Nanotechnology A new key for Agricultural sector development

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Introduction

The agricultural sector is facing different challenges, like climate change, global warming and greenhouse gas emission.

In the last decades, there is increasing demand for worldwide food production has been observed, also, an increasing request for biofuel crops, due to increasing world population which expected to reach 9.6 billion by the year 2050 .

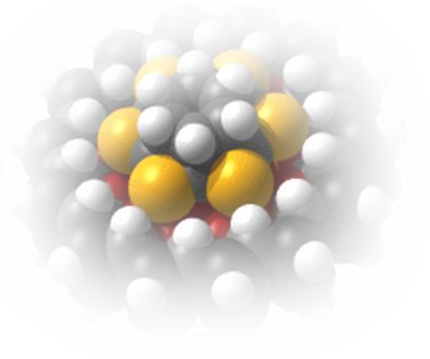
For that, global grain production requirements to feed this world population must increase by 70% approximately.

Nanotechnology is emerging out as the sixth revolutionary technology of 21st century

Nano technology have the capability to preserve soil and water by improving crop yield through the application of the same or fewer inputs, eventually saving the environment.

Why Nano Materials ?

Nano materials has unique properties like:



- Small size.
- High surface area to volume ratio.
- High movement in plant tissues and environment.
- Considerably advanced hardness, breaking strength at low temperatures and great plasticity at high temperatures.

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Nanotechnology and agriculture development

There has been significant concern in using nanotechnology in agricultural sector and the food system for it's great potential as it can improving the quality of different products.

Nanotechnology is the key to increasing agricultural production through increasing efficient nutrient system, enhance plant protection practices, effective photo capturing system in plants, accuracy agriculture,

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Applications of Nanotechnology in Agriculture

Interested on agricultural applications of nanotechnology have a risen for improved efficiency and productivity.

Direct applications of nanotechnology in plant-based agricultural production and products mainly include delivery of agrochemicals and pesticides, study of plant disease mechanisms and genomes improvement.

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Nanomaterial and agricultural applications

Nanomaterials used in the agricultural sector should play the following roles:

1. Providing effective concentration and controlled release of nutrient elements or plant protection in response to certain stimuli.
2. Enhanced targeted activity.
3. and less Eco toxicity with safe and easy delivery.

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- This advantages get up from the unique functional properties of nanomaterials, which have a much larger surface to mass ratio compared to bulk materials.

- Nanotechnology offers considerable prospects for the development of advanced products and applications in agricultural sector.

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Nano materials Forms in Agricultural sector

- Prefer used Lower concentration (5 ppm or less) for spray nanoparticles to plants and microorganisms, this concentration can absorb and penetrate better through plants,
- also, Nanoparticle size 20 nm or less could be better to apply.
- Nanotube consider the best shape for more penetration both in plants and microorganisms.

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i. Nano Fertilizers.
ii. Nano pesticides.
iii. Bio synthesized nanoparticles for agricultural.
iv. Feed additives.
v. Plant growth regulators.
vi. Veterinary medicines.
vii. Bio sensors for Aqua culture.

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The Progressive effect of nanomaterials

(1) Higher solubility of nanoparticles (NPs) in suspension.

(2) The higher surface area and particle size of the nanoparticles (NPs), which facilitates penetration of seed coats and subsequently emerging roots.

(3) and the greater bioavailability of molecules to the seed radicals (Dehner *et al*. 2010).

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Nanotechnology Delivery Systems

- Nanosensors and nano-based smart delivery systems could help in the efficient use of agricultural resources like water, nutrients and chemicals through accuracy farming.

- Spread Nanosensors in the farm can notice the presence of plant viruses and the level of soil nutrients.

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- Nano particles may enter plant leaves through stomata and the cuticle structures.

- Nano encapsulated slow release fertilizers have also become a trend to save fertilizer consumption and to minimize environmental pollution.


Nano Particle

Some applications of Nanotechnology in Agriculture

Direct applications of nanotechnology in agricultural sector mainly include delivery of agrochemicals and pesticides.

