

# Application of Nanotechnology and Nano Materials in Agriculture

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## I. INTRODUCTION

Modern nanotechnology began in late twentieth century in 1981. This technology involves the understanding, control of matter as well as manipulation of substances at the nano-meter-scale. Nowadays nanotechnology is being used in many fields. It includes agriculture, modern branches of science, various industries, astrology, biotechnology etc. Even in agriculture, there is a lack of nanotechnology for many things. They are taking precautions to ensure that they do not adversely affect the environment by using nanomaterials as a supplement to agriculture for mass production. The target of application of nanomaterials is to perform Precision farming for mass yield and sustainable development in agriculture sector. Precision is new method of agriculture which concept of inputs of fertilizer, pesticides and crop protection to match the variation to growing conditions with field. Nanotechnology is used for various management, applications such as agrochemicals, waste management, target genetic engineering, labeling and imaging, plant growth and germination, DNA sequencing, microarray, sensing disease, nano-barcodes, controlling the quality and products, water management and many others Fields. This review based on application of nanotechnology and nano materials in agriculture. To address the increasing challenges of sustainable production and food security, significant technological advancements and innovations have been made in recent years in the field of agriculture

There two types of nano materials

1. Organic Nano Material
2. Inorganic Nanomaterials

### 1.1 Application of Nanotechnology in Agriculture

Singh Neelan (2020) released an article in Journal of botica research today. Content of article is based on Nanotechnology, Nanofertilizer, Bioremediation, Photocatalysis and other materials and methodologies. In India agriculture is source of livelihood, due to increasing mass population there is shortage of food. Agricultural science has undertaken many initiatives using new technologies to find solutions that are beneficial to agriculture and the environment. Today's nanotechnology reaches at various sectors like medicine, mechanical, national security and defense, energy and environment, advance material and textile, IT, biotechnology, aerospace, transportation, electronics as well. Then said about nanoscale carriers like chitosan, cellulose, liposomes, etc. Playing their role as drug delivery mechanism and control release encapsulation, entrapment. This mechanism work at specific proportion and target delivery. Target delivery giving safety to crops and target to pests and weeds in agriculture. Microfabricated xylem vessels this tools used against pathogen and disease also supports to suspend pathogenic agent. Clay nanotubes or halloysite are tool of pesticides carrier within less amounts. It has considered as cost effective method and get Nearly 70 to 80 saving. Photocatalysis is process which is done by photolytic chemicals boost metabolism rate and increasing body growth of plants also degrading many toxic chemicals and gives stability. Similarly in bioremediation nanoparticles are able to sense toxic substances and help to reduce them from plant body delivering environmental safety. Nowadays nanofertilizers are trend in agriculture sector. They are considered as best effective tool of nutrients, provide efficiency of nutrients at low scale and get more yield. As compared to ordinary fertilizers nanofertilizers are minute harmless for environment. Fundamentals role of nanomaterials could deliver revolution in the agricultural sector. Damage due to pests and diseases is now blocked by using nanotechnology .By applying nanofertilizers, Nano pesticides, nanoagrosensors in next current year's agriculture sector are able to produce mass production as well as gives better safety to the environment

### **1.2 Nanotechnology Application in Agriculture**

RL Manjunatha et al (2019) released an article in Journal of Pharmacognosy and Phytochemistry. Given article exploring information about Nano technological, Nanofertilizer and Nano herbicide for sustainable agricultural development. First of all they have been introduced various properties of pesticides. Then mentioned about Nanotechnology applications in agriculture and food production, including how in Nano-Agriculture, nano sensors are beneficial for Precision farming. Also they introduced role of micro capsulation & their working rate of releasing, especially in biotic DNA Nanocapsules used to hijacks cell mechanism. They have applied Nanotechnology in food systems & food security which links include farm inputs, farm production systems, post-harvest management and processing and finally markets and consumers. Then about delivery of pesticides and fertilizer which increase yield of agriculture and provide nourishment by control release mechanism and secure from pest without damage from leaching of soil. Applied Nano-herbicide for effective weed control which targeting the plant & damage to root system and further whole plant body. Excessive used herbicide disturbs the nature of soil and toxic it needed to reduce, for this residue silver nano particles used for Detoxification of herbicide. They come to conclusion, the use of nanomaterials for delivery is expected to reduce the dosage and ensure controlled slow delivery, because of unique properties of nanomaterials, has developed nanosensors capable of detecting pathogens. This all harmless nanomaterials can produce sustainable condition of agriculture

