Utilization of Information Technology for the Expert System Shell of Alfalfa in the New Land

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ABSTRACT

The current study presented an expert system technology of alfalfa (ESTA) in terms of computer programs designed to mimic the reasoning of human experts. These programs, like a human expert, are able to take into account the relative importance of different criteria to the user.

These program are useful in select varieties aginst biotic and abiotic stress. It may be more important to the user, however to find resistant varieties to veriticillium wilt. and expert system is able to search a computer database to select the varieties that best reflect this particular bias.The result of this search is a list of cultivars ranked as to how well they meet the user's request.

The study describes a microcomputer program called ESTA which is an expert system for alfalfa cultivar selection. Also ESTA is an expert system used as an educational tool for extension people and the alfalfa growers.

It is designed to incorporate detailed information about alfalfa production regarding site, soil, machinery, management levels, and yield information to simulate the annual costs and returns over the alfalfa stand life. ESTA requires information from several domains of expertise such as Agronomy, Entomology, Agricultural Engineering and Agricultural Economy.

ESTA is a form of artificial intelligence, may soon become an important management tool for agribusiness dealers, county agents, agricultural consultants, and farmers. An expert system technology can make the specialized knowledge of an expert available to farmers when making critical management decisions. ESTA also informs the user as to how the recommendations or conclusion had reached on the screen or on the print – out. This expert systems modules the procedures used by a forage expert in determining agro economic recommendations for successful establishment and production of alfalfa. With this expert system, information is readily available to alfalfa producers for making management decisions relative to liming, fertilization, irrigation, drainage, weed control, longevity of stand, variety recommendations, and method and rate of seeding.

Key words:Expert system, ESTA, Alfalfa, Artificial intelligence, Management tool.

INTRODUCTION

Expert system is a form of artificial intelligence emerged as a new field nearly four decades ago. However progress was slow for several decades due to the early approach of utilizing sophisticated reasoning techniques without relying on a knowledge base (Giarratano and Riely, 1989). During the past decade, most of the artificial intelligence work shifted to knowledge – based expert systems. At present, the major limitation to the development of knowledge – based expert systems, especially in agriculture, is the lack of well – trained knowledge engineers.

The impact of using expert system for agriculture is considered to be very useful in reducing cost, and increasing yield. (Rafea *et al*.,1995)

ESTA system is a written program, normally computerized, that imitates the decision – making process of a human expert. Expert systems offer many advantages to modern day high – technology agriculture – some of these advantages are:

- Permits mass production of expertise resulting in increased availability to agricultural producers.,Very fast response when expertise is needed.,Expertise is permanent – no illness, retirement, or death.,Is easily modified and / or updated.,User can observe the reasoning involved in reaching a conclusion. And Development of C language integrated production system (CLIPS) will result in greatly reduced cost of expertise to user.

Alfalfa management requires many expert domain such as Entomology, Agronomy, Agricultural Economics, Plant Pathology, and Animal Science. In addition successful production of alfalfa requires significant management time and more capital investment than other crops (Limsupavanich. J. *et al*., 1994).

To increase the competitiveness and production of alfalfa, we have developed a series of expert system called the Alfalfa integrated management system to incorporate knowledge from several areas of expertise and to deliver the instantaneous consultations and recommendation in alfalfa production.

With the rapid proliferation of information on alfalfa cultivars, forage specialists have found it increasingly difficult to match desired criteria with specific cultivars using printed publications. One solution to this difficult, is to transfer the printed information into an electronic

form in which it can be more easily and rapidly accessed and a queried by a personal computer.

The objective of current study is to develop an alfalfa management expert system which would make the expertise of a forage expert readily available to agricultural advisors and farmers when critical management decisions must be made. This expert system was originally developed for selecting alfalfa varieties (Rhykerd, *et al.*, 1988-1989) and has been greatly expanded and updated to provide expertise for alfalfa establishment and production management decisions.

MATERIALS AND METHODS

Alfalfa Integrated management expert system consists of four units. WEED plus, Aliweev, HayMachs, and ProfAIf as displayed in (fig. 1). The main objective is to develop a system to enhance the competitiveness and profitability of alfalfa production in Egypt. Each unit of expert system is a stand a lone system. Weed plus (Mitrpanot *et al.*,1993) is the alfalfa weed management expert system containing knowledge of Egypt weeds.

Management for alfalfa growers. It provides recommendations for both preplanned and established stands of alfalfa and the cost- benfiton weed management, Alfweev (Sablla *et al.*, 1987) is the alfalfa weedvil insect management expert system designed to provide recommendations on insect management cost and practice., Haymachs (Huhnke *et al.*, 1990) is a hay harvesting and machinery expert system providing a cost analysis of specific hay harvesting operation (cutting, taking and baling), finally Profalf *(Limsupavanich, et al., 1992)* is the last expert system developed to provide recommendations of alfalfa economics and management practices.

Profal structure and- development

Profalf is a user friendly expert system developed in a haybrid-structure of shell based (Fikfs And Kehler, 1985), hypertext (Conklin, 1987) and conventional subprogram system (Maran and Beck, 1989) Profalf is implemented in the knowledge pro environment that provides both the expert system shell and hypertext system profalf manipulates the facts and the knowledge base via the expert system shell, and provides explanations, recommendations, and results via the hypertext system. In addition, it utilizes the complex simulation modely by loading and running conventional programs written in C language. These C subprograms are hidden to the user, profalf provides an easy to use menu system for program inputsud stores it as parameter files. Then, C subprograms retrieve the data from the parameter files, perform the complex computations, and generate the output into the result files.

Both the parameter files and output files act like a black board for knowledge pro, and C subroutines to communicate and exchange the information during the execution of profalf.

To develop profalf, this work had used the decomposition method dividing this system into small subsystem as illustrated in Figure 2. We acquire and interpret knowledge from the experts for each subsystem. Once the knowledge in each domain has been established, then all the experts define the interactions of the subsystems. The knowledge engineer selects the software development tool and programming language to implement PROFALF.

