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Expert System for Identification of Weeds

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ABSTRACT

Identification of weeds is essential for designing an efficient strategy for their management. However, it is a difficult task requiring expert knowledge and experience. An expert system to help researchers, farmers, extension workers and students to identify weed species of crop and non-crop lands has been developed at the Directorate of Weed Science Research, Jabalpur. The expert system uses family, scientific, common name-based classification and a mix of the text description and photographs. The system is supported by a database containing information about 337 weed species with colour images. The expert system was evaluated following the conventional expert system evaluation methodologies. Results indicated that non-expert users were able to make weed identification using the expert system efficiently.

Key words: Agriculture, Identification, Information, Knowledge, System, Weed

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1. INTRODUCTION

Weeds grow along with crops and also in other terrestrial and aquatic ecosystems. The undesirable plants deplete nutrients, water and space allotted for the intended crop, causing huge losses in crop yield. Weeds account for about one-third of the total yield losses caused by different pests, besides causing various kinds of health hazards and damaging the ecosystem function and biodiversity. Knowledge of weed biology is essential for development of economically and environmentally acceptable weed management systems. It is said that identifying the weeds is half way to control. The first step for effective weed management is accurate identification and basic understanding of the weeds' life cycle. Correct identification is an important step so that new weeds can be eradicated before they become established. Proper weed identification helps in selecting the right herbicide and the time of application to control a particular weed. Sometimes identified plant may not be a troublesome weed and help in protecting conservation of the biodiversity. Identification of weeds is possible with experience gained over a period of time. Unfortunately, specialized assistance is not always available everywhere for weed identification. In order to overcome this problem, expert systems have been developed. The primary goal of expert systems research is to enable decision makers and technicians to do their job more efficiently. The expert system technology is a new approach for weed identification.

An expert system is a computer programme that contains formally encoded knowledge of experts in a given problematic area or domain and is able to use this knowledge to provide help to a non-specialist in problem solving in that domain [1, 2]. In agriculture, expert systems were developed in various disciplines [3,4,5,6,7,8,9,10,11,12,13] that combine the experimental knowledge and experience with intuitive reasoning skills of specialists to aid in making the best decisions.

The expert system on weeds allows their identification by specifying characteristics from a variety of categories, viz., flowers, leaves and stem and sub-categories, viz., flower colour, leaf shape, and stem cross-

section. One can simply examine a weed and make choices based on its traits. There is an option to choose more obvious characteristics such as flower colour, plant height or leaf shape. All characteristics are displayed via detailed botanical glossary, which is as useful to novices as it is to professionals. With each choice you make, the list of possible plants shrink. It is easy to confirm the identity of a weed by comparing the sample specimen to the many-coloured photos. This application is as useful to the amateur enthusiast as it is for professionals in the field of weed science. An attempt was made to develop expert system for weed identification including 337 commonly found weed species cropped and non-cropped lands in the country.

2. MATERIALS AND METHODS

An expert system on weed identification was developed with the combined efforts of specialists from the concerned subject, software professionals and other technical experts. The first step in building an expert system requires knowledge acquisition[14].

For this expert system, the domain expert is the 'Agricultural scientists in the field of weed science'. The knowledge engineer codes the information in the form of rules or some other representation scheme. System editor (software expert) serves as intermediary between the domain expert and the computer that will emulate their expertise. The software expert acquires the information about the weeds in the form of facts and rules through consultation and document analysis and then prepares a knowledge base for the system. The process is repeated until a sufficient body of knowledge has been collected to build the expert system.

A study was carried at the Directorate of Weed Science Research, Jabalpur (M.P), during the period from 2002 to 2012. Category-wise listing of weeds, their characteristics and other related information were gathered through field surveys and from literature. The information about scientific names, common names, family, habit and morphological features of stem, leaves, flowers, fruits and seeds along with weed images were documented and catalogued. For capturing the weed images, field surveys were conducted all over India with the help of scientists of All India Co-ordinated Research Project (AICRP) on weed control. Every effort has been made to get the images of the weeds that are at the right stage of its growth representing its correct identity. Using picture editing software, the weed image photographs were processed in such a way that a more clear picture of a weed appears on a white background.

