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Information System (IS) for the Management of Pests, Diseases

Wafaa Mohamed Haggag[1*], Zakaria Fouad Fawzy[2], Sameh Mohamed El- Sawy[2]

[1] Plant Pathology Department, Agricultural and Biological Research Division, National Research Centre, Egypt
[2] Vegetable Research Department, Agricultural and Biological Research Division, National Research Centre, Egypt

Email Address
wafaa_haggag@yahoo.com (Wafaa M. Haggag)
*Correspondence: wafaa_haggag@yahoo.com

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Abstract:
Climatic damages in agricultural production could seriously affect the national economy. The magnitude of this possible damage could amount to billions of pounds. The forecast of possible pests and diseases in plant production is another application that requires a constant and reliable flow of weather data. The aid of information technology has changed by our world that helps to produce, store, communicate and disseminate information. Several major classes of software technologies have been used in decision making for integrated pest management applications over the past few decades. Examples of Integrated Pest Management (IPM) procedures to improve economic yields while reducing inputs include: the integration of pesticides with cultural techniques for disease control; and biological, behavioral and environmental controls of pests such as weeds. Control of the key pests and diseases on cocoa could shift from blanket calendar-based recommendations to a need-based forecasting system which would be environmentally sustainable. Geographical Information Systems and Global Positioning Systems are currently being used for variable rate application of pesticides and herbicide in Precision Agriculture applications, but the comparatively lesser-used tools of Remote Sensing can be of additional value in integrated pest management practices. Consistency in the application of this information can help in improving crop yield, in controlling crop pests, in crop diseases treatment, and in enhancing the overall crop productivity.

Keywords:
Agriculture, Insecticide, Monitoring, Forecasting , Geographical Information Systems, Crop Diseases Management

1. Introduction

The losses of yields due to pests and diseases are enormous and could well be controlled in many cases if the proper prediction and forecast existed. The availability of the climatic data is important not only for the growers and researchers, but also for the developers, planners and decision makers [1,2]. Climate change is essential pay that led to physiological stresses particularly in semiarid regions that sorely affected crop production [3]. Environmental stress as water stress , saltiness and heavy metals is highly variable in its duration and seriousness that significantly reduce the optimal plant productivity that can be accomplished [4].

Computer modeling is used to calculate fertilizer requirements, diseases and insects' prediction and planting dates. Moreover, diseases and insects prediction is determined according to the agroclimatological data especially air temperature and soil moisture.

Growing degree (GDD) is used for the prediction of diseases and insects. Several major classes of software technologies have been used in decision making for integrated pest management applications over the past few decades. These computer-based technologies include optimization, expert systems, network models, multi-criteria decision making, and integrated systems. Likely future development trends for decision support technologies over the next few decades include: Internet implementations, agent-based applications, increased social science components, and participatory decision making. Farmers, consumers and exporters in Egypt are too often faced with a serious dilemma: they must either sacrifice a significant share of their crops to pests or use highly toxic pesticides that can harm human health and the environment. Control of insect pests and diseases are mainly by the use of insecticides applied as foliar sprays using motorised knapsack sprayers. Moreover, there is no information system available to provide accurate and timely information to farmers on current population dynamics of pests to inform pest management decisions. Accurate and timely information is key for pest control in the field [5]. The main objective of any information system is to provide extension workers, farmers, researchers and other stakeholders with an effective support system for decision making on pest control and other farm management activities. This usually involves pest identification, key factor analysis of density dependent and independent variables such as weather, feeding and breeding sites, predator population, etc. and accurate timing for pest control to maximize economic returns in an environmentally sound manner [6]. There are increasing efforts at considering data and information on pest and control activities from farming communities, industry, research and extension to enhance pest management [7]. This wide source of data could be synthesised and the resultant information for pest management disseminated to all stakeholders to inform decision making. The proposed Information System for the management of pests and diseases on agriculture as outlined in this paper considers the analysis of data on pest population trends, climate and crop phenology. Such a system would also involve harnessing the opportunities provided by Information Communication Technology (ICT) to disseminate synthesised information to farmers, extension agents and other stakeholders in pest management for timely application of control recommendations. Several farming systems have used decision support systems to manage pest problems. Example include Australian cotton farms [8], soybean farms in the US [6] and for pests of rice in Vietnam [7]. In each case, application of decision support systems resulted in more judicious use of pesticides while achieving high crop yields.