Each subsystem of PROFALF is developed as a frame work where the parameters are passed between each framework. The framework with the most interactions is created first, because it is the most significant and complicated unit. Them the other frameworks are created one at a time, unit all units have been completed. The final step is to integrate and verify all units. The verifications step is a critical and time consuming process, because we need the appropriate data set to test the system and obtain the comments from all the experts (Fig. 2).

The expert system shell consists of an inference engine that determines the information that

must be obtained (and in what order) from the knowledge base and from the user.

The first step in the knowledge engineering process is for the knowledge engineer to establish a dialogue with the domain expert and elicit the appropriate knowledge from the domain expert. The knowledge engineer must then code the knowledge explicitly into the knowledge base. (Fig. 3)
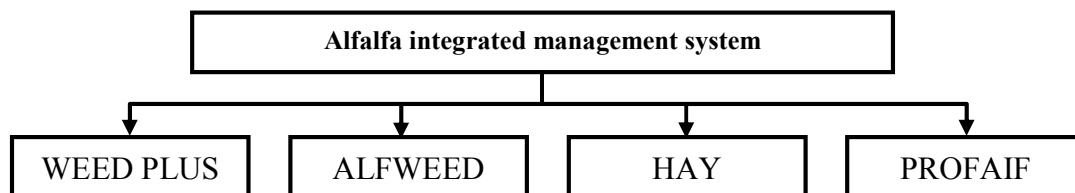

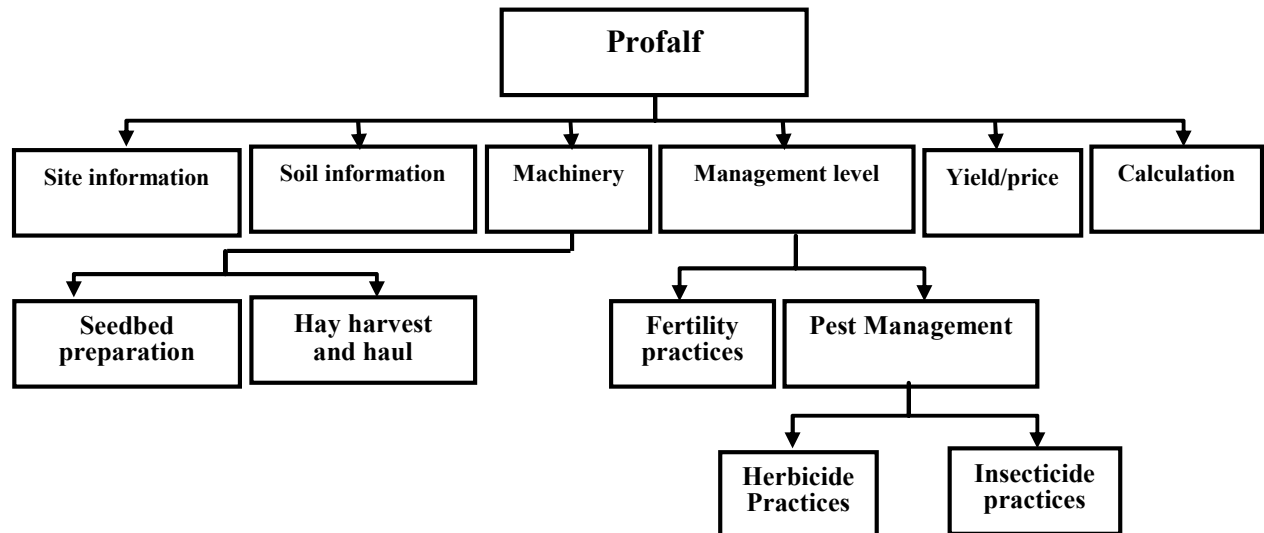**Fig. 1 .Components of the Expert system of Alfalfa**
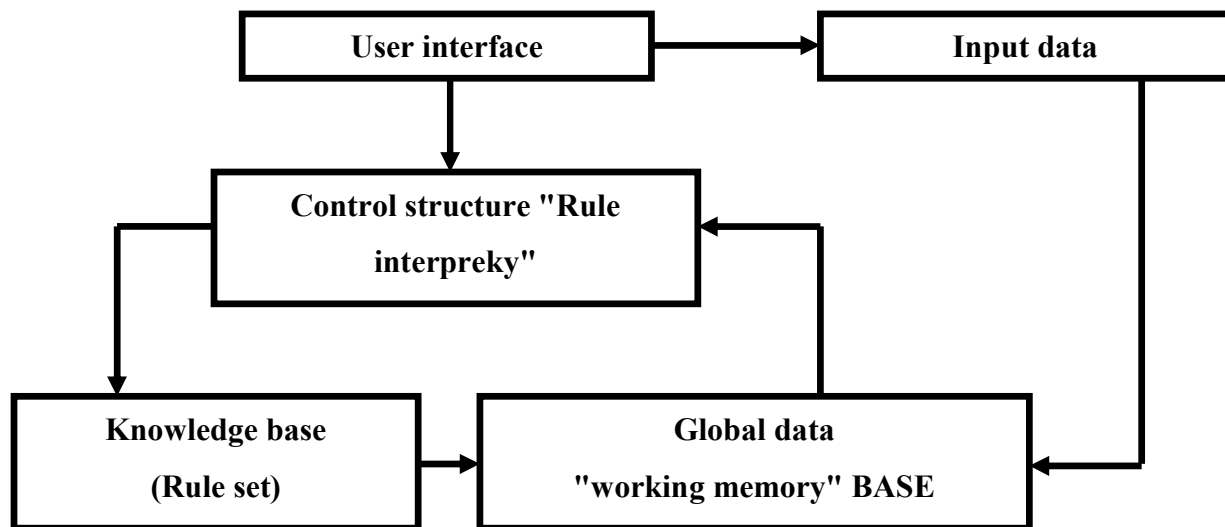
Fig. 2 . Decompostion of ProfAlf

Fig. 3.Components of Expert System program of Alfalfa

Expert system program of alfalfa design the knowledge base of alfalfa expert system was developed using the web knowledge acquisition tool (KAT) [M]. This tool was constructed by central lab for Agriculural expert systems (CLAES) using C#. It facilitates the knowledge acquisition process and producing the expertise knowledge base. The Alfalfa Expertise knowledge was acquired and formalized in design from. Then the design was reviewed by domain experts before enter using the knowledge acquisition tool. The KAT enables us to produce the knowledge based using language English and Arabic.

