EMERGING TECHNOLOGIES IN AGRICULTURE AND FOOD SCIENCE

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Karim Ennouri

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CONTENTS

FOREWORD

I am delighted to write the foreword of the book titled *''Emerging Technologies in Agriculture and Food Science''* edited by Dr. Karim Ennouri and published by Bentham Science Publishers. I know Dr. Karim Ennouri for more than ten years, and I deeply believe in the research value of interpretive discussion in the biotechnology domain.

Biotechnology is considered as the modern green revolution, offering influential instruments for efficient advanced crop plants, in addition to other organisms through constantly growing technologies aimed at well-organized employment of biological systems to benefit humanity. Applied biotechnology presents an exceptional occasion to propagate scientific perception of a variety of dynamic phenomena and processes related to ecosystems. The exploitation of data sets and the improvement of original data processing algorithms assist in developing aptitudes to process all dimensions of plant observation data and employ these data in making management verdicts and decisions.

I hope and expect that this book will provide an effective learning experience and referenced resource on the topics of agro-biotechnology, bioactive elements, monitoring of vegetation dynamics and modeling, and biotechnological innovations of natural products.

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PREFACE

Nowadays, cultivators are increasingly arranging innovative, highly technical and scientific estimations with the aim of enhancing agricultural sustainability, effectiveness, and/or plant health. Innovative farming technologies incorporate biology with smart technology: Computers and devices exchange with one another autonomously in a structured farm management system. Throughout this structure, smart agriculture can be accomplished; cultivators decrease plantation inputs (pesticides and fertilizers) and increase yields via integrated pest management and/or biological control.

Moreover, the intensive use of pesticides creates imbalances in the microbial community, which may be unfavorable for the activity of the beneficial organisms and may also lead to the development of resistant pathogen strains, increasing environmental degradation. Owing to the limitations of chemical control measures, it seems appropriate to seek a more suitable control method. Biological control appears as the most promising strategy, being environmentally safe and cost-effective for controlling several phytopathogens. Therefore, the development of novel agents can be useful in the control of plant diseases. Recently, there has been a growing interest in researching the possible use of functional biomolecules that possess a selective action against these fungi without being toxic to the ecosystem for pest and disease control in agriculture. Natural biomolecules are increasingly becoming an effective and environmentally friendly tool for the control of phytopathogenic agents.

This book resumes present innovative techniques and methodologies to complement usual plant control and breeding attempts toward enhancing crop yield and production and consequently maintaining food security.

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CHAPTER 1

Active Compounds from Pomegranate Seed: New Source for Food Applications

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Abstract: Pomegranate is an essential fruit bearing tree well cultivated in the world. Biological potential and nutritional value were very reputed in both of pomegranate fruit and its by-products, such as seeds. According to the presented information in literature, the use of pomegranate seed as a natural food preservative can be explained by its phytochemicals richness. Based on this phenolics content of pomegranate seed (PS) extracts, the current chapter will talk about its successful use as natural preservative agent in the development of healthier and shelf stable food products. This document speaking of the antioxidant and antimicrobial activities evaluation of PS and its principal active phenolic compounds identified and quantified by advances in the separation sciences and spectrometry, will perform a comprehensive review of the scientific literature. Furthermore, the impact of using PS on the food quality and agri-food products was also evaluated.

Keywords: Advanced analytical chemistry, Antioxidant and Antimicrobial activities, Biopreservation, Food and agri-food products, Pomegranate seed, Phenolic compounds.

INTRODUCTION

Because food and agri-food products preservation has become an international problem, the used chemicals are severely regulated [1, 2]. For that reason, in the previous decade, the exploitation of natural products with biological properties has been revived attention given its remarkable phytochemical and reliable

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Karim Ennouri (Ed.)

approaches for the preservation of food products. In this line, bioactive compounds of fruits and vegetables, including sources of flavonoids, phenolic acids and pigments, have been examined for enhancing human health and ensuring food security due to their biological potential [3 - 5].

