NANOTECHNOLOGY IN AGRICULTURE

DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY

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“KEY ENABLING TECHNOLOGIES” (EUROPEAN COMMISSION - 2012)

INDUSTRIAL REVOLUTION	1700s
NUCLEAR ENERGY REVOLUTION.	1940s
GREEN REVOLUTION	1960s
INFORMATION TECHNOLOGY REVOLUTION	1980s
BIOTECHNOLOGY REVOLUTION	1990s

Nanotechnology, deals with the matter at nanoscale (1-100 nm), is commonly referred as a generic technology that offers better built, safer, long-lasting, cost effective and smart products that will find wide application n household, communication, medicine, agriculture and food industry etc.

It is an emerging and fast growing field of science which is being exploited at a wide spectrum of disciplines such as physics, biology, material sciences, electronics, medicine, energy, environment and health sectors.

Materials reduced to nanoscale show some unusual properties which is different from what they exhibit on macro scale, leading to unique applications.

Precision farming

Agriculture are the basis of providing food, feed, fiber, fire and fuels. In the future, demand for food will increase tremendously while natural resources such as land, water and soil fertility are limited. The cost of production inputs like chemical fertilizers and pesticides is expected to increase at an alarming rate due to limited reserves of fuel such as natural gas and petroleum.

precision farming is a better option to reduce production costs and to maximize output, i.e. agricultural production. The process of maximizing crop yields and minimizing the usage of pesticides, fertilizers, and herbicides through efficient monitoring procedures is referred to as precision farming

Nanotechnology holds the promise of controlled release of agrochemicals and site targeted delivery of various macromolecules needed for improved plant disease resistance, efficient nutrient utilization and enhanced plant growth Nanotechnology based products and its application in precision agriculture include nano-fertilizers, nano-herbicides, nano-pesticides, nano-scale carriers, nano sensors, detection of nutrient deficiencies etc. this fast growing technology is already having a significant commercial impact, which will certainly increase in the future.

Synthesis of nanoparticles

Chemical, physical, aerosol and biological methods including chemical reduction in aqueous or non-aqueous solution, micro emulsion, template, microwave assisted.

Physical synthesis include sedimentation process, rotor speed ball mill, high energy ball mill and pot mill. For example phosphorus (P) nanoparticles are prepared by purifying rock phosphate and grinding with high energy mill.

Chemical method include precipitation and poly vinyl pyrolidine (PVP) techniques. Basically, the physical methods have affected low yields, while the chemical ones caused harmful effects on the environment due to use of toxic solvents and the regeneration of hazardous byproducts. Different biological sources have been used for the synthesis of nanoparticles and are being used in agriculture for precision farming.

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- Silver nanoparticles, Zinc Oxide nanoparticles, Titanium dioxide nanoparticles.

- Microorganisms have been explored as potential bio-factories for synthesis of metallic Nanoparticles such as cadmium sulphide, gold, and silver.

- Biological nanoparticle can be prepared by selecting microorganism to grow in a particular salt solution after preparation of microbial balls. Fungal mediated biosynthesis of nanoparticles.

- Biosynthetic methods have been investigated as an owing to ecofriendly environment concern and reduced agglomeration.

