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Development of an Expert System for Agricultural Commodities

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Abstract

An Expert System is a system that employs human knowledge captured in a computer to solve problems that ordinarily require human expertise. In agriculture, expert systems unite the accumulated expertise of individual disciplines, such as plant pathology, entomology, horticulture and agricultural meteorology and Animal Sciences; into a framework that best addresses the specific, on-site needs of farmers. Expert systems can facilitate knowledge transfer and can guide growers to take decision into different aspects of crop management for increasing the productivity and the profit margin and also combines the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops. Development of an expert system on agricultural crops will help growers in faster dissemination of expert advice for different locations at the same time and will guide them to take decision into different aspects of crop management.

Keywords: Expert system, Agricultural Crops, Knowledge base, Commodities

1. Expert system

Studies from the field of artificial intelligence have given birth to a relatively new but rapidly growing technology known as expert systems. An expert system is a computer program which captures the knowledge of a human expert on a given problem, and uses this knowledge to solve problems in a fashion similar to the expert. The system can assist the expert during problem-solving, or act in the place of the expert in those situations where the expertise is lacking [9].

2. Need for Expert Systems in Agriculture

Agriculture is backbone of Indian economy and it is primary sector of country. Growers (farmers) require advance or experts knowledge to take decision during soil preparation, seed selection, fertilizer management, pesticide management, water scheduling, weed management etc, so that to get high yield[32].Expertise for making decisions exists, but the major problem is making this talent available to the large number of farmers[9]. Agricultural knowledge deals with multiple disciplines, with multiple levels of abstraction. Producer decisions range from considering the details of how a plant needs protection frompests and diseases, to planning commodity trading and marketing. Agriculture as an enterprise is considered highly risky [24].Agriculture expert system is widely used in the various fields of agriculture and greatly promoted the modernization of the agricultural production process and for high quality and high efficiency agriculture in China [42].Expert system of extension, which consists knowledge based information, decision rules and inference engine and available on website will help the farmers not only in taking decision to what to cultivate but also the related questions [55]. Expert systems for crop management of cucumber, tomatoes, orange, lime, and wheat were developed for Egypt can be used as tools for decision making, for training, and for

technology transfer in developing countries[39].Many expert systems have been developed in agriculture to help farmers in taking proper decisions and for getting better yield. Some of the already existing expert systems in agriculture domain are presented.

3. Existing Expert Systems in Agriculture

3.1 Field crops

3.1.1 Maize

Maize AGRIdaksh: A Farmer Friendly Device: Maize expert system has four essential components i.e. the knowledge acquisition module, the knowledge base, the inference engine and the explanatory interface. The knowledge acquisition module consists of gathering of knowledge from the panel of experts of different field of maize e.g. varieties, insects, diseases, etc. It also stores the facts from textbooks, technical /extension /research bulletins. A knowledge engineer further processes it through programming and refinements. The explanatory interface allows the user to get the results in Hypertext markup language, Java script and Cascaded style sheets. This system also explains the procedure to be followed by users to get answers of queries related to maize. Thus it is very useful tool for dissemination/ accessing relevant information related to maize across the globe[21].**A Fuzzy Expert System for Diagnosis and Treatment of Maize Plant Diseases**deals with how to combat or disinfectant the infested maize plantation in order to get the desired quantity and quality of maize productivity [15].

3.1.2 Wheat

Dr. Wheat: A Web-based Expert System for Diagnosis of Diseases and Pests in Pakistani Wheatis a web-based expert system for wheat crop in Pakistan. The rule-based expert system covers two main classes of problems namely diseases and pests, normally encountered in wheat crop[33].

The cereal aphid expert system and glance n' go sampling for greenbugs : Questions and Answers. The cereal aphid pest management system is a set of computer programs to help the user manage cereal aphids in winter wheat. The expert system has a Greenbug Economic Threshold Calculator, which will calculate a treatment threshold for greenbugs based upon data the user provides. It also allows the user to print Glance 'n Go sampling plans for the appropriate economic threshold that can be used to sample several fields using a single form. Treatment thresholds calculated by the expert system incorporate weather data to predict growth rates of the greenbug population, in addition to the price of insecticide treatment and the value of the crop. The expert system also has modules to help in insecticide selection, cereal aphid identification, and natural enemy identification[46].

