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Nanotechnology the Future of Modern Agriculture

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Introduction

Agriculture is the backbone of India. More than 60% of the population relies on it for their livelihood. India became self-sufficient Food production during the Green Revolution 1960s. Food safety is always the biggest concern of mankind. Nations, communities and Governments are grappling with the problem for a long time. In particular, this is the main agenda Developing world, including India. Agriculture sector in India contributes significantly to the national economy. Science and Technology has played an important role Increasing agricultural productivity over the years. An extensive agricultural research system with a widespread machinery and government. This policy made the agricultural sector responsive to increasing demand for agricultural products. However, agriculture in recent decades. The scene has seen many challenges like Decline in agricultural profitability, natural decline in resources, recovery of new pests and diseases, Global Warming and Climate Change. There is more pressure on the growing population This sector to meet the growing food demand. To solve these problems, there is a need for Research, technology production and Diffusion along with human resources Development. Traditional Research methods should be complementary New science and technology interventions J Pure App Microbio, March 2015. Cost and time effective. Modern Technologies like bio and nanotechnologies Can play an important role in increasing production and improving the quality of food produced Farmers. Many believe that modern technology As well as securing the growing global food needs Provide environment, health and huge range Financial benefits.

Nanotechnology Science

Nanotechnology is a field of applied science and technology which deals/involves in manipulating atoms and molecules to fabricate materials, devices and systems. The term nano

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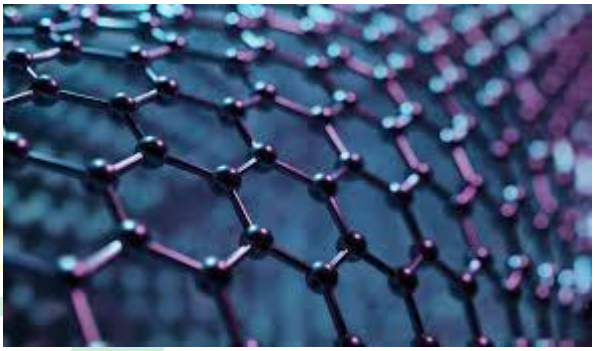
is derived from the Greek word "dwarf". Nanotechnology was first introduced in 1959, in a talk by the nobel prize-winning physicist, entitled "There's Plenty of Room at the Bottom" Richard Feynman proposed using a set of conventional-sized robot arms to construct a replica of themselves, but one-tenth the original size, then using that new set of arms to manufacture an even smaller set, and so on, until the molecular scale is reached. If we had many millions or billions of such molecular-scale arms, we could program them to work together to create macro-scale products built from individual molecules - a "bottom- up manufacturing" technique, as opposed to the usual technique of cutting away material until you have a completed component or product–"top-down manufacturing". In 1986, K. Eric Drexler introduced the term nanotechnology.



Nanotechnology has been provisionally defined as relating to materials, systems and processes which operate at a scale of 100 nanometers (nm) or less. A nanometer is one billionth of a meter or thousandth of a thousandth of a thousandth of a meter. Overall nano refers to a size scale between 1 nanometer (nm) and 100 nm. For comparison, the wavelength of visible light is between 400 nm and 700 nm. A leukocyte has the size of 10000 nm, a bacteria 1000-10000 nm, virus 75-100 nm, protein 5-50 nm, deoxyribonucleic acid (DNA) ~2 nm (width), and an atom ~0.1 nm. In this scale, physical, biological and chemical characteristics of materials are fundamentally different from each other and often unexpected. actions are seen from them. Nanotechnology considers the topics with viruses and other pathogens scale. So has high potential for identifying and eliminating pathogens.

Multidisciplinary and interdisciplinary research at the union of disciplines like life sciences, medicine, physics, chemistry, material sciences and engineering sciences are the cornerstone of nanoscience and technology. Development of products, devices and

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applications would necessitate research across a variety of disciplines that are linked together for the common goal of technology development. Several areas like water purification technology, nutrition and health care technologies, energy, textiles, electronics, advanced manufacturing and advanced materials would necessitate cross disciplinary research in the context of science and technology.

