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Expert System for Diagnosing Mobile and Immobile Nutrients Deficiency of Plants

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Abstract: *Plants are important for the world and for all living things. Plants releases oxygen from their leaves and absorb carbon dioxide gas, which humans as well as other animals need to breathe. Unfortunately, productivity and quality of plants are still quite low due to many reasons and plant nutrient deficiency as one of the important reason of low productivity and quality of plants especially in rural areas due to absence of nutritional information and agricultural expert assistance. Nutrients deficiency can have a significant impact on agriculture, resulting in reduced crop/fruit yield or reduced plant quality. The key objective of this research study is to develop and practically implement an Expert system that can help the farming community of rural areas as well as researchers or observers to timely diagnose plant nutrients deficiency. The Expert System for Diagnosing Mobile and Immobile Nutrients Deficiency of Plants (ESDMINDP) developed through using ESTA (Expert System Shell for Text Animation) as a development platform and decision tree used for hierarchical classification. Knowledge about Mobile and Immobile plant nutrients deficiency, its symptoms are extracted from agriculture experts and existing literature, then is converted into a decision tree, and then developed an Expert System for consultation. Farmers, Agricultural experts and Agriculture teachers, evaluated the proposed system and who were happy and satisfied with its performance and ease of use.*

Keywords: Diagnosing, Diagnosing Mobile and Immobile Nutrient Deficiency of Plants, Expert System, ESDMINDP, Decision Tree

1. INTRODUCTION

In Pakistan, population of rural area was reported 63.09% in 2019 [1]. Agriculture is the main sector of economy of the nation. Most of the population living in the rural areas of Pakistan have agriculture as the only source of income in these areas. But unfortunately, productivity and quality of plants are still quite low due to many reasons and plant nutrient deficiency are the important reason of low productivity and quality of plants especially in rural areas due to absence of nutritional information and agricultural expert assistance. Most of the farmers mostly relies on the agriculture experts' assistance but proportion of agriculture experts to farmers' ratio is very low and most of the experts cannot easily diagnose this deficiency. As a result, the population of rural area are always under the food security threat.

To overcome this problem there is a need of the day to implement Expert system in rural areas for diagnosis of plant nutrient deficiency. It will increase yield and quality production to reducing nutrient deficiency through timely identifying the symptoms.

1.1 NUTRIENTS' DEFICIENCY IN PLANTS

Nutrient deficiencies are the lack of the basic mineral nutrients in a plant. These deficiencies obvious themselves as stunted plant growth, staining, and shriveling leaves. While plants experiencing nutrient deficiencies are at risk, the procedure can be turned around by supplementing the plants with missing elements [2].

Fig. 1: The Figure shows Nutrients Deficiency [3]

1.2 MOBILE NUTRIENTS' DEFICIENCY IN PLANTS

Mobile nutrient deficiencies happen first in more established growth, at that point moves to new growth. This implies the deficiency will initially show symptoms in the pieces of the

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plant that have already developed or grown, like the first true leaves or the stem of the plant.

Mobile nutrients insufficiency symptoms in plants like; Phosphorus, Magnesium, Nitrogen and Potassium that are first communicated in older leaves. Molybdenum deficiency symptoms in plants initially show up between the old and new leaves [2]. Fig. 2 depicts the Phosphorus (P) deficiency in plant.

Fig. 2: Phosphorus (P) Deficiency [4]

1.3 IMMOBILE NUTRIENTS' DEFICIENCY IN PLANTS

Immobile nutrient deficiencies happen in the more youthful period of plant growth. This implies the deficiency will initially show symptoms in the pieces of the plant at recently developing or growing. Immobile nutrients deficiency symptoms in plants like; Iron, Copper, Zinc, Manganese, Chlorine, Boron, Nickel, Sulfur and Calcium. The deficiency symptoms first appear in the more youthful phase of leaves [2]. Fig. 3 depicts the Iron (Fe) deficiency in plant.