3.1.3 Rice

MyPEST,Pest activity prognosis in rice fields using fuzzy expert system approach to provide information to the farmers and researchers through the Internet since rice is the main staple food of the Malaysian and Kedah is known as 'rice bowl'. On the other hand, Fuzzy Logic approach is used to forecast the pest activity level. This is important so that early treatment or action can be applied before damage to the plant becomes worst. The system allows the users to input percentage of symptoms in uncertainty forms (high, very high, medium) rather than the common form of yes/no or absence/presence form [11].

ESRICE : An expert system for management of rice pest insects – design and implementation. It was implemented in NEW language, BASIC and dBASE III. It is composed of 13 subsystems which can forecast the population dynamics and gave the control recommendations for farmers. The results of

the system application have shown that the level of the system ESRICE has been as high as that of the domain experts in the rice pest management [12].

An expert system for rice kernel identification using optimal morphological features and back propagation neural network was developed for identifying five different varieties of rice, using the morphological features. The algorithm consists of several steps: image acquisition, segmentation, feature extraction, feature selection, and classification. A back propagation neural network-based classifier was developed to classify rice varieties [13].

A WebGIS Expert System for Rice Brown Planthopper Disaster Early-Warning in China's Shanghai was developed for rice varieties susceptibility, pest density and climatic factors in Shanghai rice planting region. The system used a straightforward set of IF-THEN rules to classify disaster. It was developed since the brown planthopper (BPH) Nilaparvata lugens (Stal) is one of the most devastating insect pests in rice planting region of China's Shanghai [14].

A Quantitative Knowledge-based Model for Designing Suitable Growth Dynamics in Rice was developed for time-course growth dynamics including stem number, leaf area index (LAI) and aboveground dry matter accumulation with desired target yield under different conditions in rice. This model overcomes the weakness of poor spatial and temporal adaptation of traditional rice management patterns and expert systems[62].

An Expert System for diagnosis of diseases in Rice Plantis a rule based expert system, using the shell ESTA (Expert System for Text Animation) [37].

3.1.4 Sugarcane

Rule based Expert System in the Use of Inorganic Fertilizers for Sugarcane Crop helps the farmers to decide what kind of inorganic fertilizers should be used on the basis of symptoms appeared (due to nutrient deficiency) on the leaves of sugarcane crop[49].

4.1.5 Sunflower

SEMAGI - an expert system for weed control decision making in sunflowers. The expert system processes and selects the herbicide(s) under the constraints of herbicide efficacy data and of a weed-crop competition model. This relates weed-infested crop yield (SY,), potential weed-free yield (SY,), weed density (RD) and weed biomass (RBio). The user evaluates the weed infestation by field survey or density counting and the program converts it into equivalent weed biomass. It also provides an economic study of any herbicide treatment selected or introduced by the user, based on herbicide treatment cost, expected yield increase from the weed control treatment and sunflower selling price[50].

3.2.Fruits

3.2.1.Sweet Orange

A Web Based Sweet Orange Crop Expert System using Rule Based System and Artificial Bee Colony Optimization Algorithm. This Expert System contains two main parts one is Sweet Orange Information System and the other is Sweet Orange Crop Expert System where information system, the user can get all the static information about different species, diseases, symptoms, chemical controls, preventions, pests, virus of sweet orange fruits and plants. In advisory system, the user is having an interaction with the expert system online; the user has to answer the questions asked by the Expert System. Depends on the response by the user the expert system decides the disease and displays its control measures[34].

3.2.2.Citrus

Flowering Expert System Development for a Phenology Based Citrus Decision Support Systemto assist growers in the timing of production practices. It is a JAVA based DSS,that includes modules for phenology, scheduling of recommended production practices, GPS-GIS on field maps that allow the system to be block specific and a record keeping system for applied production practices. A flowering expert system was developed to predict flowering intensity, start of flower bud differentiation and date of bloom. This program gives growers tools to partially manage the flowering process in Florida citrus[35].