Major challenges of agriculture can be solved by nanotechnology :

- Food security for growing numbers
- Low productivity in cultivable areas
- Lower agricultural input efficiency
- Unsustainable farm management
- Large uncultivable areas
- Shrinkage of cultivable lands
- Wastage of products
- Perishability/ low shelf life
- Post harvest losses (processing,packaging)
- Diseases and vulnerabilities to climate change due to global warming

Nanotechnology developments in India

India, with its more than one billion people, a wide landscape and a diverse socioeconomic base, has tremendous possibilities for any technological intervention including nanotechnology. India has been slow to adopt the technologies and even slower to experiment them. This has happened primarily because the risk taking ability of individuals, organizations and the Governments has been low. Moreover, because of lack of communication to the rest of the world, the level of confidence in the innovations has been low. Nanotechnology in India is a public driven initiative. Industry participation has very recently originated. Nanotechnology research and development barring a few exceptions is largely being ensued at publicly funded universities as well as research institutes.

Scope of Nanotechnology in India

For India, nanotechnology applications in agriculture and the food sector make all the more relevant and important since the Indian economy is predominantly agriculture and given the large population to feed, the food security concern is all the more serious. The Indian agricultural scenario is also characterized by diversity of soils and agro-climatic conditions

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and thus diversity in crops and fluctuation in productivity. This offers as much potential as challenges in the sector

- India's 60% population depends on agriculture, but income levels are low because productivity is low and is marred by low inputs, pests, diseases and losses.
- India has massive food requirements and has a variety of crops, fruits, flowers and vegetables but the food sector is handicapped due to inefficiencies in production, processing, storage and packaging.
- India gets excellent solar radiation, every rooftop can become a powerhouse, but solar energy is not generated because right and affordable technology is not in place.
- India gets excellent rains but still drinking and irrigation water is not available in many parts because water storage and purification techniques are not perfect.
- India is urbanizing fast but still faster is the level of pollution because of urban waste, untreated water etc.
- Most of the processing and packaging in industry and agriculture leaves behind a trail of environmental hazards, which if not tackled at this juncture, will lead and add to long term ecological problems including global warming.

Government agencies

Department of Science and Technology, the nodal department for organising, coordinating and promoting science and technology activities in India is the chief agency engaged in the development of nanoscience and nanotechnology. It is at the helm of the principal program, the Nanoscience and Technology Mission (NSTM) established to develop India as a key player in nanoscience and technology. While it will steer this initiative between the years 2007-2012 it also hosted the flagship program, the Nanoscience and Technology Initiative (NSTI) that was pioneered in 2001 until 2006.

Nanoscience and Technology Initiative (NSTI) Initiated in 2001, the NSTI has served as the primary vehicle for India engagement with nanoscience and technology. The NSTI took root when the Government of India identified the need to initiate a program that focused on nanoscience and technology in the 10th Five Year Plan. A panel on nanotechnology was established under the guidance of Prof. C N R Rao, and these helped crystallize the Nanoscience and Technology Initiative (NSTI). The focus areas of the NSTI were to Support R and D projects in nanoscience and technology through establishing Centers of Excellence

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and strengthen characterization facilities, develop human resources, Instigate and encourage international collaborative programs and Initiate joint Institution Industry Linked projects and Public Private Partnership activities.

Nanoscience and Technology Mission (NSTM)

The NSTM commenced in 2007 and is planned until 2012. The Nano Mission Council that is presently chaired by Prof. C.N.R. Rao (National Research Professor and Honorary President and Linus Pauling Research Professor, Jawaharlal Nehru Centre for Advanced Research, Bangalore) guides the NSTM. DST was assigned as the nodal agency for its implementation. The mission seeks to strengthen national capacity, leverage the progress made during the tenure of the NSTI and forge ahead in making India a globally strong player in this emerging field. The aim is to expand the national support base in terms of research and technology development, infrastructure, human resource development, collaborations and public-private partnerships.