### **1.3 Lab-on-fruit skin and lab-on-leaf towards recognition of trifluralin using Ag-citrate/GQDs nanocomposite stabilized on the flexible substrate: A new platform for the electro analysis of herbicides using direct writing of nano-inks and pen-on paper technology**

Saadati Arezoo, et al (2020) released a research article in journal cell press Heliyon and open access at science direct, in this article they introduce nano technology related extraction techniques and develop nano sensor for agricultural use. In this methodology they synthesized Ag-citrate/ GQDs and applied on apple skin and leaf and named as three electrode sensor. This developed ink were evaluated using various spectroscopic instruments After analyzed under FE-SEM that micrograph images confirmed dot particles of graphene and shown correct arrangement of the polymer sheets. This designed electrodes were dried at normal temperature and used. Ag citrate is excellent catalyst for enhancing electrical signal in the nano-ink. In that process this ink structure were recognize and conductivity resistance checked. Afterward electrodes applied and evaluate SWV and CV, DPV by chemical method. On the basis of three electrodes system has capability to be used on-site analysis of other given synthesized herbicides. In future this technique will help to detection trifluralin on the surface of apple skin at large scale quantity

### **1.4 Nanoparticles in Agroindustry: Applications, Toxicity, Challenges and Trends**

Luis A. Paramo et al (2020) published research paper in nanomaterials MDPI as open access. This article exploring detail about nanotechnology, nanoparticles, agriculture, metabolomics. Nano technological hybrid manipulated chemicals are enhancing agro production although some aspect have it to make nano technology badly affected crops. At higher concentration can generate the topical effect. Several carbon, ceramic (metal oxides), metal, and polymeric based nano materials have different characters. Where excess concentration and remaining quantity can affect to organisms and without care can lead to a series of issues to the plants, animals, and finally to humankind. They mentioned about production of titanium dioxide ( $\text{TiO}_2$ ) which further produce of  $\text{CeO}_2$ ,  $\text{FeOx}$ ,  $\text{AlOx}$ ,  $\text{ZnO}$  NPs, and carbon nanotubes large scale in European region. This high concertation can leading into some morphology, metabolomics, and genetic modifications in agricultural crops. They mentioned about Nano-toxicology, its miss interaction to non-targeted element or organism and affect particular poisonous effect to the plants. This nano chemicals offering some advantages but still disadvantages to be notice. For promotion of quantity of secondary metabolites elicitors are the good agents for different kind of production. It Concludes, there will be a demand for nanotechnology manipulated particles until the adverse effects are realized.

### **1.5 Green Synthesis of Nanofertilizer and Their Application as a Foliar for Cucurbita pepo L**

Shebl Ahmed et al (2019) released an article in Hindawi Journal of Nanomaterials. An article delivers information about synthesis of nano-fertilizers, applications. For increasing demand of blessed and sustainable agriculture, respect to worldwide 8 billion population agricultural nontechnical fertilizers for growth make place between farming style. By using microwave-assisted methodology hydrothermal method Ferric, manganese, and zinc nitrate set as precursor and extract monoxide fertilizers.

This nano particles recognized under TEM instruments and remove moisture content of extracts. These nano oxides synthesized from green chemistry technique using a microwave-assisted hydrothermal method, nano oxide fertilizer analyzed on squash plant that is *Cucurbita pepo l* and growth result were recorded. Recorded result is taken on the basis of vegetative growth parameters such as photosynthetic pigments, Proximate Analysis, Mineral Determination, Statistical Analysis etc. were level up as compare to other non-nourishing control plants. Treated of oxide nano fertilizers Got Conclusion on it, after spraying Zinc, manganese, and iron Nano oxides it giving yield in proportion of (kg/plant and tons/hectare. Including Fe Nano oxide is recorded a recorded as higher levels fruiting nutrient. This technology contributes invention of nanofertilizers as good and safe source for sustainable agriculture.

