NANO FERTILIZERS AND NANO SENSORS – AN ATTEMPT FOR DEVELOPING SMART AGRICULTURE

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Abstract

Nanotechnology is a novel discovery being explored in almost all the fields and is benefitted too; it may provide keener solutions for the current problems in the field of agriculture. Various research activities are carried out with sensors and fertilizers therefore paper is reviewed various kinds of fertilizers developed and acquaint with facts about the sensors in the same field. Nanotechnology concepts can help the farmers to know the effects before and input solutions for a better after. Controlled use of the technology will help the sustainability. In concern with the ecosystem and the farmers, these technologies will benefit the agricultural engineering and technology in overcoming all the local myths and ethics decreasing the mega problems in the agriculture arena. Availability of technology is more only proper utilization of it is.

Keywords: Nanotechnology, Agriculture, Fertilizer, Herbicide, Pesticide, Nano Sensors, Wireless Sensor, Smart Dust   Technology, Aptamers

INTRODUCTION

Agriculture is always the backbone of many developing countries. It does not only fill the people abdomen but also it is the part of economy. According to 2014-2015 censuses, India's population is almost equal to 1,270,272,105 (1.27 billion), which is really a huge number. In concern of providing food to such a big population there has to be a new technology giving more yield in short period. In that manner, nature is complex which will have imbalances which directly affects plants and crops and indirectly animals and human. In according to this, other factors which affect agriculture are deficiencies in macro and micro nutrient content, population explosion, industrialization, depletion of water source, difference in soil condition, and erosion of top soil. In agriculture the main reason to use fertilizer is to give full-fledged macro and micro nutrients which usually soil lacks. 35-40% of the crop productivity depends upon fertilizer, but some of the fertilizer affects the plant growth directly.To overcome all these drawbacks a smarter way i.e., nanotechnology can be one of the source. Since fertilizers are the main concern, developing nano based fertilizer would be a new technology in this field. Fertilizers are sprayed in many ways either to soil or through leaves, even to aquatic environments; these inorganic fertilizers are supplied in order to provide three main components, nitrogen, phosphorous and potassium in equal ratios [1]. It increases the Nutrient use efficiency (NUE) by 3 times and it also provides stress tolerating ability. Irrespective of the type of crop it can be used, it will be the complete bio source increasing the eco friendly nature, builds carbon uptake, improves soil aggregation. Since these nano fertilizers contain nutrients, growth promoters encapsulated in nano scale polymers, they will also have a slow and a targeted efficient release. Nanotechnology is gathering information of atom in nano scale range, with considering the physical, catalytic, magnetic, optical properties [2]. However, the concentration of usage chronically exposes soil microbes and micro fauna, as well as the plants themselves, to level of chemical reactivity that may be toxic [3]. When comparing to chemical fertilizers requirement and cost, nano fertilizers are economically cheap and are required in lesser amount. For years farmers have found that nitrogen uptake is the main reason for improper yield. In past recent days development of sensing devices are in boom. When it comes to test a particular analyte from the soil causing disturbance in the filed there are assays which give accurate result but it has a drawback of consumption of time and also the high cost for performing. Sensors are those give better results with the live pictures and conditions of the field [4]. Sensors do monitor changes or the effects caused by various pesticides, fertilizers, and herbicide, also the physical conditions of soil like pH, moisture level, and growth conditions of crop, stem fruit or even root, toxicity studies, it can constantly monitor the toxicity produced in the field. Since it is a human friendly sensor starts detecting and alarms farmer so as to indicate any correct measures to be taken before rather than acting for a consequence after. When it comes towireless technology certain node installation is carried out which makes the person to monitor the happenings in the fieldall the nodes can be controlled at

the same time through cloud computing or even through air programming. Therefore various types of new sensors and types of fertilizers are reviewed at glance to place nanotechnology in highest level.

NANO FERTILIZERS

Fertilizers play an important role where the ancient chemical fertilizers are replaced with nano and bio fertilizers with their efficiency and environment friendly nature. Primary use of adding is fast uptake of nutrients from the soil and giving better, faster yield. The symbiotic exchange between soil and the plant system is very efficient. When the same is applied in slow and efficient way all the required nutrients is taken up by the plant and restores the required and efficient energy in it for which the yield increases drastically. When fertilizers are in the form of encapsulated this can be achieved. Main element Nitrogen is needed in abundant and uptake of this itself causes many problems to the plants. A different type of fertilizers for different crop problems is reviewed.

