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# Role and Use of Biosensors in Agriculture

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**Biosensor**

Biosensor is a compact analytical device which is used to analyse, detect and record the biological data using the electric current. It is created to produce either a discrete or continuous digital electronic signals. This device is mainly used to determine the concentration of the chemical and other biological substances in agricultural fields and food industries. The major aim of Biosensors is to develop the quality of life, disease recognition, reduce and monitor environment and soil pollutions. Enzymes are particularly used in this device but other cellular metabolisms and antibody & antigen reactions also take place in the biosensors. In 1956, Leland C. Clark Jr. was invented the first true biosensor for oxygen detection hence he is called as "Father of Biosensors".

**Biosensors in Agriculture:**

Agriculture includes the production of crops and rearing of livestock. These elements play a major role in our daily life. These products have always been disposed to damage in the form of pests and diseases. Hence, the need for early detection in agriculture field is necessary to prevent crop diseases, insect damage, weed infestations, water deficiency or surplus, flood management and measure of crop nutrition and plant populations etc. The agriculture industry has been for a long time dependent upon human expertise for quality control. Biosensors are rapid, reliable and accurate analytical devices which are designed for the measurement of various components of agricultural samples. Therefore, biosensors can meet all the demands to accelerate the production of agricultural goods. Based on the principle of converting biological signal into electronic signal, different types of biosensors hold it applications in agriculture.

**Role and use of biosensors in agriculture**

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Biosensors can be used to forecast the possible occurrence of crop and soil diseases, which has not been feasible with the existing technology. The biological diagnosis of crops and soil using biosensor means opening the approach to reliable prevention and decontamination of soil disease at an earlier stage.

**1. Biosensors in detection of crop diseases:**

SPR (Surface plasmon Resonance) based immunosensor working on the antigen and antibody interaction. Typically, immunoassays (such as the enzyme-linked immunosorbent assay technique) employ a label (*e.g.*, enzyme, antibody, fluorescent marker). The sensitivity of the technique is very high, it can detect the pathogen in very low concentration therefore, it helps in the diagnosis of rust in early stage of **soybean rust** disease that leads to control the disease to eco-friendly way and also used for rapid sensitivity detection of **MCMV** (maize chlorotic mosaic virus) by using antibody and antigen concentration. Apply 11-Mercaptoundecanoic acid on a gold surface to form a self-assembled monolayer and a layer of anti-MCMV antibody was cross-linked on the surface for specific recognition of MCMV. The effects of coupling reaction time and antibody concentration on detection sensitivity were observed. The developed SPR sensor showed highly specific recognition for both purified MCMV and crude extracts from real-world samples.

**2. Detection of pathogens in plants:**

QCM (Quartz crystalline Micro balancer) biosensor or Acoustic-based biosensor detects plant pathogens like *Ralstonia solanacearum*, *Pseudomonas syringae pv. tomato* and *Xanthomata's campestris pv. vesicatoria*. A high density microelectrode Array biosensor detects E-coli bacteria in lettuce. The fabricated biosensor can detect the Cucumber mosaic virus (CMV) with a detection limit of long/mL. A novel portable cell biosensor system for detection of potato virus Y (PVY), Cucumber mosaic virus (CMV) and Tobacco rattle virus (TRV) was fabricated by immobilizing the vero cells carrying virus specific on their membranes. Mendes developed a biosensor that can detect the pathogenic fungus *Phakopsora pachyrhizi* that had been reported to cause rust in soybean. Gold nanorods (AuNRs) functionalized by antibodies have been used to detect Cymbidium mosaic virus (CymMV) and Odontoglossum ringspot virus (ORSV) for rapid diagnosis of viral infections. Bacteriophage -Based Biosensors have demonstrated to be successful in controlling plant pathogens. D. A. Schofield reported a phage -based diagnostic assay for detecting and identifying *Pseudomonas cannabis pv.*

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*alisalensis* from cultures and diseases plant samples. In QCM or acoustic biosensor techniques DNA of the pathogens is directly used in QCM crystalline plate.

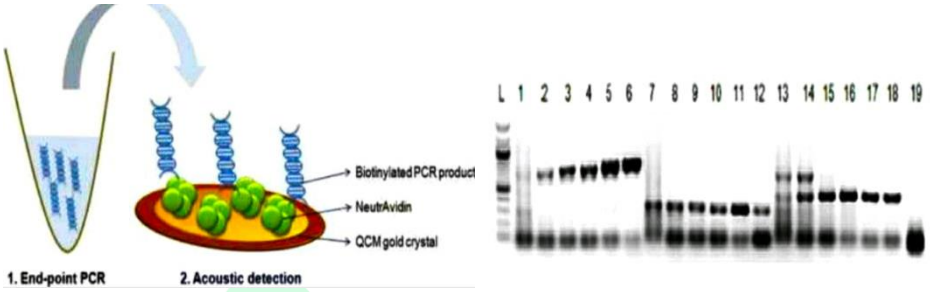


**Fig1:** End product of PCR

**Biosensors used in agronomy and soil chemistry:**

Electrochemical biosensors are used to obtain crop output yields, produce quality, tasty food and tests pH or nutrient content and in soil experiments. Electronic nose (E-nose) biosensor is an intelligent device; it has been implemented successfully for the fruit ripeness determination, detection of soil borne pathogens and insect infestations etc.