### **1.6 Nanosensors: Frontiers in Precision Agriculture**

Manoj Kaushal et al given research article present nontechnical information about Precision farming based tools such as Nanotechnocrates for Plant growth hormones Pathogen detection as sensors and control Soil conditions. As they mentioned about nano role of nano sensors, nano sensors make their important role to detect pollution via electrochemical function such as SWCNTs carbon based nano molecule. Then about monitoring function nanoparticles has potential to monitor moisture content, soil fertility, temperature, crop nutrient capacity, pathogens, plant diseases, etc. Afterward they mentioned about Zn and Fe as brilliant fertilizer which are liberate while sensing by plant SOS. For Plant Pathogen Detection used coated of agarose/nano-Au membrane and horseradish peroxidase. Also used pesticide residue as detection tool. Which gives fast responses. Ongoing result comes out on the basis of performance of biosensors, nano fertilizers and pathogen detection, overall applicability lead to increase yield and goes towards Precision farming.

### **1.7 Bio-Nanotechnology and its Role in Agriculture and Food Industry**

Thakur S, et al (2018) released research paper in journal of Molecular and Genetic medicines. Given research paper delivering an important methodologies, role of Bio-Nanotechnology by using nanomaterials. Starch- NPs are derived using capping and  $\beta$ -Dglucose as a reducing agent. By metal ions are reducing process, same phenomenon used in Laser irradiation treatment to get Metal NPs. Tollens NPs has been synthesized in presence of ammonia. About pesticides they Metal nanoparticles able to exhibit good anti-pathogenic, antibacterial, and anti-fungal activities due to electrostatic interaction in bacterial cell membrane and their accumulation in cytoplasm as well as deposition in cytoplasm. Where In this study reported that the predominant destroyer pests are affect productivity hence they should treat by engineered nanomaterials or bio-nanotechnology which collaborate to each other and perform safety to crops. Expressed need of nano fertilizers but still not much available in market, different shape and sized nano fertilizers has different role and method to perform role of nourishment. Then make point by study foodstuffs safety ,where nano materials has been develop food packing and pathogenic attack and storage safety. Come to the conclusion side application of nano materials may contain metal based reported minor risk assessment to environment and human health.

### **1.8 The Application of Nano-TiO<sub>2</sub> Photo Semiconductors in Agriculture.**

Wang Yan et al (2016) published a research paper in journal Nanoscale research letter. This article informing wide application of titanium dioxide(TiO<sub>2</sub>) as Semiconductors in role. Due to the excellent physio-chemical property with ecofriendly performance this nano molecule set a value in nanotechnology. Where mentioned about Application of TiO<sub>2</sub> Photo as Semiconductors for Pesticide Degradation, yes it's absolutely work like semiconductor. In last 2 decade farmer have been used excessive quantity of pesticides (phosphamidon), fertilizers and remain as residue, now need to

neutralize agriculture field. For that used mechanism of pesticide degradation. This point clearly discussed where photoexcitation process is done and  $H_2O$ ,  $CO_2$ , molecules separate out to make  $TiO_2$  Less toxic. Also  $TiO_2$  applied for Plant Germination and Growth with photocatalytic process, which increases the seed stress, resistance and water and oxygen intake, experimentally reported applied  $TiO_2$  plant shows impressive effect as compare to control plants. One more monitoring is done to detect Pesticide Residue.

For water purification  $TiO_2$  nano material using same functionality to decomposition of organic pollutants in short reactive species formed on the surface of a nano- $TiO_2$  photo catalyst that is exposed to UV radiation. Point of conclusion shown, its ecofriendly solution for degrading organic pollutants, preventing and controlling plant diseases with an antiviral or antibacterial function, and protecting the environment.

### **1.9 Functional nanomaterials to augment photosynthesis: evidence and considerations for their responsible use in agricultural applications**

Swift A Thomas et al (2018) released an article and published in the royal society. Approach of growing population nanotechnology brought some nano materials to develop agricultural yield and for satisfied hunger of country. Here they been used nano-bionics, this bionics nanoparticles titanium oxide are able to enter into the cells and chloroplasts of living plants, which then alter or amplify the functioning of the plant tissue or organelle as well as manipulation in photosynthesis. This enzymatic reaction increase light absorption and help to enhance crop yields. They mentioned application Related to carbon nanomaterials like carbon nanotubes (CNTs) and carbon dots (CDs) are able to functionalization to reduce the impact of the negative side-effects to increase crop yield. Water-soluble CDs have been synthesized with fluorescence maxima throughout the visible part of the electromagnetic spectrum. Came to conclusion point this Nano study differ from other which promising the maximum outcome of crop yield such as Mung bean and other crops. This technology is introduced influence of light harvesting and absorption. CNTs and CDs are the modern nano devices that delivering applications without presenting unacceptable toxicity to us or the environment.