Nitrogen fertilizers

There are ways where N is being lost in the atmosphere, and those processes include volatization, denitrification, leaching, and run off. There is a error in applying this N fertilizer to the crop, in fact continuous applying of these to the pre plants will not benefit in optimum utilization of the entire amount addedWhen the plants are harvested, they take away the nutrients which are present in the soil, therefore it is necessary to replace it by a readily available fertilizer to constantly make the nutrients available to the plants. The element required in abundant, nitrogen (N), is essential for plant growth and animal nutrition and is the nutrient taken up in largest amount by all plants. Source ofnitrogen include ammonia, diammonium phosphate, ammonium nitrate, ammonium sulphate, calcium cyanamide, calcium nitrate, sodium nitrate and urea[5] Its widely used because it is easily available, rapid action. This element's role in the environment is complex [6]. When coming to Nitrogen fertilizers, slow release of the same will be plant beneficiary. This is because a farmer can fertilize less often by providing the nutrients slowly and steadily. There was an attempt to increase the uptake of nitrogen with the application of 25 kg Mg Oha^{-1} which increased the positive uptake [7].

Potash fertilizers

Potash fertilizer taken by the plants as K^+ forming no organic compound in the plant, helps in photosynthesis process, controlling water storage and stomata opening in leaves.For the slow release of potash fertilizer, polyacrylamide based coating of pellets were used. Potash and clay was mixed together and dried for an hour, this was coated with a tooth paste for proper attachment of the polymer. This polymer was dipped in polyacrylamide polymer.The study showed the difference of dissolution with and without the coating, when the potash used is less the release is also slowed down and the release can also be maintained with less water [8]. Since the main cash crop of India and Srilanka is rice, there were studies done on rice using nano potash fertilizer as the source of potassium in rice, which resulted in increase number of grains per panicle and also the amount compared to muriate of potash was less. There are studies conducted for wheat and corn with nano coating fertilizer and slow release of the same to crops has increased the yield rate, and also effective recovery of N fertilizer [9].

Nano porous Zeolite

They usually help in slow release of the fertilizer to the plant, this way of doing makes the plant to grab entire amount of nutrients from the fertilizer supplied rather than the minimal uptake. Since it has larger surface area many molecules can fit into it and get released whenever the plant requires [10] Zeolite (Clinoptilolite) was made nano sized particles with ball mill. 1 g of this was taken in a centrifuge and stirred with 1.5M 50 ml of calcium sulphate solution for 8 hours, filtered and washed with de-ionized water, air dried. Solid: liquid ratio was maintained up to 1: 10 for synthesis purpose. [11]. Nitrogen fertilizers are very important but due to its high solubility nature it causes severe damage to the pants and the surroundings therefore a nano porous zeolite was used with urea and there was considerable increase in the uptake of nitrogen efficient urea with controlled release [12]. Aluminium zeolites are also used because they are highly porous and allow the retention of the soil. These zeolites help the dry soil also to retain all the moisture content and help to grab nutrients from the soil [13].

Zinc Nano Fertilizer

Micro nutrient, zinc has a serious deficient crisis in the world. The amount of zinc intake through daily food is very less therefore by utilizing zinc based fertilizer there are least chances of indirect supply to human. For the same nano particles can be used to coat zinc in order to get a diffusedand soluble zinc [14]. When the pH increases solubility of zinc decreases [15]. Equal ratios between surface area and size of nano particles should be carefully designed If not, total solubility of the zinc will be affected. This is shown taking ratio ofNanoZnO and bulk ZnO available on whole [16].

Nano Herbicide

In a field to consider there are unwanted plants grown along with the desired plant crops and those are called weeds. To kill these weeds, herbicides are used but conventional herbicide when sprayed has a chance of getting affected to the good crops too by this there can be huge loss in the crop yield. By using Nano herbicide which is 1-100nm range will try to mingle with the soil particle and try to destroy the entire weed kingdom from their roots by not affecting other good crops. Since the nano particles are target specific they can be used to kill the weeds and destroy it to get better yield [13]. Also there are works carried out for the controlled release of the herbicide limiting the damage caused by it to human. More widely used herbicide include triazine, herbicidesametryn and atrazin were nano encapsulated to get 84% effiecient release to the plants [17]. Adsorptive stripping voltammetry process was developed to detect herbicide fenclorim with carbon nanotubes at pH 4.0 with the adsorption techniques on the electrodes [18]. Atrazine is the widely used herbicide in order to kill the weeds and unwanted grass growing near the crops, continuous use of herbicides makes soil loose all the nutrients and make them resistant to the plants, therefore application of modified silver with nano particles and carboxy methyl cellulose makes degradation of herbicide easier [19]