Given its remarkable phytochemical content, pomegranate (*Punica granatum*) has captured increased interest [6 - 9]. Considered usually as waste, pomegranate seeds (PS) have been described as being abundant in polyphenols such as flavonoids (anthocyanins, catechins and other complex flavanoids) and hydrolyzable tannins (punicalin, pedunculagin, punicalagin, gallagic and ellagic acid esters of glucose) [10, 11]. Equally, PP's Phenolic compounds contain anthocyanins, gallotannins, ellagitannins, gallagylesters, hydroxyl benzoic acids, hydroxyl cinnamic acids and dihydro flavonol [12, 13]. Fig. (**1**) demonstrates the polyphenols structure found in pomegranate [13]. Phenolics of PS have been reported to display realistically elevated free radical scavenging activities and also powerful antimicrobial activity [14, 15]. Furthermore, their nutraceutical application, PS exposes important properties and techno-functional food applications, (*e.g.* antioxidant, antimicrobial, colorant and flavoring) [16 - 18]. PS, evenly, can proceed as notable natural additives for food and agri-food products and their quality development thus affording a well-founded alternative to synthetic antioxidants [18 - 20].

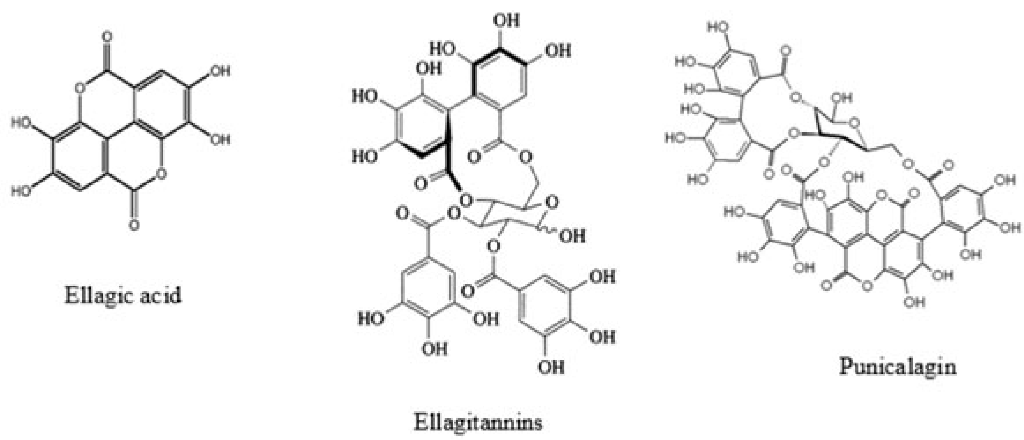

Fig. (1). Structure of polyphenols present in pomegranate.

For that reason, the existing chapter presents a cumulative in-depth knowledge on the analytical techniques exploited in categorization of PS phenolic compounds, anti oxidant and antibacterial potentials and successful exploitation of PS in food and agri-food products.

BOTANICAL ASPECTS OF POMEGRANATE

Pomegranate probably originated from Saxifragales belonging to the order Myrtales [21]. It was in 1753 that the genus *Punica*, having tropical ancestors close to Lythraceae and Sonneratiaceae, was described for the first time by Linnaeus [22]. The evolution of Punica along the xero- and cryophilic lines of development, caused its Arogenesis. Punicaceae is a monogeneric family that includes a single genus *Punica* of two species, *Punica granatum* L. and P. *protopunica* Balf. f., (syn. Socotria protopunica) with the latter endemic to Socotra Island (Yemen) whereas *Punica nana*, another form of *P. granatum* is frequently considered as third species of *Punica* [23].

More than 1000 cultivars of *Punica granatum* are present [24], native from the Middle East, prolonged throughout the Mediterranean, eastward to China and India, and on to the American Southwest, California and Mexico in the New World. The fruit itself donates rise to three parts: the seeds, about 3% of the fruit weight, and themselves possessing around 20% oil, the juice, near 30% of the fruit mass, and the peels (pericarp) who also contain the inner network of membranes. Other functional parts of the plant comprise the roots, bark, leaves, and flowers [25].

PS Phytochemical Content

From Tunisian pomegranate fruits, PS total phenolic content (TPC) was 326.7 ± 1.4 mg gallic acid equivalent/100 g fresh matters (FM) [26]. These authors confirmed that this value was in accord with preceding finding in Indian PS, which ranged from 230 to 510 mg gallic acid equivalent (GAE)/100 g FM [27].

According to Elfalleh *et al.* [28], Tunisian PS extracted with methanol had higher TPC values (11.84 GAE mg/g dry weight), flavonoids (6.79 mg rutin equivalents per dry weight (mg RE/g DW/g DW), anthocyanins (40.84 mg of cyanidin---glucoside equivalents per g DW (mg CGE/g DW) and hydrolysable tannins (29.57 mg tannic acid equivalent per g of DW (mg TAE/g DW). Gozlekci *et al.* [29] investigated the total phenolic of four Turkish PS.

