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International Decade of Soils 2015-2024

FROM THE PRESIDENT'S DESK

Artificial Intelligence in soil quality monitoring technologies can aid in the protection and conservation of soil quality by allowing for the faster and safer processing of massive volumes of data gathered during physical soil sampling and remote imaging. Soil is considered a critical resource since it is the foundation of global agriculture and food production. Unfortunately, due to geographical limitations and a lack of scientific resources, assessing soil quality can be challenging.

Artificial intelligence (AI) and machine learning (ML) technologies employed in the monitoring of soil quality and fertility employ diverse algorithms for the interpretation of agricultural data. Machine learning applications employ both supervised and unsupervised methods in order to facilitate data analysis procedures, thereby providing adequate components to offer a statistical resolution to the problems that necessitate the utilization of these techniques. Utilizing artificial intelligence technology, specifically electronic programs designed for deep learning, farmers have the capability to identify probable nutrient deficits in soil quality. Various agricultural technologies have been developed to facilitate farming practices. These technologies enable farmers to capture images using their smart phones and afterward upload these images to an artificial intelligence development system. Following a comprehensive evaluation of the issue at hand, farmers are furnished with a range of restorative methodologies and alternative approaches aimed at enhancing both the quality of the soil and the yield of the crop.

Agricultural producers currently possess the ability to utilize agricultural data sources that were previously inaccessible in order to inform their decision-making processes. These sources include satellite and unmanned aerial vehicles (UAV), humidity sensor readings, and ground-based weather stations. Concurrently, there is a continuous influx of novel monitoring and control systems into the market, which offer enhanced customization and precision in the analysis and forecasting of soil quality. Artificial intelligence plays a crucial role in soil quality analysis and the wider agricultural sector by engaging in the generalization, analysis, and processing of data obtained from diverse monitoring devices. Additionally, AI systems provide recommendations and ideas based on the analyzed data.

Increased digitization across industries will inevitably translate into agriculture. Intelligent devices, such as artificial intelligence and machine learning, can convert simple data inputs into useful knowledge. When used in agriculture, even monitoring aspects like soil quality, it has the potential to change the entire food supply chain.

Dr. T.B.S. Rajput Honored with CHAI's Lifetime Recognition Award

Dr. T.B.S. Rajput Honored with CHAI's Lifet Dr. T.B.S. Rajput, President, Soil Conservation Society of India (SCSI), New Delhi, has been honored with the prestigious "CHAI-Life Time Recognition Award-2024" by the Confederation of Horticulture Association of India (CHAI). This esteemed award was presented to Dr. Rajput at CHAI's National Conference on *"Paradigm and Dynamics of Digital Horticulture for Food, Nutrition, and Entrepreneurship"*, held at Junagarh Agricultural University (JAU) in Junagarh, Gujarat, from May 28-31, 2024.

The CHAI-Life Time Recognition Award-2024 was bestowed upon Dr. Rajput in recognition of his significant contributions to research, teaching, and technology transfer in the field of conservation of Natural Resources, specifically focusing on water and soil. His work has been instrumental in advancing sustainable agricultural practices and promoting the efficient management of these critical resources.

Celebration of 72nd Foundation Day of Soil Conservation Society of India (SCSI), New Delhi

The Soil Conservation Society of India (SCSI) celebrated its 72nd Foundation Day on September 20, 2024, in the conference room of its headquarters. The foundation day lecture, held under the esteemed chairmanship of Dr. TBS Rajput, President of SCSI, saw an enthusiastic gathering of over 80 society members.

Dr. C.P. Reddy, Sr. Additional Commissioner, Department of Land Resources, Ministry of Rural Development, Govt. of India, New Delhi was the keynote speaker for the Foundation Day lecture. In his insightful address, he highlighted some critical challenges and opportunities for India's land and water resources management. He noted that while India accounts for 17.76% of the global population and 11.54% of the world's livestock, it has only 2.4% of the world's total land area. The per capita land availability in India stands at a mere 0.23 hectares compared to the global average of 1.75 hectares. This limited land availability, coupled with escalating demands and resource degradation, poses serious threats to ecosystems and environmental resilience.

