International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 1 | ISSN : 2456-3307

Development of a Web Based Expert System for Managing Pests and Diseases of Moringa Oleifera

Amosa Babalola*[1], Olatunji Abiodun[1], Fabiyi Aderanti[1] and Abasiene John[2]
[1]Department of Computer Science, Federal Polytechnic, Ede, Nigeria
[2]ICT Center, Federal Polytechnic, Ede, Nigeria

ABSTRACT

Expert system is an artificial intelligence program or system that uses knowledge to solve a problem that ordinarily requires a knowledgeable human, it acts like the human expert. It represents expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve a problem. The health benefits of Moringa Olifera plant have long been well understood and cherished by the people of Asia and Africa and these can be traced back to centuries but the productivity of the Plant is mostly affected by pests and diseases. Detecting these pests and diseases at early stages will enable farmers to overcome and treat them appropriately. The process requires an expert to identify the disease, describe the methods of treatment and protection. Identifying the treatment accurately depends on the method that is used in diagnosing the diseases. This research presents the design and development of an expert system for managing pests' and diseases of Moringa oleifera. The system uses a rule-based approach to collect data and forward chaining inference techniques; provides a user interactive, and menu-driven environment. The symptoms associated with diseases are taken as the basis of this study. CLIPS has been used as the expert system building tool in Windows environment, while HTML is used for the web-based interface. The system has been tested by a group of farmers and students of Agriculture in Osun State, Nigeria.
Keywords : Web-based, Expert Systems, Moringa, Diseases

I. INTRODUCTION

The expert system which is also known as rule-based stems or knowledge-based system is computer program system which attempts to minimize the human ability to engage pertinent facts and string them together in a logical fashion to reach some conclusions. An expert system can also be defined as a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming [1]. Expert systems were among the first truly successful forms of Artificial intelligence software. This is because they solve real-life problems and are generally easy to use by the user. An expert system has a unique structure, different from traditional programs. It is divided into two parts, one fixed, independent of the expert system: the inference engine, and the other, a variable: the knowledge base. To run an expert system, the engine reasons about the knowledge base like a human. Moringa oleifera (syn. M. ptreygosperma Gaertn.) is one of the best known and most widely distributed and naturalized species of a monogeneric family Moringaceae. The tree ranges in height from 5 to 10 m [3].

It is found in the wild and cultivated throughout the plains, especially in hedges and in-house yards, thrives best under the tropical insular climate, and is plentiful near the sandy beds of rivers and streams. It can grow well in the humid tropics or hot dry lands, can survive destitute soils, and little affected by drought [3]. It tolerates a wide range of rainfall with minimum annual rainfall requirements estimated at 250mm and maximum at over 3000mm and pH of 5.0 – 9.0 [4. Optimum leaf and pod production require high average daily temperatures of 25–30°C (77–86°F), well distributed annual rainfall of 1000–2000 mm (40–80 in), high solar ra-diation and well-drained soils. Growth slows significantly under temperatures drought and poor soils and responds well to irrigation and fertilization. Moringa is planted either by direct seeding, transplanting, or using hard stem cuttings. Direct seeding is preferred when plenty of seed is available.

Moringa Oleifera, native of the western and sub-Himalayan tracts, India, Pakistan, Asia Minor, Africa and Arabia [5]. Moringa oleifera is an important food commodity which has had enormous attention as the 'natural nutrition of the tropics'. The leaves, fruit, flowers and immature pods of this tree are used as a highly nutritive vegetable in many countries, particularly in India, Pakistan, Philippines, Hawaii and many parts of Africa [6], [7], [8]. Moringa leaves have been reported to be a rich source of carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidants; and thus enhance the shelf-life of fat-containing foods due to the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotenoids [9]. A number of medicinal properties have been ascribed to various parts of this highly esteemed tree. Almost all the parts of this plant: root, bark, gum, leaf, fruit (pods), flowers, seed and seed oil have been used for various ailments in the indigenous medicine, including the treatment of inflammation and infectious diseases along with cardiovascular, gastrointestinal, hematological and hepatorenal disorders.