Nanotechnology-based products like nano-fertilizers, detection of nutrient deficiencies, nano-pesticides, nano-herbicides, nano-scale carriers, nanosensors, veterinary care, fisheries and aquaculture.

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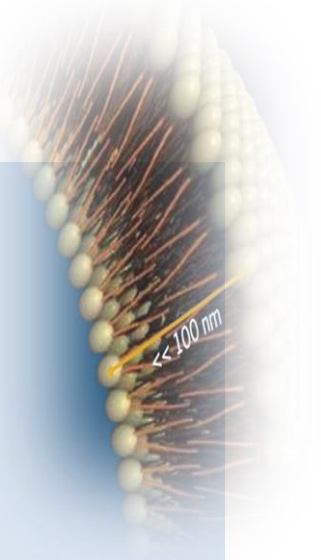
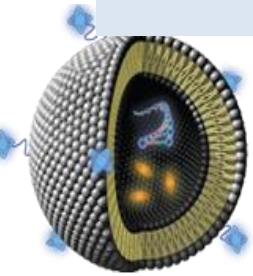


- Crop improvement
- Increase efficient fertilizers and pesticides
- Soil management.
- Plant disease detection.
- Water management
- Analysis of gene expression and Regulation
- Post-Harvest Technology.



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NANO FERTILIZERS

1. Crop improvement

Nanotechnology applications opens a great possibility in the fields of plant nutrition to meet the upcoming request of the growing population,

The nanotechnology applications have the potential to change crop production by allowing better management and conservation of inputs of different agricultural productio

From other side, nanotechnologies offer many opportunities for innovation, the use of nanomaterial in agricultural sector has also raised a number of safeties, environmental and regulatory issues.

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Uptake of nanoparticles in plant systems

Nanoparticles are adsorbed to plant surfaces and passing through natural plant openings.

Nanoparticle absorbed by different paths, there are Numerous pathways occur for nanoparticle association and uptake in plants

Uptake rates depending on the size and properties of the nanoparticles.

Smallest nanoparticles can be passing through cuticle, meanwhile, the larger nanoparticles can penetrate through cuticle-free areas. Nanoparticles must cross the cell wall before entering the intact plant cell protoplast.