The mission together with setting its sights on building capability in nanotechnology has also articulated the aim of harnessing this technology's potential for national development. The focus area and objectives of the NSTM include Promotion of basic research development of Infrastructure for nanoscience and technology research and promote Nano applications and technology development programs. Nanotechnology has many applications in all stages of production, processing, storing, packaging and transport of agricultural products. The use of nanotechnology in agriculture and forestry will likely have environmental benefits. Agriculture is an area where new technologies are often applied to improve the yield of crops. Nano Agriculture involves the employment of Nano-particles in agriculture. These particles will impart some beneficial effects to crops.

Agricultural Production - Precision farming

Nanotechnology application here makes farming more targeted and scientific. Precision farming makes use of computers, global satellite positioning systems, and remote sensing devices to measure various parameters. Accurate information through applications of Nanotechnology for real time monitoring of soil conditions, environmental changes and diseases and plant health issues.

Precision agriculture means that there is a system controller for each growth factor such as nutrition, light, temperature, etc. Available information for planting and harvest time

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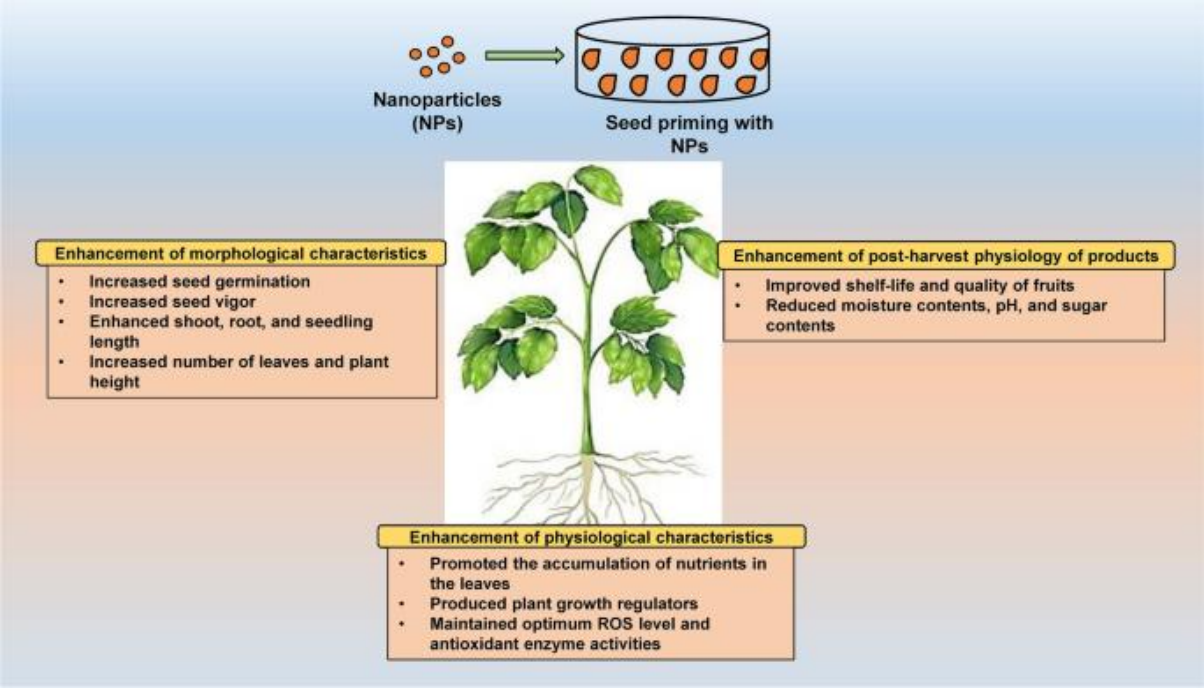
are controlled by satellite systems. This system allows the farmer to know when is the best time for planting and harvesting to avoid encountering bad weather conditions. Best time to achieve the highest yield, best use of fertilizers, irrigation, lighting and temperature are all controlled by these systems. An important nanotechnology role is the use of sensitive nuclear links in GPS systems controllers. This includes the fine-tuning and more precise micromanagement of soils; the more efficient and targeted use of inputs; new toxin formulations for pest control; new crop and animal traits; and the diversification and differentiation of farming practices and products within the context of large-scale and highly uniform systems of production.

