INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

BENGALURU

EVALUATION OF RKVY PROJECTS

OF

UNIVERSITY OF AGRICULTURAL SCIENCES,

RAICHUR

"CENTRE FOR NANOSCIENCE AND NANOTECHNOLOGY IN ENHANCING QUALITY OF AGRICULTURAL PRODUCE"

INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

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CENTRE FOR NANOSCIENCE AND NANOTECHNOLOGY IN ENHANCING QUALITY OF AGRICULTURAL PRODUCE

EXECUTIVE SUMMARY

Agriculture is always most potentiated and stable sector because it produces and provides raw materials for food and feed industries. Due to the increasing world population, increased nutrient mining, for increase the total food grain production, shrinking arable lands, restricted water availability, deteriorating soil organic matter, climate change and so many other reasons, it is necessary to use the advance technologies.

The term "Nanotechnology" has been defined as the branch of the science that deals with the understanding and control of matter at the dimensions of about 1-100 nm by the US Environmental Protection Agency. It includes controlling, building and restructuring of the devices and other materials of physical, chemical and biological features at nanoscale level, i.e., on the scale of atoms and molecules (a nanometer (nm) is one billionth (10^{-9}) of a meter). The functionality can be added to nanoparticle by interfacing them with biomolecules or structures (Tejpal Dheva, 2015).

Nanotechnology is an integration of different range of applied sciences such as chemistry, physics, biology, medicine and engineering in which the structure of the matter is controlled at the nanometer scale to produce materials having unique properties such as high surface area, target site of action and slow release.

Although the scientific studies on the applications of nanotechnology in agriculture are less than a decade old yet the prospects of nanotechnology in this field are considerable. The rapid developments in the nanosciences have a great impact on agricultural practices and food manufacturing industries. The significant interests of using nanotechnology in agriculture includes specific applications like nano fertilizers and nano pesticides to trail products and nutrients levels to increase the productivity without decontamination of soil, water and protection against various biotic and abiotic stresses. Nanotechnology may act as sensors for monitoring soil quality of agricultural field and thus it maintains the health of crops (Prasad et al., 2017). Nanotechnology will transform agriculture and food industry by innovation of new techniques such as precision farming techniques, enhancing the ability of plants to absorb nutrients, more efficient and targeted use of inputs, disease detection and control diseases. Increase the nutrient use efficiency of applied fertilizer with the help of nano clays and zeolites and restoration of soil fertility by releasing fixed nutrients. It also plays an important role in developing new generation of pesticides with the safe carriers. Nano herbicides are being developed to address the problems in perennial weed management and exhausting seed bank of weed. Levels of

environment pollution can be evaluated quickly and effectively by gas sensors and nano smart dust (Shaimaa and Mostafa, 2015). Nanotechnology has an enormous potential to offer smarter, stronger, cost-effective packaging materials, biosensors for the rapid detection of the food pathogens, toxins and other contaminants or food adulterants., preservation and packaging of food and food additives, strengthening of natural fibre, removal of various contaminants from the soil and water bodies by using functionalized nanoparticles and improving the shelf-life of the vegetables, flowers and fruits.

In recent years, some devices and tools developed by nanotechnology such as nanodevices, nano capsules etc., are being used to detect and treat the plant diseases, delivery of active components to the desired target sites, treatment of waste water and also to enhance the absorption of nutrients in plants. The targeted delivery of nanoparticles not only reduces the damage to non- target plant tissues, but also minimizes the amount of harmful chemicals that pollutes the environment. Hence, this technology is not only eco-friendly but also helps in reducing the environmental pollutants. There are some specific nanoproducts that have been developed for using as soil-enhancer products which promote the even distribution of water and storage. Thus, useful in water saving. Besides, some of the important developments in production of nanotechnology products like nanomaterials, nanostructures, nanofibers, nanotubes, etc. with unique physical, mechanical and chemical properties which make them electrochemically active. Such devices play vital role in plants and animal breeding (Prasanna, 2007), genetic engineering and also have been applied in biochemical sensors due to rapid response along with high sensitivity.