PS contained 3.3% of the overall fruit phenolic content and TPC was ranged from 117.0 to 177.4 mg GAE/L. In fact, TPC of PS from cultivars “Asinar,” “Lefan,” “Katirbasi,” and “Cekirdeksiz-IV” was 177.4 mg/L, 125.3 mg/L, 121.2 mg/L, and 117.0 mg/L, respectively [24]. Kalaycıoğlu and Erim [30] calculated the levels of bioactive compounds and antioxidant activities in juice, peel and seed of 3 genotypes of pomegranate cultured in Turkey. Results discovered that the peel extract had about 12.4-fold higher total flavonoid than that of juice extract, and

CHAPTER 2

Application of Enterococci and their Bacteriocins for Meat Biopreservation

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Abstract: Nowadays, consumers are more aware and conscious about health concerns related to foods, which increase their demand for more safe food, particularly meats, free of additives such as preservatives, and if so with natural ones. In line with this, bacteriocinogenic lactic acid bacteria (LAB) and their bacteriocins have been widely screened and studied in the last years in view of their use in meat biopreservation. This chapter presents an emphasised overview regarding enterococci and their produced bacteriocins (enterocins) as part of interesting LAB and biomolecules with promising potentialities to be used in meat preservation as alternatives to synthetic preservatives thus satisfying consumers' demand for healthy and "bio" meat. Indeed, the characteristics of enterococci and enterococcal bacteriocins were described based on published literature. Further, we have reviewed some of the research on their applications for biopreservation of meat and meat products with a focused discussion on diverse topics such as their advantages as well as the challenges and limits of their use in meat. Finally, the synergistic approaches based on combinations of enterococcal protective cultures and/or enterococcal bacteriocins with other technological concepts to improve safety and quality of meats are reported and discussed.

Keywords: Application, Bacteriocin, Biopreservation, Biopreservative, Enterococci, *Enterococcus*, Enterocin, Lactic acid bacteria, *Listeria monocytogenes*, Meat, Pathogen, Protective culture, Spoilage.

INTRODUCTION

Microorganisms represent a risk to human health from food-borne illnesses and a problem to economic losses. Considering this, chemical additives are intensively

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Karim Ennouri (Ed.)

used to inhibit microbial proliferation and extend the food shelf-life [1].

As a result, several studies demonstrated that synthetic food preservatives have been linked to toxicological problems and diseases (allergic reactions, heart diseases, neurological problems and cancers) [2]. Besides, consumers are increasingly demanding safe and "bio" foods without chemical preservatives which encourage food industries to search and apply for novel strategies based on ensuring food safety and extending their shelf-life with natural antimicrobials that fall in the principle of "food biopreservation".

Several bacteria could produce antimicrobial substances called "bacteriocins", but those produced by lactic acid bacteria (LAB) have gained a great interest in recent researches [2, 3]. Among these LAB, enterococci and their produced bacteriocins called "enterocins" have received considerable attention and were extensively studied for their potentialities to be used in food biopreservation thanks to their large spectrum of antimicrobial activities against many food-borne pathogens and spoilage bacteria such as *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus* and *Bacillus* spp [4].

For this purpose, the application of enterococci in foods could be realised according to two methods; (i) direct application of the bacteriocin-producing strain into food matrix as bioprotective culture or (ii) direct application of cell-free supernatant (CFS), partially purified or purified bacteriocin as a food preservative [5, 6]. These techno-biological strategies need in-depth studies regarding the safety aspects of the inoculated antimicrobials supported by toxicological data, their activity and efficacy in foods and their bactericoin production process prior to their legal approval by the authorities as applicable preservative agents. On the other hand, the incorporation of enterococci or their enterocins in packaging could be another technique to ensure microbiological quality and safety of foods [5, 6].

Among the foods that were much studied in the last years to be inoculated with enterococci and/or their enterocins to improve their overall safety, we could notice meats which represent an important source of valuable nutrients in the human diet [6, 7]. However, they are characterised by a very short shelf-life due to their composition ideal to various microbial proliferation and contamination leading to a health risk for consumers, a degradation of organoleptic quality (appearance, texture, odour, flavour, and colour) and an economic loss in meat industries.

