Your full article (between 500 to 5000 words)

Biosensors in agriculture

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Introduction

Biosensor is a compact analytical device consisting of biologically derived sensing element either associated or integrated with a physiochemical transducer (figure 1). It is created to produce either a discrete or continuous digital electronic signal.

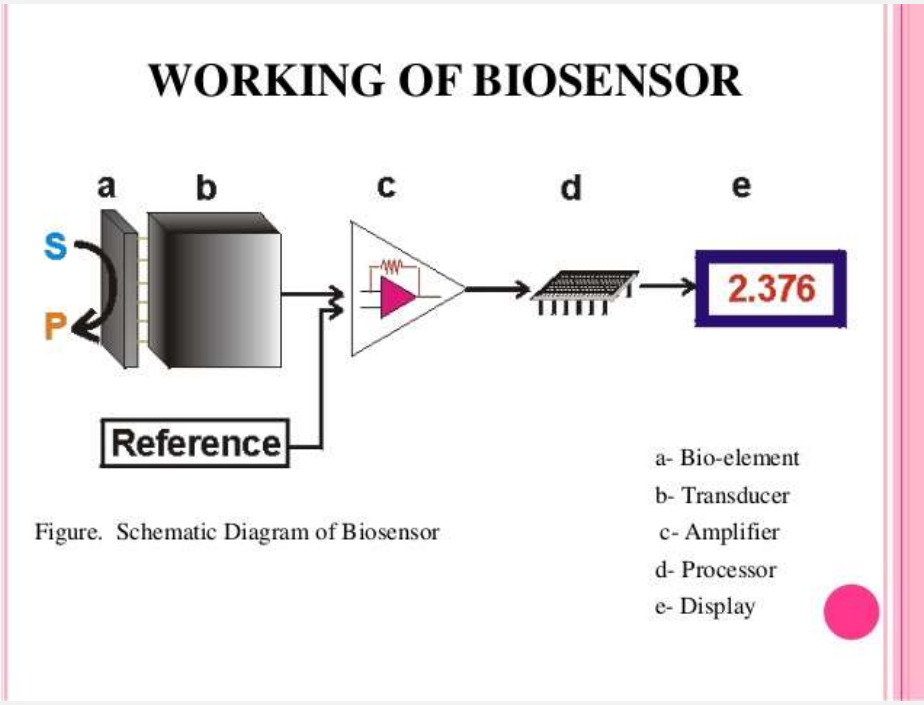

Figure. Schematic Diagram of Biosensor

Figure 1: Schematic diagram of biosensor

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Based on the principle of converting biological signal into electronic signal, biosensors can be of various types such as electrochemical biosensors, calorimetric biosensors, optical biosensors and immunosensors. These biosensors detect the signal in the form of electroactive species such as hydrogen ions or electrons, heat produced, light emission and antigens respectively. Due to this property biosensors has role in agriculture. They contribute in enhancing the production and quality of agricultural goods in following ways:

1) **Food quality control:** Quality control is an essential part of food industry and efficient quality detection is becoming increasingly important. Immunosensors are used for this purpose. It is based on the exploitation of antigen-antibody interaction. This immunoassay works similar as enzyme-linked immunosorbent assay (ELISA). The detection of antigen is done in food stuff by binding with specific antibody which is linked with enzyme carrying substrate. The amount of antigen is proportional to the fluorescence produced by antigen antibody interaction.

2) **E-nose:** It is an intelligent device, able to mimic human olfactory function. It is broadly used for the detection, recognition and classification of volatile compounds and odours. E-nose consist of sensing element, signal collection unit and suitable pattern recognition algorithm. In agricultural applications, the e-nose has been implemented successfully for the fruit ripeness determination, detection of soil borne pathogens, inspection of fish etc.

