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Biosensors: An emerging technology in plant protection

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Summary:

In current scenario, the need of agricultural commodities has been on a serious elevation due to rapid growth in world population. But plant pathogens play a pivotal role in loss of food materials which compel us to address by early and on-site detection of the crop plants. Since last decade, we have been using many laboratory-based detection techniques like polymerase chain reaction (PCR), tissue blot hybridization (TBH), gas chromatography-mass chromatography (GC-MC), enzyme linked immunosorbent assay (ELISA), Flow cytometry (FC) and immunofluorescence (IF) etc. which need complex instruments and need operating skill, costlier, tedious. To eradicate aforesaid issues there has been an inflation in developing and employing biosensors which are naturally occurred biological entities likewise Nucleic acid (DNA and RNA), enzymes, antibodies. These are very sensitive, rapid, affordable and user-friendly for even common farmers in many developing countries of the world. Nanoparticles such as gold (Au), silver (Si) have been reported to be employed successfully in the biosensors to enhance the real time observation of different reaction and sensitivity in detecting microbes. This article also explains briefly with regard to the biosensing devices available commercially and additionally the employment of artificial receptors in the array of sensors to facilitate detection of pathogens is known as electronic noses.

Key words: electronic noses, ELISA, FC, GC-MC, IF, On-site, PCR, TBH,

Introduction:

Plants are always subjected to many pathogens such as fungi, viruses, bacteria, nematodes, viroid and phytoplasma globally. The production and productivity of agricultural and horticultural crops need to be increased many folds in order to fulfil the ever-growing food requirement of the world populations. But the infection of the plant pathogens has become one of the serious and threatening factors for the food safety and security of the world (Savary *et al.*, 2012). Therefore, detection of the plant pathogens in the earlier stage of the crop plays a pivotal role to curtail the crop economic losses. The present pathogen identification and detection techniques are based on both immunological and nucleic acid which encompasses enzyme-linked immunosorbent assay (ELISA), direct tissue blot immunoassay (DTBIA), polymerase chain reaction (PCR), real time-PCR (RT-PCR), flow cytometry (FCM) and gas chromatography-mass spectrometry (GC-MS) and dot blot hybridization (DBH). Nevertheless, these methods need costly and complex instruments, time consuming and lack of onsite diagnostics to detect the plant pathogens at field level itself. Therefore now-a-days to overcome such problems there is an increasing demand for developing biosensors for detection of the pathogens.

Biosensors: What are these?

A **biosensor** is an analytical contrivance, employed for the detection and diagnostics of chemical substances that merges biological units with a physicochemical detector. The sensitive biological element such as nucleic acids, antibodies, cell receptors and enzymes etc. that binds with the analyte under interest. The transducer converts one type of signal in to another which is much more amplified than the previous signal in a physicochemical manner i.e. electrochemical, optical, piezoelectric etc. produced by the interaction between the analyte and biological unit. Hence, we can easily detect the plant pathogens by employing biosensors which is simpler, speedy and cost effective than that of conventional detection techniques (Tothill 2001).

Types of biosensors:

1. **DNA biosensors:**

   At present, the advancement in development of DNA biosensors have been paced up due to its crucial applicability in detection of plant pathogens. As nucleic acid (Either DNA or RNA) is the genetic material of all the plant pathogenic microbes. These can be employed as a potential indicator of microbial biomolecules (Warren *et al.*, 1991). The quantitative PCR which are completely automatic, sensitive, fast, simple to operate for detection of broad range of pathogens. An electrochemical DNA sensor comprising of a gold electrode with a DNA probe which

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detects the microbial biomass by electroactive hybridization (Hashimoto *et al.*, 1994). The "micro-array-chips" containing the short genomic sequences of many selected pathogens which can be employed for real time detection and identification of the pathogens.