The process of building acknowledge – base expert system is referred to as knowledge engineering. This process requires a domain expert, a knowledge engineer. And a development tool (expert system shell).

The development tool was PC plus, expert system shell from Texas instruments, Inc. the expert system shell consists of an inference engine that determines the information that must be obtained (and in what order) from the knowledge base and from the user.

However the first step in the knowledge engineering process is for the knowledge engineer to establish a dialogue with the domain expert and elicial the appropriate knowledge from the domain expert. The knowledge engineer must then code the knowledge explicitly into the knowledge base. The knowledge – based expert system is then evaluated by the domain expert. Any necessary modifications are given to the

knowledge engineer for further refinement until the domain expert is satisfied with the performance of the expert system.

The knowledge base for this alfalfa management expert was developed but could easily be modified for other regions. Alfalfa management considerations and the sequence in which they were built into the knowledge base are as follows :

▪ **Soil drainage:** The first question posed to the user concerns the soil drainage classification, since this determines whether alfalfa can be successfully grown and whether a phytophthora resistant variety will be required.

▪ **Soil pH:** Alfalfa is sensitive to soil pH. Therefore, the User is asked if the soil pH is 6.6 or above. The recommendation given is based on the response to the soil pH level of the field to be seeded to alfalfa.

▪ **Soil P test:** This recommendation is based on soil p Level supplied by user.

▪ **Soil K test:** This recommendation is based on soil K level supplied by user.

▪ **Use of alfalfa crop:** Soil improvement only or as a forage (hy or silage).

▪ **Weed control:** Choice of companion crop or herbicides for weed control during establishment.

▪ **Expected longevity of stand :** An indirect method of determining whether anthracnose resistant variety is required. Bacterial wilt resistance is also a consideration.

▪ **Variety recommendation:** A list of varieties is presented which possess the necessary attributes to assure success in establishment and production as desired by the user. Varieties can be listed by Agricultural Research Center (ARC), if desired. The knowledge a base can be easily modified as varieties are released or discontinued.

▪ **Method and rate of seeding:** Determined by input of user relative to seedbed preparation and method of seeding.

The knowledge – based were obtained from the Forage Crops Research Department (ARC). This alfalfa management system performance well and provides recommendations that are satisfactory to the domain expert. However, this expert system will not be made available to potential users in its present form due to high cost and legal restrictions. Consequently, the next step is to convert this alfalfa management expert system to ESTA. ESTA was just recently developed by the Artificial intelligence section at Central Lab for Agricultural Expert Systems The ESTA experts system tool was designed to greatly reduce the cost and legal

restrictions associated with the development and use of expert systems.

RESULTS AND DISCUSSION

In this system, the expert system (ESTA) had included two subsystem, the strategic subsystem and the tactical subsystem. The strategic subsystem consists 7 modules namely: variety selection, pre-cultivation pest control, tillage, planting, irrigation and fertilization, and harvest (Model 1).

The main function of the variety selection modules is to identify the appropriate variety for a specific field based on various parameters such as the soil types, the weather resistance to certain disease and others. The main function of the pre-cultivation pest control module is to generate recommendation of the preventive operations that should be done before cultivation based on the previous crop and other field specific historical data. The function of the tillage module is to select the appropriate machinery for tiling, and parameters. The function of the planting module is to decide on the planting date, distance between plants and method of planting, irrigation and fertilization are similar to what has been described earlier. The only difference is that they are using the ESTA system to calculate the water quantity and nitrogen quantity. The functions of the harvest module is to generate recommendation concerning the harvest date, harvest machinery, and storing the seeds.

The tactical subsystem consists of two modules, namely weed identification and, control, diagnosis and treatment. The weed identifications and control module is a picture based system such that the user can use them. The system provides advice to control this weed. The diagnosis and treatment module is similar to the corresponding module in the other systems.

In this system ASTE is a menu- based program designed to minimize the time required to learn how to use it. System operation of Expert systems of alfalfa. Since the end user is a famer and his natural language is Arabic, the Alfalfa expert system is started using Arabic. A user can run the English version by click on "Alfalfa Expert System" in the right menu. The primary application of the program is to obtain a list of cultivars that closely match characteristics desired by the user. A secondary application is to inform the user about various factors affecting alfalfa cultivar selection. These two applications will be discussed in more detail by describing a typical session with ESTA. The main menu of ESTA offers the user five choices "system" "Edit" "configuration" "Info" and "Quit" By selecting the "system" option, the user is presented with another menu which includes the option to "Make Recommendation" After selecting this option the program conducts an

interview with the user. The first request in the default configuration is "select the site and soil information (fig. 1) Choices include: Area agriculture, soil salinity and soil drainage. The next in query is "Select the level of resistance required in your area for Bacterial wilt.

The final inquiry is for the level of resistance to vericillium wilt. After this query is answered ESTA searches through the cultivars in the database (which can be configured to include only certified varieties if desired) to determine how well they match the interview question responses. The best cultivars are then ranked and displayed according to how well they match the criteria supplied (fig.1). Information on any one of these ranked cultivars is available by selecting that cultivars from the menu.

The database on alfalfa cultivars includes site, soil and pest resistance information (insects, diseases, and nematodes) (Model 1).

A subset database contains only cultivars approved by the ARC.