Nanomaterials can also be used in delivery of nutrients and pesticides in the plants (Srilatha, 2011), analysis of soil samples and waste water treatment. Agricultural wastes have attracted their uses as raw materials for the production of nanomaterials. Several efforts have been taken to obtain the nanocomposites based on biomaterials. The productions of nanocomposites are more sustainable and have beneficial properties as compared to the conventional materials such as micro composite and macro composite materials.

Nanocentre

Nano particles are tiny materials having size ranges from 1 to 100 nm. They can be classified into different classes based on their properties, shapes or sizes. The different groups include fullerenes, metal nano particles, ceramic nano particles and polymeric nano particles. Nano particles possess unique physical and chemical properties due to their high surface area and nanoscale size. Their optical properties are reported to be dependent on the size which imparts different colors due to absorption in the visible region. Their reactivity, toughness and other properties are also dependent on their unique size, shape

and structure. Due to these characteristics, they are suitable candidates for various commercial and domestic applications, which include catalysis, imaging, medical applications, energy-based research and environmental applications. Heavy metal nano particles of lead, mercury and tin are reported to be so rigid and stable that their degradation is not easily achievable, which can lead to many environmental toxicities.

Nanotechnology is a demanding field of research where new inventions and technologies are emerging. Synthesis, characterization and application are the common routes of study in nanomaterial research. To apply synthesized or derived nanomaterials like nanoparticles, nanocomposites, nanodevices, etc., they must first be characterized to gain an in-depth understanding of the properties and factors influencing their behavior. Nanomaterial characterization is a wide, complex field of study because a large number of nanomaterials and characterization techniques are available. An understanding of the morphology, spectra, thermal and mechanical properties are always required to properly apply materials. Mechanical properties of nanomaterials are crucial in applications like electronic devices, sensors, composites, etc. The structural characteristics are of the primary importance to study the composition and nature of bonding materials. It provides diverse information about the bulk properties of the subject material.

Different characterization techniques have been practiced for the synthesis and analysis of various physicochemical properties of nano particles. These include techniques such as X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), infrared (IR), Scanning Electron Microscopy, Transmission Electron Microscopy, Brunauer–Emmett–Teller (BET), and particle size analysis. Mechanical milling, chemical etching, sputtering, laser ablation and electro explosion are some of the techniques used in synthesis of nano particles. While Scanning Electron Microscopy, Transmission Electron Microscopy are used to study the morphological characterization of nano particles, X-ray diffraction technique is used for study of structural characterization. X-ray photoelectron spectroscopy (XPS), energy dispersive X-ray (EDX), Infra-Red, Raman Spectroscopy, Brunauer–Emmett–Teller (BET), and Zieta size analyzer are also the common techniques used to study structural properties of nano particles.

Any nanotechnology centre has to be fully equipped with various equipment for the synthesis and analysis of various physicochemical properties of nano particles.

Keeping the above in view, **"CENTRE FOR NANOSCIENCE AND NANOTECHNOLOGY IN ENHANCING QUALITY OF AGRICULTURAL PRODUCE"** was taken up by University of Agricultural Sciences, Raichur with Rashtriya Krishi Vikas Yojana funding. The project was implemented during 2016-17. The details of the project are as under:

1.	**Title of Project**	**:**	**"CENTRE FOR NANOSCIENCE AND NANOTECHNOLOGY IN ENHANCING QUALITY OF AGRICULTURAL PRODUCE"**
2.	**Nodal officer and Principal Investigator**	**:**	**Dr. Sharanaguda Hiregoudar,** Asst. Professor, Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur
3.	**Implementing Institution (S) and other collaborating Institution (s)**	**:**	Departments of Entomology, Microbiology, College of Agricultural Engineering, Raichur
4.	**Date of commencement of Project**	**:**	2016-17
5.	**Approved date of completion**	**:**	2016-17
6.	**Actual date of completion**	**:**	2016-17
7.	**Project cost**	**:**	Rs. 65 lakhs

The objectives of the project are as follows:

1. Strengthening of Centre of excellence Nano Science and Technology laboratory.
2. Development of nutrient based food product.
3. Studies on preparation and characterization of release characteristics of insecticides and herbicides in nano and nano encapsulated forms following standard operating procedure (SOP).
4. Development of nano material-based purification for improving the quality of the water.