By recognizing the importance of agricultural inputs in food security and the reputation risk associated with the use of very toxic agricultural chemicals, so integrated pest management (IPM) to ensure good practice is needed. IPM succeeded in developing environmentally sound practices, but struggled to communicate the value of information on the risks and benefits of IPM. The slow adoption of IPM is often attributed to the widespread gaps between farmers' knowledge and understanding of the complex and controversial issues surrounding pesticides and IPM.

Applying IPM techniques and the likely impact of a communication strategy on the overall process, it is important to first analyze the IPM knowledge content and, consequently examine knowledge needs from stakeholders involved in the IPM diffusion. Although IPM is largely seen as an endogenous innovation, mostly based on local knowledge, it must be clearly stated that such an assumption is superficial. Knowledge and information are key to correct pest management decisions. Integrated pest management (IPM), a system that emphasizes appropriate decision making, is information intensive and depends heavily on accurate and timely information for field implementation by practitioners [5]. Additionally, it is critical to strengthen the communication links between researchers and extension professionals and their clientele to expedite multi-way exchange of information and technology transfer. In addition, researchers and extension specialists need the most up-to-date information to design new projects and set future research goals and directions. Electronic communication provides an effective multidirectional exchange of information. Electronic extension systems provide 24-hour access to an inquirer of specific information to be used in planning and decision support. In fact, it is rapidly changing the way individuals exchange information and make decisions. The emphasis is, however, beginning to shift from traditional one-way flow of information from research, then to extension, and finally to end-users of information, to the more egalitarian process where the pool of total experience and knowledge available in the community, from growers, industry, research and extension, is readily exchanged through electronic means, focused learning workshops, and increased on-farm applied research. The simplistic definition of IPM Informatics is computer applications in Integrated Pest Management. The term encompasses computer-based storage, retrieval, sharing, and optimal use of pest management data, information, and knowledge for problem solving and decision-making. It includes all basic and applied fields in pest management sciences (acarology, entomology, plant nematology, plant pathology, vertebrate pest management and weed science) and is closely tied to modern information technologies, particularly in the areas of computing and communication. More specifically, IPM informatics is defined as the study, invention, and implementation of structures and algorithms to improve communication, understanding and management of IPM information. The goal of IPM informatics is the coalescing of data, knowledge, and the tools necessary to apply that data and knowledge in the decision-making process, at the time and place that a decision needs to be made. The focus on the structures and algorithms necessary to manipulate the information separates IPM Informatics from other IPM disciplines where information content is the focus.

Modern strategies for greenhouse climate control can be used in order to reduce pest and disease infestation to reduce crop losses. The rationale behind the concept of integrated plant protection, is the minimisation of chemical applications. In addition to existing dehumidification strategies, in particular, the use of climate control for integrated pest control requires registration and simulation of climate conditions at the plant canopy. To avoid intensive and expensive technical measurements, it is necessary to describe the energy and mass transport processes within the canopy, the exchange processes between air and plant elements and other surfaces. The basics of a computer-supported anti-pests and diseases climate control management will be developed based on a plant canopy model.

Actually, Agro-Information System (AIS) prototype that can support farmers with agricultural related information about a given food crop. Consistency in the application of this information can help in improving crop yield, in controlling crop pests, in crop diseases treatment. Furthermore, enhancing the overall crop productivity. A prototype AIS capable of providing possible pest control, and suggesting disease treatment for the associated pathogens, has been developed and implemented using open-source technologies.

Agro-Information System (AIS) can be used to provide information of major pests and diseases for many crops and also advice on crop protection. The public, government and agricultural decision-makers can obtain essential information and services provided by the AIS for use in areas such as agricultural disaster assessment, national vegetation monitoring, national crop yield forecasts and agro-advisories. To enhance agricultural productivity among rural farmers, it is often necessary to increase farmer's access to agricultural information and effective utilization of this information. Information Systems deal with the deployment of information technology in organizations, institutions, and society at large [9]. The information provided must be in user-friendly form, easy to access, cost-effective and well protected from unauthorized accesses. Agricultural knowledge and information system for farmers can justify the need for farmers to understand the technological principles of integrated pest management [10].