To obtain information about factors that are important to select an appropriate cultivar, the user would select the "info" option from the main menu. This reveals another menu which offers the user the choice About ESTA use of certified seed "Diseases" "Fertility" "irrigation", cutting and Insects" selecting one of these options provides access to a system of text and color pictures that are electronically cross referenced through common key words (fig. 1). This type of information system, in which related topics are linked through common key words, is known hypertext system.It provides rapid way to move back and forth from one related topic to another. Key words pertaining to

important alfalfa pests are linked to color pictures that illustrate the visual symptoms of the problem. After selecting the system option, in the ESTA program select the pest resistance was grouped into five categories corresponding to highly resistant (>50%), resistant (31-50%), moderately resistant (15-30%), low resistance (6-14%), and susceptible (0-5%).

Cultivar status was denoted as certified, discontinued, experimental, or blend. Cultivars listed as certified were those certified by the certified alfalfa seed (Module 2).

User can select the suitable inputs his/her situation. These inputs values are nominated from the farmers' usual used words (Module 1).

For variety selection, a farmer select its region, soil type and salinity then the system provides him/her by the suitable varieties (Module 2).

The expert system provides its usuer by the needed operation for land and plantation preparation according to seasons, available tools and soil type. For each operation, its detail will be displayed (Module 3).

Also, the expert system provides its users by the needed irrigation water and fertilization (Module 4, 5).

For harvesting, the system provides its with the suitable way to do it (Module 6).

It the farm is infected by disorders, the user will use the diagnosis subsystem. He / she can select the symptoms that appears in his/her farm. Then the infected disorder(s) will display, from treatment subsystem, the user will find how he/she can treat the infected Alfalfa (Module 7, 8).
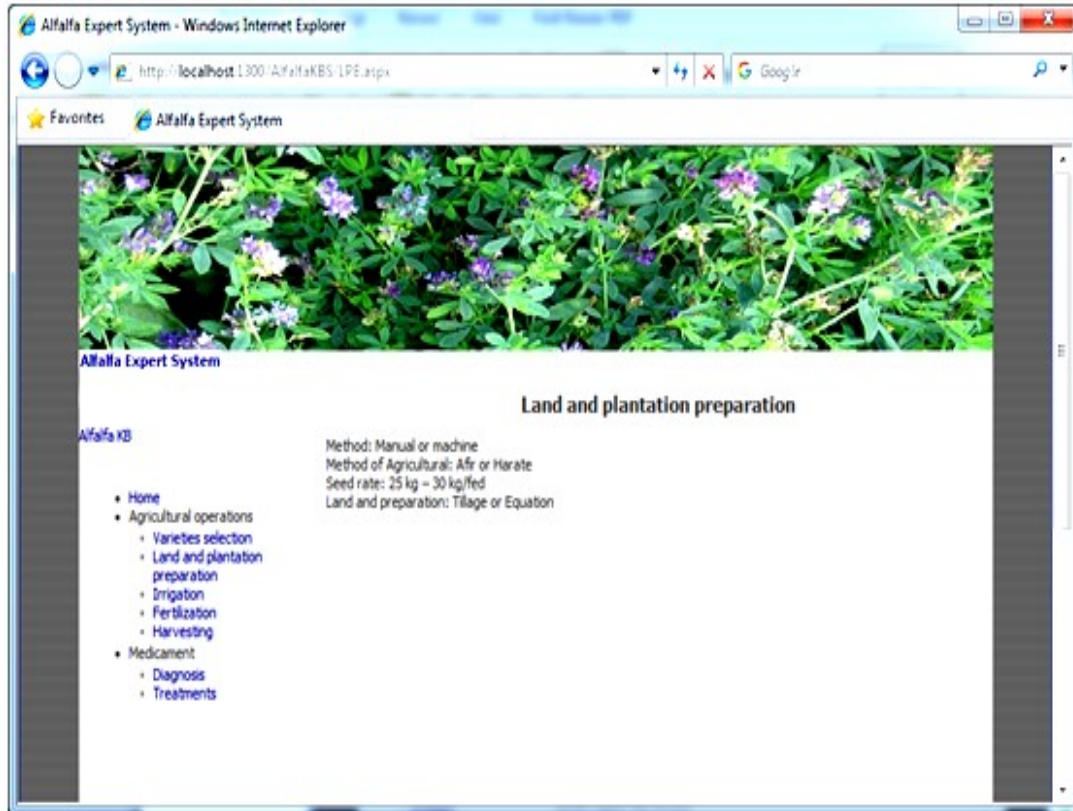