The expert system was developed using Visual Basic.Net [15, 16] as front-end application and MS Access [17] as back-end application with user-friendly menus. A prototype of the expert system was built and validated. All the images were stored in digitized form. The knowledge base contained information about 337 weeds consisting of 60 attributes clustered into 10 parameters which were stored as rules of inference for use during the reasoning process. These rules were of 'if…then…else' nature or any other valid form. The inference mechanism guided the reasoning process through knowledge base by attempting to match the facts in the database to other rule conditions. The 'inference engine' was designed to accept user input queries and responses to questions through the I/O interface and used this dynamic information together with the static knowledge stored in the knowledge base. Reports were designed using 'crystal reports' by providing flexibility to the user to view selected parameters and take the print out. Interface was provided to the back-end to access the database from 'MS Access' and to store the new information into it.

To use the system easily, the user-friendly interface was developed with GUI which allows the user to communicate with the system in a more natural way by permitting the use of simple selection drop down option menus or the use of a restricted language which is close to a natural language. Through user-interface, the user is allowed to view, query and advance search for the weed information, view the complete data for a particular weed by selecting the weed either by scientific or common name which is considered as a primary key. One powerful tool included in this system is that by using advanced search, the user can

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shortlist the weeds based on optional features such as habit, life cycle, stem type, stem shape, leaf shape, leaf edge, leaf arrangement, flower type, flower colour, seed shape and seed surface and can get the identity of a particular weed by selecting an option or combination of options.

3. RESULTS AND DISCUSSION

The main menu of this software consists of four modules, viz., weed information, search query, weed identification (Figure 1) using advanced search and about software. The scientific and common names of weeds are considered as primary key for identifying their characteristics.

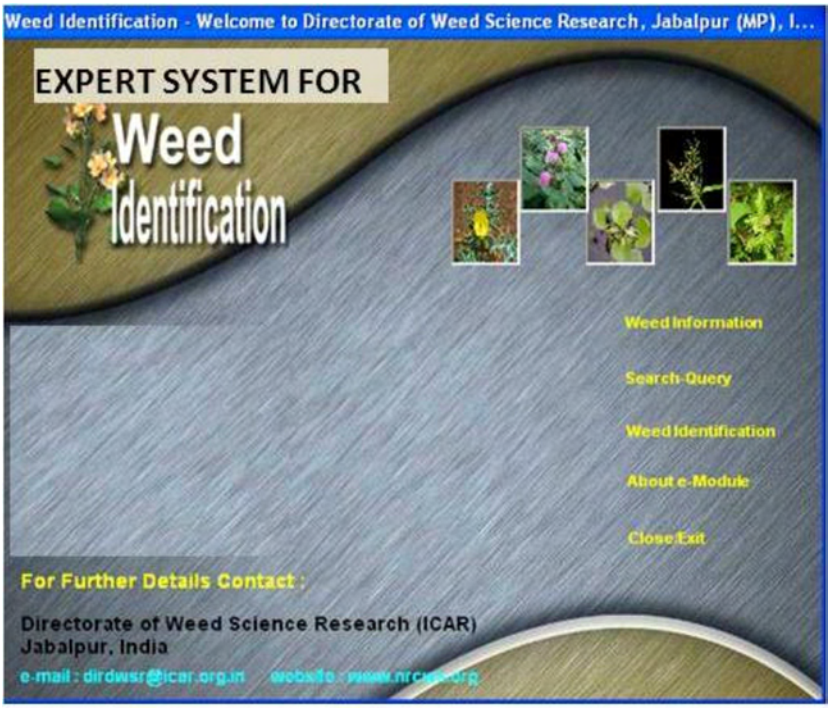

Fig. 1. Main Menu

WEED INFORMATION: It is a simple search mechanism which allows the user to search for a particular weed either by its scientific or common name. For easy searching, all the weed names are arranged alphabetically and placed into different subgroups, viz., A-D, E-H, I-L, M-P, Q-T, U-X, Y-Z. For example, if the user is searching for a particular weed and its name starts with 'G' like *Galium aparine* L., the user has to select the subgroup E-H, then a list of scientific names gets displayed. By selecting *Galium aparine* L. from the list, the information, viz., family name, habit, stem, leaves, flowers and seeds gets displayed along with the weed image as shown in Figure 2.