Recent advances in materials science and chemistry have produced mastery in nanoparticle technology, with wide ramifications in the field of agriculture. One area in particular is that of the cotton industry where current techniques of spinning cotton are quite wasteful. From harvesting the cotton to finalizing the fabric it's made into, over 25% of the cotton fiber is lost to scrap or waste.



However, Margaret Frey, an assistant professor of textile science at Cornell University, has developed a technique called electro spinning that makes good use of the scrap material that would otherwise be used to make low-value products like cotton balls, yarn, and cotton batting.

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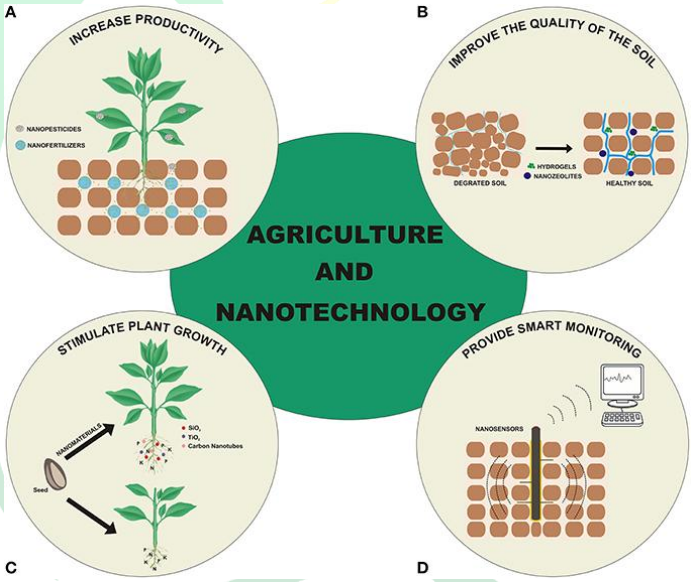
Nanotechnology and water safety in India

Nanoscience applications in water management assume a special importance for a vast developing region like India. Given the diverse geographical conditions, different regions face a range of water problems varying in terms of magnitude. Problems of safe and potable water prevail like other developing regions of the world, more so in the arid and semi arid regions. The prevalence of waterborne diseases is also quite high. Improving the quantum of supply of water as well as its quality, at an affordable cost, is what a common Indian would expect the most from the researchers and experts engaged in exploring strategic applications of nanoscience. This one area can change the socio economic scenario substantially.



Challenges in the water sector in India: Water availability has been a problem as a result of rising population, rapid urbanization, growing industrialization and expanding agriculture. Water treatment and remediation has been cited as the third most critical area where nanotechnology applications might aid developing countries. Some of the interventions includes Nanomembranes for water purification, desalination, and detoxification, Nanosensors for the detection of contaminants and pathogens, nanoporous zeolites, nanoporous polymers, and attapulgite clays for water purification, magnetic nanoparticles for water treatment and remediation and TiO2 nanoparticles for the catalytic degradation of water pollutants.

