NANO- TECHNOLOGY IN AGRICULTURE AND FOOD SCIENCE

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Introduction:

Nanotechnology has been heralded as a new industrial revolution - as in the 18th and 19[th]centuries, nanotech has the potential to bring about drastic changes in the agricultural industry. The development of new nanotech-based tools and equipment may help to increase efficiency and overcome challenges faced by the agricultural industry.Nano technology is the creation and utilization of materials, devices and systems through the control of properties and structure of matter at the nanometric scale (B.M. Prasanna). The agricultural sector will benefit greatly from nanotech-based tools to detect diseases in a rapid manner, improve the ability of plants to absorb nutrients and promote molecular treatment of diseases.Modern agriculture makes extensive use of chemicals to stimulate growth and inhibit pests and disease. Nanotechnology could help to make these substances simultaneously more effective and less harmful to the environment. Nanotechnology will play a vital role in the development of the agricultural sector, as it is capable of being used in agricultural products that protect plants and monitor plant growth and detect diseases.

1 nanometer =1 billionth (10^{-9}) of ameter (Jones *et al.*)

Nano-materials and Agriculture: (Jason C., 2013**)**

There has been significant interest in using nanotechnology in agriculture

The **goals** fall into several categories

- Increase production rates and yield
- Increase efficiency of resource utilization
- Minimize waste production

Specific **applications** include:

- Nano-fertilizers, Nano-herbicides
- Nano-based treatment of agricultural waste
- Nano-sensors

Nanotechnology and agricultural production developments:

In the near future, nanostructured catalysts will be available which will increase the efficiency of pesticides and herbicides, allowing lower doses to be used. An agricultural system widely used in the USA, Europe and Japan, which efficiently utilizes modern technology for crop management, is called Controlled Environment Agriculture (CEA). CEA is an advanced and intensive form of hydroponically based agriculture. CEA technology provides an excellent platform for the introduction of nanotechnology to agriculture. Nano-technological devices for CEA that provide "scouting" capabilities could tremendously improve the grower's ability to determine the best time to harvest the crop, the vitality of

crop, and food security issues, such as microbial or chemical contamination(Prasad*et al.*, 2014)

Nano-fertilizers for balanced crop nutrition:

In India, fertilizers, alongwith quality seed and irrigation, are mainly responsible for enhanced food grain production 55 mt in 1960s to 254 mt in 2011 coinciding with the spectacular increase in fertilizer consumptions from 0.5 mt to 23 mt, respectively (policy paper, 63 National academy of agricultural sciences, 2013). In order to address issuesof lowfertilizer use efficiency, imbalanced fertilization, multi-nutrient deficiencies and declineof soil organic matter, it is important to evolve a Nano-based fertilizer formulationwith multiple functions.Nano-fertilizer technology is very innovative but scantily reported in the literature.Currently, research is underway to developNano-composites to supply all the required essential nutrients in suitable proportionthrough smart delivery system. Indeed the metabolic assimilation within the plant biomass of the metals, e.g.,micronutrients, applied as Nano-formulations through soil-borne and foliar application.

Nanotechnology in organic farming:

Organic farming has been a long-desired goal to increase productivity with low input through monitoring environmental variables and applying targeted action. Organic farming makes use of computers, GPS systems, and remote sensing devices to measure highly localized environmental conditions, thus determining whether crops are growing at maximum efficiency or precisely identifying the nature and location of problems. By using centralised data to determine soil conditions and plant development, seeding, fertilizer, chemical and water use can be fine-tuned to lower production costs and potentially increase production all benefiting the farmer.

Nanoherbicides:

The easiest way to eliminate weeds is to destroy their seed banks in the soil and prevent them from germinating when weather and soil conditions become favourable for their growth. Being very small, nanoherbicides will be able to blend with the soil, eradicate weeds in an eco-friendly way without leaving any toxic residues, and prevent the growth of weed species that have become resistant to conventional herbicides. Whether the nano application is due to a nanosized active ingredient or the creation of a nanosized formulation through the use of an adjuvant, the use of nano application is same (policy paper, 63 National academy of agricultural sciences, 2013). Improvements in the efficacy of herbicides through the use of nanotechnology could result in more crop production without causing any harmful effects to agricultural workers.