SEARCH-QUERY: It is a powerful tool through which the user can make a query for a particular weed by selecting the leaf shape, flower colour, habit, fruit shape, stem shape, seed shape and family name. Once any one of the above options is selected, a list of scientific names of weeds that have the opted characteristics gets displayed and selecting one among the list displays the information of a particular weed having the characteristics opted. For example, if the user selects the 'leaf shape' option, a list of shapes with their name gets displayed as shown in Figure 3. If he selects one of the shapes like 'cordate' (as shown in Figure 3), a list of scientific names of weeds having cordate leaves gets displayed. The user can select one of the scientific

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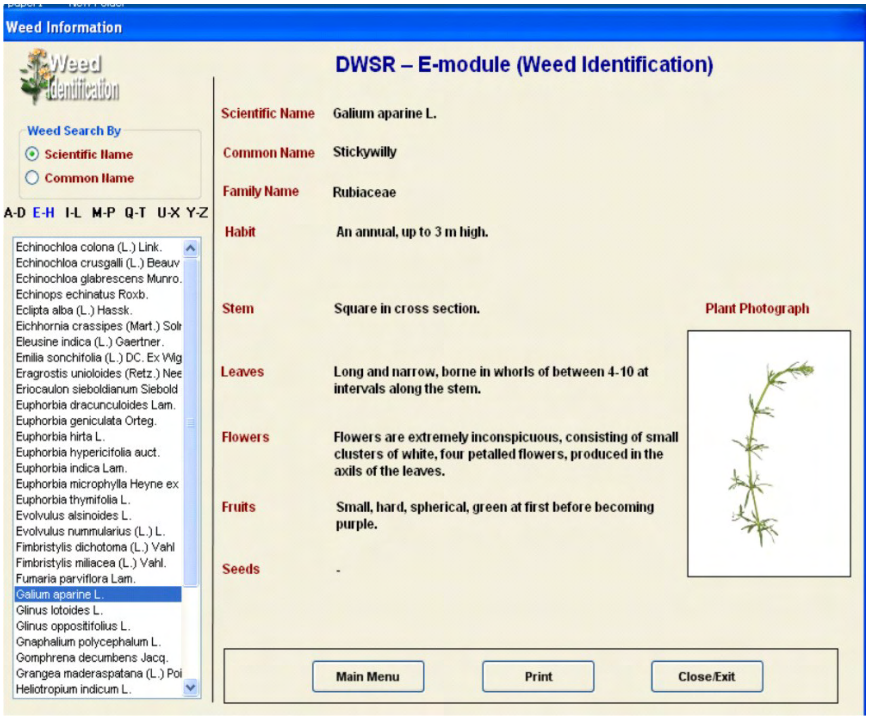