The focus of Evaluation is:

i. To examine the strength of Centre for Nanoscience and Nanotechnology to take up studies relating to nanoparticles and to evaluate the utility of the Centre for Nanotechnology for enhancing the quality of agricultural produce.

ii. To evaluate the use of nanotechnology for development of nutrient based food products

iii. To evaluate the impact of insecticides and herbicides in nano and encapsulated forms on insects and pest activity.

iv. To evaluate the importance or role of nanoparticles in waste water treatment and purification of drinking water.

Nanotechnology have its relevance in numerous fields of science. Out of them few in agriculture and allied are food technology, crop improvement (genetic modified crops), seed technology, precision farming (site specific management), nano-fertilizer for balance crop nutrition, plant disease diagnose, weed management, water management, biosensors and pest management. Controlled Environment Agriculture (CEA) technology, as it exists today, provides an excellent platform for the introduction and utilization of nanotechnology to agriculture. With many of the monitoring and control systems already in place, nano technological devices for CEA that provide "scouting" capabilities improve the grower's ability to determine the best time of sowing and harvest for the crop, the vitality of the crop and food security issues, such as microbial or chemical deterioration (Allah, 2012).

Nanotechnology is a demanding field of research where new inventions and technologies are emerging. Synthesis, characterization and application are the common routes of study in nanomaterial research. To apply synthesized or derived nanomaterials like nanoparticles, nanocomposites, nanodevices, etc., they must first be characterized to gain an in-depth understanding of the properties and factors influencing their behavior. Nanomaterial characterization is a wide, complex field of study because a large number of nanomaterials and characterization techniques are available. An understanding of the morphology, spectra, thermal and mechanical properties are always required to properly apply materials. Mechanical properties of nanomaterials are crucial in applications like electronic devices, sensors, composites, etc. The structural characteristics are of the primary importance to study the composition and nature of bonding materials. It provides diverse information about the bulk properties of the subject material.

Different characterization techniques have been practiced for the synthesis and analysis of various physicochemical properties of nano particles. These include techniques such as X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), infrared (IR), Scanning Electron Microscopy, Transmission Electron Microscopy, Brunauer–Emmett–Teller (BET), and particle size analysis. Mechanical milling, chemical etching, sputtering, laser ablation and electro explosion are some of the techniques used in synthesis of nano particles. While Scanning Electron Microscopy, Transmission Electron Microscopy are used to study the morphological characterization of nano particles, X-ray diffraction technique is used for study of structural characterization. X-ray photoelectron spectroscopy (XPS), energy dispersive X-ray (EDX), Infra-Red, Raman Spectroscopy, Brunauer–Emmett–Teller (BET), and Zieta size analyzer are also the common techniques used to study structural properties of nano particles.

Any nanotechnology centre has to be fully equipped with various equipment for the synthesis and analysis of various physicochemical properties of nano particles. The Centre

for Nanoscience and Nanotechnology was established in University of Agricultural Sciences, Raichur with external funding from RKVY and also university funding during 2011. With all the equipment required for synthesis, characterization and applications of nano particles, the Centre for Nanoscience and Nanotechnology established in University of Agricultural Sciences, Raichur has developed into a full-fledged centre for studies relating to nano particles and also as a referral centre.

Work conducted on improving the food safety and providing nutrient, diet-based food product by developing Functional Foods and Nutraceuticals was mainly confined to improving the nutritional quality of spinach by application of nano zinc.

While the experiment has given encouraging results on use of nanoparticles for improving the food quality, there is need to evaluate their use in the food produced in the area rather than attempt crops which are not normally grown in the area. The very concepts of functional foods, nutraceuticals and food supplements are new in India and are yet to establish commercially even in urban areas in the country. With a vast majority of the population in the region living in rural and semi urban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.

Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. The most common pulse pests are the cowpea weevil (Callosobruchus spp.) and pea weevil (Bruchids pisorum). The cowpea weevil has a life span of 10–12 days while the pea weevil only breeds one generation per year. Pulse beetle (Pachymerus chinensis) mainly feeds on cowpea, pea, gram, arhar, soybean, beans etc. The damage is caused by the grubs by eating out the entire content of the grain, leaving only the shell behind. Attack of these beetles often stars in the fields from where it reaches the stores. Khapra beetle and Lesser grain borer feed on arhar, peas and urd. Under these circumstances, use of nano particles for managing stored pests is a welcome idea.

Studies undertaken for designing a Nano adsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. Nano adsorbents for various types of pollutants like BOD and COD, phosphate, sulphate and nitrate were used for effluent treatment. Nano adsorbents have shown reduction efficiency varying from 64% to 97%.

Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. The model has been

installed at Government school, Mavinamatti, Shahapur, Yadgir (Dist) in collaboration with IIT, Chennai for removal of arsenic from drinking water. This has immense commercial value and the University has already developed more than 100 filters and distributed to public.

REFLECTIONS AND CONCLUSIONS

1. The Centre for Nanoscience and Nanotechnology in University of Agricultural Sciences, Raichur has been well equipped with State-of-Art sophisticated equipment for synthesis, mechanical and structural characterization and synthesis of new nano encapsulated material. The Centre for Nanoscience and Nanotechnology has developed into a full-fledged centre for studies relating to nano particles and also as a referral centre.
2. The very concepts of functional foods, nutraceuticals and food supplements are new in India and are yet to establish commercially even in urban areas in the country. With a vast majority of the population in the region living in rural and semi-urban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.
3. Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. There is need to focus on this aspect as the region is the major pulse growing region in the State.
4. Final analysis and toxicity work with selected the insecticides for control of storage pests and study the storage losses including Malathion - Nano malathion, Fenvalerate - Nano Fenvalerate, Emamectin benzoate - Nano Emamectin benzoate, Thiodicarb - Nano Thiodicarb, Sweet flag - Nano Sweet flag and Neem seed kernel powder - Nano Neem seed kernel powder is under progress. This should be completed quickly and its commercial application should be taken up.
5. Studies undertaken for designing a Nano-adsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. This should pave way for use of the technology in treatment and reuse of waste water in urban areas.
6. Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. Commercial production of the filters should be taken up in PPP model.

ACTION POINTS

i. The equipment procured under the project are exemplary. However, their maintenance cost will be too high. Hence, it is better to convert the centre on

PPP mode and generate data as well as work efficiently and maintenance on self-sufficiency mode.

ii. With sophisticated equipment, it is essential to maintain them in efficient and workable conditions always. Hence, annual maintenance contract for servicing the equipment regularly and for supply of all consumables should be ensured.

iii. The use of some of the equipment requires use of radioactive materials. A suitable protocol in use of such equipment should be developed and should be on permanent display. Further, adherence to the laid-out protocol should be ensured by proper documentation when such an equipment is used to ensure human safety.

iv. The techniques of nano encapsulation of ingredients, additives and supplements are good but should be tested for food safety and FSSAI before releasing for commercialization.

v. The techniques of nano particles mixing for effective control of insect pests is a good move. However, its economics needs to be worked out.

vi. There is need for working out cost economics of use of nano silver particles and magnetic power used for purification of water and its safety as per FSSAI standards.

vii. Side effects on nano particles on human beings needs to be worked out.

viii. Studies undertaken for designing a Nano-adsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. This should pave way for use of the technology in treatment and reuse of waste water in urban areas.

ix. Water filtration system developed for removal of fluoride and arsenic should be taken up for commercial production of the filters in PPP model.

x. Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. There is need to focus on this aspect as the region is the major pulse growing region in the State.

xi. With a vast majority of the population in the region living in rural and semi-urban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.

RESEARCHABLE ISSUES

1. The work on nano silicon needs to be streamlined.
2. Patenting and uploading of nano technology are needed.
3. Development of nano microbial compounds for multi-purpose uses.