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A Review on Uses of Biosensors in Agro-Technology

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ABSTRACT: Agriculture is the most important field for a country's self-sustaining economic development. It meets basic human needs and provides raw materials to industries. Rapid, real-time, portable, and cost-effective agricultural technologies are desired to improve human well-being and resource utilisation. Recent advances in biosensor technologies and material sciences have had a significant impact on agriculture. Biosensors can be used in crop nutrition requirements, crop management (such as pest control and irrigation), and crop harvesting (determination of crop maturity and crop marketing according to market standards, as well as food consumption safety regulation). This report discusses innovative biosensor architecture ideas as well as biosensor application.

KEYWORDS: Biosensors, Agro-Technology, Harvesting, Productivity, Food Safety.

I. INTRODUCTION

After the "green revolution," new methods of farming emerged, some of which made use of chemical pesticides which greatly increased crop yields by reducing the prevalence of these problems. The widespread use of fertilisers and pesticides has produced significant health and environmental problems, despite the fact that reliance on chemicals in green revolution agriculture has resulted to remarkable advances in the production of grains internationally. The food chain and the water cycle have been contaminated with harmful pesticide residues. Uncontrolled runoff from fields sprayed with fertiliser, pesticides, and herbicides poses a severe environmental threat. Modern agriculture is enriched with the use of technology. One such is use of biosensors in cultivation and food production. Biosensors play a very important role from production to harvesting of crop and into the dining table. Smart agriculture [1] comprises of application of biosensor technology [2, 3] to increase the productivity or yield.

The application of biosensors is also used to market the products of the farmers at a satisfactory price. Communication technology along with artificial intelligence is changing the world of Agro-Technology [4]. The world has moved immensely towards digital technology [5]. In the last 5 years wireless internet network & with the development of different types of Biosensors agriculture in modern times has become smarter and smarter day by day. Innovative sensor technology can help the farmers in several different ways to monitor, protect and manage their agro -resources from remote distance and without his physical presence [6] there by cutting down input labour cost significantly. In this article the role of Biosensors in agro -technology is illustrated along with future prospects and different challenges are also discussed. In the paper application methods of Biosensor in agriculture are elaborated starting from Soil preparation, Irrigation, Pest control to checking of food quality by consumer before consumption [7-12] etc.

II. METHODOLOGY

The application of biosensor can be divided into different categories of agriculture few of them are discussed below:

2.1 Land Preparation and Fertilization

Soil is where plants get their essential nutrients, both the large-scale ones like nitrogen, phosphorus, and potassium and the smaller ones like zinc, boron, magnesium, calcium, etc. Farmers blindly fertilise their fields without knowing the exact amount of nutrients required, driving up the cost of food production and posing health risks through the release of greenhouse gases like methane and others.

Conventional methods of soil testing in soil clinics are time cumbersome and also not much of cost effective and therefore real time technology is required to assess the exact amount of deficiency of particular nutrients. For this NPK biosensors can be used to detect the exact amount of deficient nutrients in the field without loss of time and fertilisers can be applied accordingly. This will save farmers from over fertilization, loss of time, energy and also money. N, P, K biosensors can be used to ascertain how much of Nitrogen (N), Phosphate (P), Potassium (K) is needed in the soil detected by the specific sensors.

2.2 Irrigation and pest control

The metabolic processes of micro-organisms power microbial fuel cells (MFCs), which are devices that directly transform the chemical energy in organic matter into electricity [13]. Biofilms of anodophile microorganisms are linked to the anode surface in this case. Electrons created by the oxidation of biodegradable organic molecules at the anode are transmitted extracellularly to the cathode, resulting in the generation of electricity. As a result, MFC technology serves a dual purpose by purifying wastewater even as it produces useful by products like power. The acetate, propionate, and butyrate groups in water provide the basis for the interpretation [13, 14]. Microbes with a wide range of adaptations that allow them to thrive in extreme environments are useful for water quality testing and the analysis of industrial agriculture waste. Biological oxygen demand (BOD) measurement is another useful application of MFC technology [15].