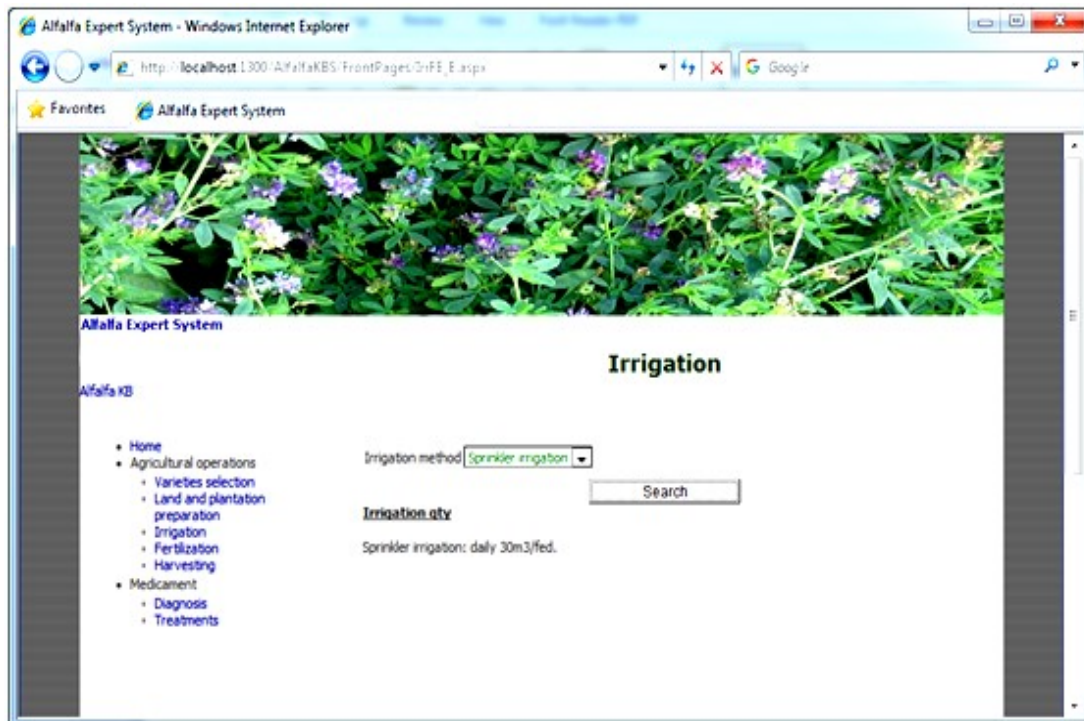**Module 1. Introduction and 7 Modules of Expert System Technology of Alfalfa (ESTA)**
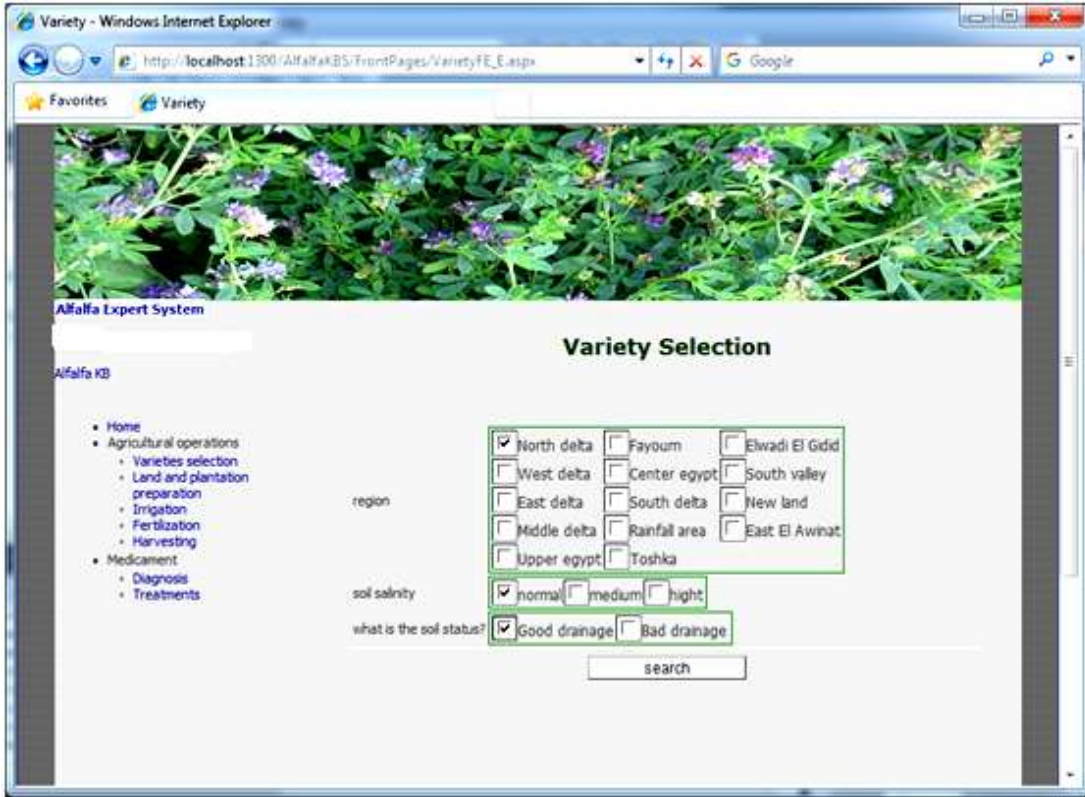
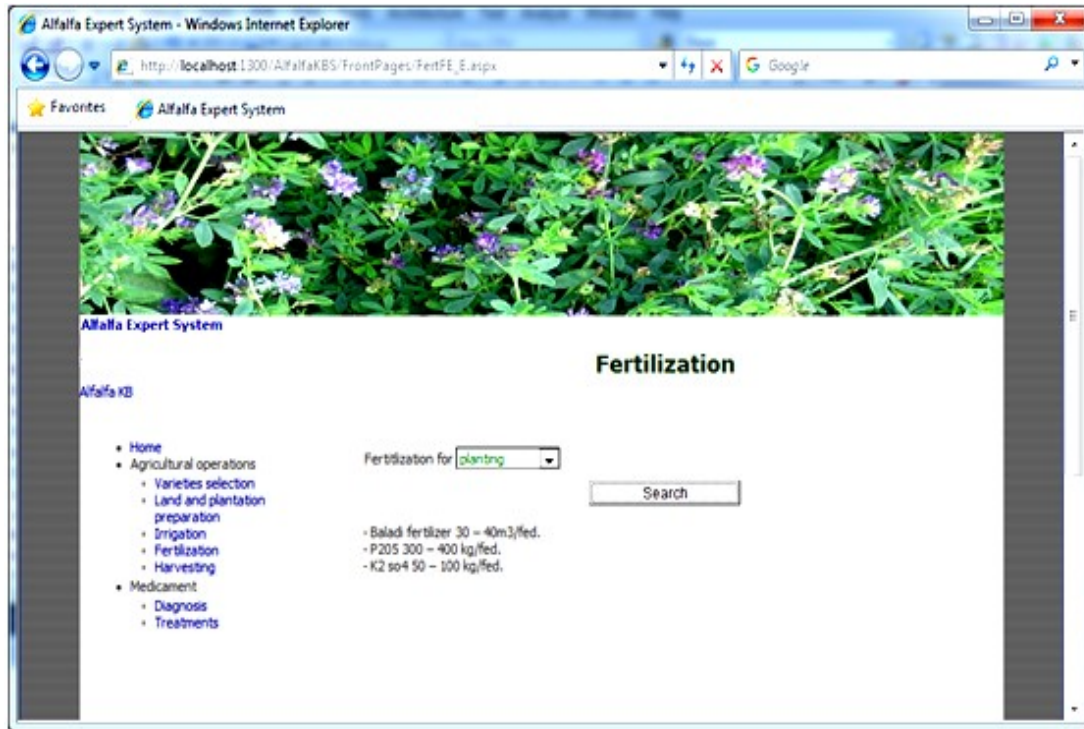**Module 2.Varieties slection of Expert system Technology of Alfalfa (ESTA)**