II. PESTS AND DISEASES AFFECTING MORINGA TREE

Plant diseases are one of the most important reasons that lead to the destruction of plants and crops. The disease occurs in plants when the plants deviated from a normal situation. Moringa is resistant to most pests and diseases, but outbreaks may occur under certain conditions. For example, diploma root rot may appear in waterlogged soils, causing severe wilting and death of plants. Mite populations may increase during dry and cool weather lead to yellowing of leaves, but recovers during warm weather.

The pests/diseases affecting Moringa tree are:
Major pests of Moringa

i. Budworm (Noorda moringae)
ii. Leaf caterpillar (Noorda blitealis)
iii. Hairy caterpillar Eupterote mollifera)
iv. Bark caterpillar (Indarbela tetraonis)
v. Pod fly (Gitona distigmata)

Others include:

i. Drechslera haraiiensis
ii. Diplodia root rot
iii. Mite
iv. Papaya powdery mildew (Levellula taurica)
v. Aphids
vi. Leafminer
vii. Termites
viii. Livestock (goat, sheep, and pigs)

The knowledge base is designed with natural language rules. It will help the farmers, agriculturist and expert domain to know how to identify a particular pest/disease and state the appropriate control measures. And also, the application is able to solve the problem facing farmer on the plantation of Moringa oleifera and reduces their stress.

The objective of this study is to design an expert system that will manage pests and diseases of Moringa oleifera. The expert system will also assist in training Agriculturist, allow farmers to identify the pest/diseases that affect the plant and motivate more people into cultivation of Moringa oleifera.

III. LITERATURE REVIEW

AI is a field of computer science that focuses on developing techniques that enable the computer system to perform activities that are considered intelligent in human and other animals [10]. It is concerned with the design, study, and construction of a computer system that behaves intelligently. The term AI was first introduced in 1956 by John McCarthy at the Dartmouth summer conference held in Hampshire [11].

The artificial intelligence has the ability to cover many cognitive skills such as Solving problems, Learning, Reasoning, Understanding languages, Recognition, seeing, etc. But most progress to date in AI has been made in the area of problem-solving – concepts and methods for building programs that reason about problems rather than calculate a solution.

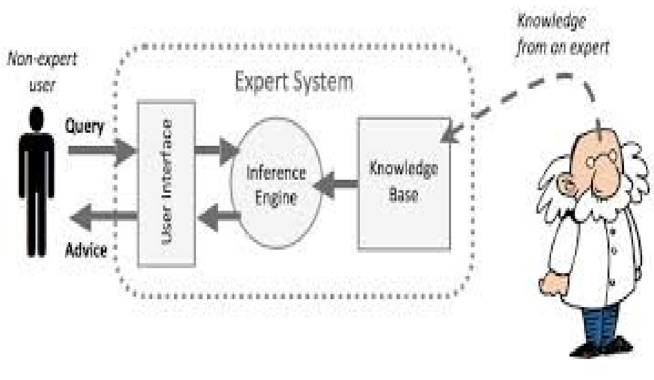
An expert system is a branch of artificial intelligence that attempts to replicate the reasoning processes of a human expert can make decisions and recommendations and perform tasks based on user input [12], [13], [14], [15]. It emulates the decision-making ability of a human expert, that is, it is intended to act in all respects like a human expert in a particular field.

The first commercial Expert system evolved as a product of Artificial Intelligence and is now available in a number of fields that requires decision-making [16]. The suitability of this technology has been recognized and realized in the field of agriculture and a few successful expert systems have been developed [17], [18]. Agriculture requires information and application of knowledge from different interacting fields of science and engineering to make a suitable decision-making that in turn depends on the interplay of these data and knowledge. This needs agricultural specializations and technical awareness in a farmer or a human expert to help the farmers in decision-making. The existence of agricultural specializations and full awareness with technological progress in a farmer is a very rare thing in our country. Human experts are not always available, may not be accessible to every farmer or if available consultation may be very expensive. The other complications are that the decisions in agriculture practice depend on a large number of factors. Thus even for a human expert, it becomes awkward to take all factors into consideration while making a decision. All such problems have resulted in the development and evolution of the concept of expert systems [19], [20]. The use of information technologies improved the knowledge base and increased the capacity to control the production practices which in turn reduces the threat and uncertainty, improved the efficiency of decision making and better recognized the variations in diverse influencing features thus depicting enhanced management policies for the farm [21].