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Nanotechnology interventions might be sought at specific junctures to alleviate the following challenges. Improve quantity and quality of water and wastewater treatment systems: The water treatment systems need to address the removal of contaminants present in the surface and groundwater in order to provide potable drinking water. Many technologies exist such as candle filters, biosand filters, activated carbon, UV and chemical based systems. These have been found suitable for contaminant removal from water; however, the performance can be improved and systems made more efficient by use of nanotechnology. Nano-enabled water treatment techniques incorporating carbon nanotubes, nanoporous ceramics, and magnetic nanoparticles can be used to remove impurities from drink-ing water and could potentially remove bacteria, viruses, water-borne pathogens, lead, uranium, and arsenic, among other contaminants. Magnetic nanoparticles could be used to filter water at the point of use to remove nanocrystals and arsenic. Nanoparticle filters can be used to remove organic particles and pesticides from water.

Nanotechnology for crop biotechnology

Nanocapsules can facilitate successful incursion of herbicides through cuticles and tissues, allowing slow and regular discharge of the active substances. This can act as 'magic bullets', containing herbicides, chemical origins which target exacting plant parts to liberate their substance (Pérez-deLuque and Rubiales, 2009). Torney et al. (2007) exploited a 3 nm meso porous silica nanoparticle in delivering DNA and chemicals into isolated plant cells.

Meso porous silica nanoparticles are chemically coated and act as containers for the genes delivered into the plants; they trigger the plant to take the particles through the cell walls, where the genes are put in and activated in a clear-cut and controlled way, without any

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toxic side effects. This technique firstly has been applied to establish DNA fruitfully to tobacco and corn plants.

Nanotechnology in Seed Science

Seed is the most important input determining productivity of any crop. Conventionally, seeds are tested for germination and distributed to farmers for sowing. In spite of the fact that seed testing is done in well-equipped laboratories, it is hardly reproduced in the field due to the inadequate moisture under rain fed conditions. In India, more than 60% of the net area sown is rain fed; hence, it is quite appropriate to develop technologies for rain fed agriculture.

A group of research workers is currently working on metal oxide nano-particles and carbon nanotubes to improve the germination of rain fed crops. Khodakovskaya et al. (2009) have reported the use of carbon nanotubes for improving the germination of tomato seeds through better permeation of moisture. Their data show that carbon nanotubes (CNTs) serve as new pores for water permeation by penetrating seed coats and act as a passage to channelize the water from the substrate into the seeds. These processes facilitate germination which can be exploited in rain fed agricultural systems.

Nano-fertilizers for balanced crop nutrition

In order to address issues of low fertilizer use efficiency, imbalanced fertilization, multi-nutrient deficiencies and decline of soil organic matter, it is important to evolve a nanobased fertilizer formulation with multiple functions. Nanofertilizer technology is very innovative but scantily reported in the literature. However, some of the reports and patents strongly suggest that there is a vast scope for the formulation of nano-fertilizers. Significant increase in yields has been observed with the foliar application of nanoparticles as fertilizer (Tarafdar, 2012; Tarafdar et al. 2012

Currently, research is underway to develop nano-composites to supply all the required essential nutrients in suitable proportions through smart delivery systems. Preliminary results suggest that balanced fertilization may be achieved through nanotechnology (Tarafdar et al. 2012.). Indeed the metabolic assimilation within the plant biomass of the metals, e.g., micronutrients, applied as nano-formulations through soil-borne and foliar application or otherwise needs to be ascertained.