After finding the nutrient deficiencies of soil and replacing them with the required amount, Biosensor finds its usefulness in crop growth management and crop care. Crops need intensive care such as irrigation, pest management spraying of pesticides and application of micronutrients when there is any sign of deficiency. Earlier, farmers had to spray without having proper knowledge of water scarcity, types of pests and the deficient micronutrients. Fig. 1 shows a typical design of biosensor clipped on the leaf to find out the water deficiency, different worms, insects and decolourisation of leaves etc and there by remedial actions can be taken with in quick time.



Fig. 1. Biosensor used for determining the moisture on the leaf.

Pests are the cause of one of the major problems faced by farmer, agriculturist all over the world. The study of pest pattern by the biosensors in the crop field and analysing the nature of the pest correct variety of insecticide or pesticide can be applied. Artificial intelligence along with biotechnology can intervene in the process of manual spreading of pesticides by just instructing the machine to spread pesticides over the crop field. This will bring in a huge benefit to the farmers who risk their health during the physical handling of pesticides [16-18].

Biosensors often detect a decrease in enzyme activity as a function of an increase in toxicity caused by a particular pesticide. Rapid regeneration activity is another advantage of biosensors based on enzymes; incubation

takes only 10 minutes before the substrate is added. The use of specific transducers for detecting enzymatic substrates and products enables accurate registration of this activity. Based on the inhibitory impact of organophosphorus and carbamate insecticides, a pH-sensitive transducer can be utilised in AchE-based biosensors to connect the amount of choline produced to enzymatic activity [19]. Biosensors based on fibre optics can detect pesticides like propoxur and carbaryl by monitoring changes in reflectance at 602 nm, which is sensitive to pH [20]. Recently, researchers have begun making nanopesticides that can be released in response to environmental cues [21].

2.3 Food Marketing and consumption

Last but not least, biosensors are being put to good use in the food processing industry, ensuring that everyone has access to healthy, pesticide-free meals. Saving time and money on sample preparation, as well as minimising the spoilage of fish and vegetables, biosensors can identify dangerous substances like formalin from fruits, fish, and vegetables in real time at the market. The great efficiency and low analysis time of biosensor technology has led to a dramatic growth in their demand from food regulators, consumers, and merchants involved in the manufacturing and marketing of food [22].

Improvement of timeliness in the food industries reduced spoilage significantly particularly in marketing of seafood and fresh fruits. The use of biosensors also has significant reduction in the cost of probe that involved sample preparation and sample analysis and huge need of expensive laboratory infrastructure [23].

III. CHALLENGES IN APPLICATION OF BIOSENSOR TECHNOLOGY AND ITS SOLUTION

3.1. Cost of Investment

The high initial expenditure required to use Biosensor technology in agricultural farmlands is a major barrier to its wider adoption. High-performance biosensors, low-power electronics, and other, currently somewhat pricey hardware and software components are essential. The problem can be fixed with the help of policymakers and multi-level cooperation.

3.2. Data connectivity

Network connectivity in India, particularly in rural India, is one of the most pressing issues that must be resolved. The majority of India's agricultural farmlands are located in the country's most remote regions, where internet connectivity has not yet reached a satisfactory level. For the country to have a biosensor-based smart agriculture sector there must be seamless connectivity and maximum coverage across the country. Therefore, it is necessary to construct a massive storage facility throughout the nation's villages.

3.3. Mass education

Education in every area of the nation is one of the most important components of intelligent agriculture. The majority of persons involved in agriculture are marginally poor, illiterate farmers. They are completely unaware of technological advancements and intelligent computing. Farmers will be able to reap the full benefits of smart agro technology if they are educated on this big data transformation, the new inventive way of smart agriculture, and the profoundly efficient use of cloud platforms.

3.4. Powerful App Development

For faultless, flawless data connectivity in 5th generation mobile communication technologies and highly developed mobile technologies, the development of robust applications is required.

IV. CONCLUSION

In this paper, we explore the most practical ways in which biosensor technology might be combined with current agricultural practises. Feeding the world's 7 billion people using developed Biosensor technology in tandem with artificial intelligence is a game-changing idea and an urgent necessity. Smart farmers can use AI and biosensors to boost food production in a sustainable way to meet the needs of a growing population. The combination of biosensor technology with contemporary communication technologies has made it much easier for many people involved in the agriculture industry to collect useful data and implement fixes quickly and cheaply.



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