Application of Nanotechnology

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- **Nanotechnology and agricultural production developments**
- **Nanosensors for monitoring soil conditions and plant growth hormone**
- ***Nanotechnology delivery systems for nutrients and plant hormones***

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OVERVIEW OF NANOTECHNOLOGY APPLICATIONS IN AGRICULTURE

- **Nanobiosensors**
- **Nanotechnology in irrigation water filtration**
- **Magnetic nanoparticles for filtration**
- **Detoxification or remediation of harmful pollutants**
- **Nanocapsules for efficient delivery of pesticides, fertilizers and other agrochemicals**
- **Nano based smart drug-delivery systems**

- **Zeolites for water retention**
- **Nanocoatings and nanofeed additives**
- **Nanoherbicides**
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- **Nanoparticles and plant disease control**
- **Nanoparticles as pesticides**

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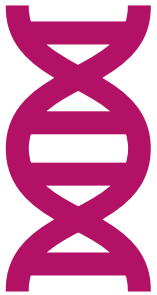
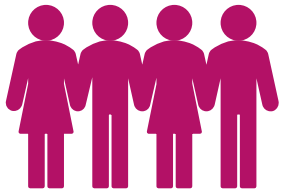
BENEFITS OF NANOTECHNOLOGY APPLICATIONS



Nanotechnology for crop biotechnology



Nanotechnology and societal stigma

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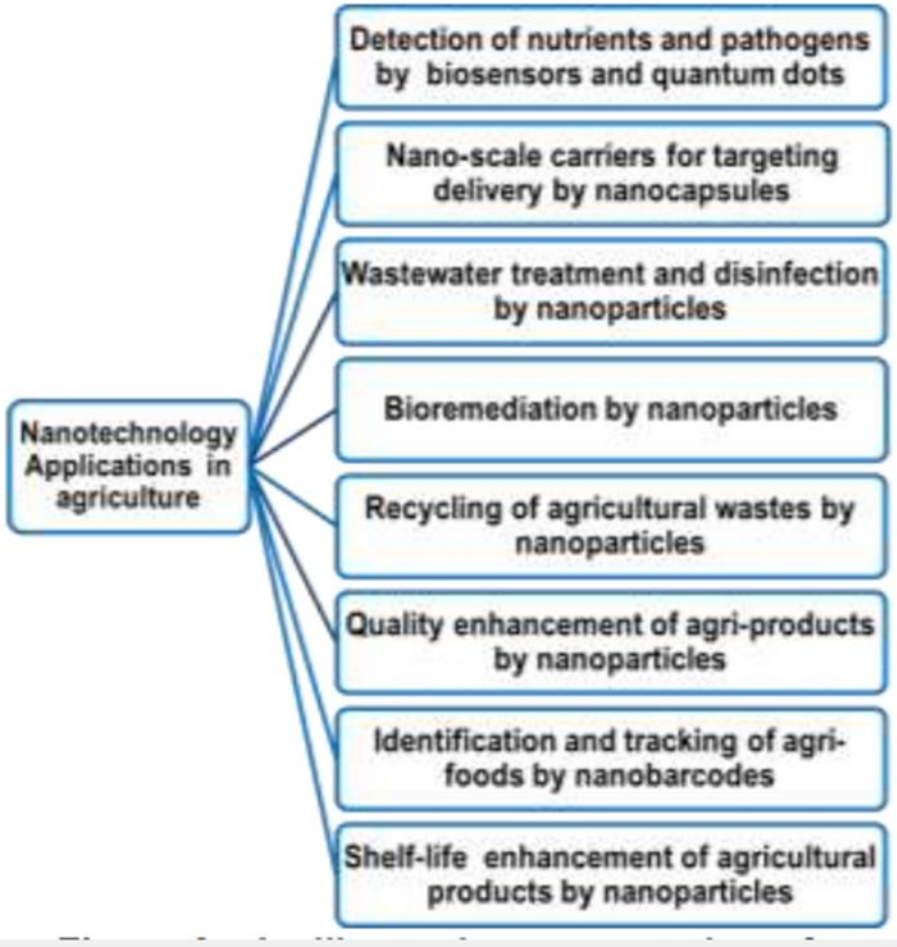
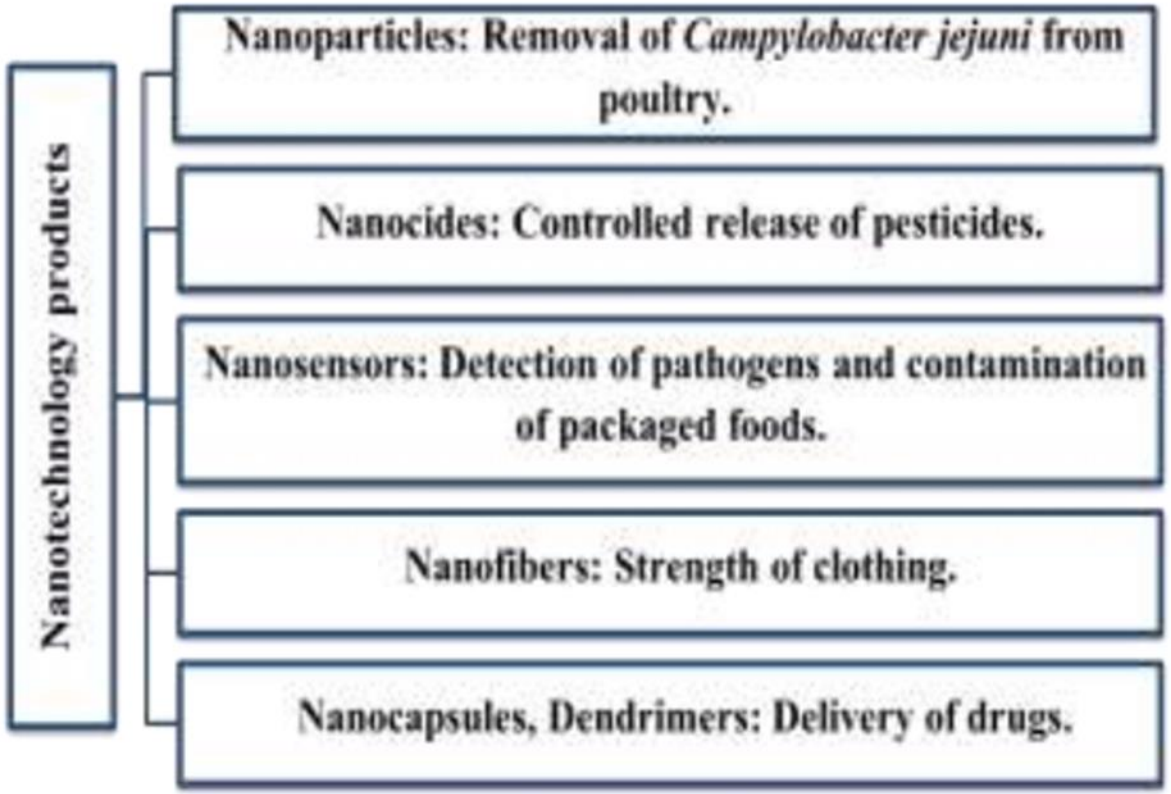
An illustrative presentation of various applications of nanotechnology in agri-food sector.





The main applications of nanotechnology in agriculture are listed below:

i. Determination of enzyme-substrate (E-S) interactions (by detection of single molecule).
ii. For more efficient delivery of fertilizers, pesticides, vaccines, growth regulatory hormones and other chemicals using nanocapsules or nanotubes.
iii. In genetic engineering of plants, delivery of desired DNA into the plants using nanoparticles.
iv. Delivery of vaccines into plants using nanocapsules.
v. The use of nanosensors for the detection of the plant pathogens, monitoring the soil conditions and plant growth, etc.