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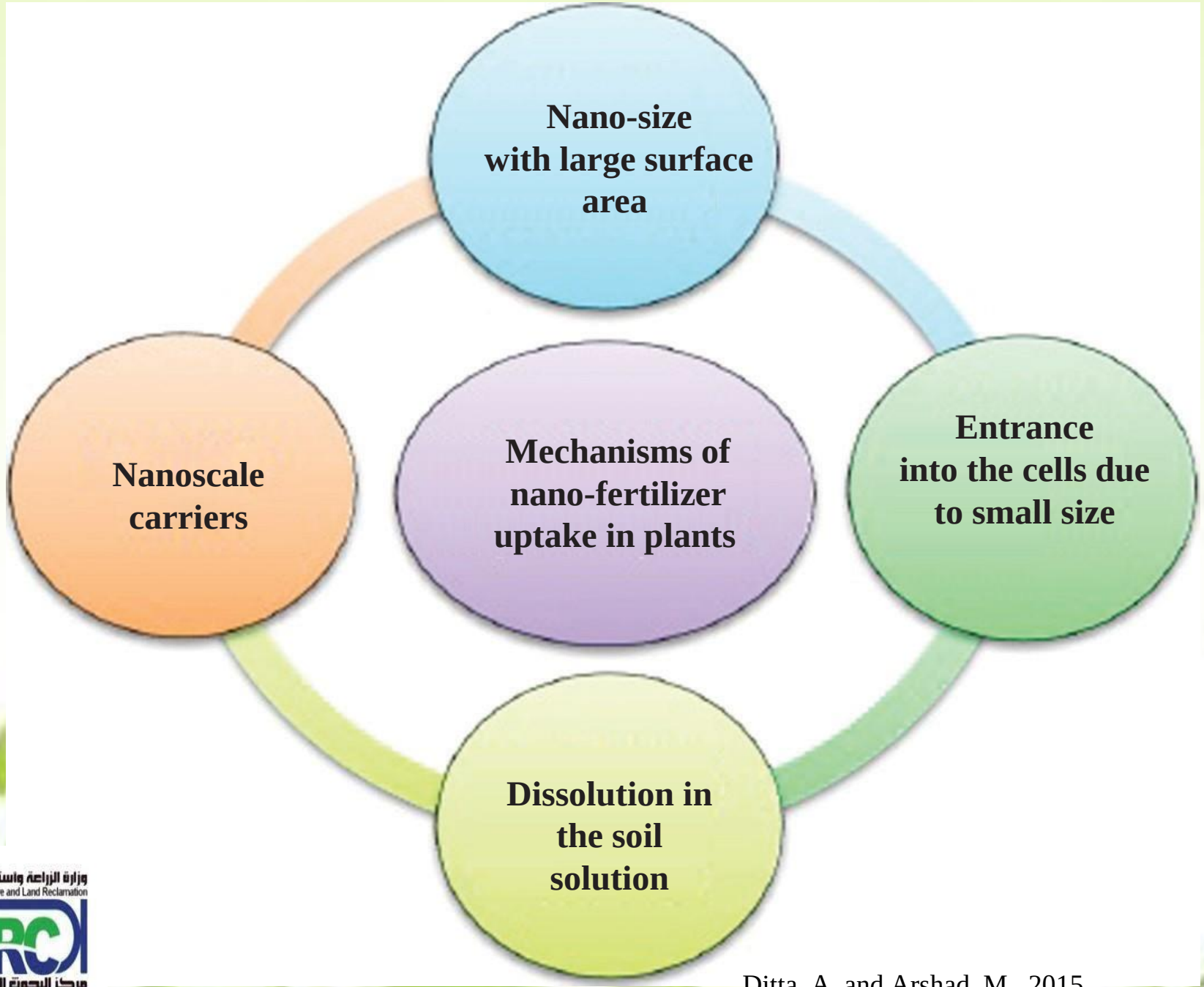

Ditta, A. and Arshad, M. 2015

Why we had to use Nano-nutrients?

The usage of nano nutrients could proposal advantages like:

- Nano-nutrients are extra useful compared to traditional chemical nutrients.
- Enhancement nutrient use efficiency. (Abobatta 2016).
- 80-100 times less requirement to chemical nutrients.
- Decrease 10 times more crop stress.
- Increas effective platform for crop disease suppression.

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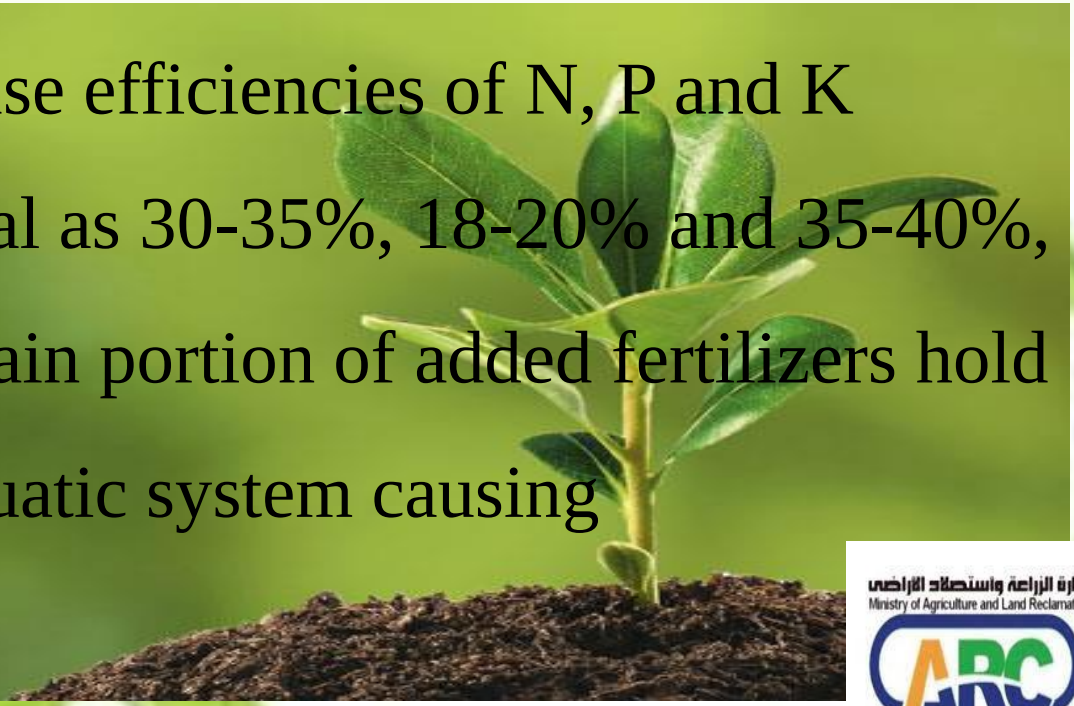
- Increase and development in the crop yield through more targeted.
- Also, Nano nutrients decrease Eco- toxicity.