This chapter will cover general features on enterococci and their bacteriocins as natural "solutions" attempting to solve these issues. Nevertheless, researchers and industries will always face conflicting challenges to assure meat safety and meet consumers' satisfaction. Furthermore, earlier works [8, 9] generally illustrated the role of enterococci and/or enterocins in diverse foods; however, a fewer [10] emphasised their functionalities in meat and meat products. With this aim, the present chapter summarises the most relevant insights obtained during the last years about the practical importance of enterococci and enterocins for use in biopreservation of meat as food example and highlights in detail their current applications in the meat industry by discussing both advantages and limitations and finally exposes some approaches with high hope to mainly overcome these limitations.

General Characteristics of Enterococci

Enterococci are Gram-positive, catalase and oxidase-negative, facultative anaerobic and non-spore-forming bacteria [11]. Until now, this LAB genus contains about 37 identified species, but *E. faecium* and *E. faecalis* remain the most abundant among them [12].

Enterococcus species can grow at a temperature range from 10°C to 45°C in aerobic conditions [13]. They can also grow in a wide range of pH (4.4-9.6) and tolerate media with 6.5% of NaCl and the presence of 40% (w/v) of bile salts [14].

Enterococci usually inhabit the alimentary tract of humans and animals, and can be present in various environmental sources such as water, soil and plants in addition to being isolated from different foods (dairy products, fermented vegetables, fish, seafoods, meat and meat products) [12].

Bacteriocins Produced by Enterococci

General Characteristics and Inhibitory Spectrum

Bacteriocins produced by enterococci are ribosomally synthesised peptides or proteins, cationic and amphiphilic in nature, pH and heat stable, and characterised by antimicrobial activities against closely related bacterial species [15 - 17]. However, recent studies demonstrated that these bacteriocins could have a large spectrum of action including other Gram-positive bacteria such as *L. monocytogenes* and *S. aureus* [18 - 22], Gram-negative bacteria such as *P. aeruginosa* and *E. coli* [19, 21 - 23], fungi and yeasts [21, 22] and in some cases viruses such as herpes viruses HSV-1 and HSV-2 [24 - 27], HSA virus [27] as well as polio and measles viruses [25].

Baceriocins of *Enterococcus* spp. are generally called "enterocins" but often we can note other nominations such as "mundticin" (referring to a bacteriocin that is

CHAPTER 3

Technological Advancement in the Detection and Identification of Plant Pathogens

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Abstract: Severe yield losses due to crop infections with pathogens such as bacteria, viruses and fungi are challenging issues in agriculture for decades across the world. To limit the impact of disease damage in economically important crops and to ensure agricultural sustainability, developing new diagnostic methods for the rapid and accurate detection of plant pathogens is essential as it helps to prevent major yield losses and preserve a good quality of products at the postharvest stage. In this context, serological techniques such as ELISA and molecular protocols based on PCR, quantitative PCR, isothermal amplification, microarrays and RNA-Seq-based next-generation sequencing are leading to more accurate detection for the most destructive plant pathogens, which reduced the economic losses due to plant disease infections. Despite their reliability in the design of an efficient management program for several plant diseases, the performance of these techniques is sometimes limited by, the unknown distribution of the studied disease, the existence of asymptomatic infections and the lack of validated sampling protocols. Recently, more sophisticated techniques such as thermography, fluorescence imaging, hyper-spectral techniques and biosensors relying on various parameters such as morphological change, temperature change, transpiration rate change and bio-recognition elements such as enzyme, volatile organic compounds, antibody, and DNA/RNA released by infected plants have been applied, either for on-site diagnostic or for detecting plant diseases over large areas. This review briefly describes the various techniques used for plant disease diagnosis and their evolution to meet the contemporary challenges.

Keywords: Biosensors, Chlorophyll fluorescence, Hyperspectral imaging, Nucleic acid-based methods, Plant disease, Pathogen detection, Serological based assays, Thermography.

INTRODUCTION

Plant diseases reduce the world's agricultural productivity by up to 40% yearly,

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Karim Ennouri (Ed.)

leading to potential economic losses and substantial environmental effects from chemical management practices [1, 2]. Thereby, monitoring and early detection of harmful pathogens are essential to prevent their spread and ease the design of successful management programs.

The accurate diagnosis of plant diseases relies on the good knowledge of the biological basis of the host-pathogen interaction and the visual specific symptoms that may develop during infection [3]. Basically, the diagnosis of crop diseases is based on assessing the visual symptoms and their severity using traditional disease scales [4]. However, these methods are too subjective, due to the similarity of symptoms and changes in the host tissue morphology caused by biotic or abiotic stress [3, 4]. In addition, visual inspection does not allow discrimination of diseased plants from symptomless ones, which underestimates the threat posed by the pathogen and hampers the predicting of possible disease outbreak onset [3, 5]. Therefore, effective management programs against harmful pathogens have to be performed before the onset of disease outbreak, which requires an accurate and specific diagnosis during the early stage of infection [6].