### **1.10 Nano-fertilizers: Bio-fabrication, application and biosafety**

Yaseen Rabaa et al (2020) present an article published in Novel Research in Microbiology Journal. In this article they have been revealed the common features of nano-fertilizers and their way of synthesis. Nano based chemicals materials are well studied material in modern agriculture, therefore this nano materials bringing development in agriculture. In this studied material they synthesized nano fertilizers from selective two ways that is Chemical and physical synthesis of nano-fertilizers and Biosynthesis of nano-fertilizers. Treated physical force on molecule and got uniform monodisperse NPs. About biosynthesis they have been extract such as proteins, enzymes, alkaloids, phenolic compounds, pigments and amines and after filtration specific extracellular proteins (enzymes) that are used for NPs synthesis. Then mentioned Nano-fertilizers as an alternative to the traditional mineral fertilizers, because of within less quantity of nano fertilizer able to provide a proper nourishment to plans without pollution. Control of nutrients release is slower as compare to other fertilizers. About pollution control & toxicity, nano-clays or zeolites are good sources that reducing environmental impact and help agro-ecological degradation. Term for solubility and dispersion, high ZnO NPs solubility may improve its efficiency as novel fertilizers with help of process of fixation in the soil. Bio agent has been used for as carrier such as Titanium oxide and Silica NPs, CsNPs provide through Nano-encapsulation method. Also noted about biosafety, there are some risks arises regarding application of nanomaterials but implementations are going on and make it safe. Point on conclusion make nanomaterials can enhance the efficiency of plant nutrients use, control the nutrients release and reduce the environmental pollution and including toxicity of soil.

### **1.11 Nano Bio Pesticide to Constraint Plant Destructive Pests**

Lade Bipin et al (2017) released an article in Journal of Nanomedicine Research. Given article exploring information about Silver nanoparticles, pest management, Nano Bio pesticides and control on Helicoverpa Armegera and Crop productivity. Keeping attitude of Global demand of bio pesticides they have been mention eco-friendly bio pesticides. They have mentioned two pest management trend those are Biological-based pest management (old trend) and Nano-based pest management (new trend), including old trend farmer have been used supportive extracts against pest and

reduce pest effect but could not vanished. In Current trend going nano tech proposed Nano based manipulated pesticide such as ZnO NP which has less cost and safe up to certain level. Also they discussed selection of pesticide, first of all nano pesticides are safe, easy to prepare, low cost, effective pesticides and work target by target so should to select modern technology. Critical points of nano-bio pesticides was it affect soil related physical , biological parameter and happening interaction between them, still implementations , researches are going on. They have been measurement for antifeedant activity and got results which shown the larva's much affected by nono pesticide (Nano-TiO<sub>2</sub> & Nano-Ag) treatment as compare to control Cds . Come to the conclusion point, present pest-control traditional options the future approach of nano-bio pesticides. Considering the nano pesticides usage for large farm it could affect land but magnetic nanoparticles could be an alternative for insect repellents with magnetic property helpful in geo-sensing technology.