Figure 2: E-nose

Source:
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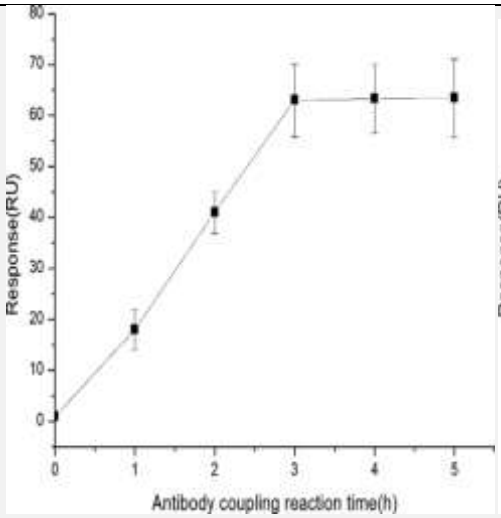
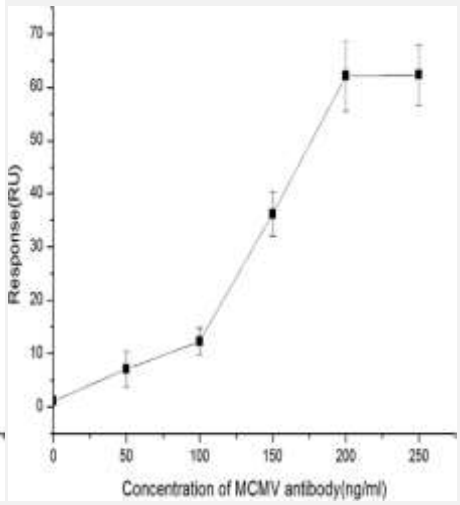
3) **Detection of maize chlorotic mosaic virus (MCMV):** SPR (Surface Plasmon Resonance) is a devise used for rapid sensitivity detection of maize chlorotic mosaic virus by using antibody and antigen concentration.



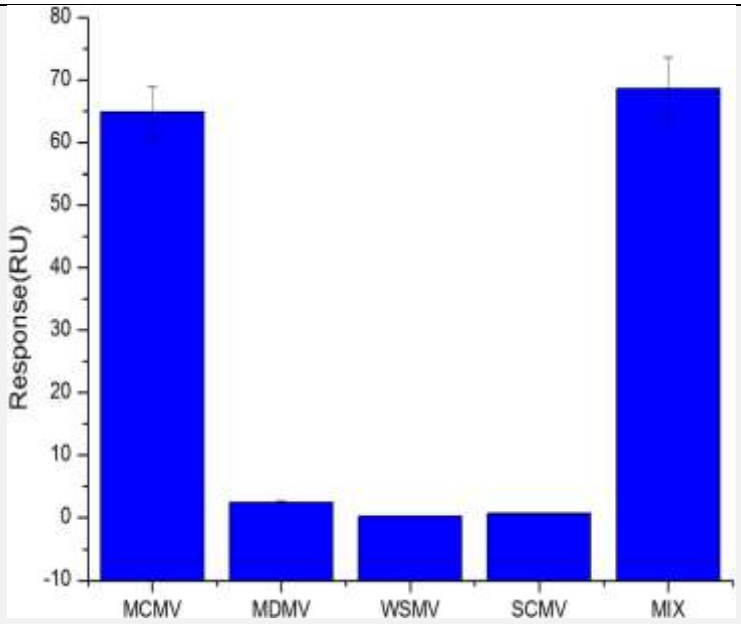
Graph-1



Graph-2

Source:(Zing, C. *et al.*, 2013)

Graph 1 and 2: Shows that sensitivity of the technique in graph-1 antibody coupling reaction time gives the highest response in less than 2 hours. It shows that magnitude of SPR is higher than that of other technique. Graph-2 shows that even very less concentration of antibody i.e. 200 ng ml^{-1} gives highest response.

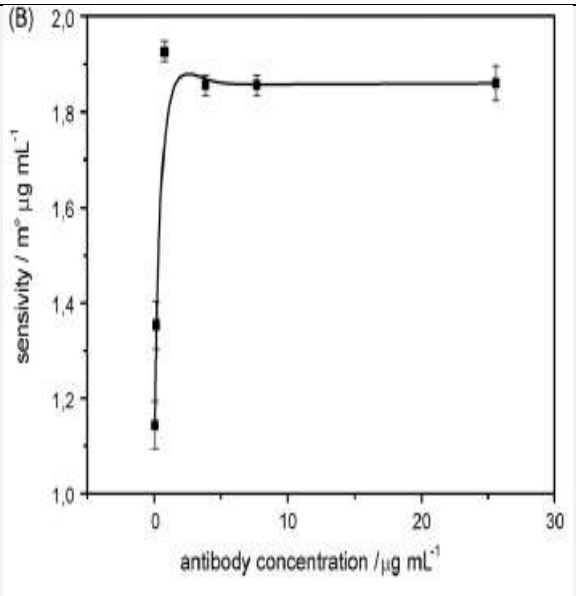


Source: (Zing, C. *et al.*, 2013)

Source: Graph 3 shows the specificity of the technique is very high. It detect the specific pathogen i.e. MCMV (Maize Chlorotic Mosaic Virus). In the study different samples for the detection has been used. But it shows the highest response in MCMV as compare to MDMV (Maize Dwarf Mosaic Virus), WSMV (Wheat Strike Mosaic Virus), SCMV (Sugarcane Mosaic Virus) and when mix sample is used graph shows high response because mix sample also contain MCMV particle. Overall graph represent the specificity of the SPR.