Top ten applications of nanotechnologies in the developing countries

Rank	Applications	Examples
1	Energy storage, production and conversion	CNT storage of H
2	Agricultural productivity enhancement	Herbicide delivery
3	Water treatment & remediation	Nano-membranes
4	Disease diagnosis & screening	Lab-on-Chip
5	Drug delivery systems	Nano-capsules
6	Food processing & storage	Coating/packaging
7	Air pollution & remediation	Nano-catalysts
8	Construction	Durability
9	Health monitoring	Sensors
10	Vector & pest detection/control	Sensors and pesticides

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Nanotechnology applications in agriculture and food production

In agriculture

- **Nano-Agriculture**
- **Controlled environment agriculture (CEA)**
- **Precision farming**
- **Encapsulating control**

In food production

- **Post harvest food processing**
- **Food packaging**

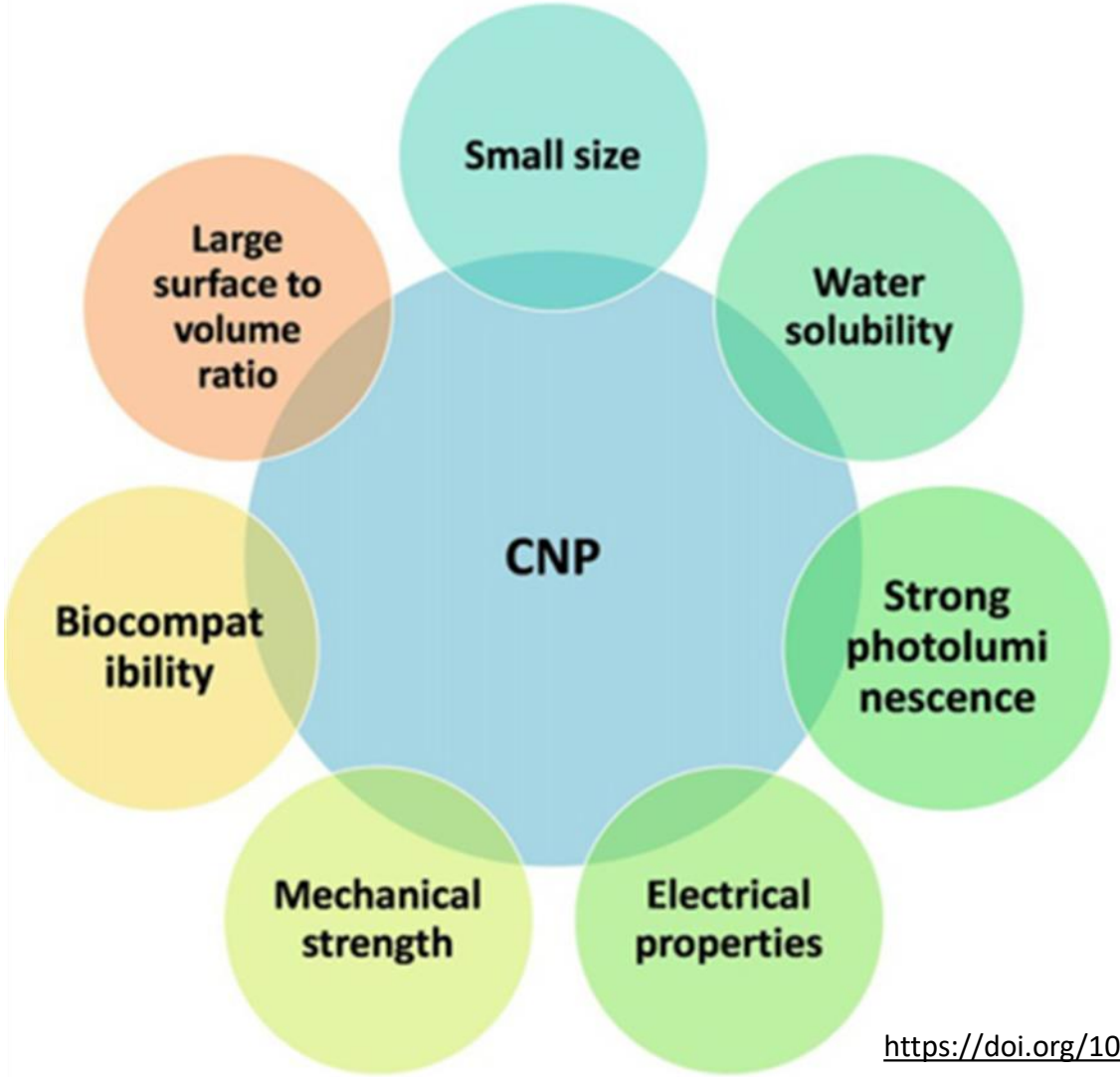
Table 1. Applications of nanotechnology in agriculture

