NANOPARTICLES FOR AGRICULTURE APPLICATIONS

Gopalu Karunakaran[*1,2], Alexander Gusev[1] and Denis Valerievich Kuznetsov[1]

*Email: karunakarang5@gmail.com

**[1]Department of Functional Nanosystems and High energy materials,
National University of Science and Technology "MISIS", Leninsky Prospect, 4, Moscow,,119049,,Russia.**

**[2]Department of Biotechnology
KSR College of Arts and Science (Autonomous)
Tiruchengode – 637 215
Tamil Nadu**

Introduction About Me

PhD: Anna University, Chennai, India. (5th Ranking in Top 10 Universities in India) (Science)

–**INVESTIGATIONS ON TOXICOLOGICAL BEHAVIOUR OF NANO SiO_2, Al_2O_3, TiO_2 AND ZrO_2 PARTICLES IN DIFFERENT ENVIRONMENTS**

Assistant Professor,

–Achievements in teaching and research

Classes	Subjects Handled	Academic Year		Results Produced % Pass
		From	To	
U G	Molecular Biology	2013	2014	100%
	Microbial Biotechnology	2013	2014	100%
P G	Principles of Microbiology	2013	2014	100%
	Food and Pharmaceutical Biotechnology	2013	2014	96%
	Molecular Biology	2013	2014	100%

Name of the students to whom I have guided for Masters Program me in Biotechnology

Mr. N. DINESH
Mr. P. SUBRAMANI
Ms. R. KANIMOZHI

Year	Number of students
	M.Sc.
2012-2014	3

Young Scientist as Post Doc:

National University of Science & Technology "MISiS", Moscow.

-NEW SMART FERTILIZER FOR AGRICULTURE, BASED ON METAL AND OXIDE NANOPOWDERS

About My Research Experience

▪**Nanotoxicology**
✓**Evaluation of toxicity of nanoparticles under different environment conditions**

▪**Biomaterials**
✓**Fabrication of composites materials for scaffold applications**

▪**Textile applications**
✓**Application of nanoparticles for UV-Protection, flame retarding and antimicrobial activity**

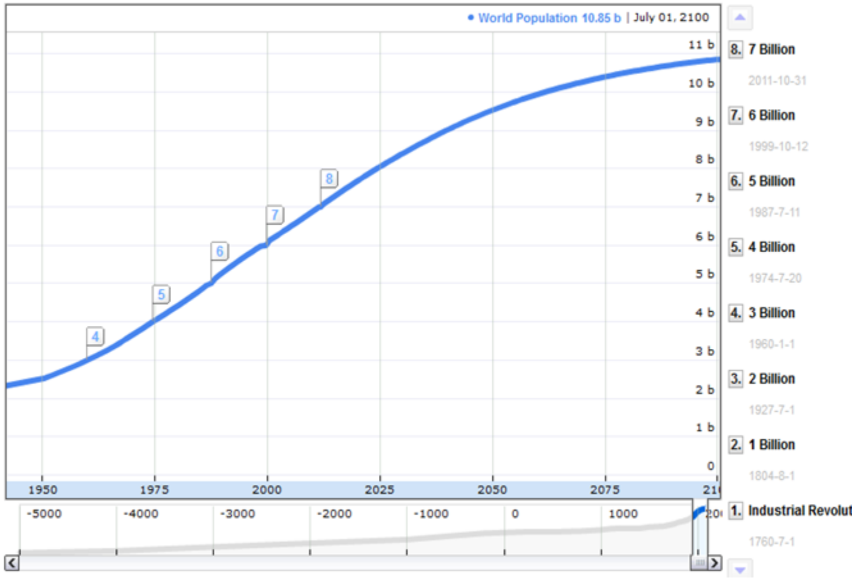
▪**Microbiology**
✓**Useful production of lactic acids, enzymes and other bio based products**

PROJECT GOAL IN NUST – MISiS

– Development of new processes and method for the production of metal and metal based nanopowders for agriculture application

– Recently there is rapid development in the total world population 7.3 billion (2015) and will reach more than 11 billion in the upcoming years (2100).
– As these populations requires food source to survive.

World Population: Past, Present, and Future



- Generally the food sources are either agricultural or meat based products.
- For meat based products lots of care and efforts to be taken.
- However, in agriculture production not much care is required.
- Moreover it is very easy and cost effective compared to meat based products.
- Usually now a days different chemicals are used in the agriculture as fertilizer, but they are very toxic to the environment.
- Thus and alternate materials are required to substitute this chemicals.

OBJECTIVE

- Synthesis and characterization of metal and metal oxide nanoparticles.
- Large scale production of metal and metal oxide nanoparticles with cost effective.
- Preliminary studies of synthesized nanoparticles towards the plant.
- Evaluate the level of toxicity of synthesized nanoparticles in the environment
- Field study of metal and metal nanoparticles towards the plant.

MATERIALS AND METHODS

1 Metal Oxide Nanoparticle Synthesis

* Biosynthesis
* Sol-gel method
* Ultra-sonication process
* Thermal process

2 Characterization

* X-ray Powder Diffraction
* Particle Size Distribution
* Fourier Transform Infrared Spectroscopy
* Specific Surface Area
* Electron Microscopic Analysis
* X-ray Fluorescence Spectrometry
* Zeta Potential
* Contact Angle Measurement

MATERIALS AND METHODS

3 Phytotoxicity Studies

* Plant treatment with metal oxides and growth inhibition analysis
* Estimation of total chlorophyll content and protein content
* Metal oxide uptake studies in plant

4 *In vitro* Toxicity Studies

* Animal cell culture treatment
* Cytotoxicity determination
* Antioxidant activity
* Biocompatibility study

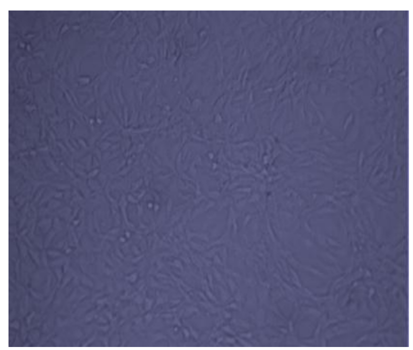
NANO PARTICLES

Soil

Cell culture

Plant

Soil



Cell line

seed

ANTICIPATED PROJECT RESULTS

- Successful synthesis of different types of metal and metal oxide nanoparticles.
- Process optimized for large scale production of required nanoparticles with cost effective.
- Preliminary studies give an idea about the level of interaction of nanoparticles with the plant.
- Toxicity studies will give an idea whether the prepared nanoparticle will harm the environment or not.
- From the field study of we can confirm the use of nanoparticles as a nanofertilizer.
- Thus, the present study we will be able to find a novel nanonuturient for substantial farming.

WORK PLAN – LIST OF ACTIVITIES AND EVENTS FUNDED BY THE GRANT

- **2015 (16.09.2015 –31.12.2015)**

- ✓ 1.1 Study of scientific, technical and legal literature on the project
- ✓ 1.2 Patent research
- ✓ 1.3 Analysis of similar studies on the project
- ✓ 1.4 List out the types of nanoparticles
- ✓ 1.5 Selection of research methods based on published data and experience of similar studies
- ✓ 1.6 Development of the work plan
- ✓ 1.7 Determination of optimal parameters of nanoparticles according to the literature
- ✓ 1.8 Development and experimental validation techniques for the synthesis of metal and oxide NPs with specified physical and chemical properties

WORK PLAN – LIST OF ACTIVITIES AND EVENTS FUNDED BY THE GRANT

- **2016 (01.01.2016–31.12.2016)**

✓ 2.1 Synthesis of starting, modified and functionalized metal NPs samples with different characteristics (particle size and shape, cleanliness, etc.)

✓ 2.2 Development and experimental validation and assessment methodology of biological properties of nanoparticles

✓ 2.3 Assessing the environmental safety of nanoparticles

✓ 2.4 Selection of the most efficient and environmentally friendly versions of the number of nanomaterials developed, as well as the choice of crops tolerant to their effects

- **2017 (01.01.2017–15.09.2017)**

- ✓ 3.1 Field tests of efficiency of nanoparticles using various processing methods, and concentrations
- ✓ 3.2 Development of technological development and use regulations of efficiency nanoparticle
- ✓ 3.3 Testing developed technological regulations under nanotechnology and agro industries

