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Nanoagriculture – Bringing to Fruition from Ideation

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Abstract

Over the past ten thousand years, farmers have routinely using their knowledge to improve food production. Recent decades have seen a bleak with food shortage looming all over the globe, especially in the developing and under-developing regions due to population explosion. Factors such as shrinking landscape, lack of arable soil, pest epidemics, extensive use of pesticides & fertilizers and nature's fury (global warming, precipitation, flood, storm, untimely raining, tsunami, etc.,) aid to the decline of the crop's yield. India's already large population is expected to become world's largest in the next fifteen years, resulting an increase in the demand for food, with a need to be met through higher agriculture productivity. At present, yield per hectares is far below the global average. Rejuvenating agricultural productivity through technology-led intervention is gaining urgency and is to be made central to the economic growth endeavor of the country. Nano technology is the latest forerunner to introduce evolution in various fields of livelihood encompassing agriculture, food processing, medicine and comforting goods. Nano agriculture has changed the way, in food produced, processed, packaged and consumed. It has revolutionized the agri-sector with new tools and techniques to enhance crops to absorb key nutrients, fight diseases, targeted treatment, for early disease detection and withstand ecological stress. This article reflects an overview of potential applications of nano technology being researched and commercialized in the agri-sector. It also explores the top-to-bottom strategy for the infusion of the scientific and technical know-how of nano technology to evolve sound production pattern in-line with the demand pattern to strengthen the socio economic fabric of the country.

Keywords: *Nano agricultur; Tsunami Pest epidemics.*

1. INTRODUCTION

The invention of Agriculture is one of the greatest revolutions of the human kind. Broadly, by definition agriculture is an art, science and industry of managing the growth and harvesting of crops involving physical, chemical and biological technologies in order to obtain maximum production. It is the riskiest profession, highly vulnerable to risks and uncertainty due to natural and human-induced phenomenon. For India, agriculture development is of fundamental importance in the achievement of sustainable development and broadband socio-economic growth. Indian agriculture scenario is mosaic, characterized by soil diversity, varied agro-climatic conditions, irrigation facilities and thus diversity in crops grown and fluctuations on productivity.

Beside, being an agriculture dependent nation where majority of its 1.1 billion populations depends on crop cultivation, the yield per hectare is far below the global average (Jean - Neol Biraben, 1980). The rice yield is one third of China's and above half of Vietnam's and Indonesia's. In 2010, Punjab's yield of rice was 3.8 tons per hectare against the global average of 4.3 tons.

India is the third largest economy in Asia after Japan and China as measured in terms of its Gross Domestic Production (GDP) and is continuing to grow rapidly. Indian agriculture is

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demographically the broadest economic sector as compared to others. While the agri- sector's share of GDP has halved in the past 30 years to around 15 percent, it still employs more half of India's workforce and accounts for much of the volatility in GDP share. It is well acknowledged that every rupee of contribution obtained from farming, is twice as effective as other interventions in alleviating hunger and poverty. Agriculture is an indirect growth driver, as a growth rate of 4 percent translates into robust demand for other sectors.

2. FACTS ABOUT INDIAN AGRICULTURE

- Total geographical area : 328 million hectare
- Net area sown : 195 million hectare
- Gross cropped area : 190.8 million hectare
- Wet irrigated area : 56.9 million hectare
- Largest cattle population : 281 million

- Largest producer of milk, coconut, ginger, cashew, turmeric, black pepper and tea.
- Second largest producer of rice, wheat, pulses, groundnuts and sugar.
- Third largest producer of tobacco.
- About 75 percent people are living in rural areas and are still depending on agriculture.
- Provides food for more than 1 billion people.
- Produce 51 major crops.
- Contribute to one sixth of the export earnings.