Fig. 3: Iron (Fe) Deficiency in Plants [5]

2. EXPERT SYSTEM IN AGRICULTURE

Agriculture production has evolved into an overwhelming business that requiring the collection and integration of information and data from numerous different sources. To stay competitive, the advanced farmers regularly depends on agricultural specialist and guides to give information for decision-making. Unfortunately, agricultural specialists' assistance generally not accessible when the farmers are in necessities of it. To lighten this issue, Expert systems were recognized as an amazing tool with broad potential in agriculture production. [6].

One of the key advantage and upside of utilizing Expert System is it have the capability to decrease the data or information that human users need to process, increase output and reduce personnel costs. Another advantage of Expert System is it performance, it perform tasks more consistently and reliably than human experts can do. Some diagnosing Expert Systems rely upon the capacity and ability of an end user to understand abnormal symptoms of the plant and to convey these symptoms through a textual dialogue. Depending upon the user's degree of comprehension of the abnormal observations, the Expert system can arrive at the correct diagnosis, if the end user interprets the abnormal observations in an incorrect manner and picks a wrong textual answer to a presented question, at that point the Expert System will arrive at wrong conclusion [6].

3. EXPERT SYSTEM

Expert System is a special piece of software or a computer program, which holds the expert knowledge about a specific problem domain, frequently in the form of IF – THEN rules, which is able to resolve the problems at a level equivalent to or greater than human expert [6].

3.1 COMPONENTS OF EXPERT SYSTEM

Components of Expert System are being shown in Fig. 4 as below [6].

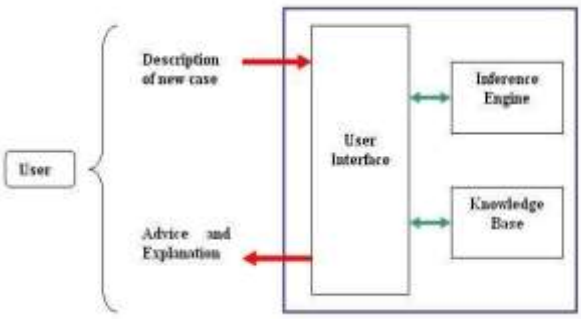

Fig. 4: Expert System Components

There are three major components of an Expert System.

- **Knowledge Base:**
  Knowledge base is the most important component of Expert system it defines all the knowledge about the particular problem domain. It is the collection of facts and rules.
- **Inference Engine:**
  The inference engine is the component of the system that selects which rules and facts to apply when trying to solve the user's query.

- **User Interface:**
  The user interface is the component of the system; User interface takes the user's query in a readable form, permits it to the inference engine, and then displays the results to the user.

4. LITERATURE REVIEW

Many Expert Systems was developed to diagnose the problem of nutrients deficiency [7-11]. However, these Expert Systems diagnose deficiency for specific crop or specific fruit plant; there is no specialized Expert System for diagnosing mobile and immobile nutrient deficiency for all kind of plants available free. The proposed Expert System ESDMINDP diagnoses the mobile and immobile deficiency for all kind of plants and was developed specifically to help poor farming community of rural areas to timely diagnose plant nutrient deficiency.

5. MATERIAL AND METHODS

In order to get the objective of this research study, the methodology of design science research was used. Design science research methodology is the most adopted and recommended methodology to find the solution of identified problems. For the selection of domain experts, the purposive sampling technique was used. The selection of domain experts for this research study based on the expertise level. The model of Expert System was developed by using knowledge acquisition process. All relevant and acquired knowledge was gathered from agriculture experts, nutrient deficiency manuals, research papers, books and articles.

5.1 KNOWLEDGE REPRESENTATION

All the Knowledge about Mobile and Immobile plant nutrient deficiency, and its symptoms are extracted from agriculture experts and existing literature, then is represented into a decision tree, and then developed an Expert System for consultation using IF…THEN rules.