Over the last two decades, detection of plant pathogens has shifted from the visual inspection of symptoms, towards molecular and immunological approaches. Several protocols relying on the Enzyme Linked Immunosorbent Assay (ELISA) and Polymerase Chain Reaction (PCR) were successfully used to resolve several cases of biotic infections [7 - 10]. The ELISA assay, which is the most used serological method, was first optimized for detecting plant viruses [11] and then applied for detecting fungal and bacterial pathogens using monoclonal and polyclonal antisera [12 - 14]. However, due to their low sensitivity and specificity, serological methods are likely unsuitable for large phytosanitary inspections. Recently, molecular DNA-based technologies have come into play with higher specificity and sensitivity, which allow detecting a low pathogen titer in the host tissues [15, 16]. The PCR-based methods targeting genus- or species- specific DNA markers have been widely employed for identifying the most harmful plant pathogens [17, 18]. Several molecular approaches such as Reverse Transcriptase-PCR (RT-PCR), Nucleic acid sequence-based amplification (NASBA), and other PCR variants (conventional PCR, Nested PCR, Multiplex PCR, and Real-Time PCR) were developed for detecting pathogens in plants and environmental samples [3, 9, 10]. In fact, molecular techniques have been successfully used to discriminate morphologically similar species, detect asymptomatic infection, and conduct large-scale epidemiological studies [19 - 22]. Nowadays, more sophisticated PCR based protocols have been designed to be rapid, quantitative with on-site diagnostic features. As an example, the real-time PCR method is designed to yield amplicons from a target region of a pathogen's genome using specific primers and fluorescent probes [23]. This technique quantifies the pathogens that cannot be isolated or cultured easily from plant tissue, or present at low concentration in the diagnosed samples [23, 24]. Portable real-time PCR instruments are now available for on-site diagnostic assays under field conditions other than the conventional diagnostic laboratory conditions [25]. The Loop Mediated Isothermal Amplification (LAMP) method was also developed to be directly applied in the field, which is reliable in large epidemiological studies and improve decision-making in disease control (Fig. **1**) [26].

Recently, non-destructive approaches, including hyperspectral imaging, thermal imaging and biosensors were developed and applied for large-scale monitoring of many plant diseases and their on-site detection (Fig. **1**) [27]. Thermography, fluorescence imaging, hyperspectral sensors and gas chromatography are the most promising technologies [28]. Actually, biosensors may check the optical features of plants within different regions of the electromagnetic spectrum, to detect early anatomical and physiological changes such as, tissue color variation, leaf shape, transpiration rate, and canopy morphology [29]. However, using spectral approaches is a matter of debate in plant pathology, due to the similarity of symptoms caused by environmental factors and those caused by biotic diseases [30]. Further, use of image analysis is rapidly increasing in the detection of the most plant pathogens, threatening agriculture production worldwide [31, 32].