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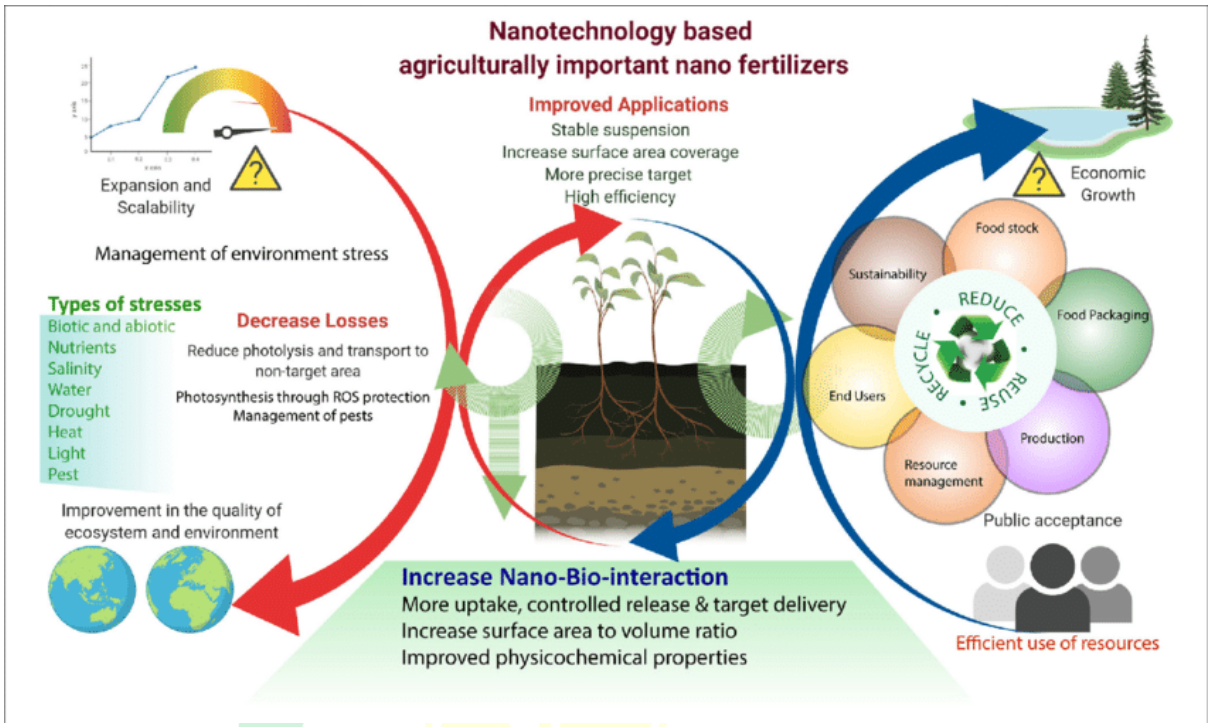

Further, the nano-composites being contemplated to supply all the nutrients in right proportions through the "Smart" delivery systems also need to be examined closely. Currently, the nitrogen use efficiency is low due to the loss of 50-70% of the nitrogen supplied in conventional fertilizers. New nutrient delivery systems that exploit the porous nano scale parts of plants could reduce nitrogen loss by increasing plant uptake. Fertilizers encapsulated in nanoparticles will increase the uptake of nutrients (Tarafdar et al. 2012). In the next generation of nano fertilizers, the release of the nutrients can be triggered by an environmental condition or simply released at desired specific time.

Nano-herbicide for effective weed control

Weeds are menace in agriculture. Since two-third of Indian agriculture is rainfed farming where usage of herbicide is very limited, weeds have the potential to jeopardize the total harvest in the delicate agro-ecosystems. Herbicides available in the market are designed to control or kill the above ground part of the weed plants. None of the herbicides inhibits activity of viable belowground plant parts like rhizomes or tubers, which act as a source for new weeds in the ensuing season.

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Soils infested with weeds and weed seeds are likely to produce lower yields than soils where weeds are controlled. Improvements in the efficacy of herbicides through the use of nanotechnology could result in greater production of crops. The encapsulated nano-herbicides are relevant, keeping in view the need to design and produce a nano-herbicide that is protected under natural environment and acts only when there is a spell of rainfall, which truly mimics the rainfed system. Developing a target specific herbicide molecule encapsulated with nanoparticles is aimed for a specific receptor in the roots of target weeds, which enter into the root system and Trans located to parts that inhibit glycolysis of food reserve in the root system. This will make the specific weed plant starve for food and get killed (Chinnamuthu and Kokiladevi, 2007). Adjuvant herbicide applications are currently available that claim to include Nanomaterial. One nano surfactant based on soybean micelles has been reported to make glyphosate resistant crops susceptible to glyphosate when it is applied with the 'nanotechnology-derived surfactant'.