4. SPR based immunosensor for early diagnosis of soybean rust:

SPR based immunosensor working on the antigen and antibody interaction and it helps in the diagnosis of rust in early stage of the disease that leads to control the disease by eco-friendly way.



Graph 4: The sensitivity of the technique is very high, it can detect the pathogen in very low concentration of antibody that is 1.8mg $ml^{-1.}$.

Source: (Mendes, R. K. *et al.*, 2009)

5. Detection of bacterial phytopathogens

QCM (Quartz Crystaline Microbalancer) biosensor or acoustic biosensor is used to detect phytopathogens such as *Pseudomonas syringae pv. tomato*, *Xanthomonas campestris pv. vesicatoria* and *Ralstonia solanacearum.*

In these technique DNA of the pathogens is directly used in QCM crystalline plate

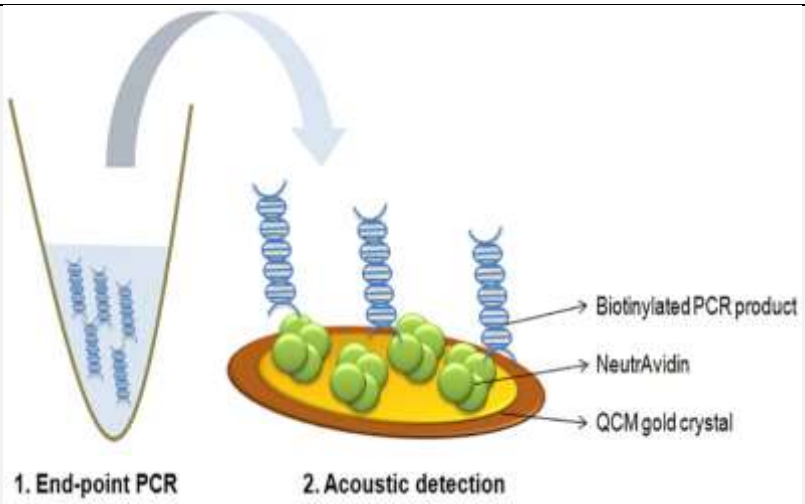


Figure-3

Source: (Papadakis, G. *et al*., 2015)

Figure 3 shows that the end product of PCR i.e. DNA of the pathogens is directly used in the acoustic detection. QSM gold crystal plate contains NeutroAvidin protein molecules which is attached to the PCR product. Results are shown in the gel documentation picture.

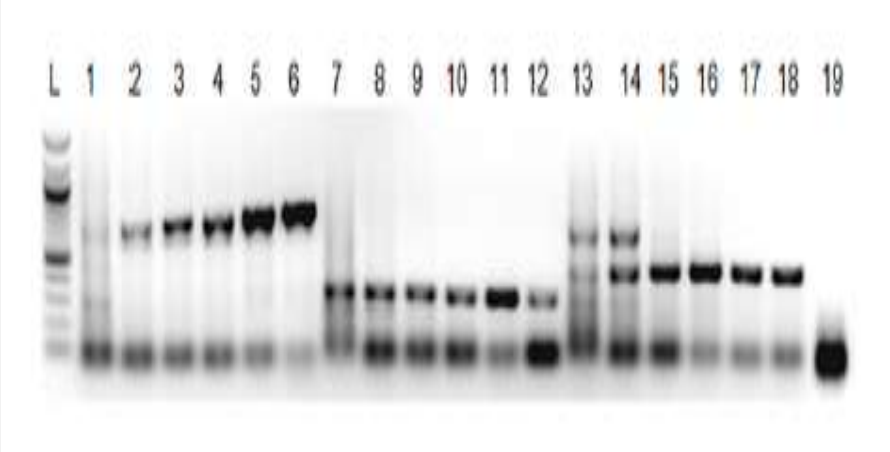


Figure 4: Gel documentation results shows the presence of *Pseudomonas syringae pv. tomato*, *Xanthomonas campestris pv. vesicatoria* and *Ralstonia solanacearum* respectively.

Source: (Papadakis, G. *et al*., 2015)

Advantages of Biosensors:

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

Disadvantages of Biosensors

- Heat sterilization is not possible.
- High cost.
- Lack of reusability - Some types of biosensors such as colorimetric test strips has single use.
- It only focus on the scientific basis of the technology.

Conclusion

Biosensors are rapid, easy to use, reliable and accurate analyzers for the plant disease detection of various agriculture crops. It has also wide use in food industry such as in quality control, fish food inspection. Therefore biosensors can meet all the demands to accelerate the quality production of agricultural goods.

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