### **1.12 Applications of Nanomaterials in Agricultural Production and Crop Protection**

Khot R lav, et al (2012) released an article which published in crop protection. This article presents technical information on carbon-based, metal and metal oxide based dendrimers (nano-sized polymers) and bio composites nanomaterials. For plant germination and growth they have been studied effects of nanomaterials on plant germination and growth treated with nano-TiO<sub>2</sub> and other nano materials including found that FTIC-labeled silica nanoparticles induced seed germination in rice, while quantum dots arrested the germination. Also they have reported Plant protection and production, for that they have used properties such as stiffness, permeability, crystallinity, thermal stability, solubility, and biodegradability to increased affinity to the target Nanoemulsions, Nano encapsulates, nanocontainers, and nanocages. This some reports taken about Plant protection and production. Next technique used for Pesticide residue detection where they have been used nanosensors. Because of excessive use of pesticides and soil pollution they have used this technique to reduce them. For Plant pathogen detection they used biomarkers, Nano-chips which are microarrays that contain fluorescent oligo capture probes. Also mentioned about Issues and future research needs which related to Toxicity, that interactions (toxicokinetics and toxicodynamics). This are the some applications of nano materials applied in such good manners which helps to promote germination, plant protection, pathogen detection, and pesticide residue detection and demonstrate potential of nanomaterials for different agricultural applications

### **1.13 Use of Nanotechnology for the Bioremediation of Contaminants**

Edgar Vázquez-Nunez et al (2020) released an article in journal MDPI. This article is discussed on basis of contaminants, nanomaterial, bioremediation, sustainability in agriculture sector. In this dissuasion they have been explored some Principles of Nano bioremediation Technologies such as techniques as phyto-nanoremediation, microbial nanoremediation, and zoo-nanoremediation. Each one playing different role as they have modified for degradation. In this study Au NPs and Cu NPs have been used for Nano bioremediation of contaminants. In this proses degradation is done by photocatalytic processes and level down the pollutants and contamination. But further observed that probable it entering in microorganisms, and the trophic transfer of NMs in the food chain and the effects on human health. This survey of bioremediation has been measured by Removal Efficiency and got sufficient result by using different use of nanomaterials. Then analyzed Biological Response during the Combined Application of Nanomaterials and Bioremediation. In this analysis got average achievement by using various bio-treatment. Then mentioned about Current and Future Development of Environmental Nano-applications based on Molecular Biotechnology, on this topic DNA Nano robots, inorganic sensors, water desalination this techno-points has been utilized. At end point of this discussion, between NPs and microorganisms for the degradation of some contaminants has been proven in batch experiments and combine techniques can control pollution and contaminant factors. This demonstrated high effectivity in the degradation of contaminants, which provides new possibilities to face environmental challenges.

### **1.14 Bare Iron Oxide Nanoparticles for Magnetic Harvesting of Microalgae**

Paula Fraga-García et al (2018) released research paper in journal MDPI nanomaterials. Given research paper providing information and new methods magnetic nanoparticles, bare iron oxides, magnetic separation, adhesion for

harvesting Bare Iron Oxide. Presence of many important chemical and metal compound, now algae is important bio-source for us. In this experiment first they have been Synthesis Nanoparticle and Characterization is done. Then by coprecipitation reaction treat in Ferric chloride ( $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ ) and sodium hydroxide (NaOH) and got Iron Oxide from algal (*Scenedesmus ovalternus*) extract by characterization in TE-Microscopy. Then Gravimetric quantification of BION concentration was determined magnetic separation took place & Harvesting efficiency (or separation efficiency) have been calculated value of approximately yield was  $67 \text{ A m}^2/\text{kg}$  by formula. Afterwards adhesive behavior check out and reported that the *S. ovalternus* is better suited for maximal separation efficiency. In High-Gradient Magnetic Separation method fractionation were determined. In conclusion noted that magnetic separation techniques and other physical separation technics are successfully applied for harvesting iron oxide nano particle. In future this technique can help to treat waste water.

### **1.15 Algal Nanotech for Biofuel Production**

Enosh Phillips (2020) released an article and published in Indian journals. Considering the increasing use of energy and population, scientists are now aiming to obtain energy using various BioSource's as an alternative source. Nanotech is used in transesterification, gasification, pyrolysis, hydrogenation and reformation of biomass derived compounds from micro-algae. They have been referred to biofuels as an alternative energy source. Due to depleted fossil fuels, demand for these alternative sources is expected to increase in the future. Techniques used in cell wall disruption, since mechanical methods available are energy consuming (sonification and hydrocavitation). Then they described two types of biofuel and the biomass from which the biofuel was prepared. Nanoparticle (NP) is  $\text{Fe}_3\text{O}_4 @ \text{silica}$ , which could be used as a catalyst for coupling process. In this they used biocatalyst by extracting microalgae from light nanotechnology and nanotech is used in transesterification, gasification, pyrolysis, hydrogenation and reformation of biomass derived compounds. They came to the conclusion that currently this method will not be used much until the fossils are eliminated and nanotechnology will continue to support it if need be.