3.2.3.Orange

CITRUS, a computerized expert system used in nutritional diagnosis of orange trees, is user friendly and permits the diagnosis of nutrient deficiencies when visual symptomology is introduced by the user while interacting with the system through question and answer. A module called DIAGFOL was constructed with Visual Basic language and annexed [40].

Non-pollution orange fruit expert system software based on ASP.NET could simulate and decide an annual fertilization plan for young and mature trees in terms of geographical position and climate. It decreases production cost, guarantee orange quality and improve economical benefit. Farmer using the system saved N input by 41-238 g/plant, P_2O_5 input 3-24 g/plant and K_2O input 1-36 g/plant and got higher yield by 6-17 kg/plant[30].

Expert system of the multimedia orange planting (MOES) was developed for expert decision making in orange viz., breed choice, alter earth and build orchard, breed seeding, planting and engrafting, field management, prevention and cure of the plant diseases and insect pests and to pick and store. Soil information system, hyper text database, photograph database, knowledge rule base are used as supplementary means [41].

3.2.4 Mango

Expert System for Management of Malformation Disease of Mango (ESMMDM)helps to predict the disease incidence and suggests appropriate integrated management strategy by collecting information about the symptoms and draws an inference and presents the user a package for treatment. The user interface was developed with the questionnaire supported by combo boxes, radio buttons and a few text boxes. There are appropriate colour photographs help the user to accurately define the problems[25].

Field Note: A Disease Specific Expert System for the Indian Mango Cropis a computerized expert system developed to help the agriculturists and the field scientists tackle the menace of the mango malformation disease[78].

An Example of Agricultural Expert Systems Being Used in India. The ESMMDM expert system has been preliminarily tested in North and North-central India by a team of researchers and scientists who observed that on an average 100-300, i.e. 20-50 kg, more fruits per plant are obtained by using the crop protection and pest management schemes prescribed by the expert system [72].

3.2.5 Pineapple

DIANA is an expert system for pineapple disorder diagnosis that provides help in the diagnosis of pineapple disorders. The diagnostic method is based on a three level logic: the field level (distribution

of the symptoms in the field), the plant level, and the organ level (leaves, stems etc.). The user interacts with the system, in order to describe the symptoms accurately [45].

PIEX, an expert system to classify pineapple varietiesin breeding studies contains botanic and genetic elements on species, cultural practices, variety images, and glossary of terminology [52].

3.2.6 Apple

POMME: A computer based consultation system for apple orchard management using Prologto manage apple orchards, provides advice regarding specific pest management, treatment of winter injuries, drought control and general pesticide selection [27]. POMME advises growers about when and what to spray on their apples to avoid infestations and also provides advice regarding treatment of winter injuries, drought control and multiple insect problems [28].

An expert system known as the Penn State Apple Orchard Consultant (PSAOC[1]) was developed to help apple growers make better decisions about production and pest management. It gives the apple grower the information necessary to reduce some purchased inputs by substituting high quality, integrated, information derived from three sources (state-of-the-art apple production and IPM knowledge; site specific, farm level data; and weather records). PSAOC expert system decreases the detrimental environmental impacts associated with pesticide and fertilizer use as well as input costs, thereby improving farm profitability and reducing economic risk[29].

3.2.7 Date Palm

An Object-Oriented Expert System for Diagnosis of Fungal Diseases of Date Palmto provide intelligent computer-based support for farmers or agricultural specialists was developed based on O-O database and O-O rule base [22].

3.2.8 Mango

AMRAPALIKA: An expert system for the diagnosis of pests, diseases, and disorders in Indian mango using Expert System Shell for Text Animation (ESTA), for the diagnosis of the most common diseases occurring in Indian mango. The expert system makes diagnosis on the basis of response/responses of the user made against queries related to particular disease symptoms. The knowledge base of the system contains knowledge about symptoms and remedies of 14 diseases of Indian mango tree appearing during fruiting season and non-fruiting season[26].