In spite of all these facts, the Indian agriculture is confronted with problems such as

i) Population Explosion

The country is facing intense problem of being squeezed between growing population and limited available natural resources. This situation has led for the scarcity and struggle to obtain the essentials (food, water, air and land) for basic living.

ii) Nature's Fury

Frequent occurrences of earthquake, floods, cyclones, tsunami, hot extremes, untimely rain and heavy precipitations affect the food harvest and production.

iii) Poor Irrigation Network

Irrigation is indispensible and contributes significantly to Indian agriculture. The water required for the agricultural purposes, is primarily dependent on monsoon that is seasonable and unpredictable often. The poor management of irrigation infrastructure and networking of rivers has led to drought like situation.

iv) Encroachment of Farm Land

In the zest of urbanization and industrialization, the land under cultivation is severely been engulfed, destroyed and is brought under concrete roof.

v) Depleted Soil

Due to adverse climatic variations caused by the persistent anthropogenic changes, the composition, pH value and alkalinity of the soil under utility is severely altered and damaged, making it unsuitable for cultivation.

vi) Pesticides and Fertilizers

Extensive usage of pesticides and fertilizers for long period has degraded the soil fertility due to accumulation, making it unsuitable for farming.

vii) Green Gas Effect

Green gas effect is another cause by which the steady state atmospheric temperature is changed due to the presence of Green House Gases (GHGs) such as carbon-di-oxide, methane, nitrous oxide, ozone and chlorofluorocarbon. These gases trap heat within the surface - atmosphere and increase atmospheric temperature.

viii) Pest Vandalism

Pest attacks contribute to the crop yield loss and severely damage the crops which may shorten their life. Due to genetic incubatory characteristics to the pesticides and population dynamics, control over the pest vandalism is quite challenging today.

Demand of food grains is expected to reach 256.3 million tons in 2016-17 and 294.97 million tons in 2026-27. The increasing load of fertilizers, pesticides and herbicides in agriculture and its adverse effects on soil and ecology has further complicated the overall scenario of food production, safety and sustainability.

With current challenges and limitations, the agriculture arena is blazing a trail for a new technology and is looking at every possible avenue to improve upon current methods and techniques, in every possible field of interest. Among numerous proposed applications, nano technology is found to have the potential in revolutionizing the areas related to food, feed, fibre and fuel. It has the power to redesign the entire agri-sector from production to conservation and processing to packaging.

3. NANOTECHNOLOGY

The application of nano technology in agriculture and food industry was first addressed by United States Department of Agriculture road map published in September 2003. The advancement of science and technology at the nano level is one of the most imperative and innovative fields in decades. Nano technology is not so much unique and distinct technological field but rather involves a greater degree of integration and convergence across the various pure science disciplines.

Nano technology involves creating and manipulating organic and inorganic matter at the nanoscale. It provides a means for creation of novel and precisely defined nano materials with tailor-made physical, chemical and biological properties controlled by molecular structure and dynamics. Nano materials operate at a scale 100 nanometre or less (1 nanometre is 1 billionth of metre) (Morary et al., 2003). These materials are found to be more active than in their bulk form, processing acute electrical, magnetical and optical properties.

Recent advances and array of applications of nano technology in agriculture and food sectors are discussed in the following section.

Precision Farming

Maximizing crop yield is the long-desired goal of any agricultural activity while minimizing inputs like water, fertilizer, pesticides, herbicides, etc. For this, networks of wireless nano sensors are positioned across the cultivated fields that provide agronomic intelligence data related to soil condition, moisture level, seeding, chemicals and water usage in order to minimize input production cost and potentially maximize the output. The nano sensors utilize carbon nano tubes or nano cantilevers to trap and measure individual protein contents. They can also be engineered to trigger an electrical or chemical signal in the presence of a contaminant such as bacteria or from viral attack. This has given birth to the concept of “Smart Fields”.

4. SMART DELIVERY SYSTEMS

With the advent of DDT, the second-half of the twentieth century witnessed a successful and continuous usage of it as a pesticide. However, in the recent years, it is found that most of the pesticides including DDT are highly toxic affecting the flora and fauna. By the methods of encapsulation and controlled release, the nano particles within the range of 200-400 nanometres incorporated in various mediums such as liquid, gel, cream and water are used with high precision for targeted delivery and preventive measures.

Syngenta, a US based agrochemical corporation is using nano emulsions, which if applied prior to the onset of the stress such as extreme heat, drought, strengthens the physical structure of the turf grass.