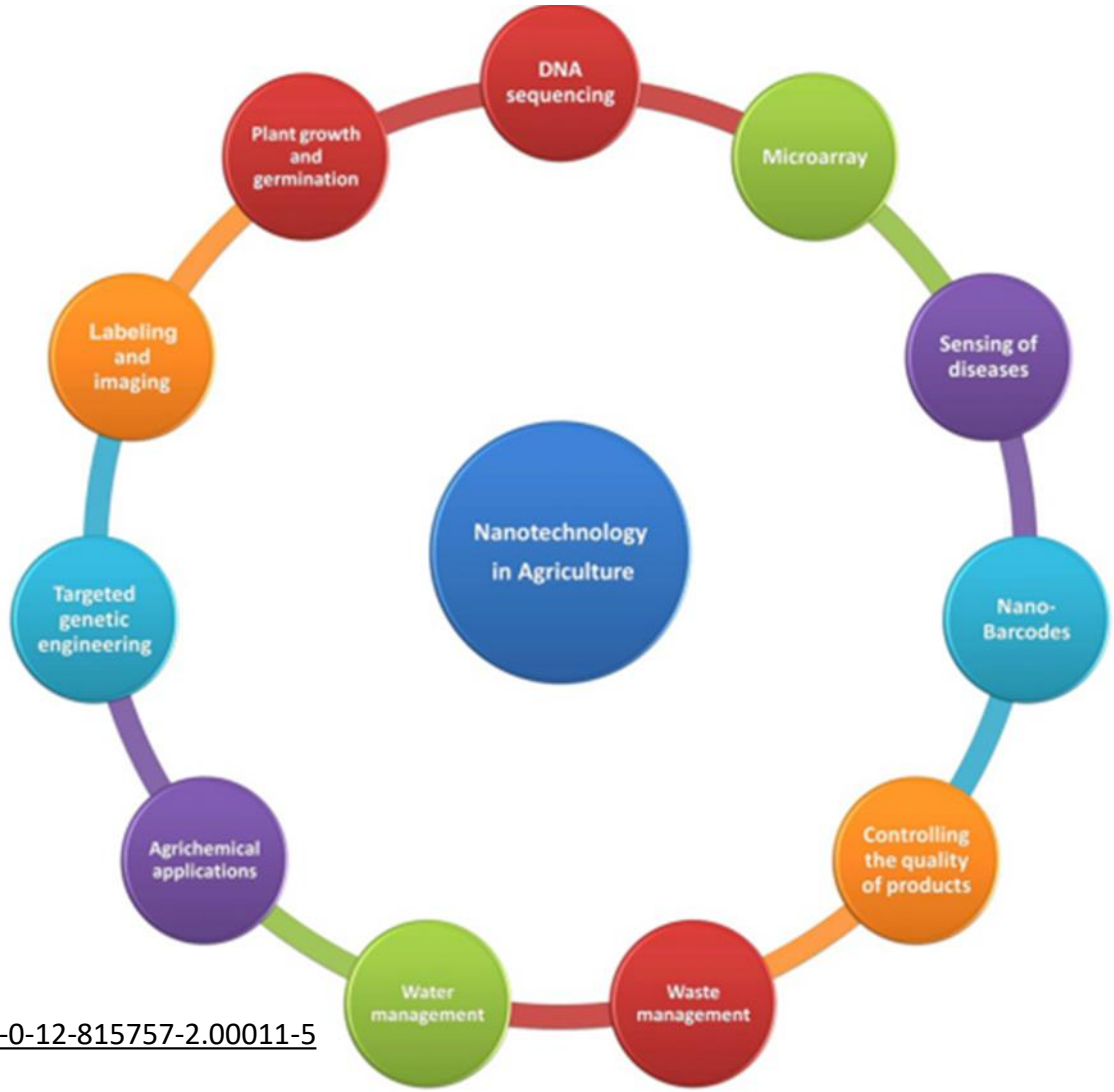
Application	Nano particles	Reference
A). Pesticide delivery		
Chemical		
Avermectin	Porous hollow silica(15 nm)	Li *et al.*, 2007
Ethiprole or phenylpyrazole	Poly-caprola ctone(135 nm)	Boehm *et al.*, 2003
Gamma cyhalothrin	Solid lipid (300 nm)	Frederiksen *et al.*, 2003
Tebucanazole/chlorothalonil	Polyvi nylpyridine andpolyvinylp yridine-co-styrene(100 nm)	Liu *et al.*, 2001
Biopesticides		
Plant origin: nanosilica for insectcontrol Artemisia arborescens	Nanosilic a (3-5 nm)	Barik *et al.*, 2008
Essential oil encapsulation	Solid lipid (200-294 nm)	Lai *et al.*, 2006
Microganisms: Lagenidiumgiganteum cells in emulsion	Silica (7-14 nm)	Vandergheynst *et al.*, 2007
Microbial product: absorption of Myrothrecium verrucaria enzyme	Chitos an/kaolin (250-350 nm)	Ghormade *et al.*, 2011
B). Fertilizer delivery		
NPK controlled delivery	Nano-coating of sulfur (100 nm layer) Chitos an (78 nm)	Wilson *et al.*, 2008, Corradini *et al.*, 2010
Genetic materia l deliveryDNA	Gold (10-15 nm) Gold (5-25 nm) Starch (50-100 nm)	Torney *et al.*, 2007, Vijayakumar *et al.*,2010, Liu *et al.*, 2008,
Double stranded RNA	hitosan (100-200 nm)	Zhang *et al.*, 2010
C). Pesticide sensor		
Carbofuran /triazophos	Gold (40 nm)	Guo *et al.*, 2009
DDT	Gold (30 nm)	Lisa *et al.*, 2009
Dimethoate	Iron oxide (30 nm),zirconium oxide (31.5 nm)	Gan *et al.*, 2010
Organophosphate	Zirconium oxide (50 nm)	Wang *et al.*, 2009
Paraoxon	Silica (100-500 nm) Carbon nanotubes	Ramanathan *et al.*, 2009, Joshi *et al.*, 2005
Pyrethroid	Iron oxide (22 nm)	Kaushik *et al.*, 2009
Pesticide degradation Lindane	Iron sulûde (200 nm)	Paknikar *et al.*, 2005
Imidacloprid	Titanium oxide (30 nm)	Guan *et al.*, 2008