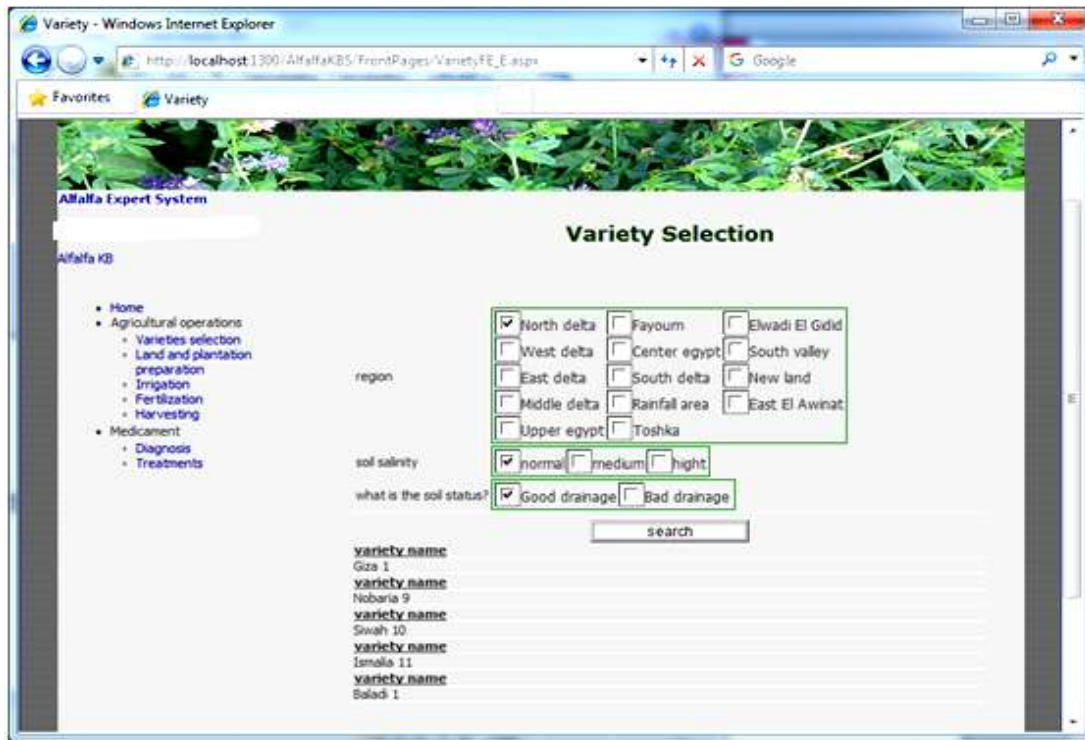
Module 2. Varieties slection of Expert system Technology of Alfalfa (ESTA)
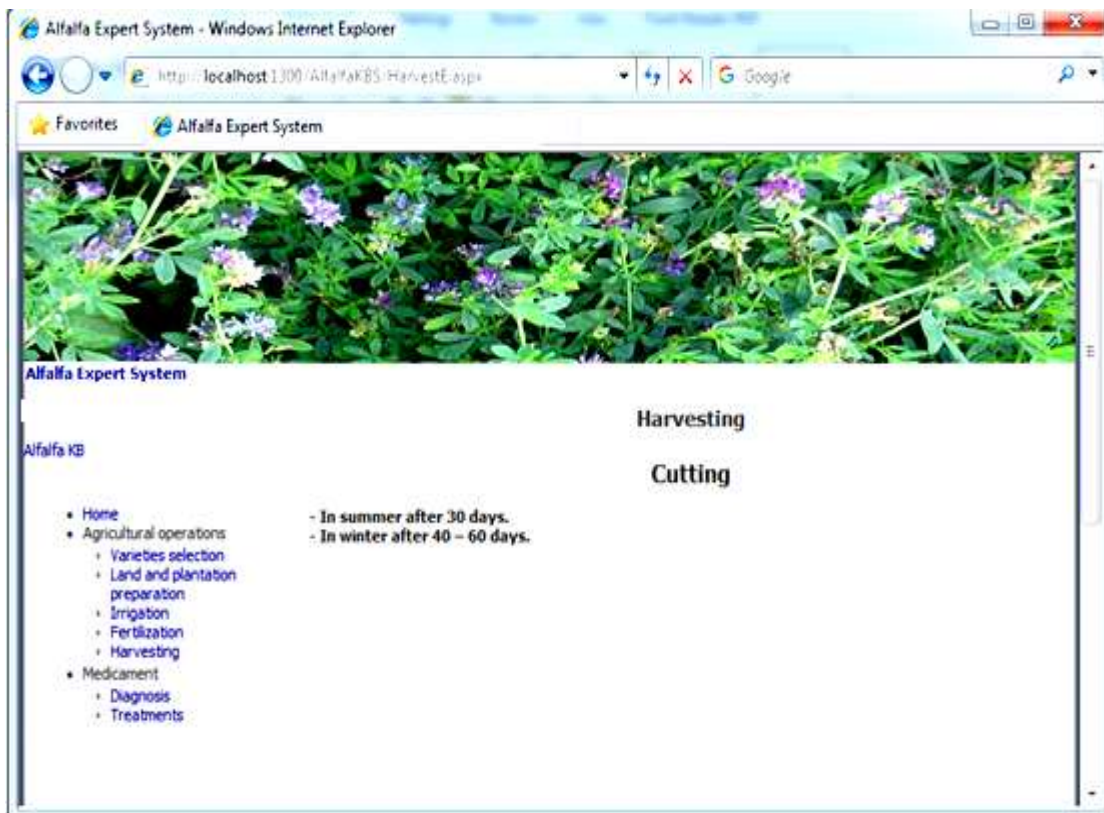
Module 3.Operation for land and Plantation Preparation of Expert system Technology of Alfalfa (ESTA)