- **2015 (16.09.2015 –Till Date)**

- ✓ 1.1 Study of scientific, technical and legal literature on the project
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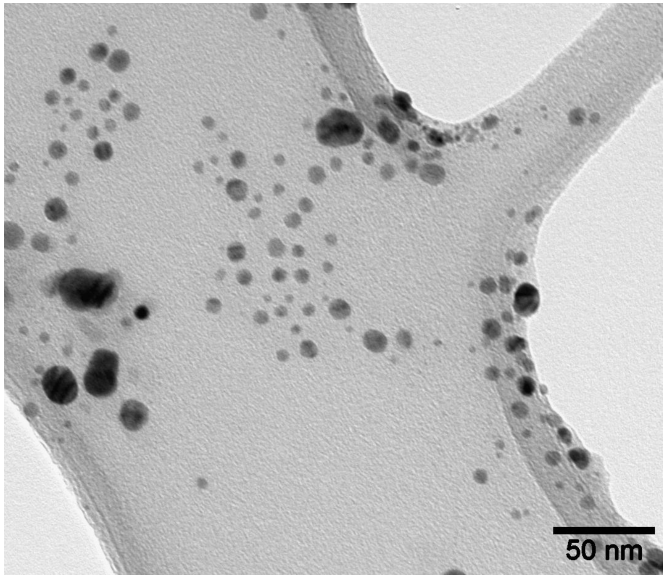
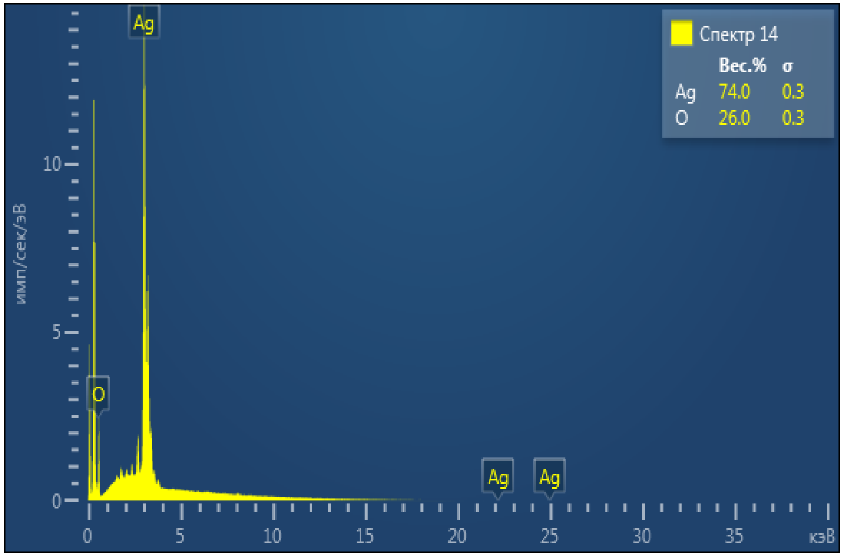
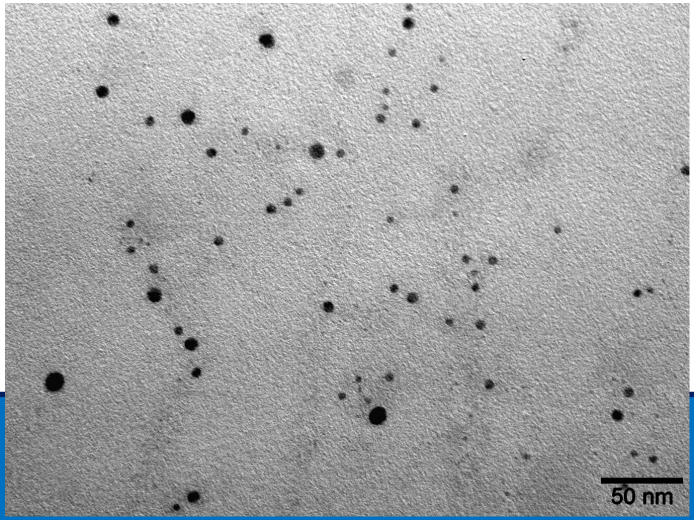
- **Biosynthesis of silver nanoparticles (AgNPs)**





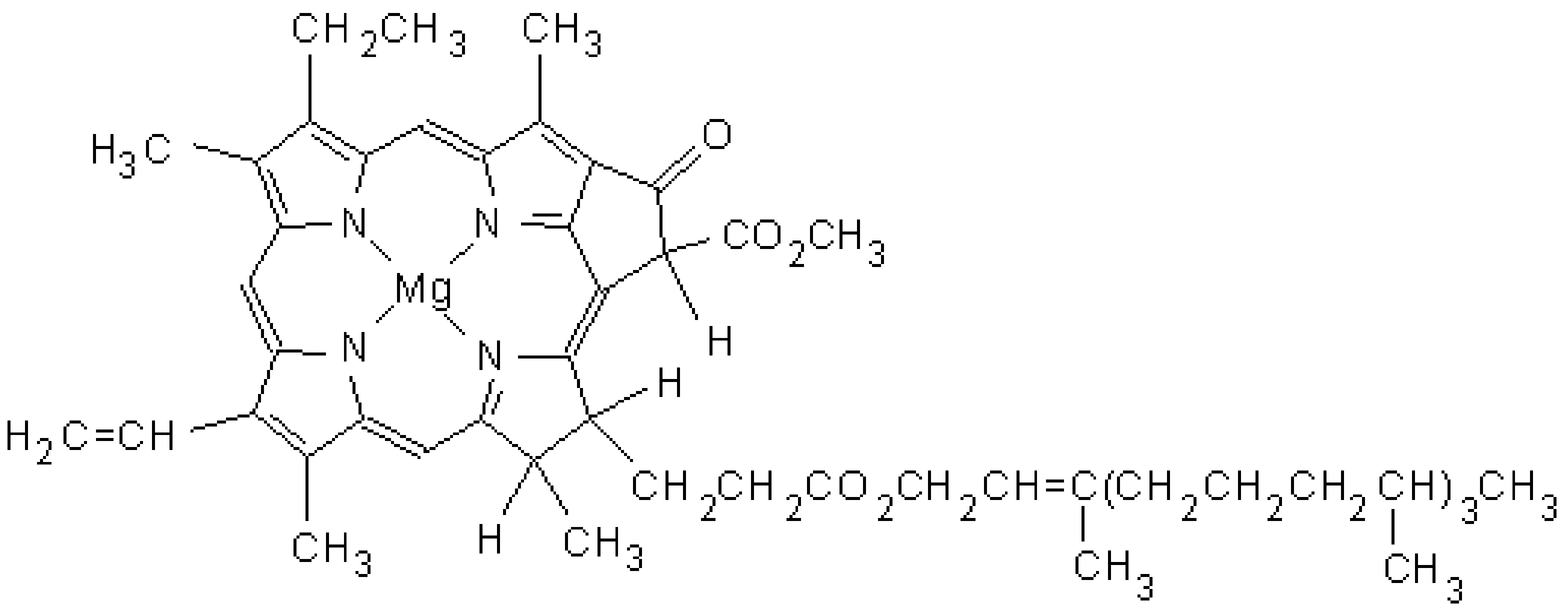


HOW NANOPARTICLES AS FERTILIZERS ?

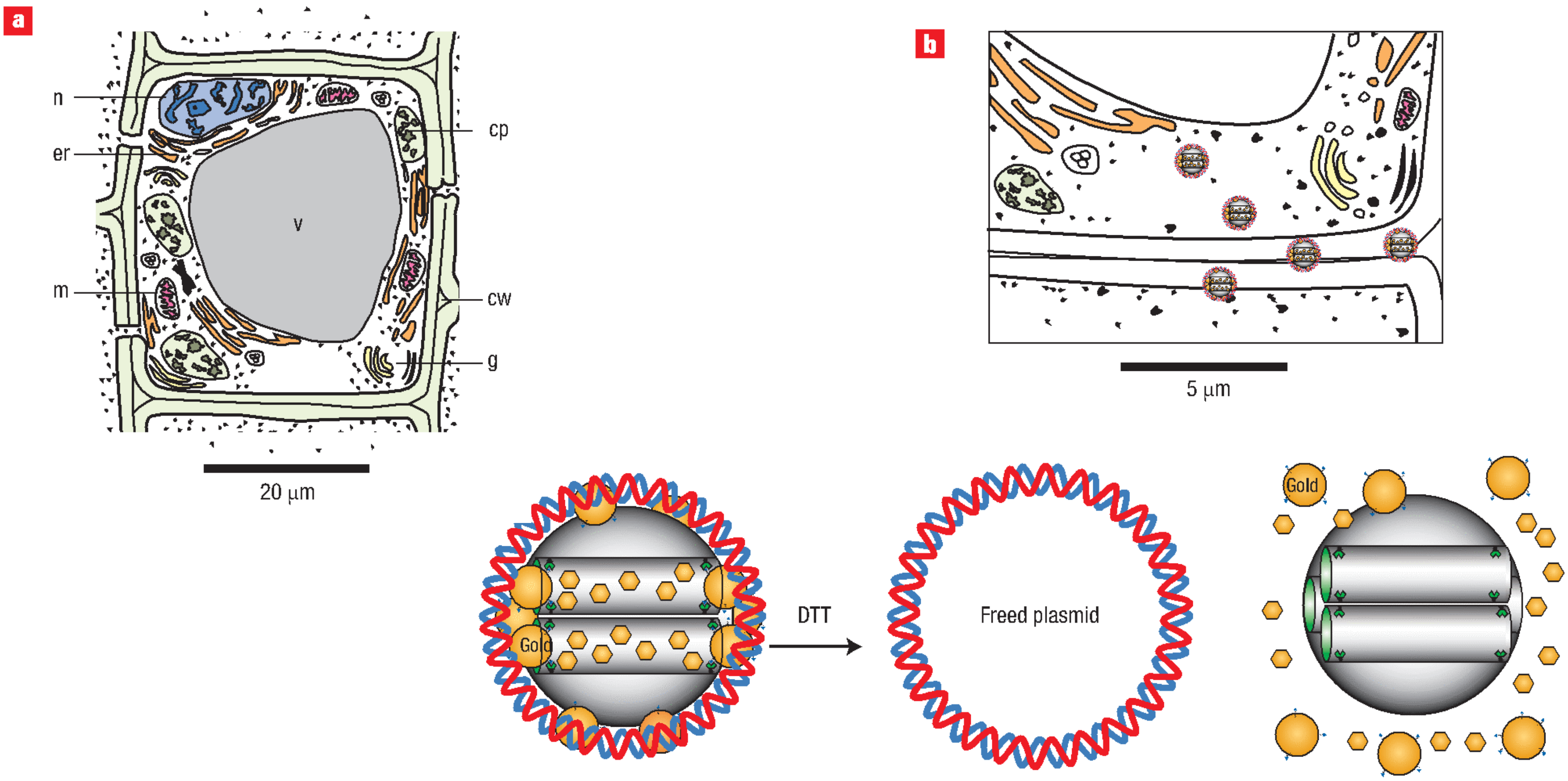
Table 39.1 Essential Nutrients in Plants

Elements	Principal Form in which Element Is Absorbed	Approximate Percent of Dry Weight	Examples of Important Functions
MACRONUTRIENTS			
Carbon	(CO_2)	44	Major component of organic molecules
Oxygen	(O_2, H_2O)	44	Major component of organic molecules
Hydrogen	(H_2O)	6	Major component of organic molecules
Nitrogen	(NO_3^-, NH_4^+)	1–4	Component of amino acids, proteins, nucleotides, nucleic acids, chlorophyll, coenzymes, enzymes
Potassium	(K^+)	0.5–6	Protein synthesis, operation of stomata
→ Calcium	(Ca^{++})	0.2–3.5	Component of cell walls, maintenance of membrane structure and permeability, activates some enzymes
→ Magnesium	(Mg^{++})	0.1–0.8	Component of chlorophyll molecule, activates many enzymes
Phosphorus	($H_2PO_4^-$, $HPO_4^=$)	0.1–0.8	Component of ADP and ATP, nucleic acids, phospholipids, several coenzymes
Sulfur	($SO_4^=$)	0.05–1	Components of some amino acids and proteins, coenzyme A
MICRONUTRIENTS (CONCENTRATIONS IN PPM)			
Chlorine	(Cl^-)	100–10,000	Osmosis and ionic balance
→ Iron	(Fe^{++}, Fe^{+++})	25–300	Chlorophyll synthesis, cytochromes, nitrogenase
→ Manganese	(Mn^{++})	15–800	Activator of certain enzymes
→ Zinc	(Zn^{++})	15–100	Activator of many enzymes, active in formation of chlorophyll
Boron	(BO_3^- or $B_4O_7^=$)	5–75	Possibly involved in carbohydrate transport, nucleic acid synthesis
→ Copper	(Cu^{++})	4–30	Activator or component of certain enzymes
→ Molybdenum	($MoO_4^=$)	0.1–5	Nitrogen fixation, nitrate reduction