Drawing attention to India's **Desertification & Land Degradation Atlas (2021)**, Dr. Reddy shared that approximately 97.85 million hectares, or 29.77% of India's land, are degraded due to erosion, vegetation loss, and salinity. Such degradation impacts soil health, water recharge, and carbon storage, with rainfed areas being the most severely affected.

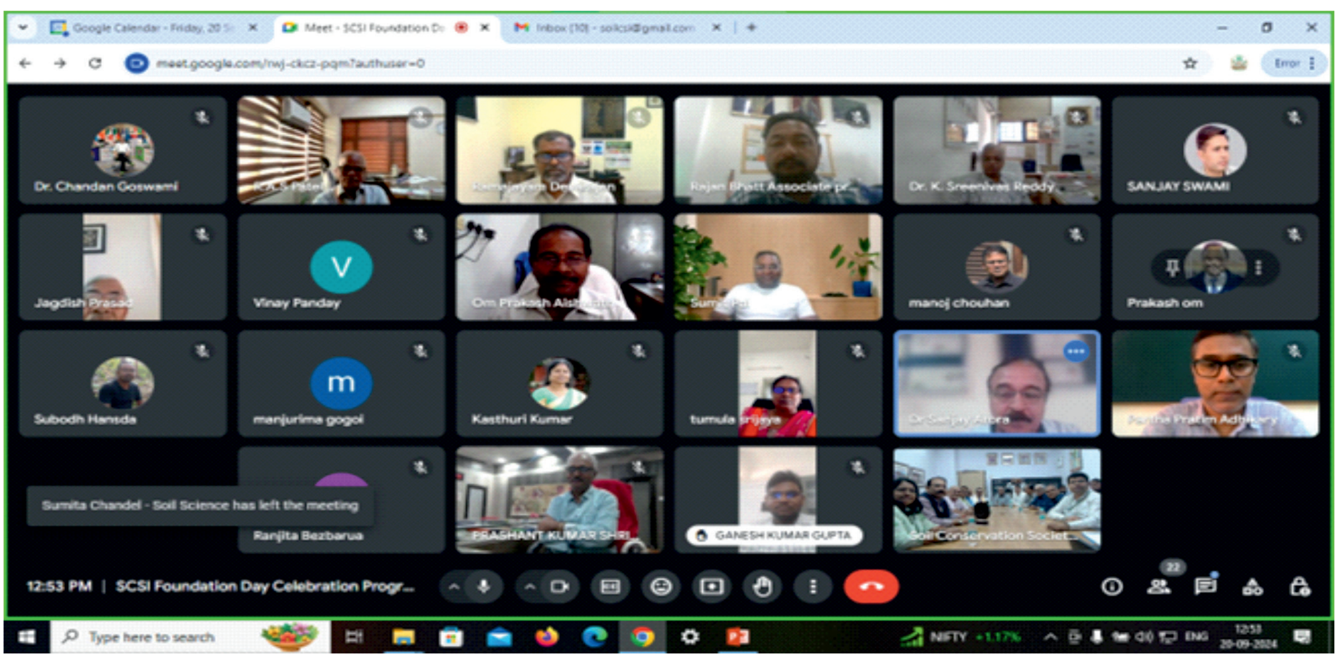
Rainfed agriculture, which covers 51% of India's net sown area, produces 40% of the country's food grains and supports two-thirds of its livestock and over 60% of farm families. Addressing the challenges faced by these areas through watershed development and a ridge-to-valley approach is crucial for conserving resources and ensuring the sustainability of irrigated regions.

