In order to realize the potential of this technology in Indian agriculture, it is important to assess the opportunities and challenges. Possible areas of nanotechnology with potential application in Indian agriculture are nano-fertilisers for slow release and efficient use of water and fertilisers by plants. Throughout this process, we believe the responsible development of nanotechnology in Indian agriculture must be emphasized. Application of nanotechnology to agriculture even at the global level is at its nascent stage and its success will be based on its ultimate acceptance by the stakeholders. In this article, an attempt has been made to address the potentiality and applicability of nanotechnology in fertiliser production and its impact on crop yield.
Keywords: Nano fertilizer, Agriculture, nutrients use efficiency, crop production,plant growth.

Introduction

Fertiliser is a critical input needed for increasing production of foodgrains and other agricultural commodities within the overall constraints of extremely limited scope for increasing land area under cultivation. The adoption of modern technology incorporating use of HYV seeds, irrigation and fertilisers in the late 60s provided the impetus for increasing production of foodgrains at an accelerated space. One of the most critical factors in our advance towards self sufficiency in foodgrains production has been increasing use of fertiliser which went up from 2.26 million tone during 1970-71 to 25.00 million tonnes nutrients during 2008-2009. The consumption of fertilisers in our country has grown at a very rapid rate since independence. Currently, India ranks second amongst the fertiliser consuming countries in the world. The continuously increasing domestic requirements of fertilisers are now being partially met by indigenous production and the balance is met through imports. Fertilisers are plant food materials like nitrogen, phosphorous, potassium, sulphur, zinc etc. Under intensive cropping system, crop removal of plant nutrients far exceeds the addition through fertilisers. The result is a net gap of about 10mt, which has to be met through the contribution of soil, organic manures and bio-fertilisers. This implies that the natural nutrient content of soil is being continuously depleted. Fertilisers cost money and their availability are limited. Therefore, urgent attention needs to be paid to the efficient use of fertilisers. Fertiliser use efficiency (FUE) is a measure of the extent to which fertiliser and management practices have worked together with the soil- climate complex in producing

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a high yield (6). Over the last 35 years, additional nutrients applied as manufactured fertilisers have been responsible for 50-55% of the yield increase in developing countries including India. Though the consumption of fertilisers is increasing steadily over the years, the use efficiency of nutrients applied through fertilisers continues to remain low, for N-30-40%, P-20%, K-55%, Micronutrients: 2-4%, owing to nutrients losses from soils or conversion of nutrients into slowly cycling/recalcitrant pools within the soils. In India, fertiliser use efficiency is declining over the years. The greatest concern is to make increased fertiliser use more sustainable, attractive and profitable to the farmer. Attempts have been made all over the world to increase fertiliser use efficiency, but not much headway has been achieved. In this context, there would be greater National Science and Technology importance of the information how to Initiative (NSTI) with investments of increase the nutrient use efficiency of over 100 cores for the next 5 years. fertilisers by the application of The potential of nanotechnology to nanotechnology in the coming years revolutionize the health care teac If Indian agriculture is to attain its mark imution and communication broad national goal of sustainable technology, and energy sectors has been agricultural growth of over 4%, it is well publicized. In fact several important that the nanotechnology products enabled by nanotechnology research is extended to the agricultural are already in the market, such as total production-consumption antibacterial dressings, transparent system, which is across the entire sunscreen lotions, stain-resistant agricultural value chain. This would fabrics, scratch free paints for cars, require focusing on technologies that and self cleaning windows. The increase agricultural productivities, application of nanotechnology to the product quality and resource use agricultural sector has yet to yield its efficiencies that reduce on farm costs, potential product in the coming era.