Nano-nutrients for stable plant nutrition

In agriculture nutrients are used for enhanced production, due to soil stream in different nutrients, for that fertilizers recompense this defects in macro and micro nutrients.

In the last few decades, use efficiencies of N, P and K fertilizers stayed continual as 30-35%, 18-20% and 35-40%, respectively, leaving a main portion of added fertilizers hold in the soil or arrive to aquatic system causing eutrophication.



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Currently, research is underway to develop nano-composite to supply all the required essential nutrients in suitable quantity through smart delivery system.

The influence of nano-fertilizer products on physiological, biochemical, nutritional and morphological changes in plants and the fate of nano-products in soil and plant systems have to be studied.

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Challenges for new-generation foliar fertilizers

The new-generation foliar fertilizers are probable to be of suspension form, containing nanoparticles with stable soluble microelement ions, which is adequate to promptly correct deficiency but does not reach the phytotoxic level.

Main challenges for Nano fertilizers

1. Solubility of Nano crystals.
2. Residence fastness on the leaf surface.
3. Distribution of fertilizer particles on the leaf surface after drying.
4. Methodology for evaluating the effectiveness.

Conventional fertilizers versus nano-fertilizers

- When comparing to chemical fertilizers requirement and cost, nano fertilizers are economically cheap and are required in lesser amount.
- Nano fertilizers increase productivity around the farm.
- Improvement in soil aggregation, moisture retention and carbon build up.
- The yield per Feddan is also much higher than conventional fertilizers, thus giving higher income to the farmers.

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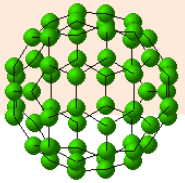
• Nano Fertilizers

- Nano-sized may increase solubility and spreading of insoluble nutrients in soil and increase the bioavailability.
- increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer resource.
- Release pattern and release rate of nutrients for watersoluble fertilizers precisely controlled through encapsulation forms of membranes coated by waxes, resin-polymer and sulfur.
- Nanostructured preparation may spread effective duration of nutrient supply of fertilizers into soil.
- Nanostructured formulation can reduce loss rate of fertilizer nutrients into soil by leaching and/or leaking.

• Conventional Fertilizers

- large particle size and low solubility reduce availability to plants.
- Bulk complex is not available for roots and reduce efficiency.
- Quick release of fertilizers could produce toxicity and terminate soil ecological balance.
- Used directly at time of supply by the plants, while, the rest is turned to insoluble forms in the soil.
- Big loss rate by leaching, float and rain off.



2. Seed Science

Seed is a basic input deciding the fate of productivity of any crop.

Conventionally, seeds are analyzed for their germination and distributed to farmers for sowing.

Various studies have showed both positive and negative effects of nanoparticles on seed germination and root elongation in plants.