Table 2. Comparison of nanotechnologybased formulations and conventional fertilizers applications (Cui *et al.*, 2010)

Properties	Nano-fertilizers-enabled technologies	Conventional technology
Solubility and dispersion of mineral micronutrients	Nano-sized formulation of mineral micronutrients may improve solubility and dispersion of insoluble nutrients in soil, reduce soil absorptionand fixation, and increase the bioavailability	Less bioavailability to plants due to large particle size and less solubility
Nutrient uptake efficiency	Nano structured formulation might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer	Bulk composite is not available for roots resource and decrease efficiency
Controlled release modes	Both release rate and release pattern of nutrients for watersoluble fertilizers might be precisely controlled through encapsulation in envelope forms ofsemipermeable membranes coated by resin-polymer, waxes, and sulfur	Excess release of fertilizers may produce toxicity and destroy ecological balance of soil
Effective duration of nutrientrelease	Nanostructured formulation can extend effective duration of nutrient supply of fertilizers into soil	Used by the plants at the time of delivery, the rest is converted into insoluble salts in the soil
Loss rate of fertilizer nutrients	Nanostructured formulation can reduce loss rate of fertilizer nutrients into soil by leaching and/or leaking	High loss rate by leaching, rain off, and drift

Applications of Nanotechnology and Carbon Nanoparticles in Agriculture





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Chapter 11 you need to read it carefully, I will add the chapter with the PowerPoint.

Nanotechnology Applications in Agriculture, Industry, and Medicine

- **Synthesis and Applications of Nanofungicides:**
- **Enzymes and Nanoparticles Produced by Microorganisms and Their Applications in Biotechnology**
- **Biological Nanoparticles: Optical and Photothermal Properties**
- **Biogenic Synthesis of Silver Nanoparticles and Their Applications in Medicine**

You will find more details regarding slide in the following link: DOI 10.1007/978-3-319-68424-6

Download the book and read it carefully


Thank you