FERTILISER PRODUCTION AND CONSUMPTION IN INDIA

The production of N and P,O, was 10.9 and 3.42 million tonnes, innovations based on nanotechnology respectively during 2008-09 as to a product, a system to deliver these against 10.9 and 3.71 million tonnes innovations based on nanotechnology in the previous year. Among the to a product delivery stage and ensure major fertiliser products, the that these reach the rural stake production of urea was 19.92 million holders at the end of the agri-value tonnes, DAP 2.99 million tonnes during 2008-09. Besides this agricultural productivity enhancement import of N, PO, KO was 3.76,3.07 as the second most critical area of and 3.42 million tonnes, respectively. application for attaining the The consumption of total nutrients millennium development goals while was 25.0 million tonnes in 2008-09 energy conversion and storage was as against 22.57 million tonnes in the ranked first and water treatment as previous year. The consumption of the third area needing focus. Studies N. PO, and K.O was 15.09, 6.51 and in these countries over the past 3.31 million tonnes, respectively durimg 2008-09.

Nutrient Use Efficiency

Depletion of soil nutrients represents deterioration on soil health, even like fertilisers etc. Ratan Lal (4) though this is not visible to the naked narrated that amongst the numerous eye. Weak soils cannot support good application of nanotechnology in soil crops or fulfill agricultural science, use of nano-fertiliser is the production targets set by planners emerging field to study upon. In and policy makers. With India, the importance of research and intensification of agriculture and development in nanotechnology has improvement in productivity levels, been recognized as of paramount the removal of secondary and importance. The Department of micronutrients has gone up manifold Science and

Technology (DST), leading to multiple nutrient Government of India, has launched a deficiencies well beyond the NPK scenario, which in fact are major constraints to achieve higher production. Nitrogen, phosphorous and potash, the three primary nutrients are required in large quantities by plants for sustaining life and their healthy growth. There are definite methods and technologies to increase use efficiency of various sources of nutrients. Efforts have been made to enhance the use efficiency of urea N by prolonging the availability of the applied N to the growing crops either applying N in splits or using urease inhibitors, nitrification inhibitors and slow release modified urea products. Band placement and basal application of phosphate fertilisers are also being practised to increase its use efficiency. Among different secondary nutrients, sulphur deficiency is considered to be most widespread. In some areas, the deficiencies of Mg and Ca are becoming important. With increasing emphasis on intensive productivity systems, demand for micronutrient fertiliser is found to increase. There is need to devise cost effective system to meet the micronutrient needs of crops for sustainable production. With the expected population of 1.4 billion by the year 2025 and minimum calories requirement, the country will need to produce about 300mt of foodgrain and for that 30-35 mt of NPK from various sources would be needed. Thus from all sources, the country will be required to arrange for the supply of about 40-45 mt of nutrients by that time. In this context, there would be greater importance of the information how to increase the nutrient use efficiency of fertilisers by nanotechnology in the coming years.

WHAT IS NANO TECHNOLOGY?

Nanotechnology is defined as the understanding and control of matter at dimension of roughly 1-100 nm, where unique physical properties make novel applications possible (1). The definition of nanotechnology is based on the prefix "nano" which is from the Greek word meaning "dwarf". In more technical terms, the word "nano" means 10%, or one billionth of something. For comparison, a virus is roughly 100 nanometers (nm) in size. The word nanotechnology is generally used when referring to materials with the size of 1 to 100 nanometers; however it is also inherent that these materials should display different properties from bulk (or micrometric and larger) materials as a result of their size. These differences include physical strength, chemical reactivity, electrical conductance, magnetism, and optical effects. Nanotechnology can work from the top down (which means reducing the size of the smallest structures to the nanoscale e.g. photonics applications in nanoelectronics and nanoengineering) or the bottom up (which involves manipulating individual atoms and molecules into nanostructures and more closely resembles chemistry or biology). Nano-particles are considered substances that are less than 100 nm in size in more than one dimension. They can be spherical, tubular, or irregularly shaped and can exit in fused, aggregated or agglomerated forms. Nanotechnology has the potential to revolutionise agriculture sector with new tools. For example, precision farming, with the help of smart sensors, will allow enhanced productivity in agriculture by providing accurate information, thus helping farmers to make better decisions.