3.3 Vegetables

3.3.1Tomato

This Expert System contains two main parts one is Tomato Information System and the other is Tomato Crop Expert System where in Information system, the user can get all the static information about different species, diseases, symptoms, chemical controls, preventions, pests, virus of tomato fruits and plants. In Advisory System, the user is having an interaction with the expert system online; the user has to answer the questions asked by the Expert System. Depends on the response by the user the expert system decides the disease and displays its control measure. This rule based expert system validates the symptoms of the tomato crop using the techniques of ID3 Algorithm and some optimization algorithms. This is a Web based Expert System with java as the front end and SQL as the backend [43].

Pest Control Expert System for Tomato (PCEST)involves two main subtasks, namely: 'diagnose' and 'treat'. The 'diagnose' subtask finds out the causes of the growers' complaints, while the 'treat'

subtask finds out a treatment plan for these causes. Common KADS methodology has been used to develop the system. Dependency network is used as one of our knowledge representation schemes in both subtasks [57].

3.3.2 Corn

Expert System PLANT/CD: A Case Study in Applying the General Purpose Inference System ADVISE to Predicting Black Cutworm Damage in Corn. It predicts the damage to corn caused by the invasion of black cutworms. The system first obtains information on the current field situation, including such information as the concentration of weeds, soil condition, and corn variety being grown. This information, coupled with black worm simulation programs, is used to predict the expected level of damage from this pest [6].

3.3.3 Onion and Chilli

Application Expert System of Forward Chaining and The Rule Based Reasoning For Simulation Diagnose Pest and Disease Red Onion and Chili Plant. Based on the evaluation on performance system verification step, the application expert system of pest and disease simulation diagnose red onion and chili plant using forward chaining and rule based reasoning and is a learning system to farmer about pest and disease in red onion and chili plant [63].

Implementation of Web-Based Chilli Expert Advisory System Using ABC optimization Algorithm focuses on the diseases and treatment to the diseases which effected the chilli plants by using the mechanism of Rule based system and Artificial Bee Colony (ABC) algorithm. This is a web based online application for online users with java as front end and MySQL as backend [69].

Chilli

The mechanism of Rule based system and Artificial Bee Colony (ABC) algorithm is used. The rules in the database is processed by the rule based system and if the required rules are not present in the database, then the system goes to the Machine learning algorithm technique and thus resulting to best global optimized solution for recognizing the diseases and specifies the treatmentsfor chilli plants[68].

3.3.4 Garlic

An implementation of expert system in garlic using (ABC) Algorithm deals with the design of garlic expert systems using machine learning algorithms to advice the farmers in villages through online. This system is mainly aimed to identify the diseases and disease management in garlic crop production to advise the farmers in the villages on line to obtain standardized yields. This advisory system is designed by using Java Server Pages (JSP) as front end and MYSQL as backend [64].

3.3.5 Soybean

SOYBUG: An expert system for soybean insect pest management to advise Florida farmers on control of four important insect pests of soybeans: velvetbean caterpillar, stink bug, corn earworm, and soybean looper. SOYBUG integrates a variety of threshold rules based on crop phenology and economics, and gives specific recommendations of pesticides and application rates[65].

A computer based advisory system for diagnosing soybean diseases in Illinois advises users about soybean diseases on the basis of symptoms. The system is easy to use, as all the symptomatic information needed for the diagnosis consists of answers to multiple – choice questions provided [71].

3.3.6 Cabbage

DIBAMOTEX is an expert system developed for the control of the diamondback moth, a pest/parasite prevalent in crucifer cops, particularly cabbage. DIBAMOTEX was developed in consultation with Caribbean experts in the field of plant pathology and pest management [47].

3.3.7 Solanaceous crops

DIARES-IPM: a diagnostic advisory rule-based expert system for integrated pest management in *Solanaceous* crop systems serves as a diagnostic, extension and educational tool in vegetable IPM and it includes the most economically important diseases, insects (noxious and beneficial insects) and nutritional deficiencies that affect these crops. EXSYS tool for Windows was used and the knowledge is represented in the linguistic form of if-then rules [2].