5.2 DECISION TREE FOR MOBILE NUTRIENT DEFICIENCY OF PLANTS

Some details of the Decision Tree diagram for Mobile Nutrient deficiency of plants [12] being shown in Fig. 5 is given as under:

- **A:** Effects mostly generalized; plants dark or light green.
- **B:** Effects mostly localized; chlorosis with or without spotting.
- **C:** Plants dark green, often developing purple or red color.
- **D:** Chlorosis with interveinal chlorosis; leaves sometimes red or with dead spots.
- **E:** Plants light green with leaves light green or yellow; no necrotic spotting.
- **F:** No interveinal chlorosis; chlorotic areas with a burning of leaf margins; spotting sometimes along leaf margins.
- **G:** Plants light green; necrotic spotting on leaves; pale leaves sometimes scorched, cupped or rolled.
- **H:** No interveinal chlorosis; distinct chlorotic and nectrotic lesions (spotting) with abrupt boundary between dead and live tissue.

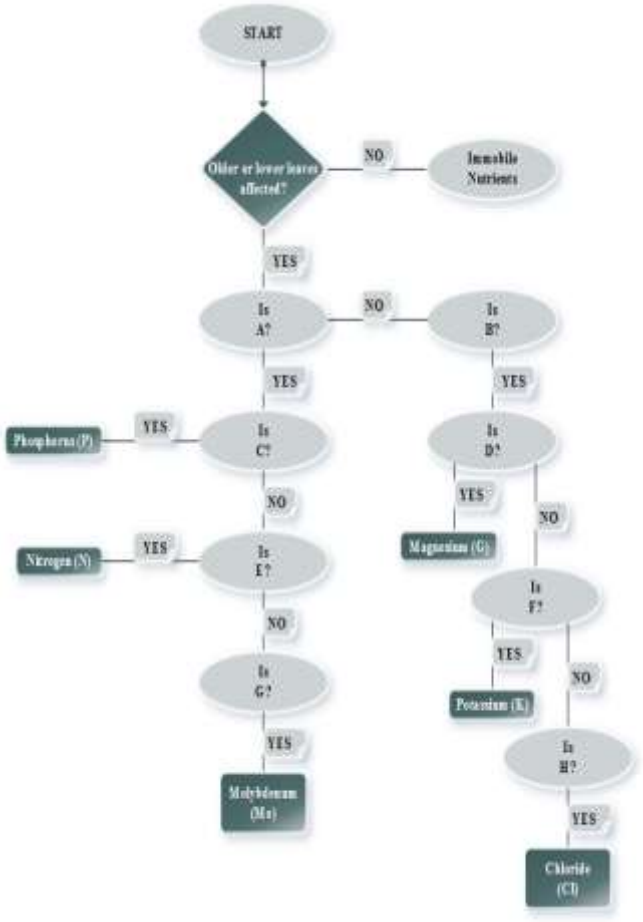

Fig. 5: Decision Tree of Mobile Nutrient Deficiency of Plants

5.3 DECISION TREE FOR IMMOBILE NUTRIENT DEFICIENCY OF PLANTS

A short detail of the Decision Tree diagram for Immobile Nutrient deficiency of plants [12] being shown through Fig. 6 as below:

- **A:** Growing point (terminal bud) dies.
- **B:** Growing point typically remains alive.
- **C:** Young leaves of terminal bud become light green at bases; leaves become twisted and brittle and die back at growing point; chlorosis of young leaves.
- **D:** Chlorosis without interveinal chlorosis.

- **E:** Young leaves with interveinal chlorosis.
- **F:** Young leaves light green; typically, no chlorotic spotting or striping.
- **G:** Sharp distinction between veins and chlorotic areas.
- **H:** Young leaves of terminal bud typically hooked at first, finally turning brown and dying back.
- **I:** Chlorosis of young leaves; tips appear withered and will eventually die.
- **J:** No sharp distinction between veins and chlorotic areas; spotty appearance.
- **K:** Middle leaves with interveinal chlorosis; stunted growth.