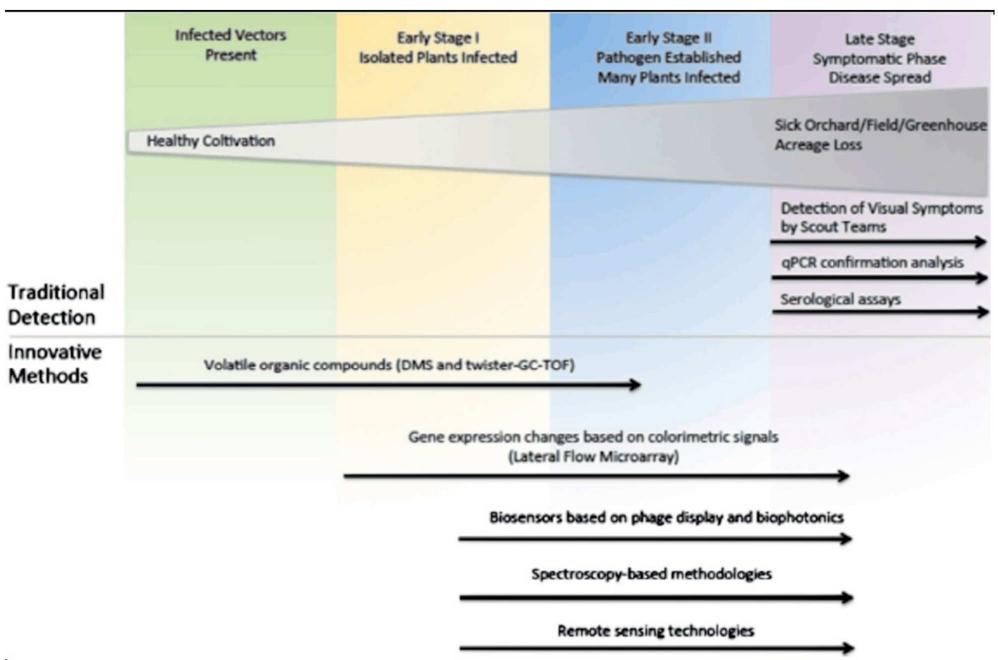

Fig. (1). Timing for useful application of traditional and innovative techniques adopted for plant disease diagnosis [86].

CHAPTER 4

Machine Learning for Precision Agriculture: Methods and Applications

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Abstract: Agriculture plays a critical role in the global economy, and pressure on agricultural systems will continue to increase as the world's population grows. Modern agricultural techniques should take into account both the increased need for efficiency and the challenges posed by climate change, which together define the competing needs for sustainable farming and increased food production. Precision agriculture (PA) refers to the use of both advanced sensor technologies and state-of-the-art data analysis techniques in order to develop data-driven decision support systems. PA can help farmers to optimize crop management through accurate yield prediction and the timely detection of plant diseases and pests. Similar techniques and sensors to those used in precision agriculture can be used in the management and monitoring of livestock or fish farms, which this paper will introduce for completeness. A survey of machine learning methods will be presented in order to provide researchers and end-users with an up-to-date starting point for their projects and use-cases.

Keywords: Artificial Intelligence, Crop Management, Data Analysis, Livestock Management, Machine Learning, Precision Agriculture, Smart Farms, Soil Management, Statistical Prediction.

INTRODUCTION

Precision agriculture (PA) is a broad term encompassing methods and enabling technologies that can provide scientific, sound and reliable decision support systems for farmers at a great level of granularity and detail. The need for such systems arises from the world's increasing population and the new challenges that climate change poses to crops. Moreover, PA technologies can improve farm management by providing timely, detailed and site-specific information on farm

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production. As a result, the costs of running a farming enterprise can be reduced and profits can be increased. However, the adoption of this new kind of approach has been sluggish and far from universal, as reported by Schimmelpfennig *et al.* in [1]. Indeed, farmers frequently implement PA solutions sequentially, starting from a few simple modules, even when the adoption of a whole PA package would be more advantageous. This could, in turn, hinder the adoption of the most innovative solutions, in that the early savings may be deemed sufficient and further risk may be unwanted. A study by Najafabadi *et al.* [2], which explored the main challenges involved in implementing PA technologies through the analysis of questionnaires, found that utilizing such systems could increase profitability and production and reduce the environmental impact of chemicals. One key concern is that the implementation of such technologies requires a substantial initial investment, both financial and in terms of the time spent learning how to use them; moreover, further time will pass before this investment yields an optimal return, an aspect that is of particular concern to small farmers. While that study mainly explored the Iranian situation, similar concerns were discussed in a study by Kritikos *et al*. [3] conducted in the European Union. Further challenges concern data quality and educational, demographic and technical problems.

The present work looks at several studies concerning various areas of application of PA technologies, the aim being to identify cases of the successful use of these methodologies in order to facilitate both further implementation and research. Other surveys can be found in the literature (such as Alreshidi *et al*. [4] and Liakos *et al*. [5]). The first of these concerns itself with tools of the Internet of Things (IoT); it provides extensive examples of possible sensors and infrastructure, and concludes by suggesting the best practices for implementing a complete pipeline for sustainable precision farming. The second survey [5] provides an extensive list and very brief descriptions of previous studies, with the aim of highlighting the most frequently utilized learning methods and the most commonly explored fields of application. One of its findings is that 71% of publications on PA are related to crops and soil applications, while the rest of them focus on aquaculture and livestock management. Fig. (**1**) shows data on the subfields of crop and soil-related domains reported in the survey. The present work will explore a limited subset of possible applications of PA to crops and the most successful methods used, as found in the literature. For completeness, a brief introduction to aquaculture and livestock management is provided.