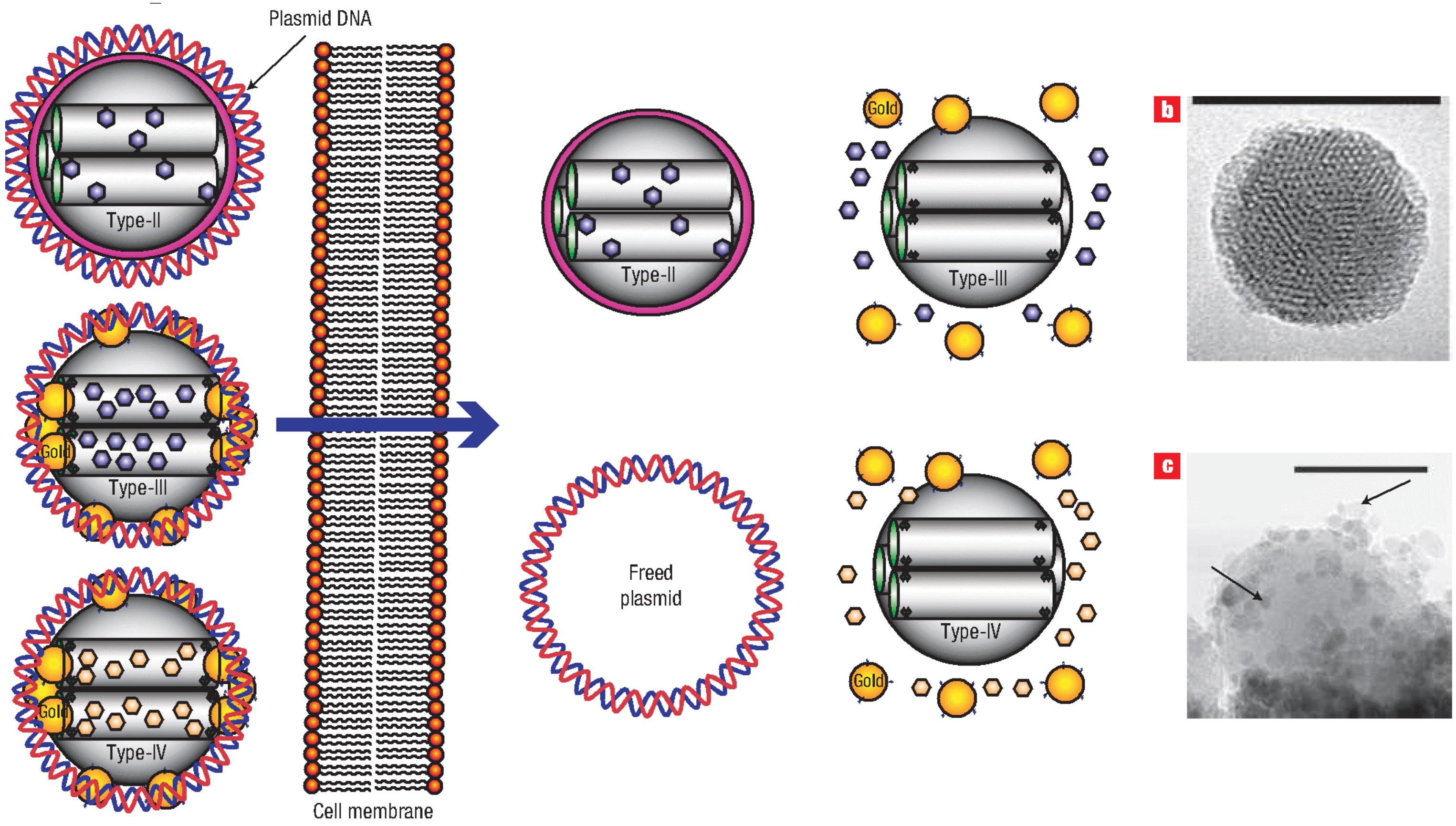
CHLOROPHYLL



- **Nanobiotechnology: Silica breaks through in plants, David W. Galbraith, Nature Nanotechnology 2, 272 - 273 (2007) doi:10.1038/nnano.2007.118**

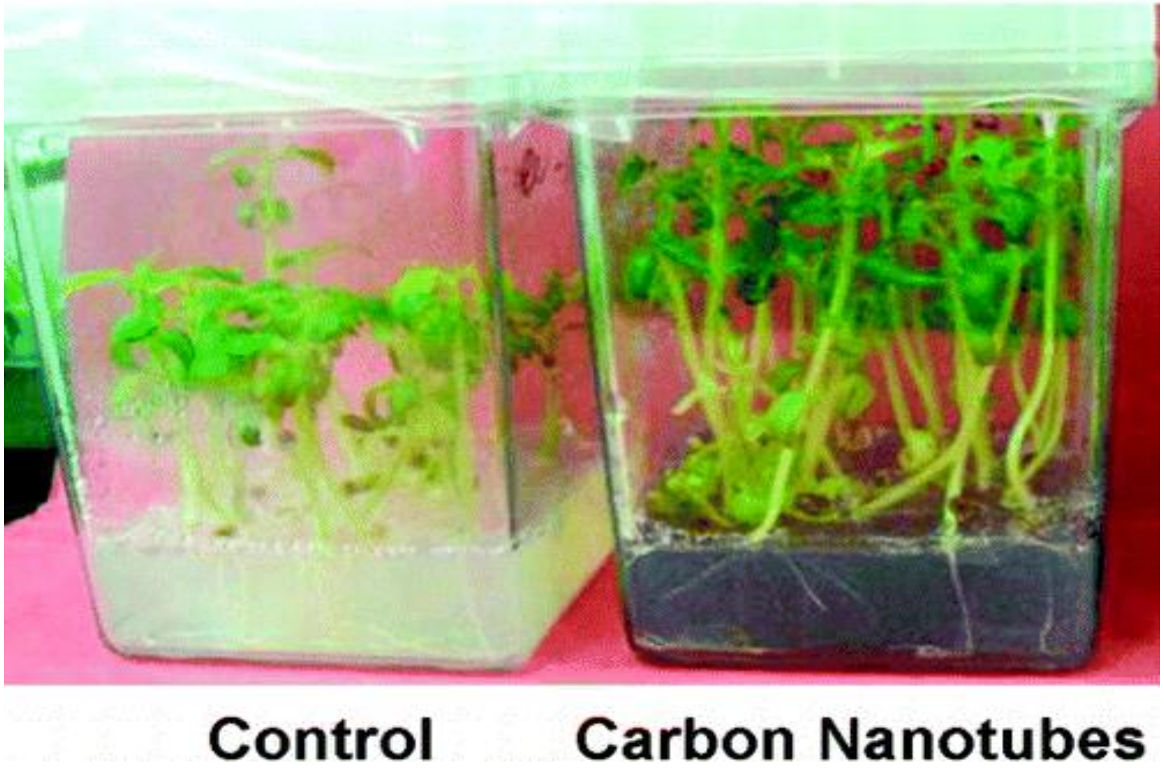


- **Mesoporous silica nanoparticles deliver DNA and chemicals into plants, François Torney1, Brian G. Trewyn2, Victor S.-Y. Lin2 & Kan Wang, Nature Nanotechnology 2, 295 - 300 (2007) Published online: 29 April 2007 | doi:10.1038/nnano.2007.108**