### **1.16 Nanotechnology in Herbicide Resistance**

Abigail Evy Alice et al (2017) released an article in intechopen as open access. Given article delivering information about herbicide, Nano herbicide and used nanotechnology in it. The development of specific herbicide molecule encapsulated with nanoparticle aims at specific receptors present at the root of the targeted weed. This nanoparticle enters the root system of the weed and gets translocated to perform its action which in turn inhibits the glycolysis of the plant root system. This target action paralyzes to target herbs and kill them. Next point introduced Polymeric nanoparticles, this polymeric nanoparticles containing atrazine herbicide were prepared and tested against target plant, *Brassica* sp., the polymeric nanoparticles encapsulated with atrazine were proven effective. Alginate/Chitosan (Ag/Cs) nanoparticles were tested by encapsulation of parquet herbicide and negative impacts were reported such as soil sorption. Inorganic nanoparticles such as Silica dioxide is more efficient without wastage. Came to conclusion, where overuse of herbicides can pollute soil as well as ground water source, though nano-techniques are more efficient than synthetic herbicides which long term remain in soil. Development of systems that would improve the release profile of herbicides without altering their characteristics and novel carriers with enriched activity without significant environmental damage is the focus areas that require further investigations.

### **1.17 Development of Stimuli-Responsive nano-based Pesticides: Emerging Opportunities for Agriculture**

Marcela Candido Camara et al (2019) released an article and published in Journal of Nano-biotechnology. Present article delivering information about Nanopesticides, Triggered release, Smart delivery, biotic-Abiotic stress and Sustainable agriculture. In this article they said about Enzyme-responsive systems, in this system enzyme-mediated response of the nanomaterial and controlled release of active compounds in a site-specific manner, also Photo-responsive systems work as Photo-responsive nanoparticles which allow spatiotemporal control of the release of active molecules by light irradiation. In Applications of stimuli-responsive systems in agriculture stimuli-responsive materials have been studied for the release of agrochemical compounds in response to physical parameters. Then same applied on soil, this condition also improved plant growth by 60.7%, compared to the control. Conclusions

and perspectives points said the applications of nanotechnology in agriculture is increases exponentially. Stimuli-responsive characteristics could reduce the premature degradation of pesticides, improve their efficacy and minimizing similar effect that affect agricultural progress with yield. This techniques are low cost, having simple procedures, and controlled-release features. Smart delivery of nanomaterials would be advance technique for agriculture of current decade.

#### **1.18 Advances in Targeted Pesticides with Environmentally Responsive Controlled Release by Nanotechnology**

Huang Bingna et al (2018) released an article, published in MDPI nanomaterials. Given article exploring information on nanotechnology, precise controlled release, environmental response, Nano delivery system etc. They have introduced developed nanomaterials and related technologies which methods provide efficient and environmentally friendly advantages. In this method nanomaterials are turned into Nano carrier system and sprayed on leaves with adhesive long term attachment. Mentioned about Delivery Systems for Environmentally Responsive, Precisely Controlled Pesticide Release, here they have been introduced photo-reactive carrier materials which composed of light-sensitive polymers that undergo rapid physical or chemical changes when exposed to light. Then introduced about Characteristics, Principles, and Research Trends in Humidity-Sensitive Pesticide Formulations which sense humidity and interact with water molecules to form hydrogen bonds or through van der Waals force to achieve hygroscopicity. Microcapsule pesticide formulations are an important application of this technology in pesticide formulation preparation. Compared with conventional pesticide formulations, these systems have advantages such as long lifetimes, reduced environmental effects, and lower toxicity. The application of microcapsule materials in pesticides and the development of new environmentally intelligent and responsive pesticide formulations represent new directions in pesticide formulation.