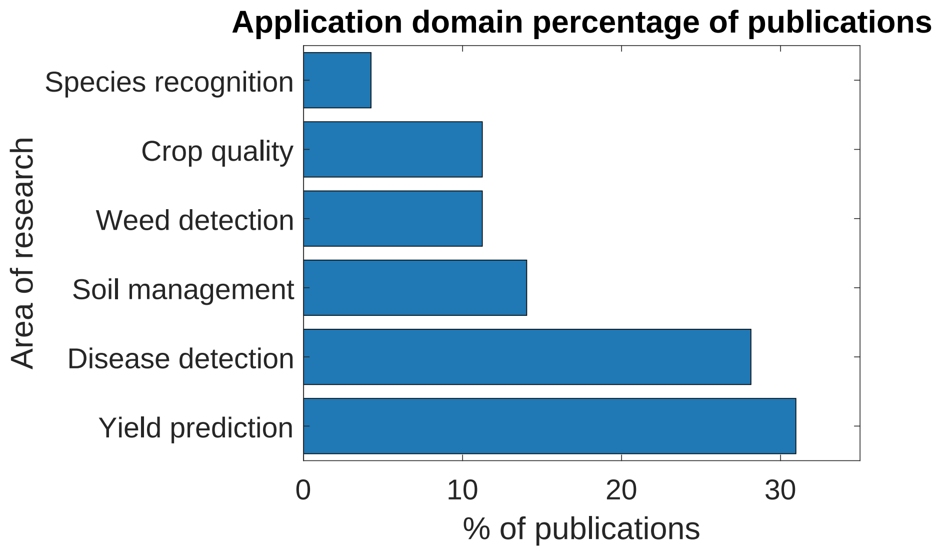

Fig. (1). Application domains by the percentage of publications.

MACHINE LEARNING AND COMPUTER VISION OVERVIEW

In order to better understand the PA applications presented and the cases of their use, the following sections will briefly introduce the terminology of machine learning and computer vision and provide terminology and pointers to the literature.

Statistics and Machine Learning

Statistical learning methods involve finding a suitable function (*i.e.*, a statistical model) to explain the behavior of a dataset. The model is built by optimizing a suitable performance measure and then quantifying how well the model describes all the available data (the training set). The data consist of a set of examples, in which an individual example is described by a set of features. A feature may be categorical, binary, ordinal or numeric. The final aim of the learning process is to generalize the descriptive capability of the model to new data, while avoiding overfitting. Statistical learning methods have led to many successful applications in various fields, such as robotics, medicine, biology and many others. While their application in agriculture is more recent, the effectiveness of the approach is beyond doubt. Finally, the term “statistical learning” is often confused with the more common term “machine learning”. Indeed, there is no clear difference between them. Machine learning is a sub-field of artificial intelligence that studies algorithms that allow a computer to learn to perform a given task. Here, we will use the two terms as if they were interchangeable. The typical flow of a statistical/machine learning approach is depicted in Fig. (**2**).

CHAPTER 5

Use of Remote Sensing Technology and Geographic Information System for Agriculture and Environmental Observation

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Abstract: Information on the environment, coverage, spatial division along by way of natural resources is a condition to accomplish the objectives of biological agriculture and sustainable development. Geographic Information System (GIS) suggests a perfect setting for incorporating spatial and characteristic information on the environment and natural resources. Furthermore, remote sensing permits making accurate records on an assortment of landscape factors which are employed for both creating baseline in addition to derivative records on natural resources used for a range of agricultural actions. Innovations in predicting and telecommunication help in the valuable functioning of most advantageous land use strategies/exploitation strategies. This chapter provides a general idea about the role of remote sensing, Geographic Information System, and digital photogrammetry. Furthermore, the chapter also identifies the progress and developments in captor technology, records processing and explanation/investigation and combination of geospatial records and data.

Keywords: Agriculture, Captor, Geographic Information System, Remote Sensing.

INTRODUCTION

Nowadays, it is clear that the surface of the globe is quickly modifying due to a range of causes at limited and local degrees, with considerable consequences for persons and also for the environment. In the aim to acquire greater comprehension, studying and forecasting the transformations, remote sensing satellite pictures and images represent a vast foundation of helpful information for cover analysis and investigation.