Fig. 2. Weed Information Menu

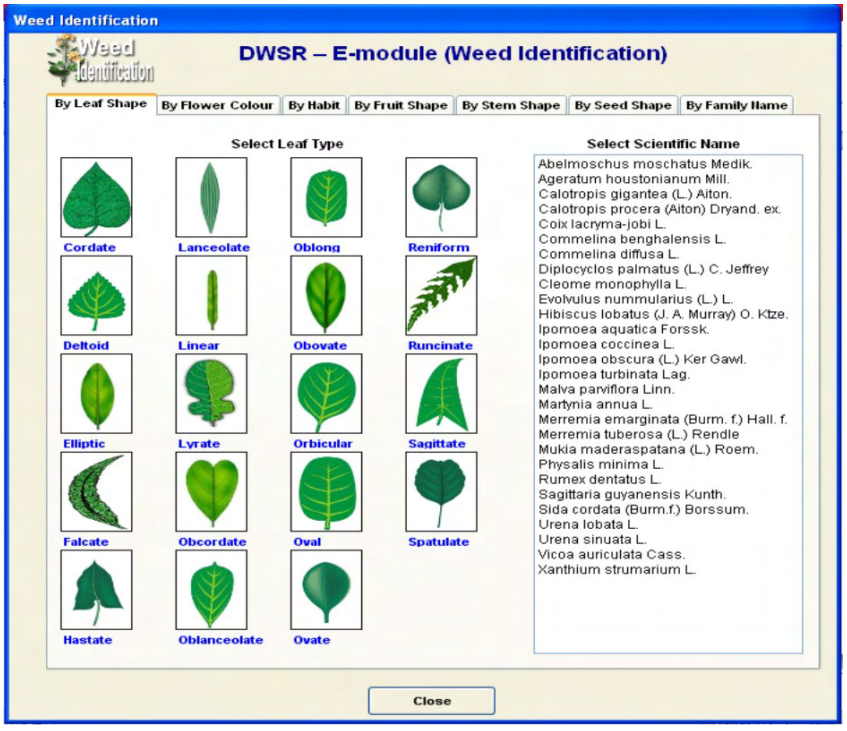

Fig. 3. Search Query (By leaf shape)

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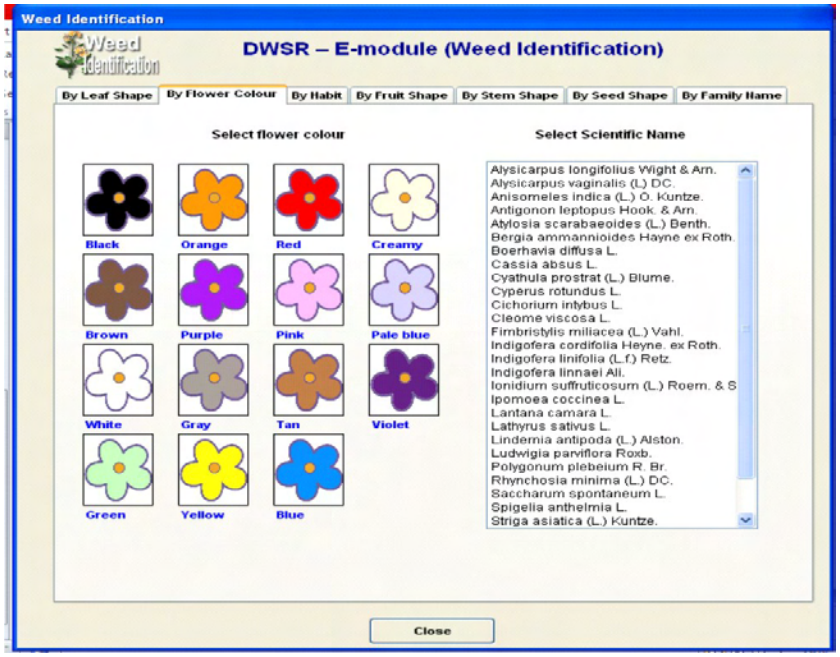

Fig. 4. Search Query (By Flower colour)

names from that list to display the characteristics of that particular weed. Similarly, the weeds can be shortlisted for identification by selecting other options like flower colour also as shown in Figure 4.

WEED IDENTIFICATION: The third module allows the user to perform advanced search for identification of weeds. The selection of parameters included in this search are habit, life cycle, stem type, stem shape, leaf shape, leaf edge, leaf arrangement, flower type, flower colour, seed shape and seed surface (Figure 5).