The **Department of Land Resources (DoLR)** plays a pivotal role in these efforts, implementing the Watershed Development Component (WDC) under the **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)**. Since 2009, the department has successfully completed 6,382 projects covering 29.59 million hectares. These initiatives have yielded significant outcomes, such as the construction of water harvesting structures and the expansion of protective irrigation. The current phase, **WDC-PMKSY 2.0 (2021-2026)**, aims to develop an additional 49.5 lakh hectares with a budget allocation of Rs. 8,134 crore.

Efforts under WDC-PMKSY include soil conservation, afforestation, and rainwater harvesting. New initiatives, such as springshed management and the cultivation of spineless cactus for biofuel, fodder, and other uses, are being explored. The DoLR continues to collaborate with various stakeholders to enhance ecosystem services and improve farmers' incomes.

Despite the progress made, Dr. Reddy emphasized that India's growing population, projected to reach 1.61 billion by 2047, will require an increase in food production. He highlighted the need for a **national land-use policy** to balance agricultural and urban demands, ensuring food security and sustainable development in the face of changing climate conditions.

The event underscored SCSI's ongoing commitment to soil and water conservation, highlighting the society's significant role in promoting sustainable agricultural practices for the betterment of India's natural resources and rural communities.



Unveiling the Economic Potential of the Spineless Cactus Cultivation for Green Economy

Dr. C.P. Reddy,

Senior Additional Commissioner, Department of Land Resource (DoLR), Ministry of Rural Development (MoRD), Government of India

The spineless cactus, scientifically known as *Opuntia Ficus-Indica*, belongs to the genus *Opuntia* within the Cactaceae family and native to Mexico. Spineless cactus has been cultivated for centuries for various purposes, including food, fodder, and medicinal uses. It is characterized by its distinctive flattened stems, commonly referred to as pads or cladodes, which lack the sharp spines typically associated with cactus spine.

The history of spineless cactus cultivation can be traced back to ancient civilizations, where it held cultural, nutritional, and economic significance. Cactus cultivation, once mainly for ornamental purposes, is now a promising venture. It is a versatile and drought-tolerant plant, thrives with minimal water, making it ideal for arid & semi-arid regions. It enhances soil water conservation, rangeland, and pastureland management. Spineless cactus produces various agricultural and food products, boosts cattle milk production, support biogas production, and provide high-value bio-leather. Its nutritious leaves, pods, seeds, and flowers have medicinal properties and can be used in alcoholic drinks. Spineless cactus also aids in land reclamation and erosion control, stabilizes soil, conserves water, and improves soil fertility. This makes it an attractive crop for farmers and commercial growers and promoting a green economy.

At present, cactus cultivation is limited to only for fodder purpose in the country. The various other economic usages of cactus as explained above needs awareness, publicity and its promotion through facilitating availability of quality planting material, package of practices and marketing avenues. Planting material for cactus is typically developed in nurseries. However, to address the shortage, tissue culture offers a promising method to ensure the availability of planting materials for large-scale national production.

The Watershed Development Component of Pradhan Mantri Krishi Sinchayee Yojana 2.0 (WDC – PMKSY 2.0) implemented by DoLR, Ministry of Rural Development (MoRD), Government of India (GoI), provides for taking up suitable plantations of various kinds which help in restoration of rainfed/degraded lands. Cactus is the hardiest plant species which requires only scanty rainfall for its growth and survival. Accordingly, DoLR is exploring various options for taking up cactus cultivation on degraded lands for realizing the benefits of its use as 5 F i.e. fuel, fertilizer, fodder, food and fashion etc. for the larger benefit of the country. It is anticipated that bio-gas production from cactus would reduce fuel import burden of the country, apart from developing degraded lands and contributing towards employment generation/livelihoods, increasing vegetation area, carbon sequestration and addressing climate change issues etc. in these areas.

The Government of India has mandated the blending of Compressed Biogas (CBG) with natural gas to reduce import reliance. Starting in April 2025, 1% of biogas will be blended into gas used for automobiles and household cooking, increasing to 5% by 2028. The Compressed Biogas Blending Obligation (CBO) aims to boost CBG production and consumption, stimulate demand in the city gas distribution sector, substitute LNG imports, save foreign exchange, promote a circular economy, and help achieve net-zero emissions. The CBO is expected to attract investments of around Rs. 37,500 crore and establish 750 CBG projects by 2028-29.