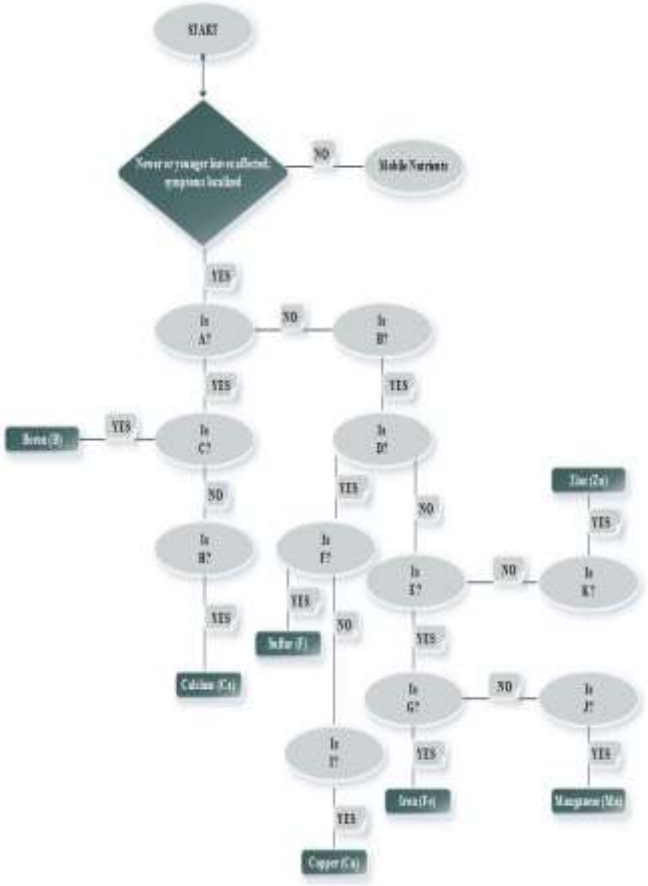

Fig. 6: Decision Tree of Immobile Nutrient Deficiency of Plants

5.4 PROPOSED EXPERT SYSTEM ARCHITECTURE

As shown in the Fig. 7 the knowledge engineer acquires knowledge from domain expertise along with searching the required knowledge in different repositories like; books, journal articles, technical reports, case histories and agricultural manuals. The acquired knowledge is represented in the form of IF -THEN or Production rules to be coded in the Knowledge Base using ESTA as a development platform by Knowledge Engineer.

Fig 7 shows the architecture of the proposed ruled-based Expert System named as ESDMINDP. The knowledge base holds essential information about the problem domain, which is the symptoms of the mobile, immobile nutrient deficiency of plants and stored as facts and rules I the Knowledge Base.

The Inference Engine then provides a mechanism to control the overall processing of the Expert System according to the instructions being provided by the Knowledge Engineer. This part of the Expert System derives new knowledge from results achieved through the fact and rules of the knowledge base. The inference engine is also used to allow the generation of new conclusions from existing knowledge in the knowledge base.

The Expert System user can interact with the Expert System through User Interface. User can provide input information to the Expert System and Expert System provides the consultation in the form of results along with giving answers to the questions, like; EXPLAIN and WHY.

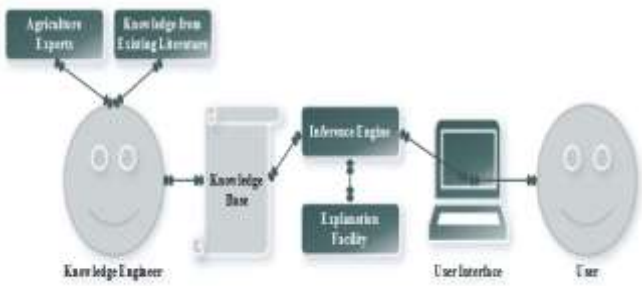

Fig. 7: Proposed Expert System Architecture

5.5 HOW ESDMINDP EXPERT SYSTEM WORKS?

The main elements of the ESTA are Titles, Sections, and Parameters. Title are used for different titles in the Expert System. Sections are used to store facts regarding problem main using forward chaining and Parameters uses variables with backward-chaining process for reasoning. The user interacts with the system by responding for the series of question as “yes” or “No” or “Unknown” till the knowledge base system decided to take action. The ESDMINDP open session of conversation by clicking on “Begin Consultation” in the Expert System. Fig 8 represents title of the Expert System.