2. **Affinity biosensors:**

In recent years, there have been tremendous development in the use of immunological sensors in detection of many pathogens. Due to the immunorecognition characteristics of the antibody or antigen, it is being employed in immunosensors due to which the detection of range of analytes has been widened (Ghindilis *et al.*, 1998). Electrochemical immunosensors can detect the pathogen by utilizing electroactive levels (Enzymes) and amplification methods. Depending up on the transducers technology used the immunosensors are divided in to many classes like optrodes, piezoelectric sensors, calorimetric sensors. As far as the affinity sensors are concerned the employment of optical devices helps in the real time monitoring of observation of binding reactions.

3. **Biocatalytic sensors:**

The sensors which employ the catalytic properties of a catalyst (Enzyme) in a biological reaction is popularly known as bio-catalytic sensors. The catalytic sensors detect the alteration in the concentration of the component after catalysing in a reaction. Among the enzymes used in catalytic sensors oxidoreductase is predominantly used. It catalyses by the oxidation and reduction processes by utilizing the oxygen and cofactors. Antibodies are also employed concurrently with the enzyme which acts as a marker from which it can produce an amplified signal to be analysed (Newman *et al.*, 1998). An enzyme called oxidase which performs the depletion of the oxygen and synthesis of oxygen in a reaction and it can be detected by a sensors amperometrically. The amperometric signals are generated either through direct or indirect (Mediated) electron transfer in an electrochemical reaction (Fig 1).

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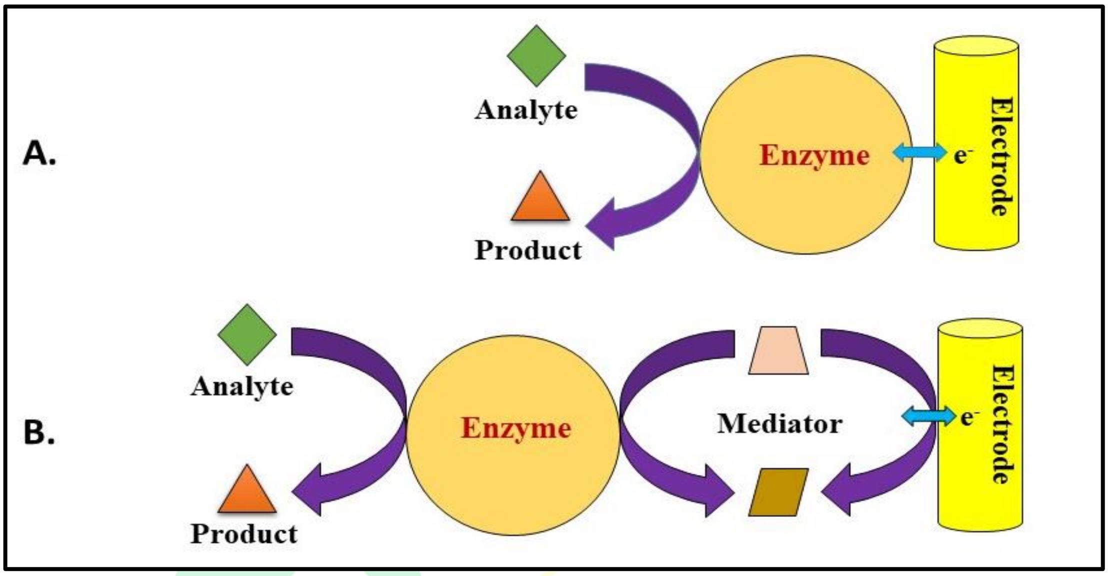

Fig 1. Schematic representation of enzymatic biosensors based on **A.** direct electron transfer and **B.** indirect electron transfer.

4. **Nano biosensors:**

The sensors which are comprising of very minute particle (Nanoparticle) for detection of any microbial biomass is known as nano biosensors. It is considered as beneficial because of its higher sensitivity and rapidity which ease the identification and assessment of pathogenic infection in plants. Fluorescent silica nanoparticles (FSNP) conjugated with antibody could able to detect a bacterium *Xanthomonas axonopodis pv. vesicatoria* causes leaf spot disease in many plants (Etefagh *et al.*, 2013). Similarly, Copper oxide nano-particles detects *Aspergillus niger* (Dubertret *et al.*, 2001).