2. Expert Systems

An important feature of the DSS concept is the ability to create and use a knowledge base. "Expert Systems" can be used to store knowledge of pest management of experts in this discipline. A Decision Support Systems (DSS) integrates a user-friendly front end to often complex models, knowledge bases, expert systems, and database technologies. Information exchange by electronic means has revitalized the role of extension services in providing information, education, and decision-making assistance to agricultural producers. Cooperative extension services in many countries have developed electronic information systems. The acquisition of knowledge by a manager so that he or she may be considered an expert certainly takes time. The assistance of expert systems to obtain knowledge, and use of this knowledge by those who have not yet achieved expert status, is of great value to decision-making. Expert systems are useful components in a DSS because they make models accessible and interpretable to non-users. They also take on the functions of a model [11]. The DSS approach is well-suited to directing the development of FIDSINFOBASE. In the concept, as shown in Figure 1, the strengths of database management, GIs, expert systems, and statistical analysis systems such as SAS, would be integrated and linked with databases and models. Each of these subsystems would handle a specific set of functions in capturing, storing, and processing data and models. An intelligent user interface would accommodate users at varying degrees of skill to direct the user to system components that would best support his or her task.

3. Integrated Agricultural Pest Management through Remote Sensing

In order to manage and predict apple diseases and insect pests efficiently, a management information system was developed based on GIS technology. The management system includes three sub-systems: basic database, predicting sub-system designed by artificial neural network (ANN) technology, and information releasing system based on Internet. In the database of apple diseases and insect pests, nine functions were provided for users such as external data input function, processed data output function, property data inquiry function, spatial data inquiry function, data analysis function, layer editing function, and data interpolation function. In the apple insect pests predicting system, the following functions were provided: renewing disease and insect pest pictures, diagnosing disease and insect pests, and predicting insect pests. The emphasis on monitoring and thorough knowledge of field conditions prescribed by IPM make new imagery sources and integrative geospatial technologies, particularly global positioning systems, remote sensing, geographical information systems and spatial analysis, powerful tools to assist in the management of pests [12]; and these tools can be considered part of an IPM system. Global Positioning Systems (GPS) and Geographic Information Systems (GIS) are by far the more commonly used of the geospatial tools [13], and have been revolutionary technologies for agriculture [14] .

Remote sensing along with Global Positioning Systems (GPS), Geographic Information Systems (GIS) and Variable Rate Technology (VRT) are additional technologies that scientists can implement to help farmers maximize the economic and environmental benefits of area-wide pest management through precision agriculture [15]. Early warnings and forecasting based on biophysical methods provide appropriate time for managing pest damage and can thus minimize crop loss, optimize pest control and reduce the cost of cultivation [16]. The results showed that remote sensing procedures could quantitatively recognize corn leaf blight over broad areas. Hence, the most promising application of remote sensing technology is its ability to obtain information about agricultural crop production system. With a minimum amount of ground sampling, remote sensing data permit identification and area measurements of crops, assessment of crop stress, pest damage, yield forecasts, range surveys and mapping of major soil boundaries including many non- agricultural applications. According to [17], multi spectral remote sensing (MRS) allowed farmers to detect early infestation of mites in large scale cotton fields due to color shifts and changes in canopy appearance over time. Now-a-days, computer-based systems have increased the speed and accuracy of forecasting, and minimizing its costs.

The management and analysis of map data are handled by Geographic Information Systems. The capabilities offered by these systems are essential in a DSS, to analyze spatial characteristics of the insect- and disease-interactions with the forest and the influencing factors of man and nature. Geographic Information System applications in forest pest management have been developed to analyze pest impact on the forest and to develop a system of stand vulnerability . Geographic Information System technology is being integrated into FIDSINFOBASE using both the mini- and microcomputer versions of the ESRl Ltd. ARCIINFO system an excellent example of a GISI database application for FlDS operations is being demonstrated in a pilot study on national pest depletion estimation. Composite maps of defoliation by intensity, and mortality, are produced in the GIs from a number of years of surveys. These are reclassified to indicate a level of impact severity for a 5-year-period. The host species volumes that are encompassed by each severity class are obtained through overlaying these classes on the national forest inventory geographic grid to determine grid coverage, and using this to extract the appropriate inventory data from national inventory.

The factors which favor the development of pests and their effect on plant parameters that are detectable by remote sensors are shown in Figure 1.