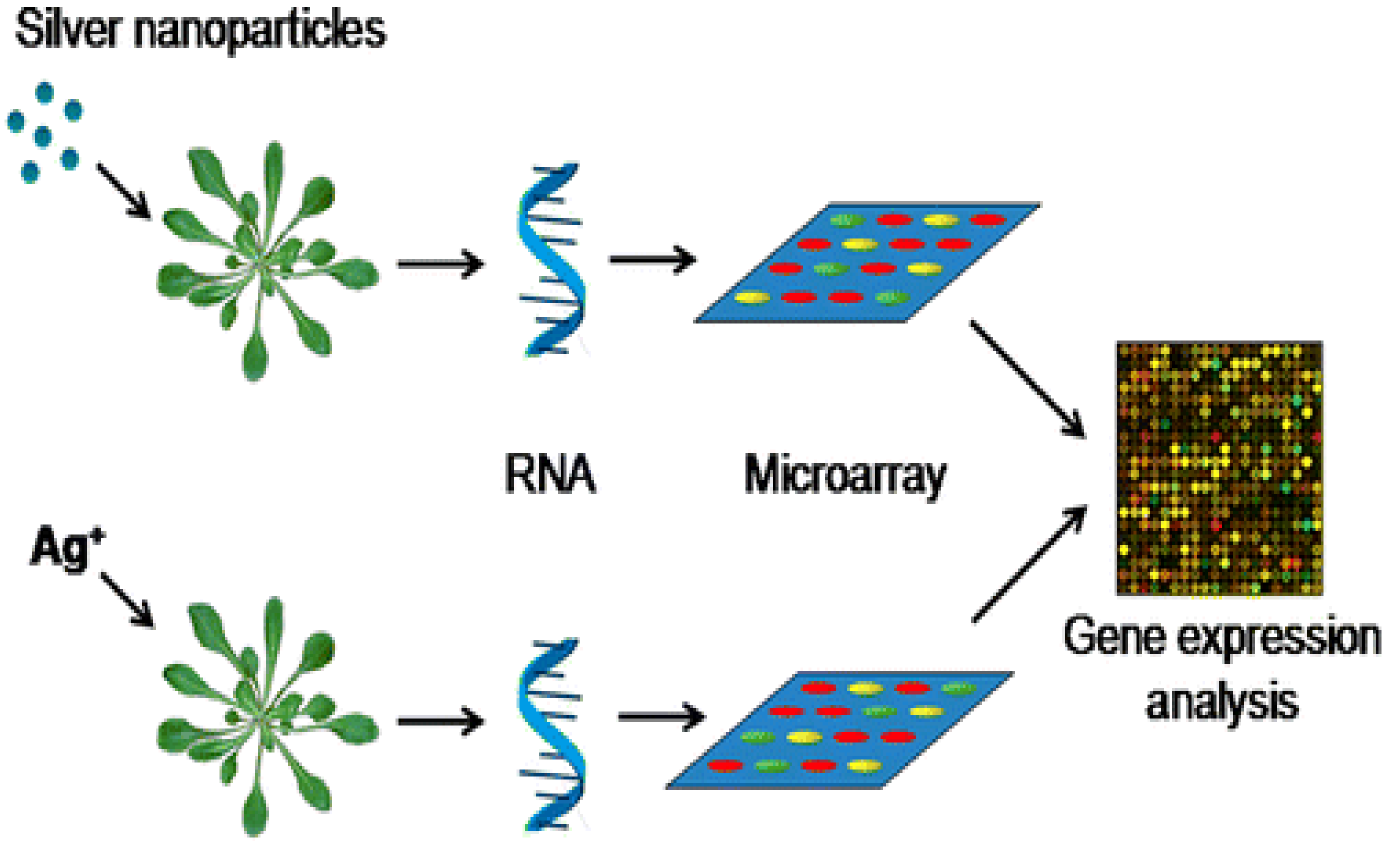


REVIEWS- HOW NANOPARTICLES AS FERTILIZERS

- **Carbon Nanotubes Are Able To Penetrate Plant Seed Coat and Dramatically Affect Seed Germination and Plant Growth, Mariya Khodakovskaya †*, Enkeleda Dervishi †‡, Meena Mahmood †‡, Yang Xu †‡, Zhongrui Li †‡, Fumiya Watanabe ‡, and Alexandru S. Biris †‡* ACS Nano, 2009, 3 (10), pp 3221–3227, DOI: 10.1021/nn900887m**

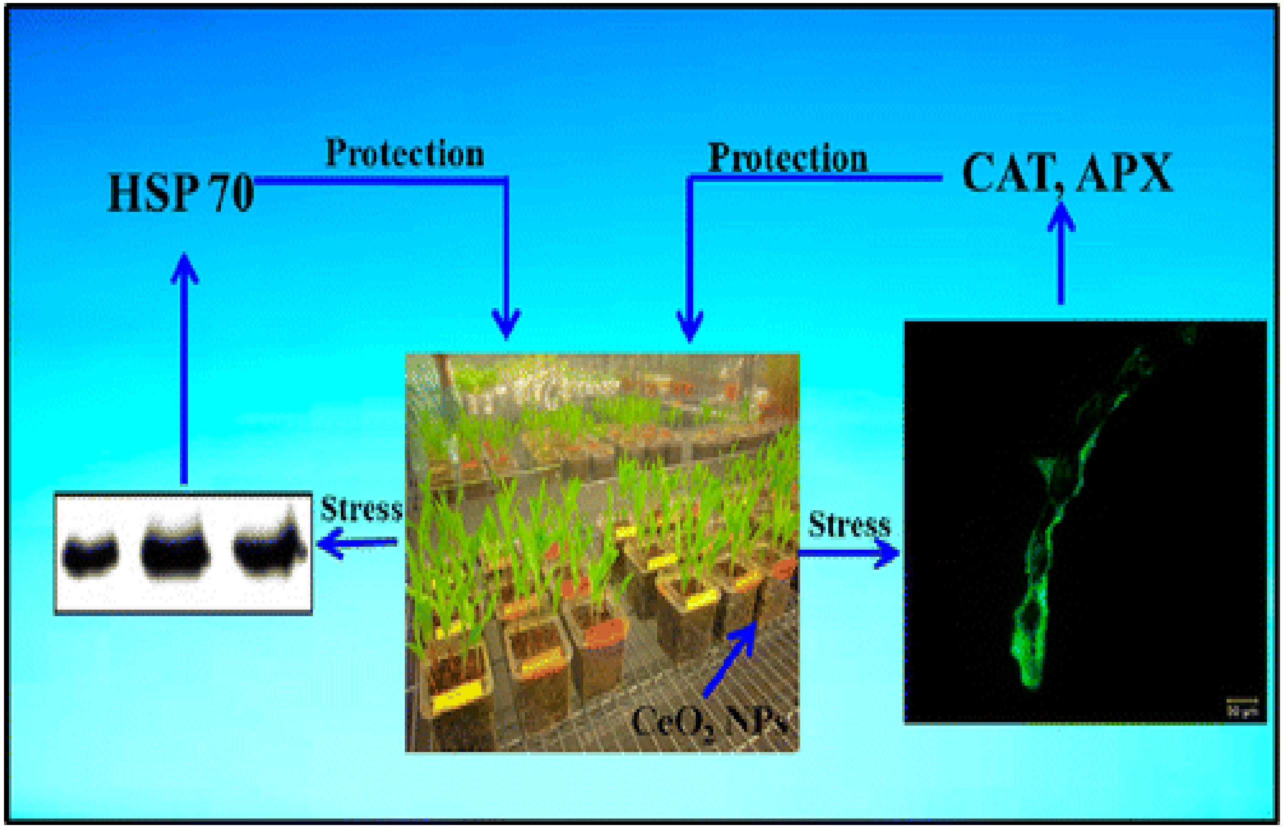


- **Changes in Arabidopsis thaliana Gene Expression in Response to Silver Nanoparticles and Silver Ions, Rashid Kaveh †, Yue-Sheng Li ‡, Sibia Ranjbar †, Rouzbeh Tehrani †, Christopher L. Brueck †, and Benoit Van Aken *† , Environ. Sci. Technol., 2013, 47 (18), pp 10637–10644, DOI: 10.1021/es402209w**



- **Stress Response and Tolerance of Zea mays to CeO2 Nanoparticles: Cross Talk among H2O2, Heat Shock Protein, and Lipid Peroxidation, Lijuan Zhao †¶, Bo Peng §, Jose A. Hernandez-Viezcas †¶, Cyren Rico †¶, Youping Sun ∥, Jose R. Peralta-Videa †¶, Xiaolei Tang §, Genhua Niu ∥, Lixin Jin ⊥, Armando Varela-Ramirez §, Jian-ying Zhang §, and Jorge L. Gardea-Torresdey †‡¶* , ACS Nano, 2012, 6 (11), pp 9615–9622, DOI: 10.1021/nn302975u**

CeNPs

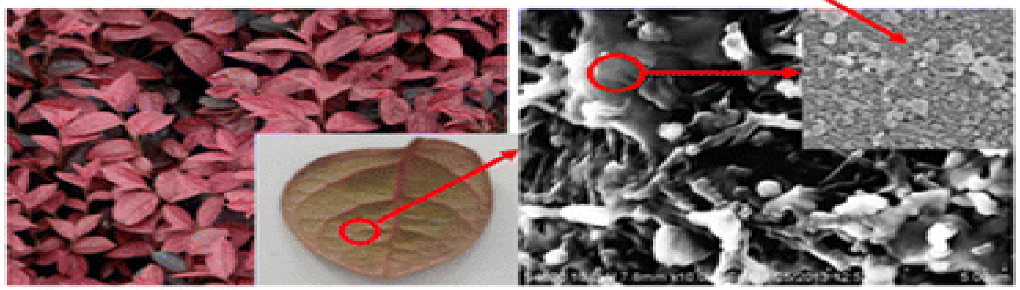


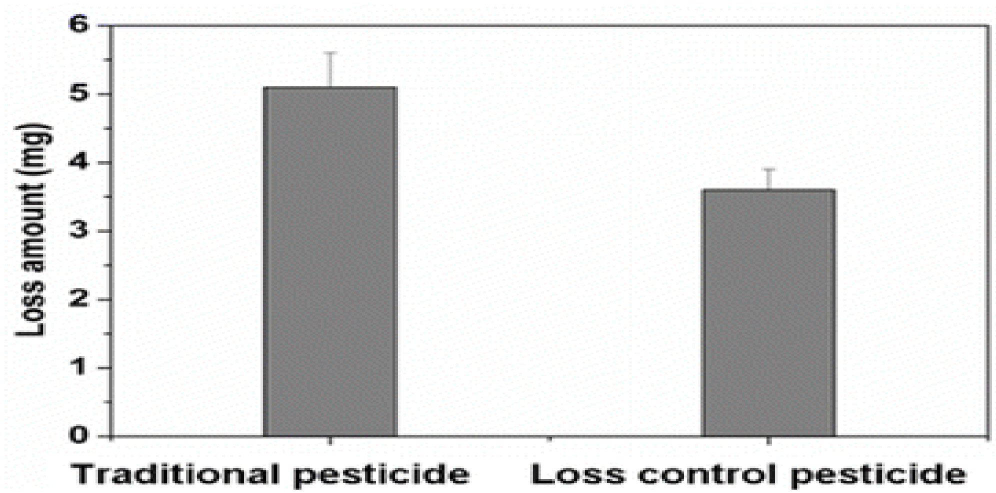
REVIEWS- HOW NANOPARTICLES AS FERTILIZERS

- **Controlling Pesticide Loss by Natural Porous Micro/Nano Composites: Straw Ash-Based Biochar and Biosilica, Dongqing Cai † § , Longhai Wang ‡, Guilong Zhang † § , Xin Zhang *‡, and Zhengyan Wu *† § ACS Appl. Mater. Interfaces, 2013, 5 (18), pp 9212–9216, DOI: 10.1021/am402864r**