Main Components of Expert System

There are two main components of an expert system; the knowledge base, and the inference engine as shown Fig. 1. The expert system receives facts from the user and provides expertise in return.

Figure 1. Components of an Expert system



A. Knowledge Base

The knowledge base is the core component of an expert system. It contains knowledge acquired from the domain expert. Building the knowledge base with the help of domain expert is the responsibility of knowledge engineer. In expert system technology, the knowledge base is expressed with natural language rules IF ... THEN...

This formulation has the advantage of speaking in an everyday language which is very rare in computer science (a classic program is coded). Rules express the knowledge to be exploited by the expert system. There exist other formulations of rules, which are not in everyday language, understandable only to computer scientists. Each rule style is adapted to an engine style. The whole problem of expert systems is to collect this knowledge, usually unconscious, from the experts.

B. Inference Engine

This is an important concept towards the understanding of an expert system. An inference engine is a statement that has two parts, an IF clause and a THEN clause. The inference engine may draw solutions or conclusions from the knowledge base, based on the facts provided by the user. It acts as an interpreter that interprets which rules match with the facts. One advantage of inference engine is that it uses reasoning which more closely resembles human reasoning.

A rule-based expert system consists of if-then rules, a bunch of facts and an interpreter controlling the application of rules, given facts. A single if-then rule assumes the form 'if X is A then Y is B'; if part of the rule 'X is A' is called antecedent or premise and then part of the rule 'Y is B' is called consequent or conclusion.

C. Knowledge Engineering

The building, maintaining, and development of expert systems is known as knowledge engineering. Knowledge engineering is a "discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise".

There are generally three individuals having an interaction with an expert system. Primary among these is the end-user, the individual who uses the system for its problem-solving assistance. In the construction and maintenance of the system there are two other roles: the problem domain expert who builds the system and supplies the knowledge base, and a knowledge engineer who assists the experts in determining the representation of their knowledge, enters this knowledge into an explanation module and who defines the inference technique required to solve the problem. Usually, the knowledge engineer will represent the problem-solving activity in the form of rules. When these rules are created from domain expertise, the knowledge base stores the rules of the expert system. Various studies in Expert Systems are also presented in [22], [15], [23], [24], [25], [26], [27], [28], [29], and [30].

IV. EXPERT SYSTEM FOR MANAGING PESTS AND DISEASES OF MORINGA OLEIFERA

This study; "expert system for managing pests and diseases of Moringa Oleifera" is a rule-based expert system for diagnosing the pests and diseases of Moringa plant using CLIPS as the programming language. Forward chaining inference mechanism is employed in the expert system. This is a menu based interactive system where systems communicate with the user in common understandable language.

The causative organisms for symptoms are classified as pest/disease name. The symptoms are stored in facts list. Different rules exist for different symptoms. The system consists of 35 rules. It provides a simple, interactive, text-oriented, command prompt, menu-based interface. It stores all the rules as a batch file. So the series of rules can automatically read or run directly from a batch file as a result of a batch command.

A. Background/Literature Review

The first step in developing an expert system is to study the background details and concepts about expert systems and made the literature review from books, websites, journals, etc. There are already several expert systems developed in many fields including agricultural field. In case of plant diseases, there are many expert systems available and they used different approaches and different tools. Some systems are specially designed for diagnosed pests/diseases of crops such as cucumber, Indian mango, tomatoes, olive crops, wheat, cassava, and so on.

Concepts: Concept is the second step in the expert system development process. It studies about an expert system and its internal parts, how it works, different concepts like rules, inference methods, constructs, facts, etc. The expert system for managing pests/diseases of Moringa plant uses rules-based approach and forward chaining inference method.