5. **Electronic noses:**

These sensors are based on the application of the manmade receptors in the array of sensors especially used by the food industry to detect the various toxic substances secreted by the various microorganisms in order to achieve the food safety standards (Gibson *et al.*, 1997). The combination of computer modelling and molecularly imprinted polymers (MIP) assist in developing artificial receptors to increase the range of detection receptors.

Commercialized devices:

It is very much crucial to ensure the availability of the biological detecting elements (biosensors) commercially so that every researchers and scientist could apply it at the point of concern. Till date the devices commercialized are Lateral flow devices, tissue print ELISA, ELISA kit. In addition, many devices have been reported in literature like pocket kit for detection of viruses infecting orchids, fore site diagnostic kit to detect Xanthomonas wilt of banana (Hodgetts *et al*., 2015).

Conclusion and future aspects:

The article describes about the undomesticated benefits of the different biosensors employed for the detection of the pathogens. Due to its sensitive and specific feature of detection we can assess the extent of hazardous chemicals are being used by the farmers in agriculture for production as well as protection of plant. Also use of biosensors is important in food-based industry to eliminate or minimise the hazardous substances in the agricultural food products. Biosensors should be discovered and prepared which must and should consisting of few vital features such as handy and transportable, easily to operate, wide adaptability for wide range of temperature and pH and the most importantly it should be cheaper and simple configuration to facilitate better understanding during use of the device by illiterate farmers in major parts of the world. There has been an increasing trend for extensive research on the electronic noses and discovery of many artificial receptors for detection and diagnostics of plant pathogens (Keshri *et al*., 1998).

References:

Dubertret, B., Calame M., Libchaber, A.J. (2001) "Single-mis-match detection using gold-quenched fluorescent oligonucleotides," *Nature Biotechnology*. 19(4):365-370.

Etefagh, R., Azhir, E., Shahtahmasebi, N. (2013) "Synthesis of CuO nanoparticles and fabrication of nanostructural layer bio-sensors for detecting *Aspergillus niger* fungi," *Scientia Iranica*. 20(3):1055-1058.

Ghindilis, A. L., Atanasov, P., Wilkins, M., Wilkins, E. (1998) "Immunosensors: electrochemical sensing and other engineering approaches," *Biosensors and Bioelectronics.* 13(1):113–131.

Gibson, T., Prosse O., Hulbert, J., Marshall, R., Corcoran, P., Lowery, P., Ruck-Keene, E., Heron, S. (1997) "Detection and simultaneous identification of microorganisms from headspace samples using an electronic nose." *Sens. Actuators B*. 44, 413–422.

Hashimoto, K., Ito, K., Ishimori, Y, (1994) "Sequence-specific gene detection with a gold electrode modified with DNA probes and an electrochemically active dye," *Anal. Chem*. 66:3830–3833.

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Hodgetts J., Karamura, G., Johnson G., Hall, J., Perkins K., Beed F., Nakato V., Grant M., Studholme D.J., Boonham N., Smith, J. (2015). *Plant Pathol*. 64(3):559–567.

Keshri, G., Magan, N., Voysey, P. (1998) "Use of an electronic nose for the early detection and differentiation between spoilage fungi," *Letters in Applied Microbiology*. 27:261–264.

Newman, J. D., Tigwell, L. J. Warner, P. J. (1998) "Biotechnology Strategies in Healthcare: A Transatlantic Perspective," *Financial Times Report, June*.

Savary, S., Ficke, A., Aubertot, J., Hollier, C. (2012) *Food Secur*. 4:519–537.

Tothill, I., E. (2001) "Biosensors developments and potential applications in the agricultural diagnosis sector," *Computers and electronics in Agriculture.* 30:205-218.

Warren, W., Wheat T., Knudsen, P. (1991) "Rapid analysis and quantitation of PCR products by HPLC," *J. Biotechniques* 11:250–255.