Given the objectives of the CBO, it is important to identify multiple biomass sources for biogas production. Spineless cactus is a promising biomass source with various uses. Systematic pilot research is needed to maximize the production of the best cactus varieties across multiple locations. The International Centre for Agricultural Research in Dry Areas (ICARDA) has established a 2 cubic meter bio-digester at their farm in Amlaha, Madhya Pradesh. ICARDA's experiments with a 90% cactus biomass and 10% cow dung as feed stock generated biogas with 64% methane. Keeping this in view, DoLR has decided to undertake larger pilot projects using cactus for biogas production and is collaborating with States for large-scale cactus plantations. The State Level Nodal Agency (SLNA) of Rajasthan, Balram Seva Trust, Hingonia Goshala, Jaipur, ICAR, ICARDA, IGFRI, and DoLR have prepared plans for a pilot cactus plantation project at Hingonia Goshala, Jaipur. A Memorandum of Understanding (MoU) was signed among the DoLR, ICAR, ICARDA, and Rajasthan SLNA.

In Hingonia Goshala, Bassi, Jaipur, a significant initiative is underway to evaluate the feasibility of using spineless cactus biomass for biogas production. This project is being conducted in collaboration with the operational Compressed Biogas (CBG) plant run by the Indian Oil Corporation Limited (IOCL) with support from the Shri Krishna Balram Trust. The CBG plant currently using cow dung as feed stock to produce biogas, which is supplied to Akshaya Patra in Jaipur for cooking gas needs, however, the available cow dung has proven insufficient to maximize the plant's capacity.

To address the need of biomass, a full-scale pilot project has been initiated to use spineless cactus biomass as an alternative and supplementary raw material. As part of it, a 4-hectare cactus nursery at Hingonia Goshala with funding from the WDC-PMKSY 2.0 has been established. The project aims to plant 400 hectare of spineless cactus. Additionally, the project will explore the potential for producing green hydrogen from the cactus biomass. This innovative approach not only aims to ensure the full utilization of the CBG plant's capacity but also to assess the economic viability of biogas production using cactus biomass before expanding the practice to other States. Many States have expressed their willingness to take up pilot cactus plantation under WDC-PMKSY 2.0. The successful implementation of this cactus pilot could potentially lead to sustainable and alternative energy sources, promoting environmental conservation and economic development in the region.

Further, round the year production can be taken under low-cost greenhouse condition. Under greenhouse, spineless cactus can be harvested regularly at an interval of 15-20 days with an average yield of 1.5 kg tender cladodes per plant per year. Thus, the farmer can get regular income from this crop. Preliminary studies indicated that Rs 150 to 200 per plant per year may be obtained from different fresh products of vegetable, fruits and processed items (such as squash, pickle, jam, candied products etc.) from a full-grown plant after 3-4 years of planting. Thus, a farmer can get an income of Rs 500 to 600 per square metre area under greenhouse condition with an estimated benefit cost ratio of 3:1.

In addition, cactus cultivation can enhance carbon sequestration in drylands. Through photosynthesis, cactus plants store carbon in their above-ground biomass and roots. Cactus pear is very effective as it absorb 550 mol CO_2 per m^2 of cladode surface area daily, thus making it as a valuable carbon sink in dry areas.