pesticide/biochar and biosilica

SiNPs

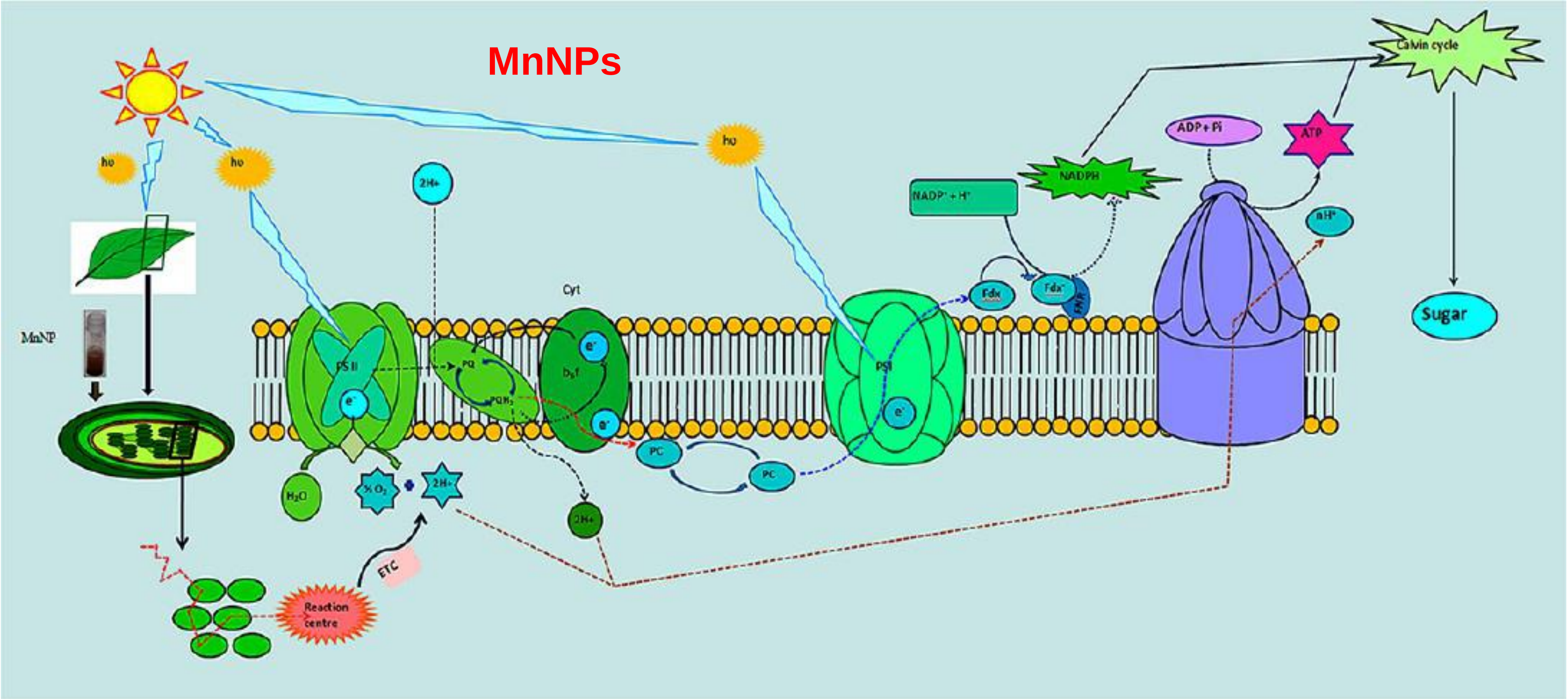




loss amount of pesticide after washing

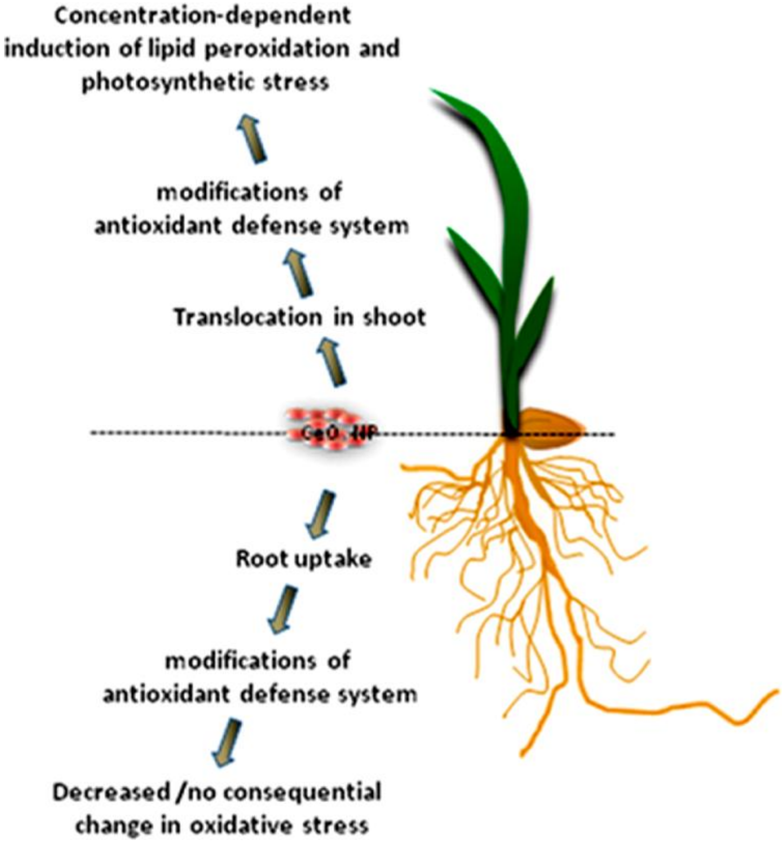
REVIEWS- HOW NANOPARTICLES AS FERTILIZERS

- **Photochemical Modulation of Biosafe Manganese Nanoparticles on Vigna radiata: A Detailed Molecular, Biochemical, and Biophysical Study, Saheli Pradhan,*,† Prasun Patra,† Sumistha Das,† Sourov Chandra,† Shouvik Mitra,† Kushal Kumar Dey,†, Shirin Akbar,† Pratip Palit,‡ and Arunava Goswami†, dx.doi.org/10.1021/es402659t | Environ. Sci. Technol. 2013, 47, 13122–13131.**

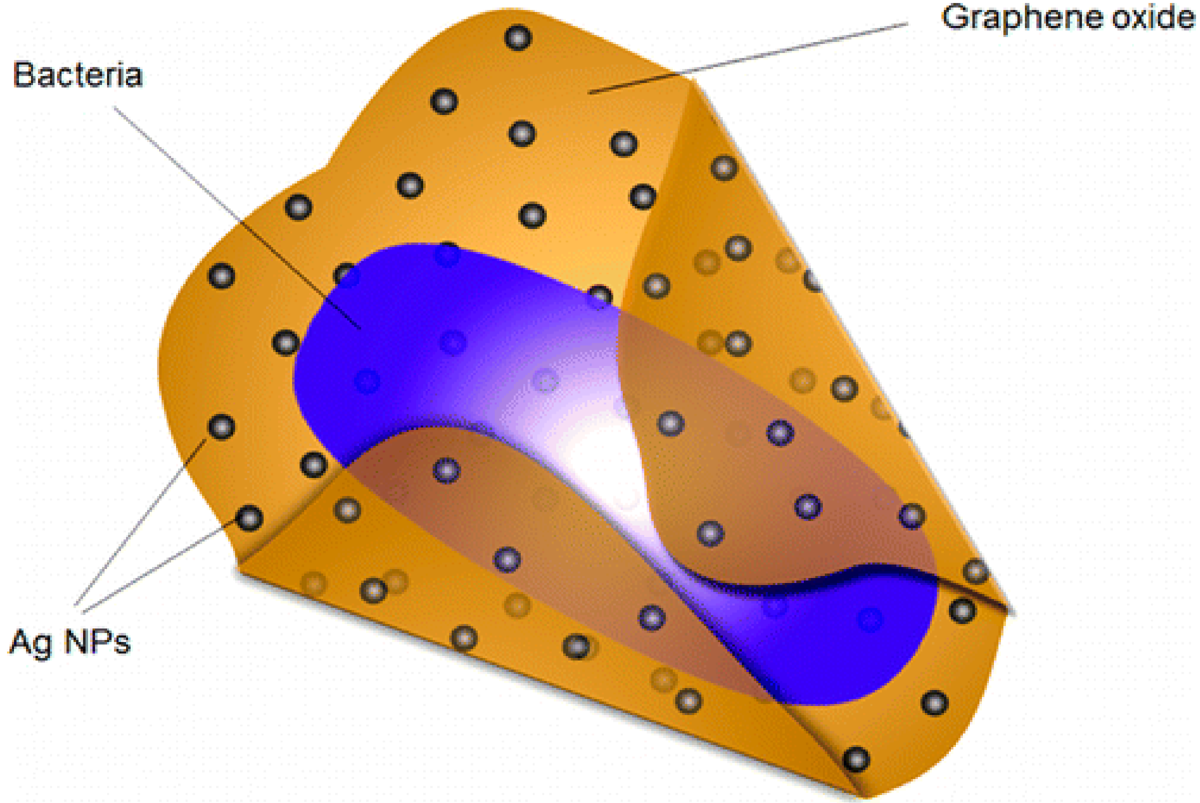


- **Effect of Cerium Oxide Nanoparticles on Rice: A Study Involving the Antioxidant Defense System and In Vivo Fluorescence Imaging, Cyren M. Rico,†,∥ Jie Hong,‡ Maria Isabel Morales,† Lijuan Zhao,†,∥ Ana Cecilia Barrios,†, Jian-Ying Zhang, § Jose R. Peralta-Videa,†,∥ and Jorge L. Gardea-Torresdey*,†,‡,∥, dx.doi.org/10.1021/es401032m | Environ. Sci. Technol. 2013, 47, 5635−5642**

