Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 06 (NOV-DEC, 2022)
Available online at http://www.agriarticles.com

Nanotechnology and It's Applications in Wheat

([*]Himansuman, Parul Gupta, Aavdhoot B. Dharmadhikari and Himanshi Jhalora)
Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, 313001
[*]Corresponding Author's email: himansuman.bhalothia@gmail.com

Wheat (*Triticum aestivum*) is main staple food grain crop, grown in a range of environments over an area of 224.49 million hectares (M ha) with an annual production of 792.40 million metric tons. (USDA, 2021). In India, it is grown in area of 31.76 million hectares with production of 109.52 million tones and productivity of 3508 kg/ha. Despite of this significant growth, the world population in some parts is still facing hunger crisis due to insufficient availability of food grains. To meet the future food demands imposed by overwhelming increasing population which is expected to reach nine billions in 2050, the world wheat production must continue to increase by 2% annually. This challenge of increasing wheat production is daunting as the wheat cropping system at present is constrained by climatic fluctuations, poor soil health and has increased risk of epidemic outbreak of diseases and insect-pests. To address these challenges, innovative technologies with a potential of increasing the sustainability of the present day cropping systems are required to be introduced in modern agriculture. Among these technological advancements, nanotechnology is gathering significant contemplations due to its wide spectrum applications in agriculture and allied sectors. It has a wider application in the field of crop production, food security, sustainability and climate change and is being utilized for developing several precise tool sets like nanofertilizer, nanopesticide, nanoherbicide, nanosensor and smart delivery systems for controlled and sustained release of agrochemicals. Recent research evidences indicated that intervention of nanotechnology in wheat farming is still in its early stages, although have bright prospects for efficient nutrient utilization through nanoformulations of fertilizers, breaching yield barriers through bionanotechnology, surveillance and management of pests and diseases and development of new-generation pesticides etc.

Nanotechnology at a glance

The study of the properties of structures smaller than 100 nano-meters (nm) is called as "nano-science", and designing and development of such structures in this size range alongwith their applications in a particular field is referred as Nanotechnology. The Royal Society defines nanotechnology as the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale (RSRAE, 2004). In nanotechnology, prefix "nano" comes from Greek word "dwarf". Several nanomaterials like nanoporous zeolites, nanocapsules, nanosensors and carbon nano tubes have the tremendous potential to protect host plants from biotic and abiotic stresses. Recent evidences indicated that wheat is sensitive to climate change due to direct effects of changes in temperature, precipitation and carbon dioxide concentrations, and also due to indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases.

Applications and effects of nanotechnology in wheat

Nanotechnology holds immense potential in wheat farming. Several studies showed that nanotechnology play vital role in alleviating stress-induced alterations in plants. The possible use of nanotechnology includes delivery of nanocides, nanomaterials encapsulated pesticides, for controlled and targeted release, as well as the stabilization of pesticides with nanomaterials. The impact of nanotechnology on wheat growth and development is gaining remarkable contemplation due to its potential to improve seed germination, growth and wheat protection through the controlled release of agrochemicals, with the ensuing reduction in the amounts of agrochemicals applied and the minimization of nutrient losses from fertilizer application during wheat cultivation.

Nanoparticles (NPs) containing essential metals are considered in formulations of fertilizers to enhance plant nutrition in soils with low metal bioavailability. However, in various studies researchers have reported that multi-walled-carbon nanotubes (MWCNTs) have a magic ability to influence the seed germination and plant growth. They induce the water and essential Ca and Fe nutrients uptake efficiency that could enhance the seed germination and plant growth and development. A novel and biocompatible hydrated graphene ribbon (HGR) could promote germination of aged wheat seed and enhance resistance to oxidative stress. The metabonomics analysis indicated that HGR could upregulate carbohydrate, amino acid, and fatty acids metabolism that determined secondary metabolism, nitrogen sequestration, cell membrane integrity, permeability, and oxidation resistance. Titanium dioxide nanoparticles (nTiO2) are promising as efficient and beneficial nutrient source for plants to improve biomass production due to enhanced nitrogen assimilation, photoreduction activities of photosystem II and electron transport chain, scavenging of reactive oxygen species. It is clear that the applications of nanotechnology in wheat breeding are gradually moving from the theoretical possibilities into the applicable area and will play an important role in improving the existing wheat status in future.

Future challenges and directions

The integration of nanotechnology with wheat farming has immense potential to cope with global challenges of food production, sustainability and climate change. However, despite the emerging picture of potential applications of nanotechnology in wheat improvement so far, their relevance has not reached up to the field conditions. Hence, there is a need to make extensive and focussed research efforts on following directions.

- Nanotechnology can have both positive and negative impact on agro-ecosystem. Therefore, it is necessary to vigilantly study the relationship of NPs and wheat microbiome. Further, in order to understand the interaction of NPs with the different molecules that are present in plant cells, studies on the analysis of any changes in gene expression under the influence of nanoparticles are also necessary.
- Nanotechnology can provide tools to fine tune the properties of wheat plant, their productivity and tolerance to biotic and abiotic stresses. Hence, a clear picture of the interaction of different nanomaterials with wheat crop and their mechanism for genetic and molecular modification are required to be explored.
- Experimental validation of the permissible limit of use of nanoparticles dosage within safety limits need to be clarified. The interaction of nanomaterials with plants differs with the type of NPs, the applied concentration of NPs, the time of treatment, the plant genotype and the stage of development etc. So, these facts should be kept in mind while performing nanotoxicity studies and selection of permissible level together with studying transgenerational and trophic chain transfer effects.

- Research on nanosensor is of high value for rapid diagnosis and effective pest management. Therefore, it will be interesting to explore the application of nanosenors for sensing wheat pests in fields and in grain storage structures.

Conclusion

Despite of these potential benefits, the application of nanotechnology in wheat improvement could come with risks for the environment non-target plants, beneficial soil microbes and other life forms which could be affected if nano-materials are misused. Therefore, a better understanding of the agro-ecological consequences of nanotechnology, especially it relates to dose response, release of ions, and nanoparticle specific effects of mineral nutrients is important to fully harness its promised benefits as nano-formulation applications.

Presently, no knowledge base so far exists for the transformations and bioavailability of nano-particles to plants and organisms in soils. There is a pressing need exists to elucidate the basic properties of nano-particles and different processes that govern their fate in soil and plant and, their bioavailability. This understanding will help us to reap the benefit of nanotechnology without producing adverse ecological consequences.