Conclusion

Overall, the spineless cactus represents a remarkable example of a plant species that has transcended cultural and geographical boundaries, evolving from a traditional staple into a globally recognized crop with diverse economic and ecological significance. Its continued cultivation and utilization hold promise for addressing contemporary challenges in agriculture, food security, and environmental sustainability. Cactus cultivation presents a unique opportunity to harness the economic potential of arid and semi-arid regions while promoting sustainable practices and biodiversity conservation. By embracing innovative cultivation techniques and exploring diverse economic usages, spineless cactus cultivation represents a paradigm shift towards a more sustainable and resilient economy. By harnessing the ecological and economic potential of these resilient plants, nation can foster green growth, alleviate poverty, and mitigate the adverse effects of climate change. However, realizing this potential requires concerted efforts from policymakers, researchers, and various stakeholders to promote investment, innovation, and knowledge transfer in spineless cactus cultivation.

Biosensors: A New Era in Agriculture

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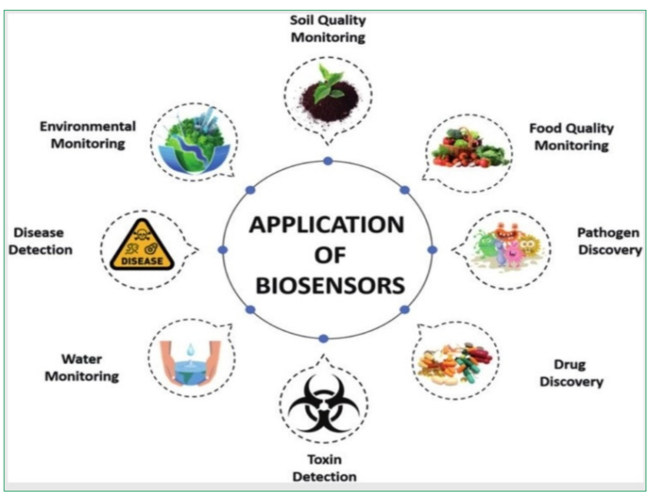
Biosensors are the analytical instruments which convert biological reaction into an electrical signal. They ought to be extremely accurate, reusable, and unaffected by external factors like pH and temperature. The biosensors, their architectures, transducing mechanisms, and immobilization method require multidisciplinary study in engineering, chemistry and biology. Biosensor materials are divided into 3 classes depending on their mechanism: biocatalytic which includes enzymes, bio affinity which includes antibodies and nucleic acids, and microbe-based which includes microorganism.

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 exposed 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. The concentrations of chemicals such as pesticides, herbicides, and heavy metals in the soil and groundwater can be determined using biosensors. With the development of technology, biosensors can now be used to anticipate the probable emergence of soil disease. More efficient early prevention and purification of soil sickness is made possible by using a biosensor toperform biological soil diagnostics. Based on the principle of converting biological signal into electronic signal, different types of biosensors hold its applications in agriculture.

Principle of biosensors

Signal transduction serves as the foundation for the operation of biosensors. These components include bio recognition elements and electronic systems composed of display, amplifier and processor.The biosensor's detector, transducer, and reader components mediate the biological interaction between an analyte and its biological component, helping the researcher determine whether or how much analyte is present. The biosensors' reader section generates a signal proportional to the concentration of analyte present, which is subsequently output in the proper way.



Application and role of biosensors in agriculture

Biosensors can be used to forecast the potential occurrence of crop and soil diseases, which has not been achievable with the existing technology. The biological diagnosis of crops and soil using biosensor means opening the approach to effective early detection and decontamination of soil disease.

- ***Biosensors in agronomy and agricultural soil chemistry:*** Electrochemical biosensors are employed in soil experiments, to measure pH or nutrient content, to manufacture high-quality, palatable food, and to acquire agricultural output yields. The Electronic Nose (E-nose) biosensor is an intelligent gadget that has been implemented successfully to detect insect infestations, soil-borne diseases, and fruit maturity, among other things.
- ***Biosensors in detection of plant pathogens***: QCM (Quartz crystalline Micro balancer) biosensor or Acoustic-based biosensor detects plant pathogens like *Ralstonia solanacearum*, *Pseudomonas syringae* pv. tomato and *Xanthomons 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 ring spot virus (ORSV) for rapid diagnosis of viral infections. Bacteriophage -Based Biosensors have demonstrated to be successful in controlling plant pathogens.
- ***Biosensors in detection of crop diseases:*** SPR (Surface Plasmon Resonance) based immune sensors working on the principle of antigen and antibody interaction. Immunoassays (such as the enzyme-linked immune sorbent assay technique) often employ a label (e.g., enzyme, antibody, fluorescent marker). Due to the method's exceptional sensitivity, the pathogen can be found in samples at incredibly low concentrations. Therefore, it helps in the diagnosis of rust at an early stage of soybean rust disease that leads to control the