Problem Selection: Selecting an appropriate problem is very important in the development process. There are some general considerations be made before starting to develop an expert system. There should be a clear understanding of the problem, from where to get the expert's knowledge or how to carry out knowledge acquisition and who will be the users. At least a Moringa tree has been observed in order to see how the disease affected it. This study selects the problem of diagnosing the pests/diseases of Moringa plants by developing an expert system using the tool CLIPS version 6.3 and Window/Dos environment.

B. Knowledge Acquisition

Knowledge elicitation was performed through knowledge acquisition. It is the process of transfer the problem-solving expertise from knowledge source to computer code. Basic information about the Moringa pests/diseases, symptoms and the pest/disease management were collected from books, different websites, journals, and domain (human) experts. There are several techniques to do knowledge acquisition such as direct interview, internet, diagram, trees, etc. The method used in this study is the direct method. The knowledge acquisition for this project consists of an interview of a domain expert, consulting National Horticultural Research Institute to gather relevant information and relevant textbooks to acquire appropriate information.

C. Data Collection

Collection of data is also called knowledge elicitation which is the process of collecting data from domain experts. This stage involves the consultation of domain experts which are the most important individuals in an expert system design process. In this project, data is acquired by consulting the domain experts in the field, National Horticultural Research Institute to gather relevant information and reading through relevant textbooks. This involves constant interaction with the expert and extraction of relevant information comprising the diseases, pests, symptoms/signs and the control measures. About thirteen (13) diseases were gathered as shown in Table 1.

D. Tool Selection

The expert system was developed using CLIPS language version 6.3 in Window platform. CLIPS are a specially designed tool for expert systems. CLIPS expert system may be executed in three ways: interactively using a simple, text-oriented, command prompt interface; interactively using a window/menu/mouse interface on certain machines, or as an embedded expert system in which the user provides a main program and control execution of the expert system. In addition, a series of commands can be automatically read directly from a file when CLIPS is first started or as the result of the batch command.

E. Knowledge Representation

The collected knowledge has been converted into CLIPS knowledge base syntax. That is facts and rules. Currently, the expert system consists of 35 rules. Each rule is a symptom. There is a brief description of the cause of each symptom. So the expert system can help the user to give knowledge about the symptom or the cause of the symptom, provide brief information on Moringa and how to control the pest/disease.

F. Development Process

This includes

- Analysis
- Design
- Coding
- Testing
- Implementation

Analysis: In the expert system for managing pests/diseases of Moringa tree 35 different rules were used. These rules involve main menu, Moringa information, pests/disease's name, symptoms and the management or control measures.

TABLE 1. Data collected for Diseases and Pests of Moringa oleifera plant.

S/N	Moringa Diseases/pests	Characterized by
1	Pod fly (Gitona distigmata)	Damage developing fruit causing fruit rotten, drying and splitting of fruit from tip and oozing of gummy exudates from fruit.
2	Drechslera haraiiensis	a. Pods reaching maturity showed extensive rot. b. elliptical or elongated sunken spots with reddish brown raised margin a. Pods shrunken to thinner dimensions at their stigmatic ends b. Pods rotten and dried up pre-maturely leaving raised spots
	Diplodia root rot	Causing severe wilting and death
4	Mite	a. Yellowing of leaves b. Bites on various parts c. Make minute webs around the growing tips or leaf edges
5	Termites	Eating up the cutting stems planted
6	Bud worm (Noorda moringae)	Larva bores into flower buds and causes shedding
7	Leaf caterpillar (Noorda blitealis)	Larva feeds on the leaflets reducing then into papery structures
8	Hairy caterpillar (Eupterote mollifera)	Scraping of the bark, severe infestation and defoliation of the tree.
9	Bark caterpillar (Indarbela tetraonis)	Zig-zag galleries and silken webbed masses comprising of chewed material and excreta of larva
10	Papaya powdery mildew (Levellula taurica)	Yellowing of leaves, and stunted or distorted growth. The fungus itself is then seen as visible white powder on the surface of leaves and stem.
11	Aphids	Sap-sucking insects, so can weaken the plant. They can also carry diseases and viruses from plant to plant.
12	Leafminer	They feed on leaves, making tunnels between the upper and lower surface.
13	Livestock (goat, sheep and pigs)	They eat up moringa seedlings, pods and leaves.