Module 4. Irrigation water of Expert system Technology of Alfalfa (ESTA)

Module 5. Fertilization rates of Expert system Technology of Alfalfa (ESTA)

Module 6. Harvesting of Expert system Technology of Alfalfa (ESTA)

Module 7. Diagnosis and Medicament subsystem of Expert system Technology of Alfalfa (ESTA)

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Module 8. Treatment subsystem of Expert system Technology of Alfalfa (ESTA)

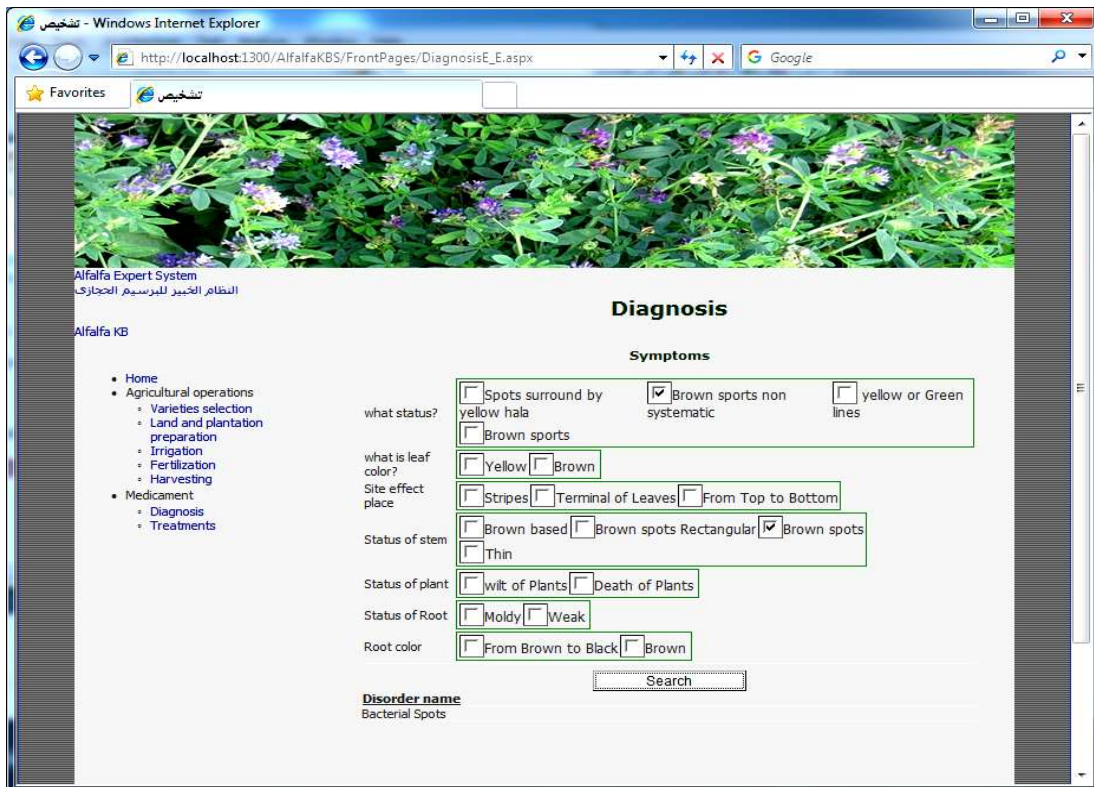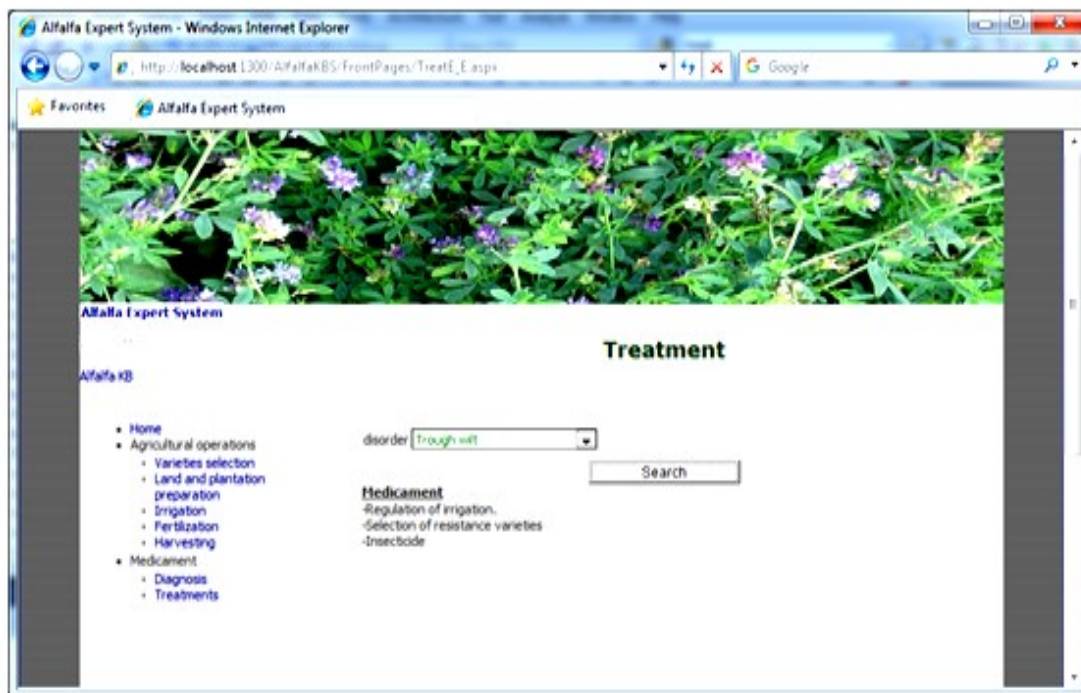Similar results were observed by (Rafea *et al*., 1995), (Rhykerd *et al*., 1993), (Limsupavanich *et al*., 1994), (Criswell *et al*., 1991), (Conklin *et al*., 1987), (Mitrpanont   *et al*., 1993), (Sabella   *et al*., 1989), (Conklin *et al*., 1987), (Giarratano *et al*., 1989) and (Rhykerd *et al*., 1988).