**3. Biosensors in Organophosphorus:**

Organophosphorus are the group of chemicals compounds that widely used as insecticides, pesticides and herbicides in modern agriculture for controlling a wide variety of insects, pests, weeds and disease transmitting vectors. The concentration of insecticides, pesticides, herbicides and heavy metals in agricultural lands is increasing in day to day. These aspect contaminates the soil and environment and causes many health hazards to living organisms. Monitoring of the Organophosphorus compounds is necessary in agricultural lands for healthy and sustainable development. Biosensors can play a major role in detecting and monitoring organophosphorus levels in the soil and groundwater.

**4. Biosensors in pesticides and its residues detection:**

Pesticides are the most abundant compounds present in water, atmosphere, soil, plants and food. Public concern over pesticide residues has been drastically owing to the high toxicity and bioaccumulation effects of pesticides and the serious risks that they pose to the environment and human health. It is therefore crucial to monitor pesticide residues by using various analytical methods and techniques. Enzymatic sensors based on the inhibition of a selected enzyme are the most extensively used biosensors for the determination of the pesticides. Based on this principle various types of biosensors are used for the detection of

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pesticides. Immunosensors are biosensors that use antibodies or antigens are the specific sensing elements and provide concentration dependent signals. This detects and monitors pesticide residues in rapid speed. Electrochemical acetylcholinesterase (AChE) biosensors are simple, rapid and ultra-sensitive tools used to detect carbamate pesticides in fruits in vegetables. The pesticide biosensors were applied in the detection of carbaryl and methomyl pesticides in food samples. The AChE biosensor detects and analyses the carbaryl and methomyl concentrations in given samples. These biosensors were stable for a period of 2 to 120 days. Monitoring of the Organophosphorus pesticides dichlorvos and paraoxon at very low levels has been achieved with liposome based nano-biosensors. This biosensor system has been successfully used as colorimetric screening device for pesticide analysis and also to the detection of total toxicity in drinking water samples etc.

**5. Biosensors for detection of Herbicides:**

The biosensor measured and detects the herbicides (*e.g.*, 2, 4 dichlorofenoxiacetic, diuron and paraquat) that inhibits photosynthesis in plants such as the phenyl urease and triazines etc. Photosystem 2 -based biosensors are used to detect photosynthetic herbicides.

**Novel cyanobacterial Biosensor for detection of Herbicides**

The cyanobacterial Biosensor is sensitive to herbicides at the parts-per-million level, which is appropriate for detecting residues in groundwater and soil, in addition, the biosensor provides information on the bioavailability of the herbicides in environmental samples.

**Biosensors for Monitoring pesticides and Herbicides:**

The Concentration of pesticides and herbicides in agricultural lands is increasing. These chemicals released intentionally into the environment and through various processes contaminate the soil and environment. There is a lack of monitoring of these contaminates these causes many health hazards. Biosensors can be used to compute the levels of pesticides and herbicides in the soil and groundwater.

**6. Biosensors used for quantification of Nitrates in plants.**

Two bacterial biosensors *Enterobacter cloacae* and *E. coli* detects the quantity of nitrate present in the soil and also the bacterial biosensors are useful to estimate the microbial niches in complex natural environments such as the rhizosphere.

**7. Biosensors for detection of food pathogens and mycotoxins:**

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Biosensors are also used in food industry for detecting chemical pollutants, food-borne pathogens, microbes and food quantification in soft drinks etc. Optical biosensor detects the presence of *Salmonella* and *Typhimurium* in milk and apple juice within 45mins. Electrochemical magnetic biosensors are used for detecting *salmonella* bacteria in milk. Fluorometric biosensor detects and quantifies aflatoxins. These toxins are mostly found in agricultural products. Electrochemical antibody/enzyme detects aflatoxins B1 in spices and olive oil, aflatoxin M1 in milk. Electrochemiluminescent aptamer biosensor defects the presence of Ochratoxin A in beer and coffee samples.

**Advantages of Biosensors in Agriculture:**

1. It gives specific and accurate readings.
2. It is easy to handle.
3. It can also measure non-polar molecules.
4. There is no need of continuous monitoring.
5. It is a sophisticated tool for the detection and monitoring phytopathogens.

**Conclusion and Future prospects:**

Food losses due to crop infestations from pathogens such as bacteria, viruses and fungi are persistent issues in agriculture for centuries across the globe. There is a need for novel biosensors in order to detect, minimize and monitor the disease induced damages in crop growth, harvest and post-harvest losses as well as to maximise productivity and ensure agricultural sustainability, advanced disease detection and prevention in crops are imperative. The major features of biosensors are stability, cost, sensitivity and reproducibility. The need for fast on-line and accurate sensing opens up opportunities for biosensors in many different agricultural areas in-situ analysis of pollutants in crops and soils, detection and identification of infectious diseases in crops and livestock.