Synthesis of Nano-particles/ Nano- electrical conductance, magnetism, fertilisers

There are large numbers of techniques available to synthesize different types of nano-materials in the form of colloids, clusters, powders etc. Nanotechnology is an interdisciplinary subject. There are therefore various physical, chemical, biological and hybrid techniques available to synthesize nano-materials.

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Amongst the methods there are numerous advantages of using chemical methods:
•Variety of sizes and shapes are possible
• Low temperature synthesis(350°C)
• Simple techniques
• Large quantities of the materials can be obtained
• Materials are obtained in the form of liquid but can be converted into dry powder or thin films quiteeasily
• Self assembly or pattering is possible
•Doping of foreign atoms (ions) possible during synthesis Inexpensive, less instrumentation compared to physical methods

Nano-fertiliser

Nano-fertiliser may be defined as the nano particles, which can supply essential nutrients for plant growth, have higher use efficiency and can be delivered in a timely manner to a rhizospheric target or by foliar spray. Currently, productions of slow- release and super sorbent nitrogenous and phosphatic fertilisers are of high demand in the agricultural sector.
Several researchers of different countries have started their investigations to produce highly productive nano-fertilisers to boost agricultural production. A few examples are as follows:
Xiu et al. (7) reported that the natural kaoline and abandoned foam plastics could be used to prepare nano- subnanocomposites through the methods of organic material intercalation, semi emulsification, and cut at high velocity techniques for the preparation of cementing and coating of nanosubcomposites of slow/controlled release fertilisers. Besides, two kinds of nano- subnanocomposites were tested in this study using several instruments, including the scanning electron microscope (SEM), the X-ray diffraction (XRD), the infrared ray spectrum (IR), and the laser granularity. The main results were: 1) the organic material was intercalated in the layers of kaoline clays, and the natural kaoline exfoliated into nanometer sized layers. The organic agent and clays formed nanocomposites through hydrogen bond combination. 2) The SEM pictures of polystyrene starch nano-subnanocomposites showed that many pores and rugas were present on the surface of film at sizes ranging from 10 to 20 nm. These nano-subnanocomposites were used as the cementing and coating materials of slow/controlled release fertilisers.

Nano Hi Technology Fertiliser from Germany

Lithovit is a unique new hi-yield fertiliser-natural limestone super- activated by Nano Hi Technology. It is a new and unique foliar fertiliser that enhances productivity, is safe for the environment and is suitable for yield up to 30% organic farming and for all field crops, grasslands, fodder plants, intensive cultivation, horticulture and forestry. Lithovit is easy to use as a water suspension, is harmless to humans and animals, and is not hazardous to water. Benefits are 1) improved yields, quality and storage properties, 2) accelerated growth and intensified green colouration 3) increased resistance, growth, and pests. vitality. 4) enhanced supply of essential trace elements to plants and 5) reduced water requirements.
Nanoporous zeolites of different sizes are being used for more efficient, slow and thorough release of fertilisers for plants. David Kargbo at Temple University, USA, has given the specific method for production of Nanoporous zeolites. This method involves fabricating zeolites by heating ash

(municipal or fly) in the presence of sodium hydroxide. These zeolites have a nano-scale channel system ranging in size from 0.4 to 1.4 nm and a high surface area.

There are numerous nano-enhanced products and nanobased tools and methods with immediate application to addressing the issues pertaining to low use efficiency of inputs water, fertilisers etc. These include nano- enhanced products such as nano- fertilisers with a nanobased smart delivery system (use of halloysite) to provide nutrients at desired site, time and rate to optimize productivity. Using such nanoscale formulations of agricultural chemicals can enhance the use efficiency of input and minimize losses into the environment.

Nano-Gro Fertiliser

AGRARIUS Ltd. is the exclusive distributor of Nano-Gro. Nano-Gro is a fine grained pellet which offers substantial increases in both crop yield and quality. It is available in four quantity variants depending on requirements, number of Nano- Gro pellets: 2,8,48,100. It increases crop yield up to 30%.

