

Chapter 8

Nanotechnology Applications for Sustainable Crop Production

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ABSTRACT

Innovations in nanotechnology revolutionized the world in all sectors, including medicine, biotechnology, electronics, material science, energy sectors etc. In fact, the existing literature also points towards the potential application of nanotechnology in global food production and alarming situation of food scarcity. With the advancement of nanotechnology, use of nanofertilizers for yield enhancement, nanopesticides for insect pests and disease control and nanosensors to monitor soil and plant health becomes one of the most fascinating and promising lines of investigation to achieve sustainability. Furthermore, nanobiotechnology application enables gene transfer to expand the genetic base of crop varieties against different biotic and abiotic stresses. Some lacunas which may resist commercialization of nanotechnology are cost, industrial setup, and public attitude towards the health and food safety issues. Sincere attempts are required to answer these questions and develop suitable strategies to solve any problems, we might encounter in near future.

INTRODUCTION

Rise of human civilization was started with agriculture and cultivation of crops nurtured the development of human society. In developing countries, agriculture is known as the backbone of the national economy, as their livelihood depends on agriculture (Brock et al., 2011). Unfortunately, current agriculture is plagued by many problems; some of them are natural and some others are manmade. Food security with ever increasing population, limited availability of land and water, changing climate, pest and disease incidence and accumulation of pesticides and fertilizers in food stuffs are the biggest global challenges. In view of this, different technological innovations like synthetic pesticides, hybrid seeds,

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fertilizers, high yielding varieties and transgenic were developed to boost the current agriculture system worldwide. These practices felicitates via enhancing agriculture productivity, by precisely using the same inputs and conserving soil and water resources (Prasad et al., 2012). However, extreme reliance on these innovations has many side effects as well. Problems using improper fertilization involve micronutrient imbalance, nitrate pollution and eutrophication (Savsi, 2012). Similarly, heavy pesticide application made agriculture sector paralyzed with serious problems, i.e. death of non-target organisms, pesticide resistance, bio-magnification and other human and environmental health hazards. Genetically Modified (GM) crops are one of the greatest attempts to minimize chemical treatments. Unfortunately, pests may also develop resistant against GM crops, as they have already developed resistance to many pesticides. Furthermore, environmentalists suspect novel genes may trigger unknown side effects with more severe, long-standing ecological and economic consequences. High yielding crop varieties are more prone to pest and diseases because of their narrow genetic base. Each of these modern agriculture innovations, except new strains of plants is totally reliant on the energy resources, especially petroleum. Global petroleum production is predicted to arrive at a maximum in the coming decades and to decline thereafter, a phenomenon known as peak petroleum. (Frumpkin et al 2009). The world's population is projected to reach 8 billion by 2025 and 9 billion by 2050, which could place an unprecedented pressure on the global food system (Sekhon, 2014). This situation calls the production of an additional 1 billion tones of cereals and 200 million tones of meat annually (Ghasemzadeh, 2012). Furthermore, the rising demand for meat puts huge pressure on agricultural land because farmers need to grow crops to produce animal feed (Sekhon, 2014). In view of the facts described above, there is an urgent need to conserve the natural resources along with sustainable agriculture production, so that negative effects on environment will be minimized (Densilin et al., 2011). In this context, nanotechnology has a remarkable potential to revolutionize agriculture and allied fields by target farming that involves the use of nano-sized particles with unique properties to enhance crop and livestock productivity (Batsmanova et al., 2014; Scoot and Chen, 2014). Nanotechnology is one of the most promising approaches for sustainable agriculture with high crop productivity, limited deterioration of natural resources and ability to feed the world's rapidly-growing population (Anonymous, 2009). The term "nano" is adapted from the Greek word "nanos" meaning "dwarf." A nanometer, thus, is one billionth of a meter. Particles have at least one dimension between 1 and 10 nanometers are considered as "nanoparticles" (Thakkar et al., 2010). The name nanotechnology describes diverse technologies performed on a nanometer scale with extensive applications in medicine, biotechnology, electronics, material science, agriculture, and energy sectors (Shekon, 2014; Parisi et al., 2014). It has been emerged as one of the most exciting areas of science and technology with promising applications in agriculture, including the targeted delivery of genes, fertilizers, pesticides and phytohormones (Torney et al., 2007; Melendi et al., 2008; Chen and Yada, 2011; Ghormade et al., 2011; Khot et al., 2012; Campos et al., 2014; de Oliveira et al., 2014). Applications of nanotechnology in modern agriculture have large impact on human life through the development of nano particles for better seed germination and seedling growth (Raskar and Laware, 2014), nanofertilizers for controlled release of nutrients (Naderi and Shahraki, 2013), nanocapsules for herbicide delivery (Grillo et al., 2013), nanosensors for pesticide detection (Menon et al., 2013), encapsulation of botanical insecticides (De Olveria et al., 2014) etc. Nanoparticles based agrochemical formulations enables slow release of the active ingredient and extension of its duration of action (Kah et al., 2013; Kah and Hofmann, 2014). As compared to conventional formulations, additional benefits associated with the use of nanoformulations are better protection against untimely degradation and improved uptake of the active ingredient, thus allowing reductions in pesticides dosage, application frequency and environmental

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