Nano-pesticide

Persistence of pesticides in the initial stage of crop growth helps in bringing down the pest population below the economic threshold level and to have effective control for a longer period. Hence, the use of active ingredients in the applied surface remains one of the most cost-effective and versatile means of controlling insect pests. In order to protect the active ingredient from the adverse environmental conditions and to promote persistence, a nanotechnology approach, namely "nano encapsulation" can be used to improve the insecticidal value. Nan encapsulation comprises nano-sized particles of the active ingredients being sealed by a thin-walled sac or shell (protective coating). Recently, several research papers have been published on the encapsulation of insecticides. Nano-encapsulation of insecticides, fungicides or Nematicides will help in producing a formulation which offers

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effective control of pests while preventing accumulation of residues in soil. In order to protect the active ingredient from degradation and to increase persistence, a nanotechnology approach of "controlled release of the active ingredient" may be used to improve effectiveness of the formulation that may greatly decrease the amount of pesticide input and associated environmental hazards. Nano-pesticides will reduce the rate of application because the quantity of product actually being effective is at least 10-15 times smaller than that applied with classical formulations, hence a much smaller than the normal amount could be required to have much better and prolonged management. Several pesticide manufacturers are developing pesticides encapsulated in nanoparticles. These pesticides may be time released or released upon the occurrence of an environmental trigger (for example, temperature and humidity, light). Nano-based viral diagnostics, including multiplexed diagnostics kits development, have taken momentum in order to detect the exact strain of virus and the stage of application of some therapeutic to stop the disease. Detection and utilization of biomarkers, that accurately indicate disease stages, is also an emerging area of research in bio-Nanotechnology. Measuring differential protein production in both healthy and diseased states leads to the identification of the development of several proteins during the infection cycle. Clay nanotubes have been developed as carriers of pesticides at low cost, for extended release and better contact with plants, and they will reduce the amount of pesticides by 70-80%, thereby reducing the cost of pesticide with minimum impact on water streams.

Nanotechnology in organic farming

Organic farming has been a long-desired goal to increase productivity (that is, crop yields) with low input (that is, fertilizers, pesticides, herbicides among others) 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 centralized 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. Precision farming can also help to reduce agricultural waste and thus keep environmental pollution to a minimum.

Nanoparticles and Recycling Agricultural Waste

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Nanotechnology is also applied to prevent waste in agriculture, particularly in the cotton industry. When cotton is processed into fabric or garment, some of the cellulose or the fibres are discarded as waste or used for low-value products such as cotton balls, yarns and cotton batting. With the use of newly-developed solvents and a technique called electro spinning, scientists produce 100 nanometre-diameter fibres that can be used as a fertilizer or pesticide absorbent. **Conclusion**

Nanotechnology can help enhance agricultural productivity, a Greater use of agricultural inputs, in a sustainable manner Effective, and minimizing harmful by-products of the environment or human health. Nanotechnology Applications in primary agriculture, value addition, Saving crops and food can be brought about A sea change in India's agricultural scenario

Nanotechnology plays a vital role in development. The agricultural sector is capable of using Agricultural products that protect plants and monitor the plant Detection of growth and diseases. Scientists and researchers should Work to minimize the potential risks associated with it Technology. Control of proper authorities and measures To increase popularity and implement Acceptance of technology among common people.

Thus, applications of nanotechnology Agriculture can prove to be a big boon. In the field There are many more opportunities in agriculture Explore and reap great potential in the future. There is an urgent need for products and methods For an open discussion on nanotechnology Agriculture and Food. Currently there are manyA dozen food and beverage products Nanotechnology in the market according to them producers or experts. Governments and food Companies in many countries are investing Hundreds of projects developing nanotechnology In Food and Agriculture. Nanotechnology can be applied in all aspects of the food chain Improving food safety and quality control and Novel food ingredients or additives, such as leading to unexpected health hazards.