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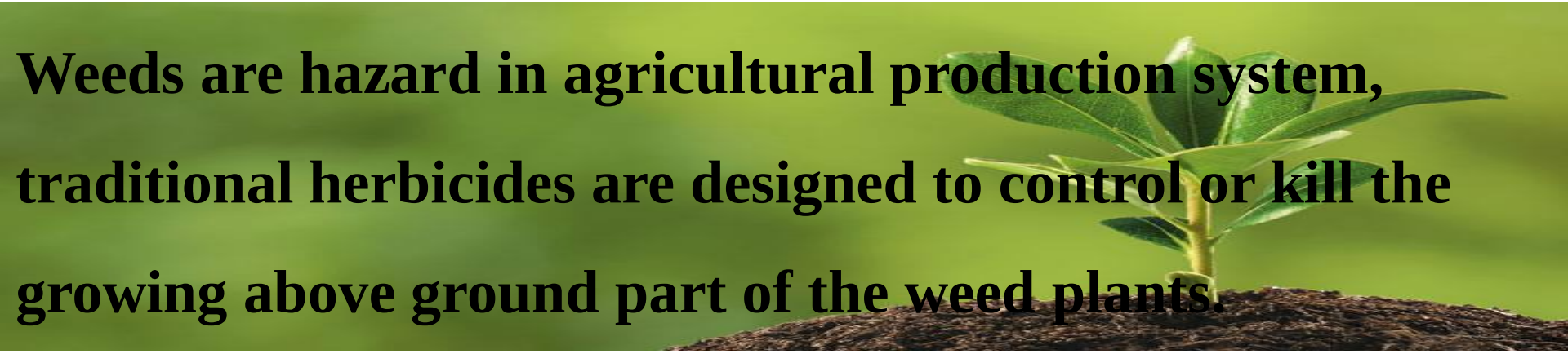
- Different researches revealed that, Nanomaterials like carbon nanotubes (CNTs) work as new pores for water permeation by penetration of seed coat and act as an entrance to channelize the water from the substrate into the seeds and increases the germination.

3. Nano-herbicide for effective weed control



Weeds are hazard in agricultural production system, traditional herbicides are designed to control or kill the growing above ground part of the weed plants.

Developing a target specific herbicide molecule encapsulated with nanoparticle are targeted for specific receptor in the roots of target weeds, which enter into system and translocated to parts that reduce food reserve in the root system.

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- Herbicides inside nano particles are established that can be timed-release or have release linked to an environmental trigger.
- Less nano herbicide is required to achieve the reduction weed reduction effects.
- If the active ingredient is combined with a smart delivery system, herbicide will be applied only when necessary according to the conditions present in the field.

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Positive effects of Nano materials in crop protection

4. Nanopesticide

- **Nano pesticides either active ingredients or inert ingredients with a particle size of 100 nm or less.**

- Nanopesticide delivery techniques are Nano emulsions, Nano encapsulates, Nano containers, and Nano cages.
- Nanomaterials can be used as a coating or protective layer to enable slow release of traditional pesticides and fertilizers (**Corradini et al., 2010)**
- Pesticides inside nanoparticles are being developed that can be timed-release or have release linked to an environmental trigger (Nair et al., 2010).

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There are different kind formulation of a pesticide:

- **Nano emulsion.**
- **Nano suspension.**
- **Nano encapsulation.**
- **Nano particles.**

SOME OF NANO-PARTICLES CONTROLLING THE PLANT DISEASES

- Nano Carbon
- Nano Silver
- Silicon
- Nano-sized SilicaSilver
- Nano Alumino-Silicate

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- Nano – encapsulated agrochemicals designed in such a tactic that they hold all indispensable properties such as:
  - Actual concentration with high solubility, stability and effectiveness.
  - Time controlled release in response to certain stimuli.
  - Less Eco toxicity with harmless.

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- Easy mode of delivery thus avoiding repetitive application.
- Enhanced targeted activity.

- Some of the nano particles are used for controlling plant diseases such as nano forms of C, Ag, Si and aluminous silicates.

Nano materials as Antifungal

- The use of nano materials could offer new methods to enhance the stability of the biological agents, It reduces various plant diseases caused by spore producing fungal pathogens (**Ghormade *et* al., 2011**).

