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Knowledge Base System for Maize CropNutrients Deficiency Identification

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Abstract:*The Cereal crop maize is the common cultivated crop in Ethiopia low lands. Even though the crop is the livelihood of most of the farmers and needed to increase food production in grain, the desired agricultural productivity output in agricultural sector is very low. This is due to lack of technological and nutritional information, most of Experts cannot easily identify nutritional deficiency disorder and weak exchange of information between agricultural experts and farmers. Identifying those nutrient deficiency disorders at early stage enable to increase crop yields, fruit production and minimize frequent diseases occurrence because of nutrients deficiency. Thus, there is a need of developing knowledge base system to identify the deficiency of the maize crop and helps unexperienced field expertise in the agricultural sectors. Therefore, this study was conducted by considering the aforementioned challenges and to help mainly domain experts during identification of maize nutrient deficiency. The study has been attempted using the knowledge base system architecture and investigated different sources of knowledge to acquire from the domain through interview of experts, observation and document analysis. This source of data gathering methods were used to identify the nutrient deficiency disorder for maize. The acquired knowledge was discussed with domain experts and modeled using decision tree structure. Then the modeled knowledge is represented using rule base approach to use by prolog programming language. After this the study of the proposed model was built and the proposed model performance were tested and evaluated using system performance and user acceptance techniques. Finally, the proposed model was produced a system performance of 80% accuracy. The user acceptance testing was performed with the domain experts and the system on average scored 81.6% based on user acceptance evaluation criteria. The system has an overall accuracy of 80.8% according to the system performance and user acceptance testing.*

Keywords:*Decision Tree, Knowledge Base, NutrientDeficiency*

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I. Introduction

In Ethiopia, most of the population lives in rural area which needs to increase food production in grain [1]. Even though there are sufficient agricultural resources in the rural area, the farmers had not got sufficient agricultural productivity outputs in terms of quality and quantity. This is due to lack of technological and adequate nutritional information, most of the farmers needed advising from domain expertise, the proportion of agricultural experts to farmer ratio is low and also most of Experts cannot easily identify nutritional deficiency and weak exchange of information between experts and farmer [2]. This results to low agricultural production and poverty. Because of the above-mentioned problems most of low-income smallholders' farmers depend heavily on soil nutrients [3]. For the betterment of producing good crop yield and fruity product with quality and quantity, crops needed macro nutrient and micronutrient in the soil. If the needed nutrients were not in enough amount, it will have a consequence on growth and health i.e. deficiency disorder problems will occur [4]. This crop nutrient deficiency disorder symptoms affects the metabolism process of the crops and also the nutrient disorder not easily identified by expertise to took appropriate action on the crops.

To overcome this agriculture transformation is needed that relies on agricultural specialists and advisors who provide information to farmers based on their technological literacy and a kind of knowledge base system that aims to capture the knowledge of human experts and document analysis to support decision making process to expertise is needed [5].

Developing such kinds of model give domain experts what to decide immediately after the deficiency disorders occurred, to increase the skill of the development agents and the type of nutrient deficiency disorder identification, implementation of the system will increase yield and quality production by reducing nutrient disorder through identifying the symptoms early and also a possibility of replicating to areas with similar topography, soil type, humidity and temperature

II. Research Methodology

In order to realize the objectives of this research, the design science research methodology was used. Since design science research methodology is recommended to find a solutionfor those identified problem. Purposive sampling technique was used to select domain experts for knowledge acquisition [6]. The selection criteria of domain experts for the study was based on the profession and expertiselevel. The knowledge acquisition process was used to design the knowledge base system model. The acquired knowledge was collected from agricultural experts, the nutrient disorder manuals, research papers, books and articles.

III. Data Analysis and Interpretation

To analyze and interpret the knowledge acquired fromdifferent data source, descriptiveresearch approach was used.The result shows that nutrient disorders identification is a great challenge.Because most of the crops have responded common symptoms for nutrient deficiency.Based on the data analysis and interpretation result, the researchers assured that knowledge base system is important to identify the nutrients deficiency disorder of the maize crop in order to support agricultural expertise for decision making process.