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Explanation and examination of remote sensing imagery engage the recognition and/or measurement of diverse targets in a picture in order to extract practical information about details [1]. There are many applications of remote sensing in the agricultural sector. In fact, Remote sensing is employed to predict the expected crop productivity and yield over a given region and decide how much of crop will be collected under particular conditions. Moreover, Remote sensing technology has been influential in the examination of different crop planting structures. This skill has been applied principally in horticulture manufacturing, where flower development patterns can be analyzed and a forecast made out of the analysis [2]. Moreover, it also plays a significant function in the assessment of plant health crop state and the extent to which the crop has withstood stress. This data is then used to determine the crop quality. Furthermore, it plays a significant function in pest detection in farmland [3].

Remotely sensed satellite examinations from space have basically revolutionized the approach in which researchers learn the atmosphere, mountain, soil, flora, sea, and other ecological aspects of the globe ground. More than fifty years of the satellite surveillances of the globe have offered realistic images and they are the foundation for a novel scientific concept: the earth-system discipline. Remote sensing methods are essential in obtaining valuable information of the globe *via* detectors. The remotely assembled records will be examined in order to acquire data about objects, regions being studied [4]. In addition, it comprises the test and explanation of the obtained records and descriptions, which are the most features that offer pertinent information for ecological researchers in checking globe reserves [5]. Multi-spectral imagery can be employed for the quantification and monitoring of resources through a specified duration of time. Remote sensing methods assist developing regions in studying possible deforestation and transformations in vegetation cover. Besides, geographic information systems are great tools when employed in geographical sciences and land exploitation domains. The energy source, as electromagnetic energy, is the critical mean necessary to pass on information from studied objective to detector. Remote sensing knowledge formulates the utilization of an extensive assortment of Electro-Magnetic Spectrum (EMS) since Gamma Ray towards extended Radio Wave. In fact, Wavelength areas of electro-magnetic emission have diverse names varying from Ultraviolet (UV), Gamma ray, Visible Light, x-ray, Infrared (IR) to Radio Wave [6].

Remote sensing is officially identified as the discipline of finding data in relation to a region, object or event *via* the study of information obtained *via* a tool that is not in direct contact with the region, entity or event in examination [4, 5]. The foundation of *remote sensing* technology is based on the measurement and analysis of the patterns of electromagnetic radiation. Remote sensing uses include a large number of functions, covering the action of satellite arrangements, picture records achievement and memorisation, the consequent data recording, analysis, distribution of saved records and illustration results [5].

Remote detection gives proof that is credible, justifiable, and truthful for decision makers at an assortment of levels [7]. Food security issues, for the most part, happen in remote, horticultural locations with ineffectively developed authority and statistics gathering framework. Checking food production in these regions has necessitated that FEWS NET puts resources into remote estimates that do not depend on reporting of yield and territory planted data of the sort that would be employed. The Famine Early Warning Systems Network, subsidized by the U.S. Organization for International Development, attempts to improve worldwide food protection through the arrangement of significant and early data to guideline makers of people in danger of starvation. Food security, which happens when all individuals consistently have access to adequate, secure, and healthy food to keep up a solid and dynamic life [8], is a basic apprehension in the main survival cultivating economies of arid regions of Africa. Rural inhabitants, depending on rain-fed farming and pastures for their livings, are especially vulnerable to shifts in atmosphere conditions [9]. Monitoring developing conditions utilizing remote sensing data is presently a fraction of early caution that can moderate or even avoid the loss of lives and works related with food security emergencies [10].

Geographic Information System (GIS) is a device that makes visual representations of data and executes spatial investigations with the purpose of making informed decisions. Geographic Information Systems are very useful in being capable to plot and deduct current and coming variations in rainfall, temperature, crop yield, *etc.* [11]. Geographic Information System application in agriculture has been progressively taking part in an essential position in crop production throughout the world by way of assisting farmers in growing production, decreasing costs, and managing their land resources more efficiently [12]. Geographic Information System is applied in agriculture, such as rural mapping performs a crucial function in checking and management of earth and irrigation of any selected arable land. Geographic Information System applied in agricultural mapping acts as imperative equipment for the supervision of the agricultural sector by taking and implementing accurate records into a mapping environment [13]. Geographic Information System is applied in agriculture to help in the management of agricultural resources. Geographic Information System aids in the enhancement of the existing structures of obtaining and generating GIS and resources data [14].

The ability of Geographic Information Systems to study and represent agricultural environments and workflows has found them to be extremely advantageous to those engaged in the agricultural trade. Geographic Information Systems have the

SUBJECT INDEX

A

Karim Ennouri (Ed.)

B

C

D

E

F

G

H

I

K

L

M

N

O

P

R

S

T

U

V

W

Y