Nano Pesticide

Pesticide contains four different sub categories which will act on different target objects but action is the same either completely destroy or making plant resistant. Those categories include herbicide acting on unwanted weeds and grasses, insecticide on various insects, fungicides for few molds, algae and disinfectants for the control of bacteria and making them not to spread. So preparing this pesticide in the form of a shell or in a closed envelope will make it a slow and efficient release, soil run off rate can be decreased, increase solubility [20]. An emulsion coating of pesticide was developed, with the proper mixing of oil and water, a water insoluble , β-cypermethrin was developed and compared with uncoated product for stability and effectiveness in spraying [21] . Another spodopteralitoralis, an important pest which affects major plant kingdom developing its resistivity to almost all the pesticides was effectively controlled against hydrophobic nano silica coated tomato and it showed positive response of destroying the pests at 300-350 ppm respectively [22] . When citric acid molecules were combined with multi walled carbon nano tubes certain pesticides like Zineb and Mancozeb are trapped in aqueous solution which led to encapsulated pesticide which led to a serious threat for a particular fungi type *Alternaria alternate* fungi [23]

NANO SENSORS

Carbon Nano tube

Tubes are in cylindrical shape and mostly made up of carbon molecule with the difference in number of wall construction. These carbon molecules are held in position with strong van der Waals force making its application in packaging of particles, filtration, energy storing device, monitoring environment and many more. The reason for this numerous application is its flexibility alone. When it comes to agriculture sector, these multi walled carbon nano tubes have played a beneficial role in increasing the growth rate, water intake, uptake of essential nutrients from the soil. With the incorporation of varied ranges of carbon tubes different yields were noticed along with this when an external Fe supplement given the Ca ion made balance and maintained the yield [24]. To other crops like maize, wheat, peanut and garlic this multi walled tube with concentration of 50 µg ml^{-1} has given good results in increase in the length of root and shoot, seed germination time, enhancement in growth and had well developed root system [25]. C nano tubes help plants to

retain their water content and it also increases the production rate drastically with very less amount of nano material like just 50 µg ml^{-1}, tomato production increased with treatment of fullerene which is an unbelievable event in agriculture [26].

Nano Aptamers

Aptamers are those which work with the principle of target specific binding with high affinity, they are single stranded nucleic acid, they fit for the target in all the way forming three dimensional with strict bonding can be produced in vitro [27]. Aptamer selection have certain criteria based on which it is selected for different process it includes the size range between nano or pico molar ranges. SELEX (Systematic Evolution of Ligands by Exponential enrichment) [28]. This kind of sensors gives more specific and effective detecting plant diseases, crop resistances and yield production. Initial detection can help irradiate the problems well before. In order to know the proper regulation happening in the system there is no need to distress the cell instead a sensor to monitor cell to cell signaling with the help of photoluminescence target specific device, i.e insulin binding aptamer was deviced to monitor extinction of lights from cells to get the signal [29]. In cases dealing with herbicide and pesticide (Atrazine and Malachite green) respectively, an efficient aptamer sensor was devised to monitor the toxicity level in food which is kept for consuming with the luminescent assay technique [28]

Smart Dust Technology

Mainpurpose of creating smart dust technology was to monitor the environmental hazards, energy usage and create awareness to human about the same. It can almost detect everything in the surrounding like monitor the temperature, track traffic, etc. It gains popularity in a way of its operation. It can be monitored with wireless radios, transducers irrespective of location of the sensor, its size is very small due to which it can be undetectable [30]. These are the devices made up of micro sized electro chemical sensors contained in it. Major power of sensing itself to the environmental changes, automation and computing has made it come to greater extent but still there are major drawbacks faced by this technology like the impact on environment, toxicity, how far will this be helpful in the field of agriculture. Mainly it works on three principles, sensing, processing and computing