3.3.8Mushroom

CROPPRO aids farmers in four major areas of crop production such as: crop management problems, pest control, financial considerations, and tutoring on various crop topics. Hypertext and interactive graphics are used extensively, which serve to enhance the system's interface and effectiveness. The Shiitake mushroom was chosen as a test case for this expert system [8].

3.3.9 Greenhouse vegetables

Greenhouse

Expert System for Greenhouse Production Management. Sensors were put on proper locations and connected with the data collection modules and the data collection modules were connected with a computer in which monitoring and control software had been installed. The system automatically recorded environment information at a certain interval and was put into expert system by the ACCESS database files and supported greenhouse management system with proper decision-making. It includes Consultation of basic cultivation information, dealing with botanical characteristics, requirements of growth environment and cultivation techniques during each growth stage, Consultation of frequent pest/disease and nutrient deficiency symptom in greenhouses and chemicals for prevention and treatment, Diagnosis and recognition of pest/disease and nutrient deficiency and decision on greenhouse environment control for on/off-line operation mode[79].

Cucumber

The harrow expert system for greenhouse vegetables: This expert system for greenhouse cucumber management is based on a general model of Integrated Crop Management for greenhouse crops for managing the complex greenhouse cropping system which requires a multidisciplinary approach that integrates pest and disease protection strategies with routine cultural practices and environmental and fertigation regimes into a common decision-making process or Integrated Crop Management strategy [19].

Aubergine, bean, cucumber, lettuce, pepper and tomato

VEGES—A multilingual expert system for the diagnosis of pests, diseases and nutritional disorders of six greenhouse vegetables: aubergine, bean, cucumber, lettuce, pepper and tomato. It is developed on a PC-based shell and distributed to extension services and individual farmers for a nominal charge, accompanied by a new language translation module which allows a non-specialist user (e.g. extension officer) to translate the knowledge base to the native language or dialect of the local farmers. Applicable to the LT greenhouses of the Mediterranean area where low production

costs are of paramount importance. The language translation module extends the application of the product to the significant vegetable production industry of southern Europe and northern Africa [10].

3.3.10 Chilling injury of vegetable

An expert system for diagnosing chilling injury of vegetables: Temperature management is the most widely used method to extend the postharvest life of vegetables. An expert system was developed to diagnose CI symptoms for several commodities. Diagnosis is determined by applying rules and certainty factors based on user responses to queries on the type and extent of visual symptoms [18].

3.3.11 Vegetable fertilization

N-EXPERT - A decision support system for vegetable fertilization in the field. Field studies in Germany showed that vegetable growers often make nitrogen fertilizer decisions by rules of thumb, which means that they regularly use too much nitrogen. Fertilization which meets the requirements of environment protection and prevents leaching of nitrogen is only possible if it is made after a detailed analysis. N-Expert calculates field specific fertilizer recommendations for vegetable crops [3].

Amaranth, spinach and cauliflower

Use of a Modified N-Expert System for Vegetable Production in the Beijing Region with different irrigation regimes for a rotation of amaranth (*Amaranthus tricolor* L.), spinach (*Spinacia oleracea* L.), and cauliflower (*Brassica oleracea* L.). There was a significant decrease in residual N_{min} at harvest in treatments using the modified N-Expert recommendation system compared with conventional N practice [54].

Fertilizer Adviser Crops: an expert system for Tasmanian cropsdesigned to advise consultants and sales staff about the appropriate fertilizer program for crops grown in Tasmania from the knowledge drawn from many sources, including results from fertilizer trials conducted in the State and elsewhere, and theoretical knowledge about nutrient removal and soil chemistry. The single page output gives a fertilizer recommendation for that crop, including lime requirements, basal fertilizer application, topdressing and trace element advice where appropriate [56].

Fertilizer decision support system for farmers in Northeast China : a case study at Tong-le village is a GIS based software package that can be used to help farmers select fertilizer application rates and manage soil nutrients[38].

Mineral identification

ARule-Based Expert System for Mineral Identificationis based on the physical characteristic of the forty minerals as the knowledge domain. The inference engine is rule-based as suggested to be better by previous researchers. Visual Basic is used for the implementation while Microsoft Access is used for creating the database[48].