The system can give reasoning for the symptoms like what is the cause of the symptoms. Each symptom is represented as rule in this based system.

The transcript of some of the used rules are as follows:

Rule 1

```
(defrule get_base_fruitRot
        (declare (salience 100)) ?bs
<- (base_symptoms(fruit_rot nil))
        =>
        (printout t "|--------------------|" crlf)
(printout t "  Does the fruit Rot (yes/no):")
        (bind ?result(read))
        (printout t "|----------------------|" crlf)
        (modify ?bs(fruit_rot ?result))
(defrule getPodFlyDrySplit
        (base_symptoms(fruit_rot yes)) ?pd
<- (pod_fly(dry_spilt nil))
(printout t "|----------------------|" crlf)
        (printout t "
Are there drying and spliting of fruit from tip (yes/no): ")
        (bind ?pdresult(read))
        (printout t "|-----------------------|" crlf)
```

(modify ?pd(dry_spilt ?pdresult))
(defrule getPodFlyexudate
(pod_fly(dry_spilt yes))?pd
<- (pod_fly(gummy nil))
=>
(printout t "|---------------------|" crlf)
(printout t " Are There oozing of gummy exudates from tip (yes/no): ")
(bind ?pdresult(read))
(printout t "|---------------------crlf)
(modify ?pd(gummy ?pdresult))

The English interpretation of the above rules;
The user choice is 1: run-Moringa pest and disease
IF the fruit is rotten,
AND drying and splitting of fruit from tip,
AND oozing of gummy exudates from light,
THEN the pest is Pod fly.
Rule 2
(defrule get_base_extPodRot
(declare (salience 100))
(base_symptoms(fruit_rot no)) ?bs
<- (base_symptoms(ext_pod_rot nil))
=>
(printout t "|----------------------|" crlf)
(printout t "Does matured pods show extensive rot (yes/no): ")
(bind ?result(read))
(printout t "|----------------------|" crlf)
(modify ?bs(ext_pod_rot ?result))

The English interpretation of the above rules;
IF Pods reaching maturity showed extensive rotteness,
AND elliptical or elongated sunken Spots with reddish brown raised margin,
AND pods shrunken to thinner dimensions at their stigmatic ends,
AND pods rotten and dried up pre-maturely leaving raised spots,
THEN the disease is Drechslera haraiiensis.
Rule 3
IF the root shows severe Wilting and death,
THEN the disease is Diplodia root rot.
Rule 4
IF leaves are yellow,
AND there is bites on various parts,
AND make minute webs around the growing tips or leaf edges,
THEN the pest is Mite.
Rule 5
defrule get_base_severeWilt
(declare (salience 100))
(base_symptoms(fruit_rot no)(ext_pod_rot no))
?bs <- (base_symptoms(severe_wilt nil))
=>
(printout t "|------------|" crlf)
(printout t " Are the severe wilting and death (yes/no):")
(bind ?result(read))
(printout t "|------------|" crlf)
(modify ?bs(severe_wilt ?result))
IF the cutting stems planted Are eaten up,
THEN the pest is Termites.
Also;
Rule 6
IF Larva bores into flower Buds and causes shedding,
THEN the pest is Bud worm.
Rule 7
IF Larva feeds on the leaflets reducing them into papery structures,
THEN the disease is Leaf caterpillar
Rule 8
IF bark is scraping,

AND causes severe infestation
and defoliation of the
tree,
THEN the pest is Hairy
caterpillar.
Rule 9
IF there is zigzag galleries,
AND silken webbed masses
comprising of chewed
material,
AND there is excreta of larva,
THEN the pest is Bark
caterpillar.
Rule 10
IF leaves are yellow,
AND there is stunted or
Distorted growth,
THEN the disease is mildew.