CeNPs

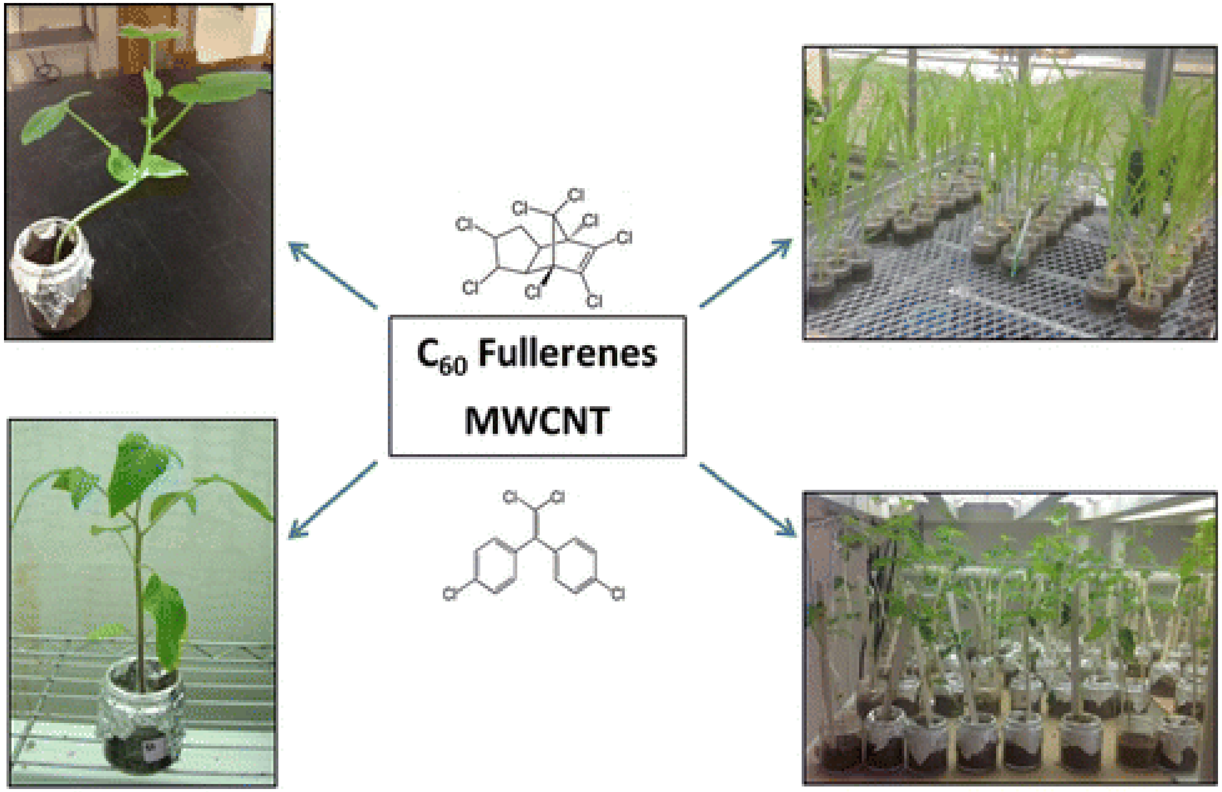


- **Nanotechnology in Plant Disease Management: DNA-Directed Silver Nanoparticles on Graphene Oxide as an Antibacterial against Xanthomonas perforans, Ismail Ocsoy †, Mathews L. Paret †, Muserref Arslan Ocsoy †, Sanju Kunwar †, Tao Chen †‡, Mingxu You †‡, and Weihong Tan †‡* , ACS Nano, 2013, 7 (10), pp 8972–8980, DOI: 10.1021/nn4034794**

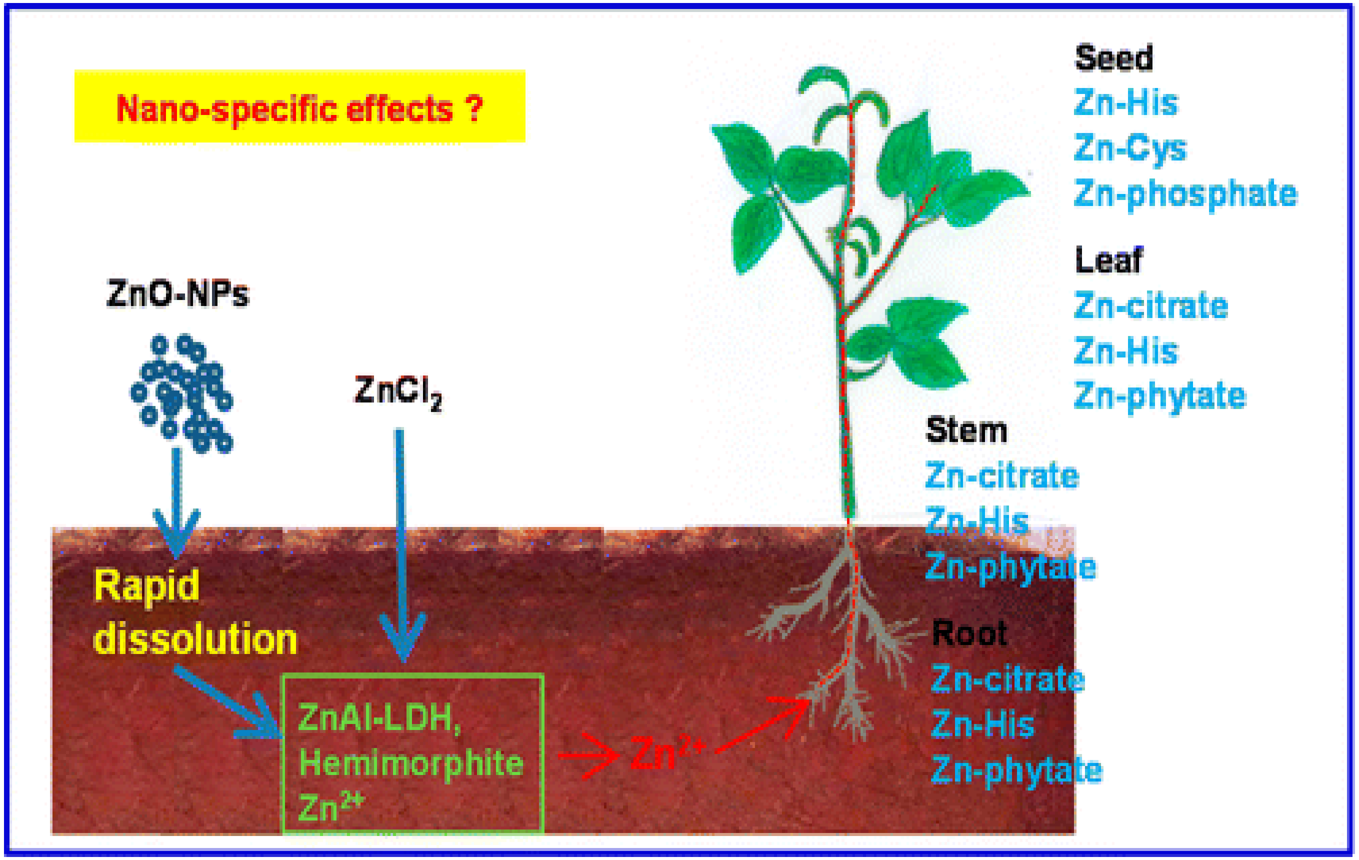


REVIEWS- HOW NANOPARTICLES AS FERTILIZERS

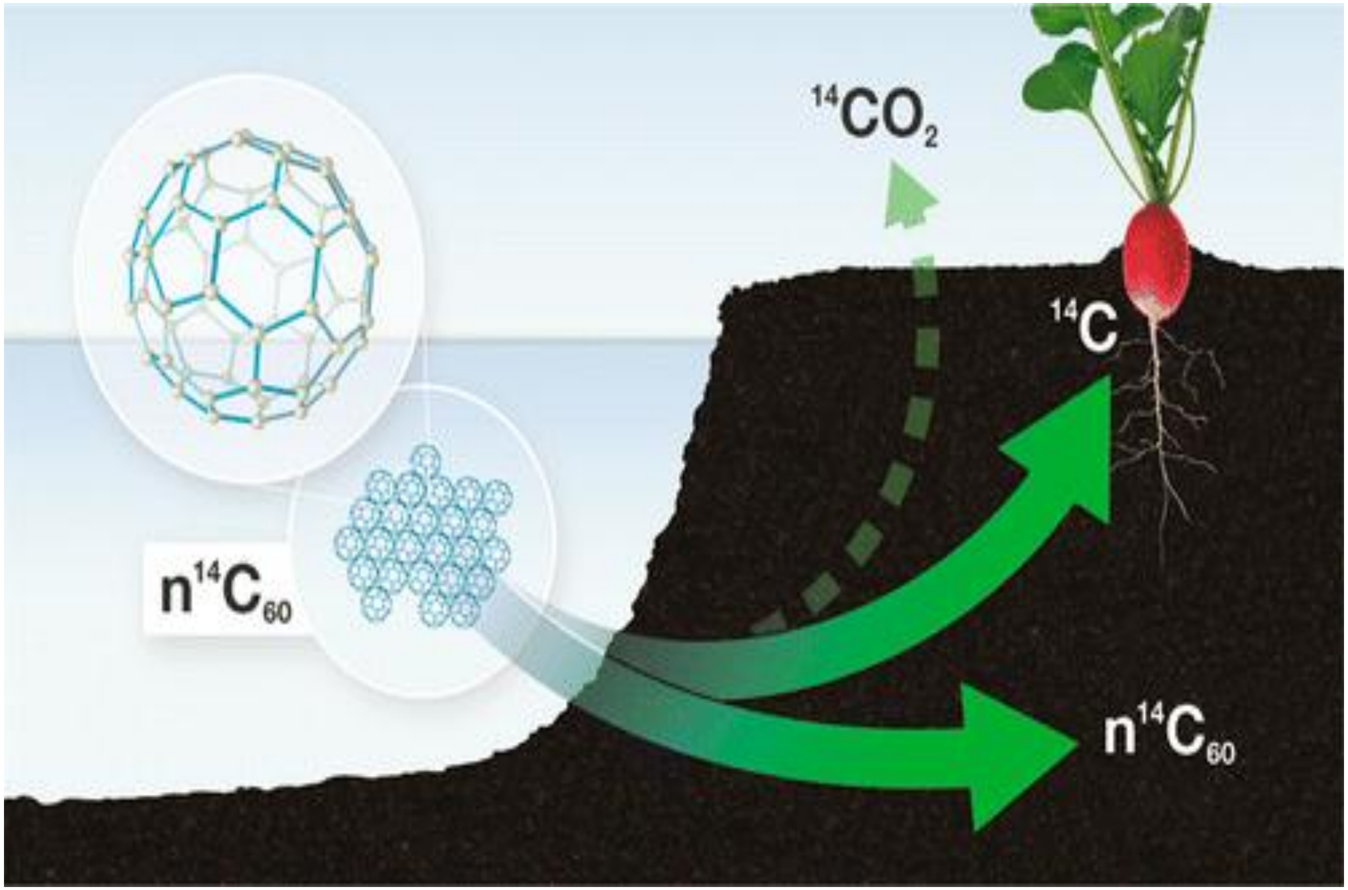
- **Multiwalled Carbon Nanotubes and C60 Fullerenes Differentially Impact the Accumulation of Weathered Pesticides in Four Agricultural Plants, Roberto De La Torre-Roche †, Joseph Hawthorne †, Yingqing Deng ‡, Baoshan Xing ‡, Wenjun Cai §, Lee A. Newman §, Qiang Wang ∥, Xingmao Ma ∥, Helmi Hamdi ⊥, and Jason C. White, Environ. Sci. Technol., 2013, 47 (21), pp 12539–12547, DOI: 10.1021/es4034809**