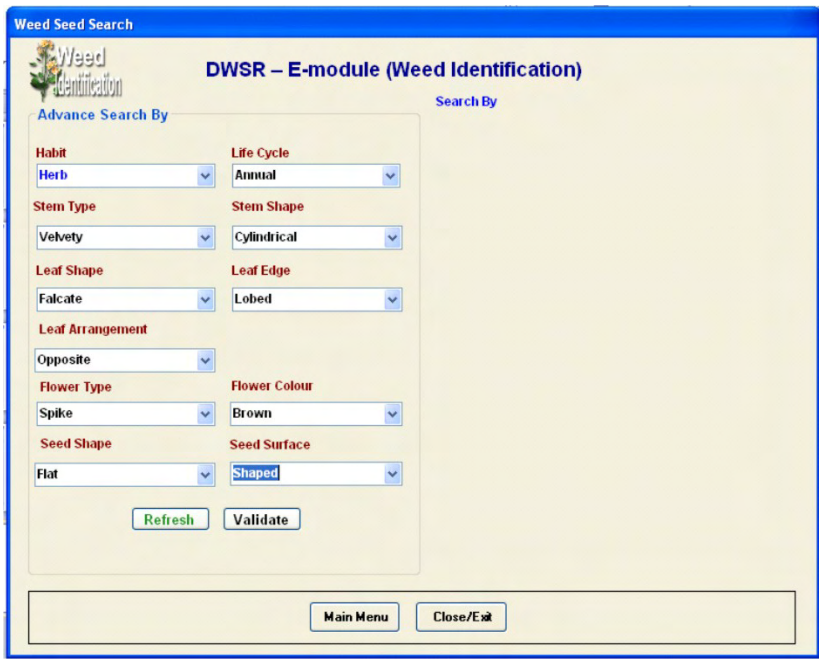

Fig. 5. Advance Search Menu

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The parameter 'habit' consists of the type of plant such as 'herb, shurb and grass' as options; Life cycle consists of 'annual, biennial and perennial' as options; Stem type consists of 'hairy, velvety, angular, glabrous, cylindrical and fistular' as options; Stem shape consists of 'glabrous, cylindrical, ridged, grooved, square and triangular' as options; Leaf arrangement consists of 'opposite, alternate, whorled and rosette' as options; Flower type consists of 'single, spike, raceme, panicle, umbel, compound and composite' as options; Seed shape consists of 'globular, heart, flat, thick, triangular, kidney, disc and granular' as options and Seed surface consists of 'stellate, shaped, findy, shiny, smooth, rough, sparsely and glandular' as options. Once the user selects any one of these options, then a particular list of weeds grouped under that particular option gets displayed. Then the user can select the option to get its characteristics displayed.

ABOUT SOFTWARE: This is portable software, which makes it possible to execute this software in any system. For this, a 'SETUP' programme is created (executable file) including all the files and data. Any user can install this software by running this 'SETUP' programme, and the execution of the software is self-explanatory.

4. CONCLUSION

From the researcher's point of view, knowledge-based systems have a potential to help to organize and synthesize knowledge and information of different types. It is possible to focus and apply diverse avenues of research to solve difficult problems, link together quantitative data, simulation models and basic research results into knowledge base. The idea of an expert system is shifting the focus of the research community to knowledge dissemination in contrast to knowledge accumulation. The expert system in combination with powerful personal computers and devices like CD-ROM has the potential to open whole warehouses of accumulated knowledge for agricultural development.

The main purpose of the expert system is to serve as delivery systems for extension information and management for the decision makers. It also plays an important instrument in agricultural education. It helps in dissemination of up-to-date scientific information in a readily accessible and easily understood form to agricultural researchers, advisers and farmers. With the help of the expert system, the farmers can produce higher quantity and quality agricultural produce by using optimum resources. Further modification and additions to current system will be a continuous process based on the information and impressions received from various stakeholders.

Results of validation indicated that non-experts were able to make identification using this expert system. Those who tried this expert system opined that the system had educational and management importance. The use of herbarium lookalike colour images is an asset as it makes the identification an easy process and makes the system acceptable to many. This expert system will be made available on the website of the Directorate of Weed Science Research, Jabalpur (M.P., India). The suggestions for refinement if any will be considered to make the system accessible to every one.

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