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الملخص العربي

استخدام تكنولوجيا المعلومات في بناء نظام خبير للبرسيم الحجازي تحت ظروف الأراضي الجديدة

عبد العزيز بندق، شيرين النحراوي، مريم خزمان، هند حبيبه، أمل حلمي

نظم الخبرة هي أحد تطبيقات علـم الـذكاء الـصناعي والذكاء الصناعي هو أحد علوم الحاسب الآلي الذي يهـتم بحل المشاكل التي تحتاج إلى التفكير والذكاء البشري ومن مجالات الذكاء الصناعي في نظم الخبـرة Expert system وفي هذا البحث تم عمل نظام خبيــر "برنامج" للبرسيم الحجازي يساعدنا علــى صـياغة الخبـرات والمعـارف وتخزينها واستخدامها فـي الإدارة الزراعيـة لمحصول البرسيم الحجازي ومراحل بناء النظـام الخبيـر للبرسـيم الحجازي هو:

– استخلاص المعرفة من الخبراء وتحليلها وتمثيل المعرفة في صورة يمكن معالجتها آلياً.

وتطوير البرمجيات لتنفيذ النظام الخبير (البرنامج) على الحاسب لمحصول البرسـيم الحجـازي والنظـام الخبيـر "البرنامج" للبرسيم الحجازي بقيمة مجموعة مجموعة من النظم هي:

النظام الخبير للري والتـسميد والعنايــة بالمحـصول والنظام الخبير لتشخيص الآفات والنظـام الخبيـر لعـلاج الآفات.

والبرنامج يعتمد على مجموعة من البيانـات الأساسـية التي يتم إدخالها ومعالجتها وتخزينها حيث ينقسم البرنـامج إلى مجموعتين:

١- تتعلق بالإدارة الزراعيـة Agricultural Management وتشمل الري والتسميد والعناية بالمحصول.

٢-تتعلق بحل المشاكل الموجودة فـي الواقـع Problem Solving وتشمل تشخيص الآفات والتحقق من وجودها وكذلك العلاج المناسب وللمستخدم أن يختار ما يـرتبط من قائمة الاختيارات التي يوفرها له البرنامج.

– نظام الري– نظام التسميد – نظـام العنايـة بالبرسـيم الحجازي – نظام التشخيص – نظام علاج الآفات.

ويهدف النظام الخبير "البرنامج المـصمم" للبرسيم الحجازي إلى تقـديم جـدول الـري المناسب للمـساحة المنزرعة في الموقع وذلك من خـلال اسـتخدام البيانـات المتاحة عن البرسيم الحجازي مثل المـساحة المنزرعـة وتاريخ الزراعة ونظام الـري المـستخدم ونـوع التربـة ودرجات الحرارة والرطوبة النسبية ويشمل جدول الـري المقترح لمقننات الري لكل أسبوع وعدد الريات.

كما يهدف النظام الخبير (البرنامج المـصمم) للبرسيم الحجازي إلى تقديم جدول برنامج التسميد المناسب لموقـع البرسيم الحجازي وذلك اعتماداً على البيانـات الأساسـية المتاحة في نظام الري وذلك لوجود علاقـة كبيـرة بـين النظامين من حيث العلاقة بين كمية ميـاه الـري وكميـة السماد المطلوب وأيضاً العلاقة بين عدد مرات الري وعدد مرات التسميد لذلك يقوم نظام التسميد بتقديم جدول واحـد متكامل لكلا من الري والتسميد في نفس الوقت حيث يظهر جدول الري والتسميد ورقم الشهر وكمية السماد المطلوبـة في التسميد الواحدة واسم السماد المستخدم لكل من عنصر

النيتروجين (N) والفسفور (P) والبوتاسيم (K) والمغنـــسيوم (M) وعدد مرات التسميد في الشهر.

وكذلك الوحدة الخاصة بكمية السماد بالإضافة إلى كمية المياه المطلوبة في الرية الواحدة وعدد مرات الــري فـــي الأسبوع ... جدول التسميد المقترح لأرض قوامها .... ويوضح كمية الـــسماد لكـــل أســـبوع لمـــساحة مقـــدارها .... وكذلك برنامج الري.

ويهدف هذا النظام إلى تشخيص المرض أوالأمـــراض الموجودة بحقل البرسيم الحجازي وذلك من خلال الإجابـــة على مجموعة من الأسئلة لتحديــد المـــشاهدات الخاصـــة

بالإصابة ومكان تواجدها بحيث يقوم النظام الخبير بتحديـد الآفة أوالآفـــات الموجـــودة بحقـل البرسـيم الحجـــازي والمشاهدات الخاصة بالإصابة تتمثل فـــي لـــون الأوراق وشكل الأوراق للبرسيم الحجازي والتي من خلالهـا يـتم تشخيص المرض.

واخيرا يهدف هذا النظام إلى تقديم العـــلاج المناسـب للمرض الموجود بحقل البرسيم الحجـــازي وذلـك حـــسب المرض الموجود ودرجة الإصابة ويقـــدم النظـــام الخبيـــر للبرسيم الحجازي قائمة بالمبيدات التي يمكــن اســتعمالها والوقت المناسب للعلاج وكمية المبيد ودرجة تركيزه.