- **Fate of ZnO Nanoparticles in Soils and Cowpea (Vigna unguiculata), Peng Wang *†, Neal W. Menzies †, Enzo Lombi ‡, Brigid A. McKenna †, Bernt Johannessen §, Chris J. Glover §, Peter Kappen §, and Peter M. Kopittke †, Environ. Sci. Technol., 2013, 47 (23), pp 13822–13830, DOI: 10.1021/es403466p**

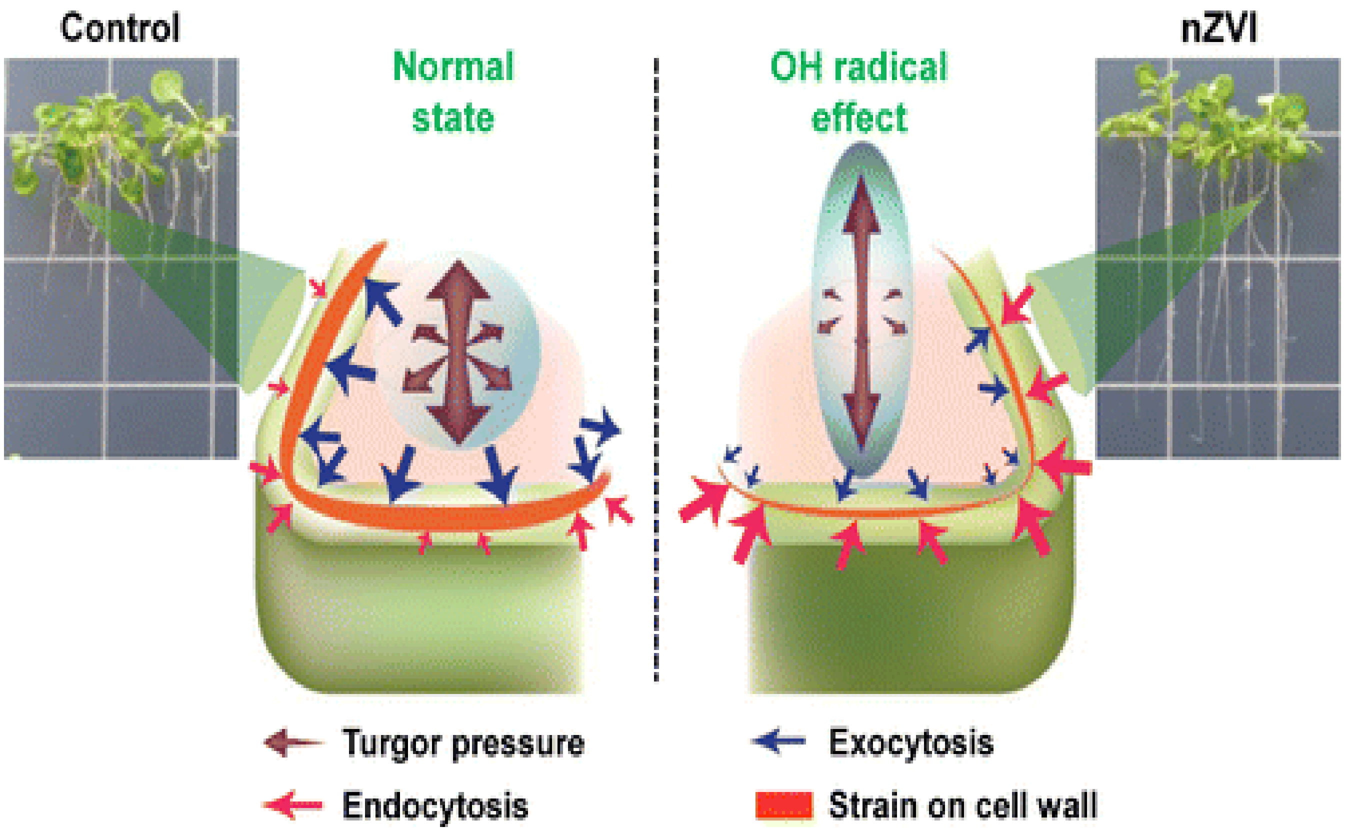


- **C60 Fullerene Soil Sorption, Biodegradation, and Plant Uptake, Raghavendhran Avanasi †, William A. Jackson ‡, Brie Sherwin † § , Joseph F. Mudge †, and Todd A. Anderson *† , Environ. Sci. Technol., 2014, 48 (5), pp 2792–2797, DOI: 10.1021/es405306w**



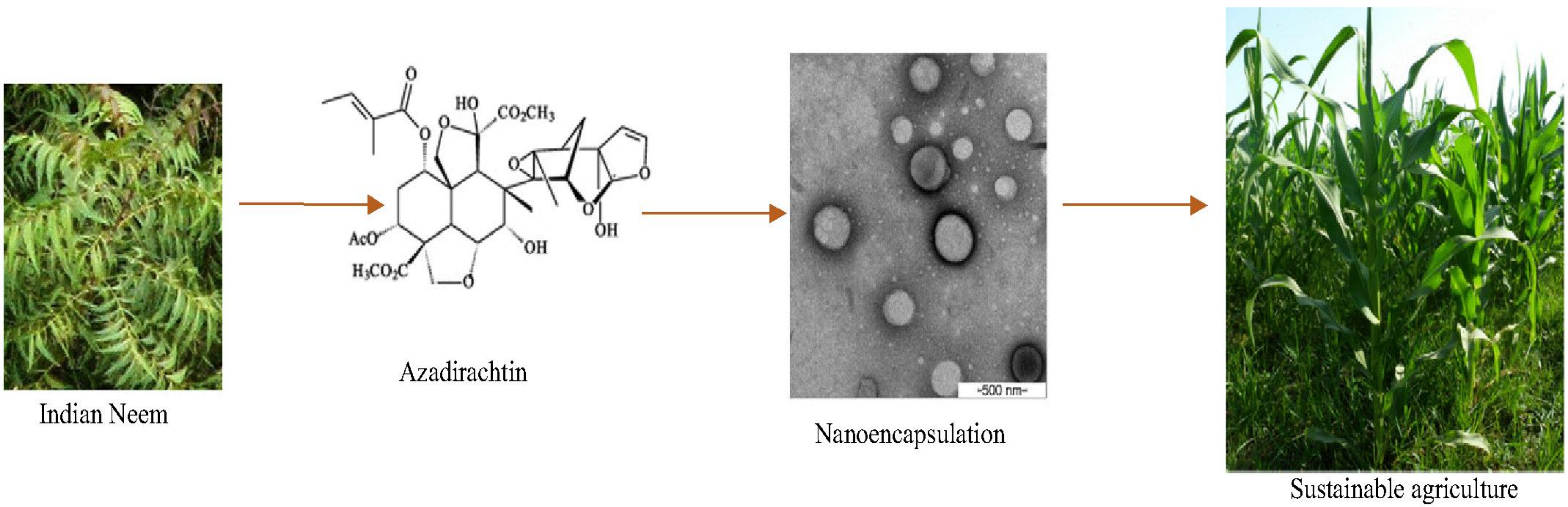
- **Exposure of Iron Nanoparticles to Arabidopsis thaliana Enhances Root Elongation by Triggering Cell Wall Loosening, Jae-Hwan Kim †, Yongjik Lee ‡, Eun-Ju Kim †, Sungmin Gu ‡, Eun Ju Sohn ‡, Young Sook Seo §, Hyun Joo An §, and Yoon-Seok Chang †* , Environ. Sci. Technol., 2014, 48 (6), pp 3477–3485, DOI: 10.1021/es4043462**