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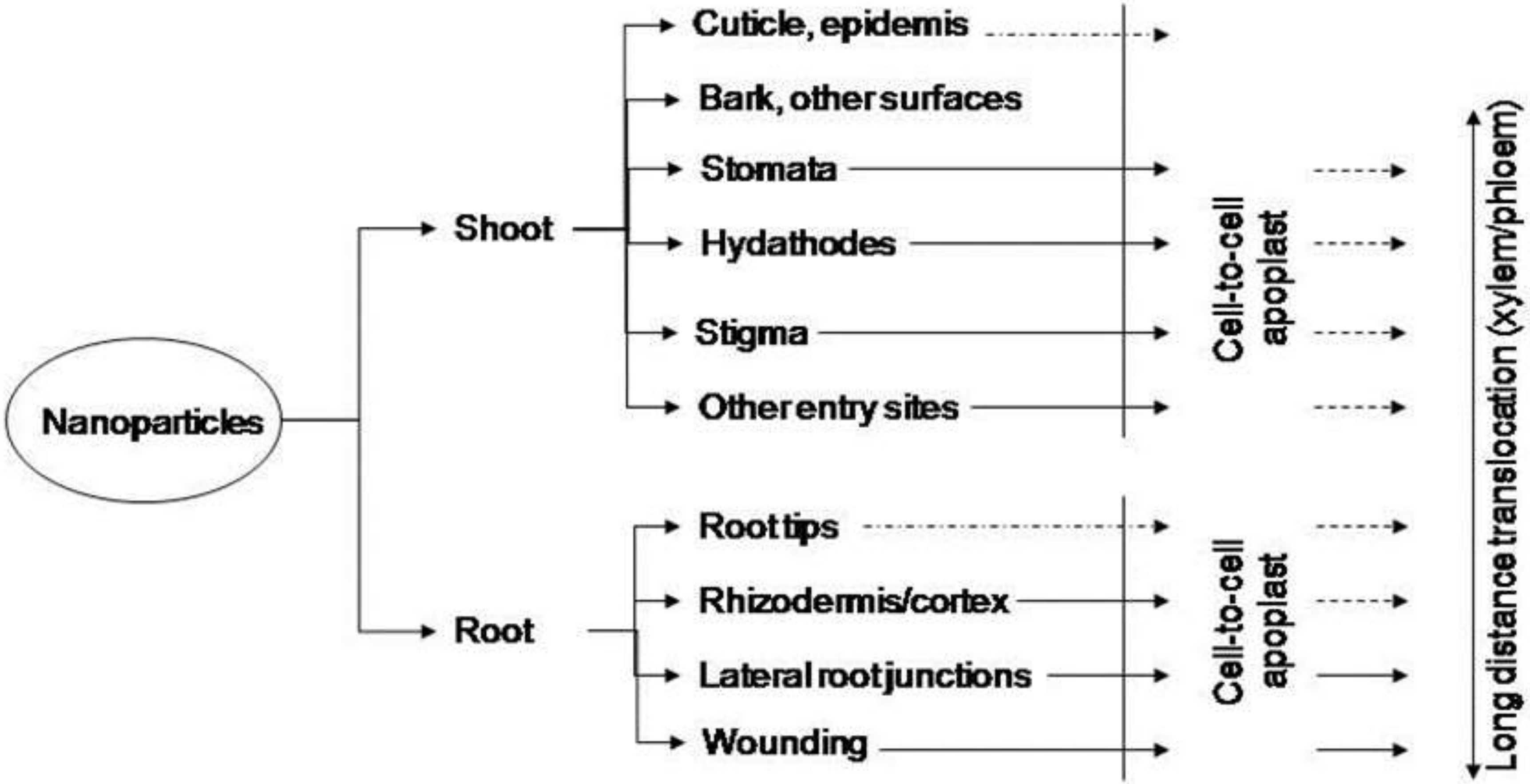
Uptake of nano-particles in plant system



- Nanoparticles are adsorbed to plant surface and taken up through natural nanometer plant opennings.

- Several pathways exist or predicted for nanoparticles association and uptake in plants.

- Nanoparticle uptake into the plant body can use different paths.

- Uptake rates will depend on the size and surface properties of the nanoparticles. Very small sizes nanoparticles can be penetrate through cuticle.

- Larger nanoparticles can penetrate through cuticle-free areas, such as hydathodes, the stigma of flowers and stomata’s. Nanoparticles must traverse the cell wall before entering the intact plant cell protoplast.

- Result suggests that only nanoparticle less than 5 nm in diameter will be able to traverse the cell wall of undamaged cell efficiently.

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Application of nanoproducts in precision agriculture

Plant germination and growth

Seed is a basic input which decide the fate of productivity. Traditionally, seeds quality is determined by their germination percentage. Despite recording higher germination percentage (80-90%) in laboratory, seeds shows lower germination percentage in fields. In recent years, various researchers have studied the effects of nanomaterial's on plant germination and growth with the goal to promote its use for agricultural applications.

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Zheng *et al*. (2005) studied the effects of nano and non-nano TiO_2 on the growth of naturally-aged spinach seeds. It was reported that nano-TiO_2 treated seeds produced plants that had 73% more dry weight, three times higher photosynthetic rate, and 45% increase in chlorophyll a formation compared to the control over germination period of 30 days. The growth rate of spinach seeds was inversely proportional to the material size indicating that smaller the nanomaterial's the better the germination.

The key reason for the increased growth rate could have been the photo-sterilization and photo-generation of "active oxygen like superoxide and hydroxide anions" by nanoTiO_2 that can increase the seed stress resistance and promote capsule penetration for intake of water and oxygen needed for fast germination.

The authors concurred that the nano size of TiO_2 might have increased the absorption of inorganic nutrients, accelerated the breakdown of organic substances, and also caused quenching of oxygen free radicals formed during the photosynthetic process, hence increasing the photosynthetic rate.

Khodakovskaya *et al*. (2009) at university of Arkanasas, USA, used carbon nano-tube for improving the germination of tomato seeds. The reason for the result is that carbon nano tube served as new pore for water permeation by penetration of seat coat and act as gate to channelize the water from the substrate in the seeds. This method can be utilized in rainfed ecosystem.

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Reference:

Mohsina Anjum and Satya Narayana Pradhan, Application of nanotechnology in precision farming: A review, Int. J. Chem. Stu. 6 (2018) 755-760.