disease to eco-friendly way. Using antibody and antigen concentration, it is also employed for the rapid and accurate detection of MCMV (maize chlorotic mosaic virus).

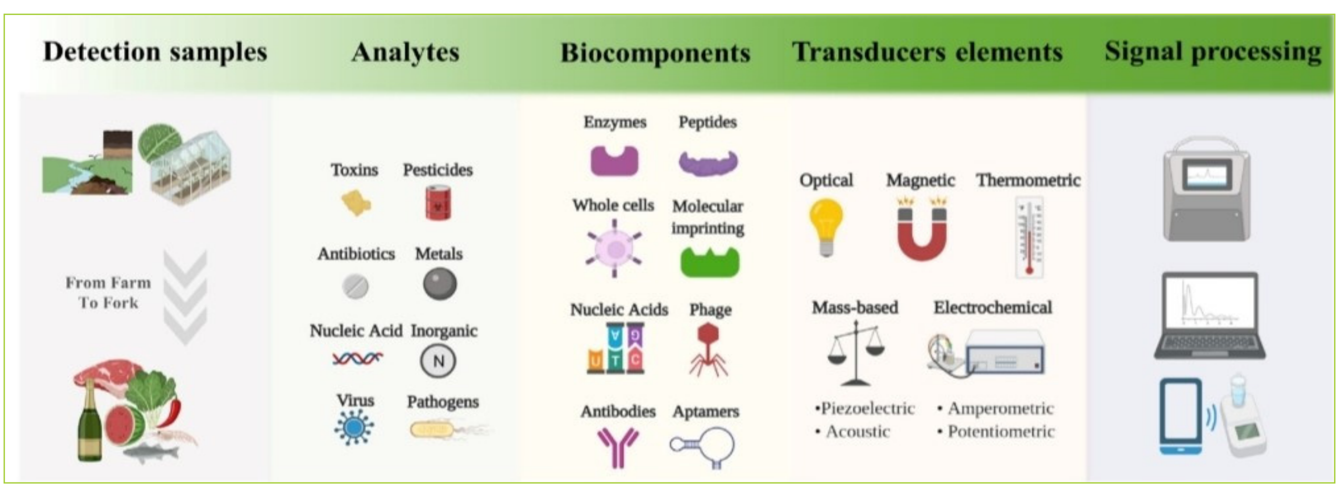
- *Biosensors in organo-phosphorus:* Organo-phosphorus are the group of chemical compounds that widely used as insecticides, pesticides and herbicides in modern agriculture for controlling a wide variety of insects, pests, weeds and disease transmitting vectors. The concentration of insecticides, pesticides, herbicides and heavy metals in agricultural lands is increasing day by day. These aspects contaminate the soil and environment and cause many health hazards to living organisms. Monitoring of the organo-phosphorus compounds is necessary in agricultural lands for healthy and sustainable development. Biosensors can play a major role in detecting and monitoring organo-phosphorus levels in the soil and groundwater.
- *Biosensors in pesticides and its residues detection:* 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 pesticides. Immunosensors are biosensors that use antibodies or antigens as the specific sensing elements and provide concentration dependent signals. Electrochemical acetylcholinesterase (AChE) biosensors are simple, rapid and ultra-sensitive tools used to detect carbamate pesticides in fruits and vegetables. The AChE biosensor detects and analyses the carbaryl and methomyl concentrations in given samples. 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.
- **Biosensors for detection of herbicides:** The biosensor measured and detects the herbicides e.g., 2, 4 dichlorofenoxiacetic, diuron and paraquat, that inhibit photosynthesis in plants such as the phenyl urease and triazines etc. Photosystem 2 -based biosensors are used to detect photosynthetic herbicides.
- **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.
- *Biosensors for detection of food pathogens and mycotoxins:* 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. 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. Electro chemi luminescentaptamer biosensor detects the presence of Ochratoxin A in beer and coffee samples.