FeNPs

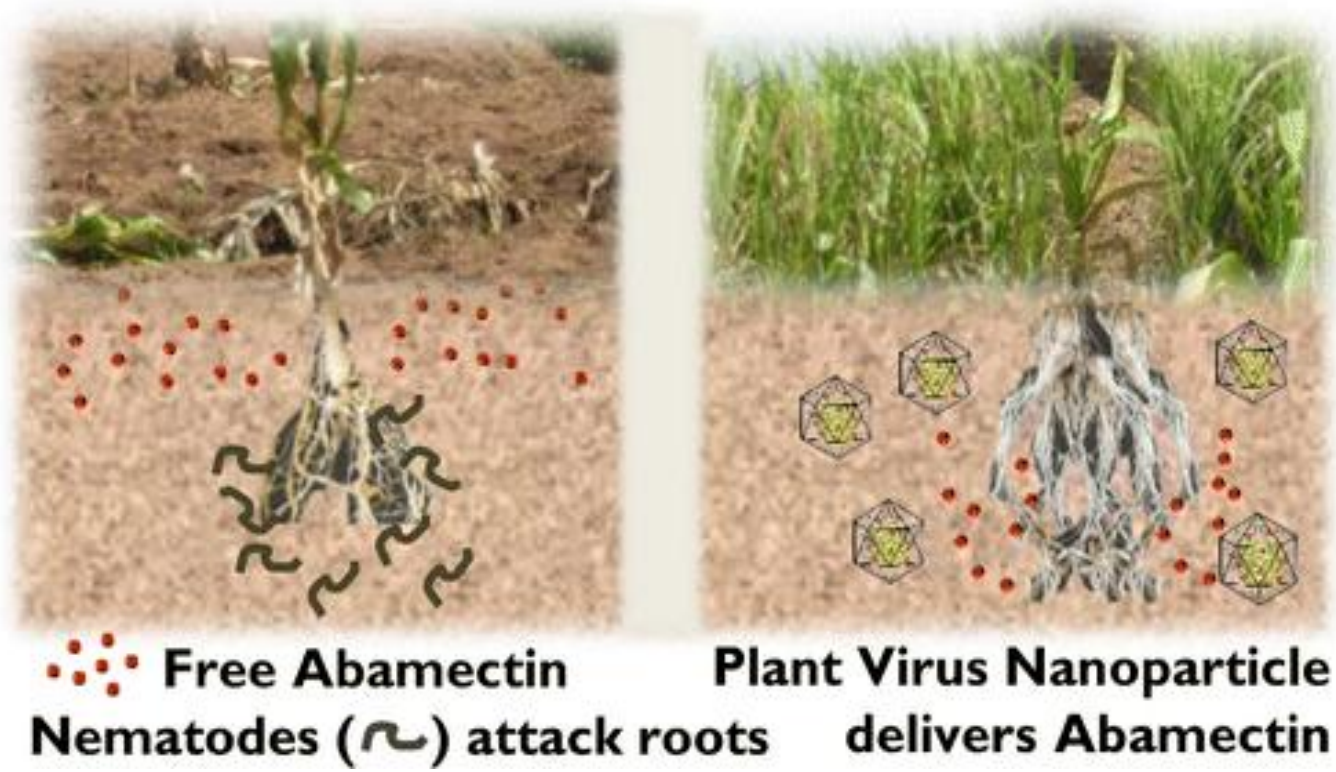


REVIEWS- HOW NANOPARTICLES AS FERTILIZERS

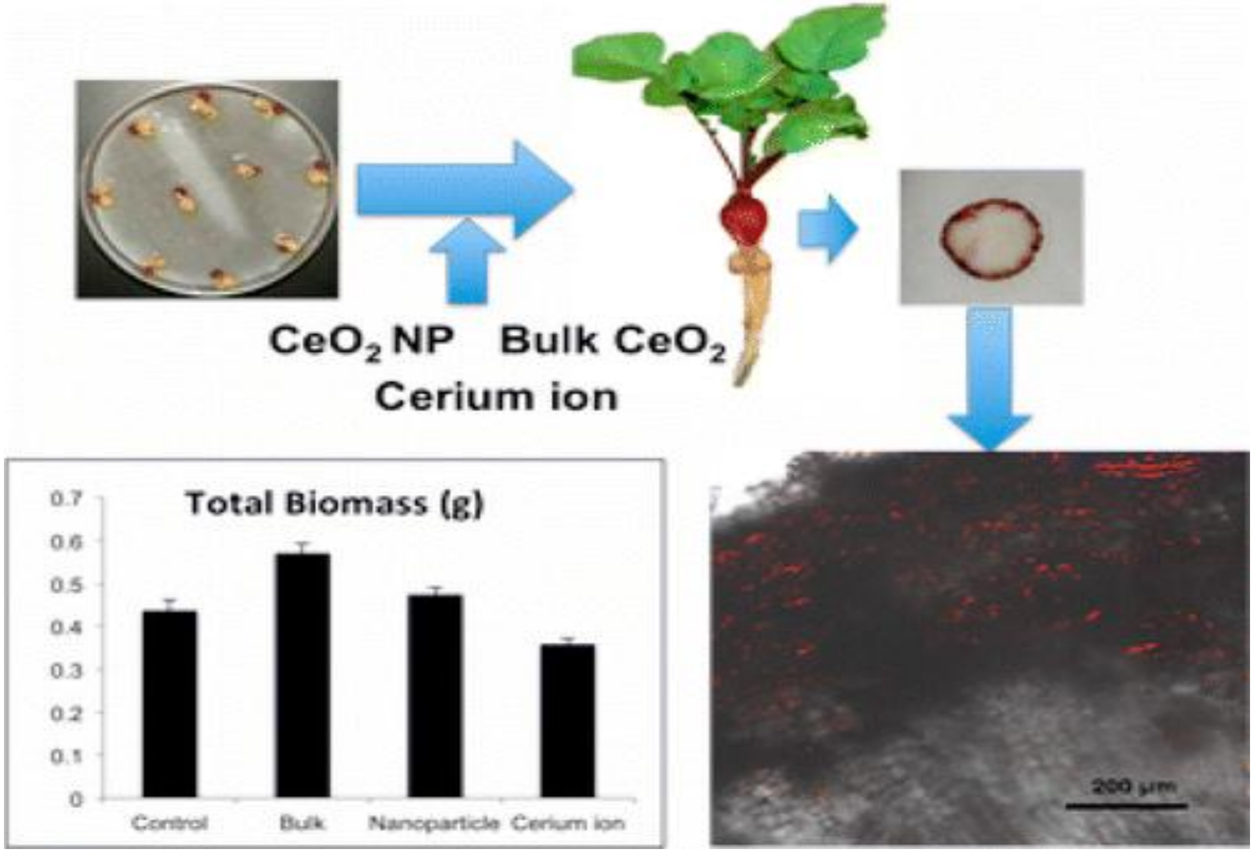
- **Application of nanotechnology for the encapsulation of botanical insecticides for sustainable agriculture: Prospects and promises, Jhones Luiz de Oliveira a,1, Estefânia Vangelie Ramos Campos a,b,1, Mansi Bakshi c, P.C. Abhilash c, Leonardo Fernandes Fraceto a,b, Biotechnology Advances 32 (2014) 1550–1561.**



- **Development of Abamectin Loaded Plant Virus Nanoparticles for Efficacious Plant Parasitic Nematode Control, Jing Cao †, Richard H. Guenther ‡, Tim L. Sit ‡, Steven A. Lommel ‡, Charles H. Opperman ‡, and Julie A. Willoughby *† , ACS Appl. Mater. Interfaces, 2015, 7 (18), pp 9546–9553, DOI: 10.1021/acsami.5b00940**



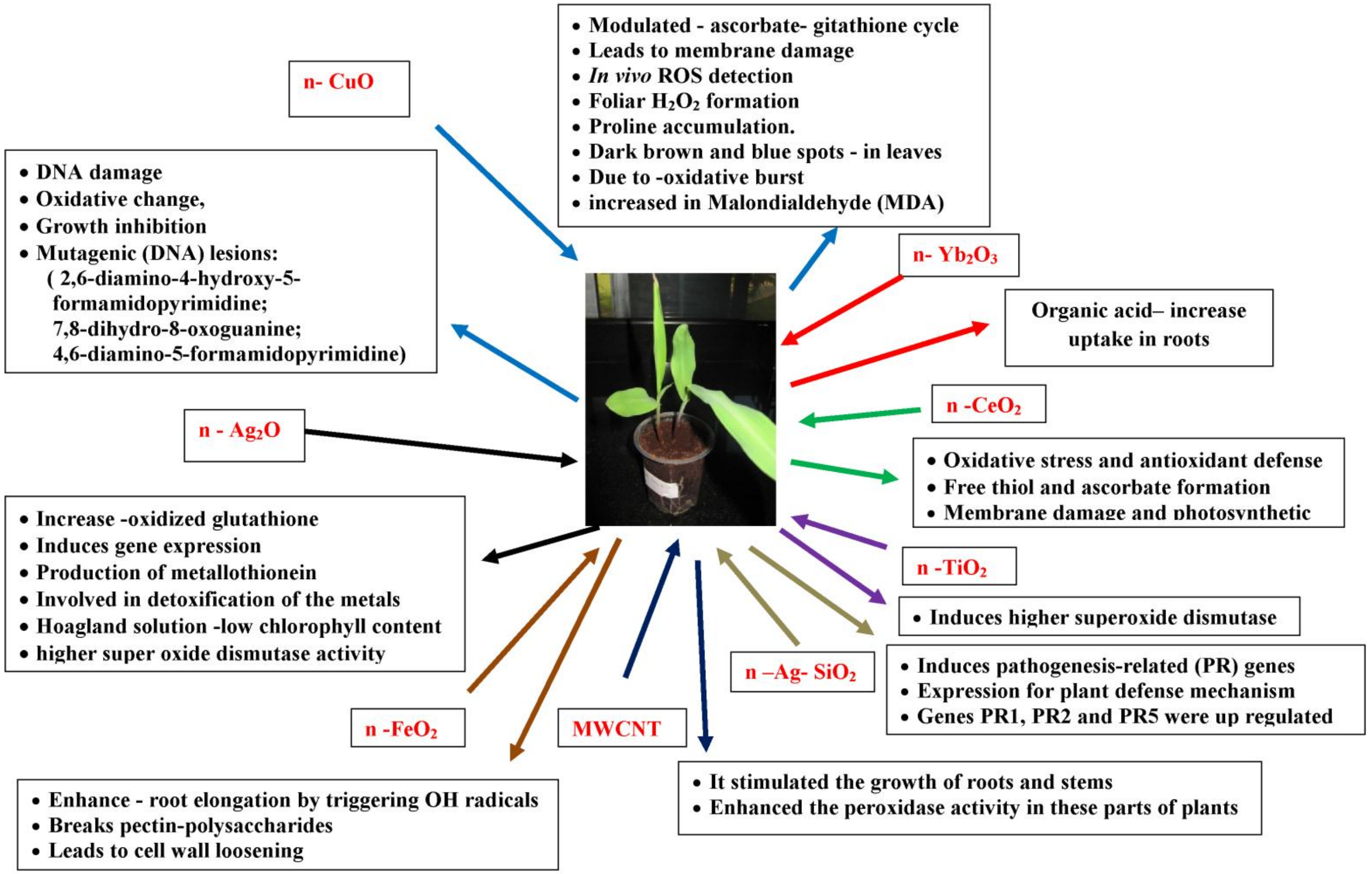
- **Uptake and Accumulation of Bulk and Nanosized Cerium Oxide Particles and Ionic Cerium by Radish (Raphanus sativus L.), Weilan Zhang †, Stephen D. Ebbs ‡, Craig Musante §, Jason C. White §, Cunmei Gao †#, and Xingmao Ma *†, J. Agric. Food Chem., 2015, 63 (2), pp 382–390, DOI: 10.1021/jf5052442**



REVIEW – CONCLUSION

- **Nanoparticles exhibits different ways of application in Agriculture**
- **It expands our knowledge in the filed of agriculture**
- **But still the complete mechanisms and importance about the use of metal and metal oxide is not enough**
- **It clearly defines a new area of research**
- **It also shows that further research is required in this field**

- **New Smart fertilizer based on nanomaterials is an emerging and promising area of upcoming research: A review, Gopalu Karunakaran, Alexander Gusev, Arup Ratan Mandal and Denis Kuznetsov (Under preparation)**



FUTURE WORK

- **2015 (01.11.2015 –01.12.2015)**

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- ✓ 1.8 Development and experimental validation techniques for the synthesis of metal and oxide NPs with specified physical and chemical properties

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  National University of Science and Technology "MISIS“
- Vice-rector –**Prof. Dr. M. R. Filonov**
  National University of Science and Technology "MISIS“
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- Personal – My Family members and Friends

Thank you