- Some of the nano particles are used for adjusting plant diseases such as nano forms of Ag, Si, C and aluminous silicates.
- A mixture of TiO2,Al and Si was described to be effective in controlling downy and powdery mildew of grapes (Bowen *et* al., 1992).

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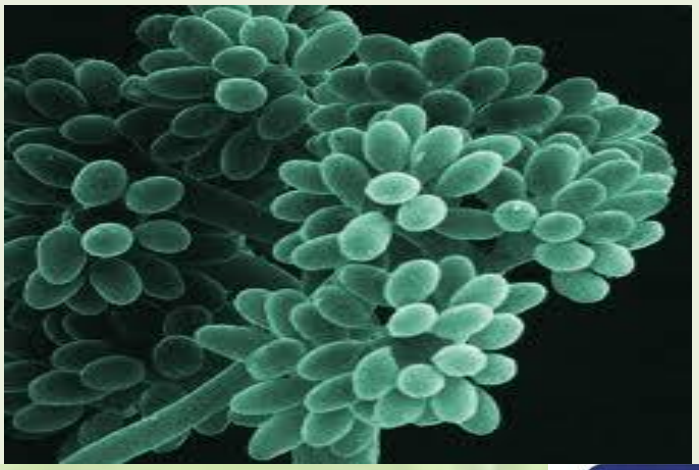
- A mixture of TiO_2,Al and Si was described to be effective in controlling downy and powdery mildew of grapes **(Bowen *et* al., 1992).**

- Nano Ag is known to have strong bactericidal and broad spectrum antimicrobial activities.

- The efficacy of Ag NPs in prolonging the vase life of cut flowers was studied and cleared the inhibition of microbial growth and reduced vascular blockage which enhanced the water uptake and maintained the turgidity of gerbera flowers(Nair et al., 2010)

- NP Ag has the antifungal activity on *Bipolaris Sorokiniana* to reduce fungal diseases on perennial Ryegrass (**Jo *et* al 2009**).

- ZnO nanoparticles inhibited the fungal growth of *Penicillium expansum by* influencing cellular functions, which caused deformation in mycelia mats. (Abd-elsalam 2013).



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5. Nano sensors

- Nano sensors with immobilized bio receptor probes that are selective for target analyzing molecules .
- Nano-sensors use to determine the time of crop harvest, detect crop health and determine microbial or chemical contamination of the crop.

According to the unique properties of nanomaterials, detection pathogens at low levels as parts per billion was developed by nanosensors.

From other side, nanotechnology also has solutions for degrading persistent chemicals into harmless and occasionally useful components.

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- Nano sensors used to diagnose disease caused by infecting soil microorganisms, like:

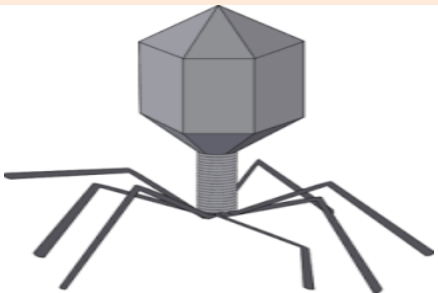
  bacteria,

  viruses,

  and fungi

through the quantitative measurement of differential oxygen level in the respiration of good microbes and bad microbes in the soil. **(Rai and Ingle., 2012)**.

For the herbicides detection by checking the oxygen level in soil.



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6. Enhancing food industry

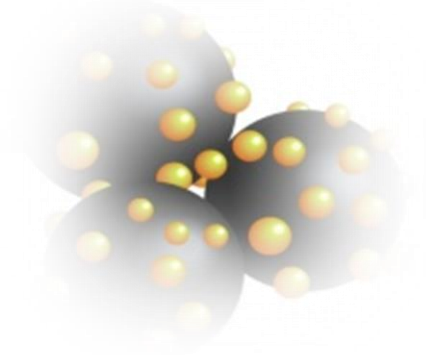
Nanomaterials are used in food industry to prevent microbial spoilage of packaged food, to improve colors, flavours, taste and texture and increase the bioavailability of vitamins and minerals.