#### **1.19 Application of Nano-technology in Weed Management**

Yadav Ambreesh Singh et al (2015) released an article, published in Journal of Crop science and Technology. Given article is providing technical information nano tools such as biosensor, nano-herbicides, nano-polymer and nano-pesticides. Weedicides are affect plant-specific chloroplast, inhibition of lipid biosynthesis, interference with cell-division by disrupting the mitotic sequence inhibition of cellulose biosynthesis and deregulation of auxin-induced cell growth and because of foliar absorption high respiration take place and weed become kill. In this management they have been used nano herbicide for effective weed control, by encapsulation smart delivery system this nano chemical substances enter inside plant body parts like rhizome etc. and only targeted species become die within less amount and without leaving any toxic residues in soil as well as environment. In recent decade many concentration dependent pesticides usage is remain in soil as residue. For maiming they have been used degradation method, with help of silver modified nanoparticles to neutralize atrazine under controlled environment. Applications of this smart tools of nanotechnology will revolutionize the agriculture without wastage. Ultimately the pollution will reduce.

#### **1.20 Applications of Nanotechnology in Sensor-Based Detection of Foodborne Pathogens**

Kumar Harsh et al (2020) released an article in MDPI Sensors publication. Given article delivering information on safety, sensor and foodborne pathogens detection by nano sensor. Every year globally, contaminated food is responsible for 420 000 deaths and 600 million cases of food-borne infection. For that they suggest response of biosensors to highly specific, quick, free from interference, and has low limits for detection, but still the non-targeted microorganisms can interfere with the operations of biosensors. For that they have been sorted Criteria for Selection of Nanomaterials for use in metal based and oxide based Biosensors dependent on its properties. Then they have been again sorted for Toxicity studies of various used in sensor development under in vitro and in vivo conditions, including Multiwalled Carbon nanotubes, Quantum dots (Cadmium telluride), Dendrimers (PAMAM) and other metal based nanoparticle have been mentioned, which allotted for their work. Also said about Current Status and Future Prospects, they have shown its proficiency in detecting pathogenic microbes and resulted in an answer to different problems related to biotransformation and metabolism of ingested NPs and introduced Types of nanomaterials used to sense fabrication of food borne pathogens and their toxins detection. Come on conclusion point, Nano-sensors have the

potential to meet both the demand of miniaturization and low-cost analytical devices. Early detection can stop food spoiling and further loss of food. This sensing mechanism will be beneficial to reduce toxicity of food as well as inhibit deaths by consuming contamination of food.

## **II. RESULTS AND DISCUSSIONS**

Nanotechnology will play a vital role in the development of the agricultural sector, as it is capable of being used in agricultural products that protect plants and monitor plant growth and detect diseases. Scientists have been working towards exploring new applications of nanotechnology in agriculture and the food industry - if these discoveries are applied sensibly, the environment, the agricultural sector and the food industry will indeed see tremendous changes for the better in the coming years. Nanotechnology guarantees a breakthrough by improving in nutrients efficiency through nanofertilizers to increasing yield and nutritional quality through bio nanotechnology, protection from pest's disease, host parasites interaction at molecular level. Approach of disease management is completed with various pesticides and newly developed iRNA pathway have been used to target various pest. Complications of Seed germination have been solved by using SiO<sub>2</sub>, TiO<sub>2</sub> and zeolites by encapsulation method target pest have been suspended. Using carbon nanotubes seed germination allow by breaking of seed coat. Using nano carrier system target delivery by nanomaterials being possible to restrict pollution. By using silicate Nanoparticles it is possible to inhibit moisture and stop food spoiling condition. Using metal oxide nanoparticles now possible to reduce biomes and carcinogenic material in Water management. In Drug delivery techniques various drugs delivery is done through encapsulation method and slow released methods. Nanosensors have been used for detection of pathogen, oxidative agents, pollutants, pest, excessive nutrients and degradation of pollutants.

## **CONCLUSION**

- Nanotechnology is capable of being used in agricultural products that protects plant and monitor plant growth and detect diseases.
- Nanoparticles are biodegradable and target specific so they can be successfully employed in production of nano capsule for delivery of fungicides, pesticides, fertilizers and other agrochemicals
- The potential benefit of nano tech for agricultural production need to balance against concern for soil, water, environment and occupational health of workers
- The success of this advancement depend of knowledge and awareness of potential toxicological effect of nano-agrochemicals and other nano-materials, risk of exposure user acceptance and regulation issue
- Over the next two decades green and golden revolution would be accelerated by mean of nanotechnology.

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