5. DISEASE DETECTING MECHANISM

With the advent of nano fabrication and invention of modern characterization of tools and techniques, it is now possible to study the physical, chemical and biological features of plant cell with disease causing pathogens. These studies has resulted in better understanding of plant pathology

related to flagella motility and bio-film formation which in turn is used to detect and control several diseases and protect the crop. Micro-fabricated xylem vessels with nano-scale features have revealed a way for better understanding of kinematics of bacterial colonization of xylem vessels(Cursino et al., 2009).

6. TARGETED DELIVERY SYSTEM

Nano-scale delivery vehicles that include encapsulation and entrapment, polymers and dendrimers, surface ionic and weak bond structures, which can be used to deliver and release the intended payloads to the crop. It also helps to address chemical run-off and alleviate the environmental consequences. By mean of control release mechanism, the ingredients are slowly up-taken and hence avoid temporal over-dosage and aids reduced usage of fertilizer chemicals.

7. NANO RE-ENGINEERING MECHANISM

This mechanism is concerned with creation of novel plant varieties from scratch using synthetic biology that results in re-engineered the crop traits. This has extended the growing season, enabling year around production. Researchers this field have succedded in drilling holes through the membranes of rice cells to enable insertion of a nitrogen atom to re-engineer the rice DNA. This has altered the colour, taste and aroma of the rice significantly.

8. LIGNOCELLULOSIC NANO MATERIALS

These materials obtained from crops and trees can be ued as light weight reinforcements in polymeric matrix as nano composites (Mathew et al., 2006) (Laborie et al., 2009). Such applications may find a place related to packaging, construction and automobile body structure.

9.NANO PACKAGING

Conventional packaging is intented largely in nature to serve as a passive protective and preventive barrier to and from the external souroundings.With the introduction of nanocomposites such as Montmorillonite (also known as Bentonite) along with polymers, is found to have the following advantages over the conventional packaging materials such as enhanced permeable behaviour of the materials,increased barrier properties against thermal,chemical and microbial,improved mechanical strength and heat resistance properties,developed proactive antifungal surfaces and sensing as well as signalling properties to microbiological and biochemical changes[15].Thus “Smart Packages” with intelligent functionalities, is effectively been implemented for food safety and handling.

10. NANO COMFORTING PRODUCTS

A number of companies such as LG Electronics, Samsung and Daewoo have come out with nano based refrigerators. These so-called “Smart Fridges” is attributed with intelligence by incorporating silver nano particles. These nano particles are found to inhibit bacterial growth, eliminate odour, increase shelf life and maintain freshness of food.

11. CURRENT SCENARIO IN INDIA

Still being in the bench-top exploration stage, the success of nano technology depends on many factors like complexity of the technology, environmental benefits, health and occupational risk assessment and management, market demand, profit margin etc.

The current level of knowledge of nano technology does not allow a fair assessment of the merits and demerits arising from the applications of it in the agriculture and food sectors. As a perquisite, before arriving to the conclusion, it is necessary for a better understanding of the risks drawn from applying it on-field.

There is a need to democratize the nano technology by strengthening the linkages between academia, industry and policy-makers. Appropriate

strategies are to be postulated to channelize the research efforts to reap socio-economic benefits of this advance technology under a regulatory oversight board. The regulatory board may be constituted with experts from scientific, green farming, government, business and consumer community. This board may carry out assessment procedure and ensure law and policies to address the liability and various issues inherited with the application of nano technology in agriculture, having unknown and unrevealed environmental and health impacts.

12.CONCLUSION

Nano technology is regarded as an emergent technology and is expected to leave no-field untouched by its ground breaking control of physical, chemical and biological properties of materials and their related scientific revelations. It has a tremendous potential to provide state-of-the-art solutions to problems and challenges faced by the agriculture and food sector. As observed in India, the adoption of nano technology in the agriculture and food sector is at a nascent stage, surrounded with uncertainty and lack of exploitation of its benefits from the closed walls of laboratories to the actual farm-level implementation and practices. Therefore, it is important to ensure an urgent upfront attention on nano agriculture by both public and private parties to bring-in a sea change with priority for strengthening and enhancing the quantity and quality of the food chain output and to preserve the texture of the environment. Thus, initiating an "Era of Bio-happiness" based on efficient and equitable utility of nano technology and natural resources.

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