The application of nanomaterials has also enabled the development of innovative packaging materials that can improve the safety and shelf life of products.

These scenarios have directed to innovative developments in the agriculture, food and other related sectors.

Nano-encapsulated used as flavours and color enhancers.

Also, Biodegradable nanosensors used for temperature and moisture monitoring.



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- Nanoparticles for antimicrobial and antifungal surface coatings.

- Nanoclays and nanofilms as carrier materials to avoid spoilage and oxygen absorption.

- Nanoparticles used to discover chemicals of foodborne pathogens,

Smart packaging with Nano silicon embedded durethan polymer to enhance the shelf life of the food materials (**Sastry *et al.*, *2011).***

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Nano Technology and Safety

Due to our limited knowledge of different effects of nanomaterials on human health and special properties of nanomaterials there are concerns about their safety.

Further information is required on the state-of-the-art of different applications of nanotechnology as fertilizers, pesticides, food additives, nano-packing materials and feed additives.

Negative Effects of Nano Materials

- High concentration of nanosilica silver formed some chemical injuries on the experienced plants.
- Nano particles on biological systems and the environment such as toxicity generated by free radicals leading to lipid peroxidation and DNA damage.

- Extremely high doses of nano materials are associated with fibrotic lung responses and result in inflammation and an increased risk of carcinogenesis. (**Oberdorster *et* al., 2005**).
- Nanoparticles could accumulate in soil, water and plants.

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Summery

- The agricultural sector is facing many challenges, such as climate change, greenhouse gas emission and global warming.
- In the same time there is increasing demand for global food production has been observed and an increasing demand for biofuel crops.

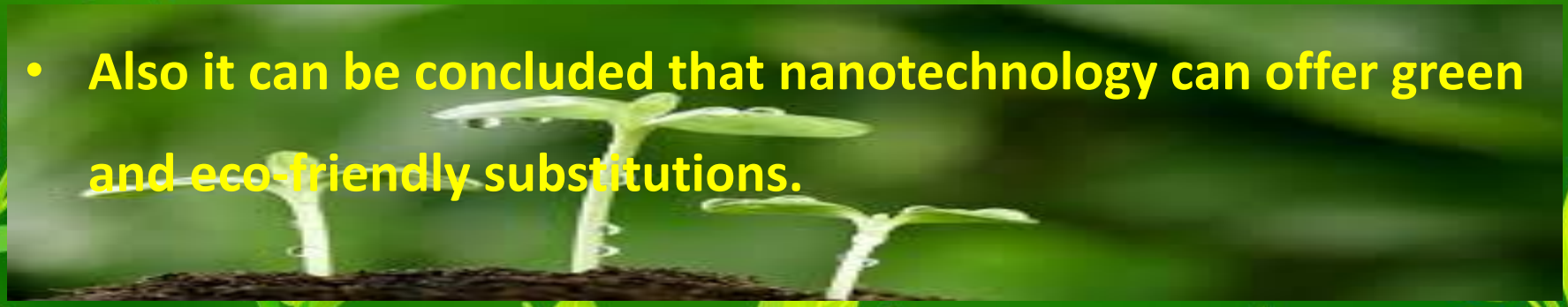
Nanotechnology and nano materials have been verified to have great potential in developed solutions to many challenges facing agricultural sector today and in the future.

- This lecture highlights role of nanotechnology in developing agricultural sector and some of the most hopeful and significant nanotechnology applications in agriculture.
- There are numerous nano products and applications used in different steps in agricultural production like nano-fertilizers, nano-pesticides, nano-herbicides, detection of nutrient deficiencies, nano-scale carriers, nanosensors, fisheries, aquaculture, and Nano barcode

- We could achieve to increase agricultural sector development efficiency through increasing productivity of different crops, increased soil vitality and decreasing the pollution, with using nanotechnology in production, could be counted as the best solution to this problem.

CONCLUSION

- Nanotechnology has been proved to have excessive potential in developed solutions to numerous challenges facing agricultural sector today and in the future.



- **Also it can be concluded that nanotechnology can offer green and eco-friendly substitutions.**

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Thank
You