Nano-food industry: (Nano-forum Report)

During the last three years, food industries have witnessed that the nanotechnologyhas been really integrated in a number of food and food packaging products. Thereare now over 300 Nanofood products available on the market worldwide. Today, the Nanotechnology is no longer an empty buzzword, but an indispensablereality in the food industry. The impact of nanotechnology is huge, ranging frombasic food to food processing, from nutrition delivery to intelligent packaging. It isestimated that the nanotechnology and Nano-bio-info convergence will influence over40% of the food industries up to 2015. There is a strong need to develop Nanofoodthrough Nano-engineering of food ingredients. Under this, texture, taste,

flavourandcolor of food ingredients can be modified using nanoengineering without losing theirnutritional value or with improved nutritional quality. Nanotechnology can extend theshelf-life of perishables like fruits, vegetables, and flowers during transportation, thuspreventing the post-harvest losses.

Recent Developments: (Will Soutter, 2012)

With nanotechnology gaining recognition in the agricultural and food sectors, scientists and experts in the scientific field have recently showcased their nanotechnology expertise to farmers. Three significant innovations were demonstrated:

- The scientists have planned to develop a plastic storage bag lined with nanoparticles that are capable of reacting with oxygen and preventing cassava from rotting. In this way, the farmers can prolong the shelf life of cassava and prevent wastage of this vegetable.
- A milk container was designed with a nanopatterned, antimicrobial coating that helps the dairy farmers to preserve milk for a prolonged time period as they take almost a whole day to reach the cooling centers. These nanotechnology-based milk containers replace the currently used plain plastic bags.
- The scientists have also planned to develop nanopatterned paper sensors to detect bovine pregnancy in order to enable the dairy farmers determine if their cows will run dry without milk due to udder infection or pregnancy.

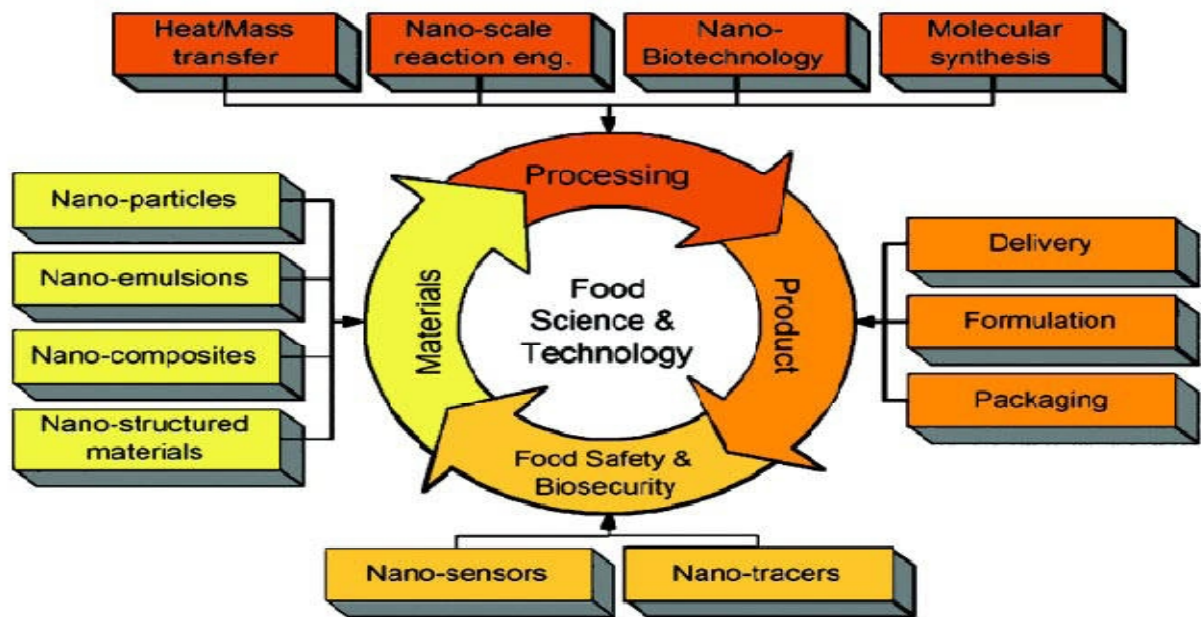**Where is Nano-science in Agriculture and Food Science?**

Image source :Moraru, 2003

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