3.4 Spices

3.4.1 Pepper

Expert system for integrated plant protection in pepper (*Capsicum annuun* L.) was developed for improving decision-making by pepper growers. The knowledge was obtained from the literature and from the experts for developing this expert system. The knowledge was represented in the knowledge base of the expert system in a series of IF–THEN rules. The system is supported by a data base

containing information for the identification of 11 weeds, 20 insects, 14 diseases, three abiotic factors and control measures. The system is enhanced with 87 photos and drawings that assist the user in the identification process and choosing control measures [4].

Expert System for Identification of Red Pepper Plant (*Capsicum annum* L.)designed and developed for identification of 12 general diseases of red pepper plant. Disease identification in this software system was based on the visual symptom of disease(s) in various plant growth stages, similar to the standard rules in plant protection science [75].

3.5 Plantation Crops

3.5.1 Oil palm

Expert System Land Evaluation for Oil Palm Cultivation (ESLEOP). Land evaluation assesses the suitability of land for specified land uses. This software was developed using climate, land qualities and land characteristics as diagnostic criteria in order to speed up the process of land assessment for oil palm cultivation in tropical regions. The results showed that ESLEOP evaluated land suitability for oil palm cultivation faster than the conventional method and can be used in Peninsular Malaysia[74].

3.5.2 Coffee

CPEST: An expert system for the management of pests and diseases in the Jamaican coffee industry. The sheer amount of knowledge required on climate, topography, soil type of the farm, agronomic practices, crop phenology, biology and damage potential of the pests and options available for suppressing their population below the economic injury levels typically resides within a few experts and is not easily available to farmers. In order to make this knowledge more widely available, CPEST, an expert system for managing pest and diseases of coffee in a developing country was developed [1].

3.5.3 Tea

TEAPEST: an expert system for insect pest management in tea. It is a rule–based, object–oriented expert system for insect pest management in tea which identifies major insect pests of tea and suggests appropriate control measures. 'TEAPEST' shows good performance as evident from its performance evaluation[5].

Development of the Diagnostic ExpertSystem for Tea Processing can presume the cause of the defect of the processed tea was developed to contribute to the improvement of tea processing. The inference engine, the core of the system adopts production system which is well used on artificial intelligence, and is coded by Prolog as the artificial intelligence oriented language[77].

3.5.4 Olive crop

Expert system for pests, diseases and weeds identification in olive crops was developed for improving decision-making by olive oil growers. The knowledge was obtained from the literature and from experts. The knowledge was then represented in the knowledge base of the expert system in a series of if-then rules. The system is supported by a database containing information for the identification of 9 weeds, 14 insects and 14 diseases. The system is enhanced with 150 photos and drawings that assist the user in the identification process [66].

3.5.5 Cotton

COMAX incorporates the knowledge of a model of cotton production to provide advice on the growing and management of this crop. The expert system uses the cotton model to predict crop growth and yield in response to weather conditions, soil variables, and pest damage. COMAX is capable of providing recommendations for management decisions on a daily basis to maximize cotton yields [7].

IPM CALEW Cotton: an integrated expert system for cotton production and management is a user-friendly computer program that simulates human problem-solving behaviour. Growers can use this system to help manage crop production or predict the effects of any one decision on subsequent events[81].

3.6 Other agriculture expert systems

3.6.1 Fruit Fly

Fruit Fly Expert Identification System and Systematic Information Database is designed to help users identify organisms. The Expert System has three components: The program, data sets and images. The users are professional identifiers who are already familiar withtraditional identification aids, like keys, and are familiar with their organisms. Help files are provided so almostanyone should be able to run this program. It is ONLINE whenreading the menus and general help screens [16].

3.6.2 An Artificial Neural Network based Expert System for Fruit Tree Disease and Insect Pest Diagnosisis based on artificial neural network (ANN) and geographic information system (GIS). A multiple knowledge acquisition approach was adopted, consisting of interview expert, questionnaire, Web-based search and literature review. A GIS platform (ArcInfo) can provide the functions of spatial and temporal analysis, and was used to analyze and display the development tendency of fruit tree disease and insect pests [20].