Benefits of using biosensors in agriculture

It provides precise and detailed readings, and easy to handle. Non-polar molecules can also be measured. There is no need of continuous monitoring. It is an advanced instrument for identifying and monitoring phyto-pathogens.

Conclusion and future Prospects

Food losses resulting from crop infestations by pathogens like bacteria, viruses, and fungi have been a recurring problem in agriculture for generations worldwide. 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. In crops, advanced disease detection and prevention are essential. The major features of biosensors are stability, cost, sensitivity and reproducibility. Opportunities for biosensors in a variety of agricultural domains, such as in-situ monitoring of contaminants in crops and soils and the detection and identification of infectious diseases in crops and livestock, are created by the need for quick, precise, and online sensing.



SCSI Foundation Day Observed by Meghalaya Chapter

The Meghalaya Chapter observed 'Foundation Day' of the Soil Conservation Society of India on 20th September, 2024 at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Barapani.

Dr. N Janaki Singh, Associate Professor (Soils) & General Secretary of the SCSI-Meghalaya Chapter welcomed all the members in the foundation day celebration. Sharing the historical aspect, he informed that the Soil Conservation Society of India was first established at Hazaribagh, Bihar (now in Jharkhand) and later on the HQ was shifted to New Delhi. He informed that this year, they are celebrating 73rd foundation day of the society today. He added that the SCSI is mandated to the welfare of farmers and all the rural people whose livelihoods are associated with the management of natural resources. It works for the cause of conservation, development, management and sustainable use of the soil, land, water and associated resources of plants and animals. The SCSI extends its activities by establishing State Chapters in various parts of the country and at present, 23 State Chapters of the SCSI are functioning including the Meghalaya State Chapter at CPGS-AS, Barapani. He also highlighted the concentrated efforts of SCSI team at national and international level in conserving the natural resources since its inception.

Dr. Amit Mishra, Associate Professor (Soils) highlighted the importance of joining the SCSI during master or doctoral degree programmes, elaborated the benefits in academic career like participation in annual conference, publication of research papers, articles, keeping in touch with recent research trend, and learning about innovative approaches for sustainable management of soil and water resources. Dr. Lala I P Ray, Professor (Soil & Water Conservation) emphasised the need of collective efforts for conserving natural resources in Meghalaya as the entire state is hilly and need more attention. Ms. Ventina Yumnam also shared her views about how she is being benefitted from the SCSI activities such as getting exposure by attending conferences, online lectures, quiz and essay competitions, and winning various awards. She urged the fellow students to join the SCSI team and contribute for the noble cause of soil and water conservation.

Dr. Sanjay Swami, Professor (Soils) & Chairman of the SCSI-Meghalaya Chapter also extended greetings to all the SCSI team members on the occasion of 73rd foundation day. In his presidential remarks, he appraised the house about various activities taken up by the Meghalaya Chapter of SCSI for improving soil and environmental health in the hilly tract of Meghalaya and shared that their efforts in this direction has been recognized by the SCSI HQ as the Meghalaya Chapter was conferred with the prestigious Best Chapter Award - 2020 and again in 2023 among 23 state chapters of SCSI in the country. He added that this is the result of hard and dedicated work of all its members and congratulated the Meghalaya Chapter team.

Many members of SCSI-Meghalaya Chapter also participated in this event. The programme ended with vote of thanks proposed by Mr. Deepak Kumar, a student member of the Meghalaya Chapter.

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