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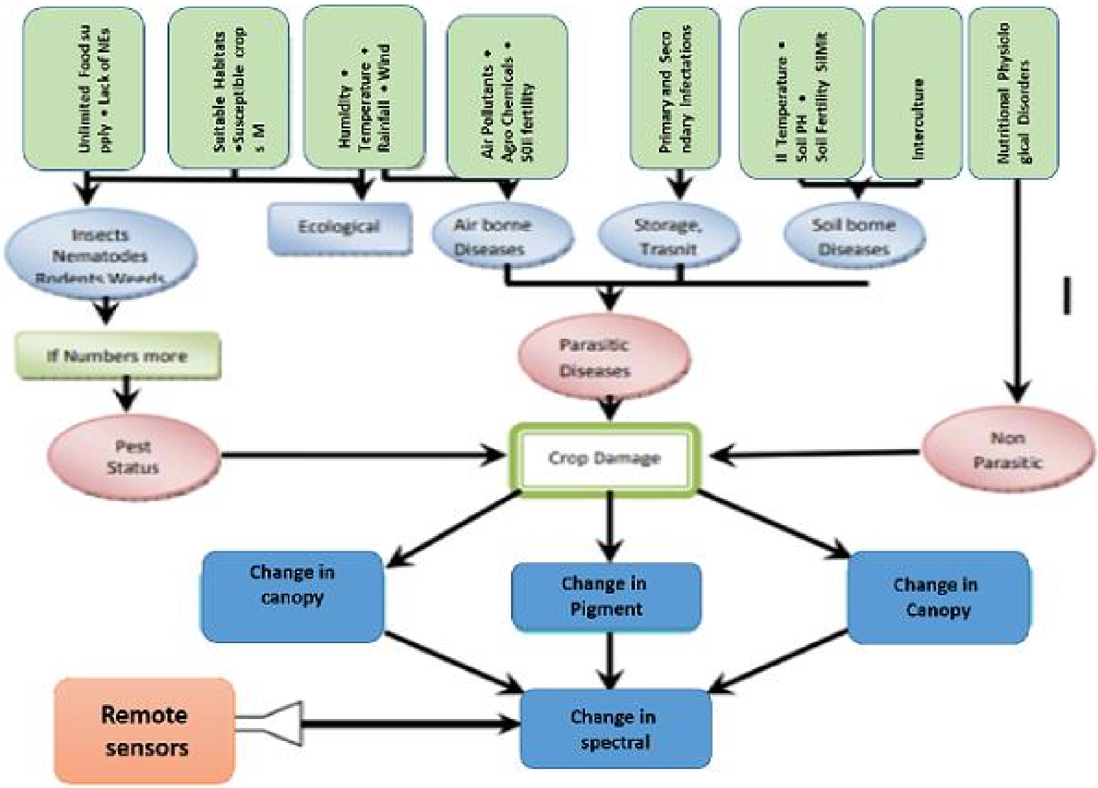

Figure 1. *Development of crop pests and diseases leading to crop damage and its detection through remote sensing [18].*

Several remote sensing techniques have been developed. Initial recognition of pest infestation by means of remote sensing will spreads, for precision farming practice. Normalized Difference Vegetation Index (NDVI), Standard Difference Indices (SDI) and Ratio Vegetation Index (RVI) are used for analyses using ENVI 4.8 and SPSS software. Remote sensing and spectro-radiometry showed distinct differences between broad leaf hosts and non-host grasses. High spectral resolution remote sensing imagery with more bands and narrower bandwidth is required for remote sensing diagnosis of crop disease stress [19].

4. Mapping of Geographical Distribution of Pests along with GIS

GIS is another tool, which can be used effectively for mapping geographical distribution of pests, delineating the hotspot zones. GIS methods can be divided into two sub groups. Remote Sensing and Digital Cartography. Remote sensing has also been used in conjunction with GIS for monitoring changes in crop conditions. [20] Mino et al., (1998) used multi-temporal satellite data to distinguish grasslands of different ages, monitor changes in management and evaluate grassland quality. District wise geographical maps of rice and cotton pests have been prepared at NCIPM [21].

The cost of pesticides treatments in pest control programmes could be reduced significantly, Health risks to farmers, sprayers and the environment from the careless and inefficient use of pesticides could also be minimized. To achieve this, a well-coordinated national pest management framework with a monitoring component is needed.

In recent years thematic mapping has undergone a revolution as the result of advances in geographic information science and remote sensing [22]. The results of this work are of great importance as they represent the soil productivity constraints of all over the region. The digital database allows policy makers, planners and experts to overcome some of the shortfalls of data availability. It also facilitates the integration of the data in internal and external network, this can realize by a systematic manner of the digital database [1,3,22]. The incorporation of the obtained data from different resources can be achieved to fulfill the sustainable development requirements.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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