System Evaluation and Testing

The developed expert system, an expert system for managing pests and diseases of Moringa oleifera tree was tested by domain expert and farmer to determine the integrity and reliability of the system. The system was able to produce the desired result based on their input (Yes/No) to the questions posed by the system. Each modules program was also tested in which during the period of program testing, a number of points were visible, and these include, the importance of generated result and the response time of generated result. The efficiency and capacity of the developed system have been tested by supplying new data to the program and examine the output to see if the desired results are obtained. After the subprograms had been tested thoroughly, the system as a whole is then tested to ensure that it does the task assigned.

V. CONCLUSION

In this research work, development of a web-based expert system for Pest and disease of Moringa oleifera has been presented. The usefulness of computer in our daily activities cannot be overemphasized since it has been contributing immensely to the human application in solving problems. Application of computer in this expert system gives room for knowledge update which is very useful. In the study, new knowledge about new a disease can be added to the system and an improvement on the diagnosing can as well be adjusted. The study is worthwhile considering the advantages it brings both to the experts in the field and to any other individual (farmer) who is willing to make use of them. The system has been found out to be very useful, most especially in developing nations like Nigeria, where we still have a large number of unskilled farmers.

VI. REFERENCES

[1]. Jackson, Peter (1998), Introduction to Expert Systems (3 ed.), Addison Wesley, p. 2, ISBN 978-0-201-87686-4

[2]. Luger, George and William A. Stubblefield. 2004. Artificial Intelligence: Structures and Strategies for Complex Problem Solving (5th Ed.). The Benjamin/Cummings Publishing Company, Inc...ISBN 978-0-8053-4780-7. http://www.cs.unm.edu/~luger/ai-final/tocfull.html

[3]. J.F Morton. 1991. The Horseradish Tree, Moringa pterygosperma (Moringaceae) - A Boon to Arid Lands? Economic Botany 45, 318-333.

[4]. M.C. Palada, and L.C Chang. 2003. Suggested cultivation practices for Moringa. AVRDC Publication #03-545; http://www.avrdc.org/LC/indigenous/moringa.pdf.

[5]. C. Palada. 1996. Moringa (Moringa oleifera). A versatile tree crop with horticultural potential in the sub-tropical United States, Hort. Science Vol. 31(5) September.

[6]. J. D'Souza, and A.R Kulkarni. 1993. Comparative studies on nutritive values of tender foliage of seedlings and mature plants of Moringa oleifera Lam. Journal of Economic and Taxonomic Botany 17(2): 479-485.

[7]. F. Anwar, and M.I Bhanger. 2003. Analytical characterization of Moringa oleifera seed oil grown in temperate regions of Pakistan. Journal