A nano-class composite liquid fertiliser is also produced which contains N, P, K, monose, amino acids, trace elements, soil microbes and water. Its advantages are rich broad-spectrum nutrients, easily assimilated, and high effect on increasing yield of plant and its power to resist against diseases and pests.

Nano-5 Organic Fertiliser

Nano-5 is a natural mucilage organic fertiliser containing the ingredient G- protein. The following three steps will lead to more efficient cultivation. Firstly, dilute Nano-5 in water with a dilution factor of 1:500- 1000 and apply generously saturating the plant and soil over the roots. The optimum effects of Nano-5 occur during the initial two hour period after spraying. Secondly, as it is not easy to kill larger pests over 2 cm in length apply Nano-5 three to four times over a period of 9-12 days with a dilution factor of 1:500-1000 each time saturating the plant and the soilover the roots. This will ensure that the threat from insect, pests and disease can be resolved. Thirdly, after following steps one and two, repeat the spraying of Nano-5 with a dilution factor of 1:1000 once a week during the growing period prior to harvesting. The long-term use of Nano-5 can effectively prevent and control insect pests and plant diseases, whilst increasing the amount of nutrients available to the plants. Plants that have successfully been treated with Nano-5 have higher levels of nutrients, are healthier, and have more rapid growth. Nano-5 raises the survival rates of plants which have suffered from flooding and decreases the impact of global warming. Nano-5 can eliminate the problems associated with continuous cultivation of land; it also shortens the time required from planting to harvesting allowing more harvests per year. This increases farmland productivity and can help reduce the amount of agricultural land under cultivation whilst still satisfying man's needs for increased food production. For optimum effects, Nano-5 is best applied within 6 hrs of dilution, after 8 hrs, particles in Nano- 5 will begin reverting to their pre- treatment condition leaving no residue.

Nano Diatomite and Zeolite Ceramic Crystal Powder

A nano diatomite and zeolite ceramic crystal powder which is a new environmental material made by combining high-quality natural diatomite and zeolite together (weight ratio 5:2) and by using most advanced nano technology, wherein the ceramic crystal powder has the capability of producing great benefits for society through advances in health care, a cleaner environment, and agriculture.

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Benefits

• Crystal powder that retains the porosity for more water retention, about 55% more water retention than other materials.

• Crystal powder, which improves the value and efficiency of fertilisers by its controlled holding and slow release process of nitrogen and phosphorus since the ceramic crystal powder of the present invention can absorb nitrogen and phosphorous in the air and then combining with water to release the nutrients gradually to the plant or grass.

• Crystal powder, which has the ion change capability to remove effluent toxins.

• Crystal powder, which can reduce (2008-09). nutrient loses from leaching and growth so as to increase crop yields.

CONCLUSIONS

The diffusion of high yielding varieties, increased use of fertilisers and increase in irrigated area led to massive agricultural growth in India during the era of Green Revolution. There has been a phenomenal growth in fertiliser consumption during the past four decades. The impact of increased use of fertilisers could be noticed from higher productivity of foodgrains and commercial crops until the last decade. It is also clearly marginal holdings tend to use more fertilisers with a view to maximizing agricultural production from their limited holdings. More than 40 years have passed since the green 5:15-20 (2006) revolution, and now there are signs of fatigueness in agricultural productivity. 8. Yu, Eukki Qi (Misty Li-Ming In the present scenario, Indian Chang). United States Patent And agriculture is passing through a Trademark Office Granted Patent critical phase and there is need for higher and efficient use of fertilisers (2005). to enhance agricultural productivity in future. As the price of fertilisers is shooting up and huge amount of fertilisers are being used by the farmers, one percent increase in fertiliser use efficiency will help to attain substantial economic benefit at the national level. In this context, there would be greater importance of the information how to ince the nutrient use efficiency of fertile by nanotechnology in the coming yo However, much expected ever revolution in agricultural secte India may be achieved droog nanotechnology, provided systematically designed regulat mechanisms involving all the stakeholders are developed.

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