3.6.3 An Expert System for Identifying Plants from Their Visible Featuresis an interactive one which asks questions to a non-expert user and gradually narrows down the possibilities, eventually deciding about the identity of the plant in question. Currently it identifies forty-eight plants of types tree, vine, or shrub [53].

3.6.4 An Expert System for Tractor Selection. A user friendly expert system to assist the farmer in tractor selection was developed. It utilizes Nebraska Tractor Test data from 1980 to 1986 along with information provided by the farmer to make selection decisions. The expert system provides the farmer with a list of tractors that are best suited for a specific operation[58].

3.6.5 Expert System for Identification and Management of Abiotic Stresses in Tobacco (*Nicotiana tabacum*).Symptoms of the tobacco leaf affected by abiotic factors sometimes resemble biotic factors, misleading in identification of actual causes for taking remedial measures. The information on abiotic factors on tobacco and their symptoms was established and an expert system was developed for identification and management of abiotic stresses in tobacco. The expert system was developed using Visual Basic.Net as front-end application and Oracle as back-end with user-friendly menus. It enables viewer/farmer to identify his problem with different abiotic stress symptoms displayed and identify problem as well as remedial measures [61].

3.6.6 An expert system for planning and designing dairy farms in hot climates. The developed expert system is able to plan and design several dairy farm facilities; specify their different dimensions; and compute the required amounts of construction. It plans the farmstead layout; and determines the water and electricity requirements versus the available sources on site. It calculates the capital investment and the fixed, variable, and total costs [70].

3.6.7 A knowledgebased expert system for planning and design of agroforestry systems. UNU-AES is a prototype Knowledge-Based Expert System (KBES) designed to support land-use (agricultural, forestry, etc.) officials, research scientists, farmers, and individuals interested in maximizing benefits gained from applying agroforestry management techniques in developing countries. It uses a total of 235 decision rules to develop its recommendations[82].

3.6.8 Using Expert Systems as a Training Tool in the Agriculture Sector in Egypt. The results of this study suggest that the expert systemcan be an effective training tool in agriculture extension programs[76].

3.6.9 Developing an expert system for plant disease diagnosis was developed using two different methods of plant diagnosis step by step descriptive and graphical representational methods since the plant diseases are one of the most important reasons that lead to the destruction of plants and crops. It plays the role of an agricultural engineer and provides the user with different methods of diagnostic treatment [60].

3.6.10CROPES : A rule based expert system for crop selection in India. Crop selection is a crucial and decisive task, given the dynamic environment of agricultural systems created by differences in climate, soils, topography, cultivation practices, and available resources. It is a PC-based expert system (CROPES) for selecting crops in a region in Tamil Nadu, India. It recommends crops to a farmer at an early stage of crop planning based on location, climate, and farm level information pertaining to soils and available resources [80].

3.6.11 An information technology enabled Poultry Expert System: Perceptions ofveterinarians and veterinary students. The Poultry Expert System (PES) was developed using Visual Basic 6.0 and MS Access on selected dimensions of poultry farming. Its efficacy was tested among the Veterinarians and Veterinary students. PES is an IT enabled tool for faster dissemination of expert advice in multiple locations at the same time [36].

4. Conclusion

With the recent growing population and high farmer to extension worker ratio, there is a great need for an intuitiveknowledge based system, which may suggest suitable solutions to the farmers [21].Online expert systems have the capability to transfer location specific technology & advice to the farmers efficiently and effectively [21].Direct dissemination of expert knowledge to agricultural producers through computer programs will increase product quality as well as the profit margin [27]. So researchers have to try to develop such an expert system which will guide to Growers to take decision into different aspects of crop management like soil preparation, seed selection, pest management, fertilizer management, weed control, irrigation management, nutrition management etc. [67].Expert systems are a better option over traditional systems[73]. It is proven that expert systems in agriculture helps a lot in increasing the crop production [51]. Expert system is offered as the second choice after expert on consultation [63].

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