of Agricultural and Food Chemistry 51: 6558-6563.
[8]. F. Anwar, M. Ashraf, and M.I. Bhanger. 2005. Interprovenance variation in the composition of Moringa oleifera oilseeds from Pakistan. J Am Oil Chem Soc 82: 45–51.
[9]. L.J. Fuglie. 1999. The Miracle Tree: Moringa oleifera: Natural Nutrition for the Tropics. Church World Service, Dakar. 68 pp.; revised in 2001 and published as The Miracle Tree: The Multiple Attributes of Moringa, 172 pp. http://www.echotech.org/bookstore/advanced_search_result.php?keywords=Miracle+Tree
[10]. G. Buchanan. Winter 2005. "A (Very) Brief History of Artificial Intelligence", AI Magazine: 53-60, http://www.aaai.org/AITopics/assets/PDF/AIMag26-04-016.pdf, retrieved 2007-08-30.
[11]. B. Amosa, R. Akande, A. Sobowale and M. Hameed. 2015. “Web-based expert system for diagnosis and management of Kidney Diseases”. International Journal of Current Research and Academic Review. 2015, Volume 3 Number 2. pp. 9-19
[12]. J. Giarratano and G. Riley. 2004. Expert Systems: Principles and Programming. 4th Edn., Thomson/PWS Publishing Co., Boston, MA., ISBN: 0534937446.
[13]. L. Shu-Hsien. 2005. Expert system methodologies and applications. A decade review from 1995 to 2004 Expert Syst. Appl., 28: 93-103.
[14]. S. Azaab, S.A. Naser and O. Sulisel. 2000. A proposed expert system for selecting exploratory factor analysis procedures. J. College Edu. Gaza, Palestine, 4: 9-26.
[15]. B. Amosa, H. Arowolo and E. Faleye. 2012. “An Expert System for Management of Poultry Diseases”. International Conference on Computer Technology and Science (ICCTS 2012). New Delhi, India. 2012, Vol. 47, pp.113 - 117.
[16]. J. Durkin. 1993. Expert System: Catalog of Applications. 1st Edn. Intelligent Computer Systems, Inc., Akron, OH. ISBN 0-12-670553-7.
[17]. B.C. Freeman, and G.A. Beattie. 2008. An overview of plant defenses against pathogens and herbivores. The Plant Health Instruct. 10.1094/PHI-I-2008-0226-01
[18]. J. Durkin. 1994. Expert Systems: Design and Development. 1st Edn., Prentice Hall, Englewood Cliffs, NJ., ISBN: 0-02-330970-9.
[19]. B. Blackmore. 1999. Developing the principles of precision farming. Proceedings of Agrotech 99, Barretos, November 15-19, Barretos Institute of Technology, Brazil, pp: 133-250.
[20]. O.C. Maloy. 2005. Plant disease management. The Plant Health Instructor, 10.1094/PHI-I-2005-0202-01
[21]. Blackmore, B., 2000. Using information technology to improve crop management. Proceedings of AgMet Millennium Conference, Feb. 29, Institute for Jordbrugsvidenskab, Dublin, pp: 30-38.
[22]. Kenneth Laudon, Jane Laudon, and Eric Fimbel. 2010. "Management Information Systems: Managing the Digital Firm", Business & Economics, edition, chapter 11-3.5.
[23]. Rafea. 1994. Agricultural expert systems development in Egypt, Proceeding of International Conference on Expert Systems for Development (ICES), Bangkok, Thailand.
[24]. C.P. Yialouris and A.B. Sideridis 1996. An expert system for tomato diseases. Computers and Electronics in Agriculture, 14, 61-76.
[25]. M.B. Riley, M.R. Williamson and O. Maloy. 2002. Plant disease diagnosis. The Plant Health Instructor. 10.1094/PHI-I-2002-1021-01
[26]. A. EI-Dessoki, S. Edrees and S. EI-Azahry. 1993. CUPTEX: An integrated expert system for crop management of cucumber (ESADW-93). Molar, Cairo-Egypt, May 1993.
[27]. P. Rajkishore, K. Ranjan and A.K. Sinha. 2006. AMRAPALIKA: An expert system for the diagnosis of pests, diseases and disorders in Indian mango. Knowledge-Based Syst., 19: 9-21.
[28]. V. Lopez-Morales, O. Lopez-Ortega, J. Ramos-Fernandez and L.B. Munoz. 2008. JAPIEST: An integral intelligent system for the diagnosis and control of tomatoes diseases and pests in hydroponic greenhouses. Expert Syst. Appl., 35: 1506-1512.
[29]. B.M.G. Amosa, O.B. Olalere, K.A. Kawonise, A.O. Fabiyi and A.A. Fabiyi. 2015. Expert System for Diagnosis and Management of Kidney Diseases. International Journal of Computer Trends and Technology (IJCTT) ISSN: 2231-2803. Vol. 30 No 3 – December 2015 pp. 132-137

[30]. B.M.G. Amosa, B.A. Orisawale, K.A. Kawonise, A.O. Fabiyi and A.A. Fabiyi. 2015. Development of a Web Based Expert System for Diagnosis and Management of Childhood Pneumonia International Journal of Science and Advanced Technology (ISSN 2221-8386) December, 2015. Volume 5 No 12 pp 7-18