Wireless Sensors

Technology has improved, a strong proof for this sentence is that monitoring all the activities from any place and not necessary to be present at the location of the activity happening. For the same purpose, wireless technologies has been developed, but still it is in its baby steps going through all the required field trials before the full fledge utilization. In spite of all these it is in a position of use where radio frequency and transducer incorporated sensors are in use [31]. These kind of sensors help in maintaining optimal growth of the plant by continuous monitoring the soil and environmental conditions. There are CCTV installed at the field which takes picture of the site and it is easy to maintain a database of all these for further purposes [32]. This technology is well used in cattle monitoring, rain water quality, ground water quality. Nodes will be placed at certain distances to monitor every act happening in the field [33]

ADVANTAGES OF NANO FERTILIZERS

Nano coatings and technology can help in numerous ways to reduce costs and increase productivity around the farm. Insulation can be a major issue for farmers, keeping products chilled or livestock at safe temperature. Even bee hives can be protected. Cold rooms can be coated to reduce temperature loss by 40%, reducing the need to run refrigerators. Condensers can be coated to also run much more efficiently. Here nano coatings can offer compelling value. By simply coating the stone, wood, glass, metal, plastic (almost any surface) around the farm, one can create an "easy-clean" and anti-corrosive coating to the surface without the need to apply detergents and aggressive cleaning materials. Cleaning cycles become much easier with around 40% less water usage and labour. Farm buildings, fences and assets can be badly damaged by mildew, mold and corrosion. Nano technology can help here too by preventing surfaces becoming spoiled by rain, bacteria & environmental corrosion. Painted surfaces can remain perfect for up to 21 years and more using environmentally friendly nano solutions. All electrical connections can be nanomimized to operate safely in wet and damp conditions. Some sheep farmers complain about loss of wool caused by dirt on healthy sheep.Nanomaterials could even be used to control the release of the fertilizer such that the nutrients are only taken up by the plant, and not lost to unintended targets like soil, water, or microorganisms [34]. These days nano particles are almost used in all the products like room fresheners, shampoos, laundry objects,

biomedical products, and textiles [34].The silver released from all these products are in the form of elemental Ag-NP which at end reaches the waste water stream [35]. Nevertheless of all these when coming to risk assessment when Ag-NP were present in a pilot waste water treatment plant which transformed to Ag_2s thereby strongly decreases the release of toxic Ag+ in solution [36]

DISADVANTAGES OF NANOTECHNOLOGY

The Catchy term 'Nanotechnology' also pose some risks and problem towards the health and also towards environment. When considering risk and safety interm of the same will be relevant to only certain area. The initial studies performed for nano materials have caused serious health hazards and also showed toxic effects, also when entered into human body caused tissue damage reaching all the vital organs. Another emerging technique is utilizing silver nano particles for the delivery of fertilizers to plants because of their antimicrobial properties, but studies have considered that it poses serious threat to ecosystem causing membrane damage, reducing the annual growth of grass, depletion photosynthesis in alga (chlamydomonasreinnardtii). Silver nano particles are usually difficult to recover, some plant species tends to use this nano particle maximum and accumulates in its tissue exceeding the limit. Soybean an important cash crop in most of the country was produced using manufactured nano materials with fossil fuel equipment that will allow NNM to locally deposit on the crop. With routine waste water treatment plants, Results were impacts on plant - microbe interaction affecting N_2 fixing symbiosis for which some metals are sensitive.

CONCLUSION

Nanotechnology in many fields is in its primary stage, seeing al such new innovations it clearly tells that it has a great scope and for any new technology to that matter there will be objection and rejections, overcoming all the myths and ethics this will reach heights in its own manner. While comparing it to the ancient assay techniques there is huge difference in the accuracy, smart nature, effectiveness, cost for operation, ease of construction and many others. But still when it comes to agriculture sector it is behind from all other existing techniques. The only way is to educate people of interest and provide them few sample products and make them use it and get the satisfaction of the same pupil for the technology to rise. If there is equal supports from both public and private sectors more novel techniques and more researches can be carried out but because of lack of knowledge in common man many dreams of reputed institutions and young budding research fellows innovative ideas are shattered. This technology will help in feeding generations and not a single one. There is awareness created on the risks of consuming and performing few operations rather than the benefits and effectiveness of the technology. In spite of all these drawbacks there is continuous research carried out in nanotechnology, there will be a day which will come in near future for an accepted nanotechnology.

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