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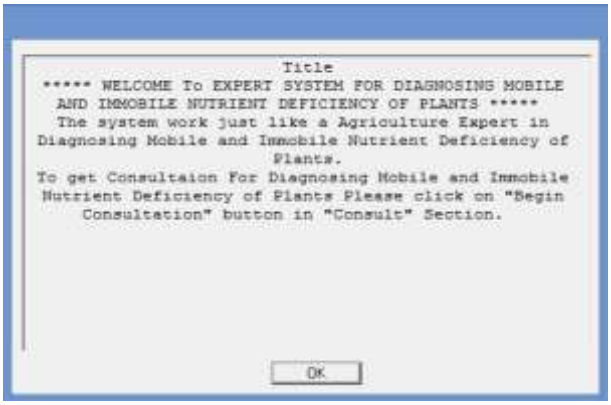

Fig. 8: Title of the Proposed ESDMINDP

5.6 PROPOSED EXPERT SYSTEM CONSULTATION

In Fig. 9: shows the beginning of Consultation for diagnosing Mobile Nutrient Phosphorus (P) deficiency of plant. It will ask questions from the users to diagnose deficiency just like an agriculture expert.

Fig. 9: Beginning of Consultation for diagnosing Mobile Nutrient Phosphorus (P) deficiency

In Fig. 10: It describes the symptoms of Phosphorus (P) deficiency of plant.

Fig. 10: Symptoms of Phosphorus (P) Deficiency

In Fig. 11: It also describes the symptoms of Phosphorus (P) deficiency of plant and ask question from user to diagnose deficiency.

Fig. 11: Symptoms of Phosphorus (P) Deficiency

In Fig. 12 shows, the proposed system finally diagnosed nutrient deficiency of plant. The deficiency is Mobile Nutrient Phosphorus (P) deficiency in plant.

Fig. 12: Results of diagnosed Phosphorus (P) Deficiency of Plant

Similarly, the proposed Expert system ESDMINDP diagnose all Mobile and immobile deficiencies of plants.

6. ESDMINDP Expert System Evaluation

At an initial evaluation stage, Agriculture experts, Agriculture teachers tested and evaluated the proposed Expert system who were satisfied with its performance and ease of use.
They were asked to evaluate the following features of the proposed Expert System:

- Is the Expert system easy to use?
- Is the system more efficient in time?
- How does accurately a system reach a decision in diagnosing plant nutrient deficiency?

7. CONCLUSION AND FUTURE WORK

In rural areas of Pakistan, the availability of agriculture experts is very low compare to the total number of farmers that are trained in the field of agriculture. Different factors are identified such as shortage of skilled work force in the domain area, the skill level of the experts, shortage of budget and the complexity of identifying nutrients deficiency. To address the above-mentioned problems in this research paper, the proposed expert system named as ESDMINDP was introduced to support farmers of the rural areas to timely diagnose the mobile and immobile nutrient deficiency of plants. The poor farmers of rural areas get faster and more accurately diagnosis of plant nutrient deficiency. This expert system does not need extensive training to use; it is easy to use and update.

In this study the actual plants images cannot directly manipulate to the modeled prototype. Therefore, it will be better for researchers to develop an image based diagnostic expert system that might predict the type of nutrients deficiency disorder based on the responded symptoms from the actual plant.

The approach, which I adopted in this research study to solve the problem, can be used to develop expert systems in other agricultural crops to reduce dependence on human experts to save time, effort and money.

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