IV. Knowledge Representation

During the knowledge modeling, the possible presence of nutrient deficiency disorder for common nutrient elements for maize was identified [7]. The model was represented using a better performer decision tree structure using rule base knowledge representation techniques in the form of IF …Then Rules [8]. The decision tree structure was figured out by considering the number of nutrients deficiency symptoms that shared in common in each decision tree structure, the acquired level of the nutrient element in the crop and the mobility effect of the nutrient deficiency symptoms. To represent the name of the symptoms in each of the decision tree for simplicity purposethe researchers was used letters.

4.1 Decision Tree of Mobile Nutrient for Maize Crop

A: Spindly stalk, weak stalk or purplish stalk, Stunted growth and retarded matured
B: Short internode and excessive lodging, leaf edges ragged
C: Small ear with fail to fill at tip
D: Yellowing leaf tip
E: Shallow root
F: White or yellowish streaking between leaf vein mainly on lower leaves
G: Curling of leaf or ear
H: Iron accumulation in joints

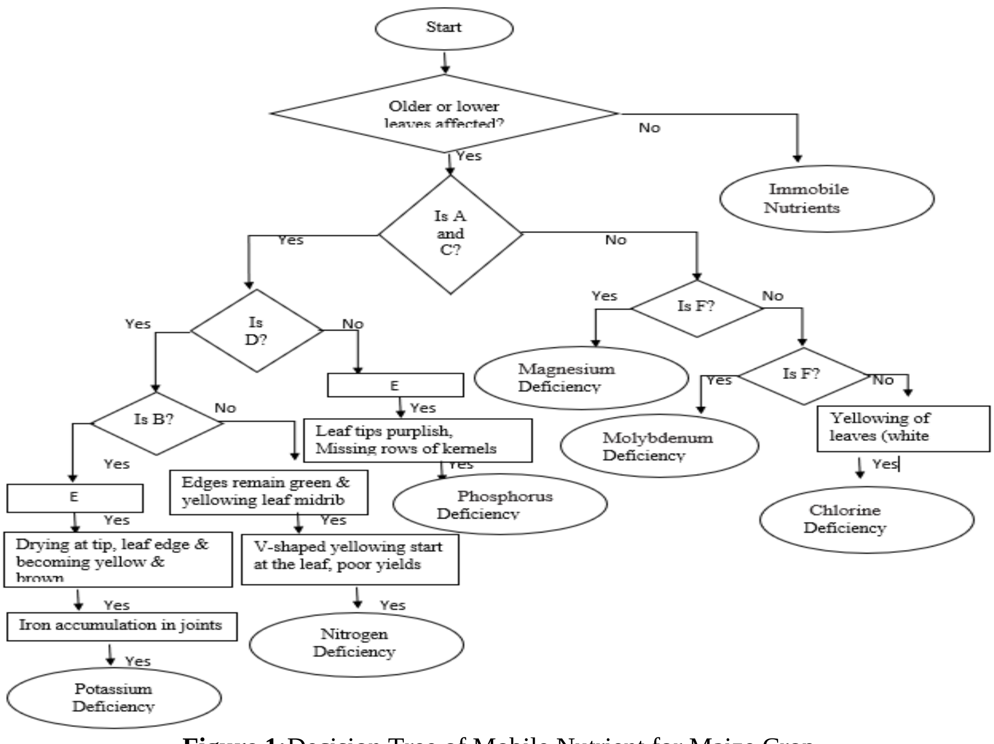

Figure 1: Decision Tree of Mobile Nutrient for Maize Crop

4.2 Decision Tree of Immobile Nutrient for Maize Crop

A: Chlorosis or yellowing of young leaves
B: Leaf tip shows light green (whitish spot) with curved back
C: Interveinal chlorosis in newer leaves
D: Delay maturity and stunting growth
E: Interveinal areas become pale green to white
F: Yellow to white interveinal chlorosis on older leaves first
G: leaves may become reddish-purple
H: Short internode and stunted growth
I: Yellow or white spots on leaves with brown streaks
J: Brown leaf streak
K: The veins, midrib and leaf margin remain green
L: Broad white to yellow bands on each side of midrib
M: Narrow yellow or white stripes between veins of upper leaves

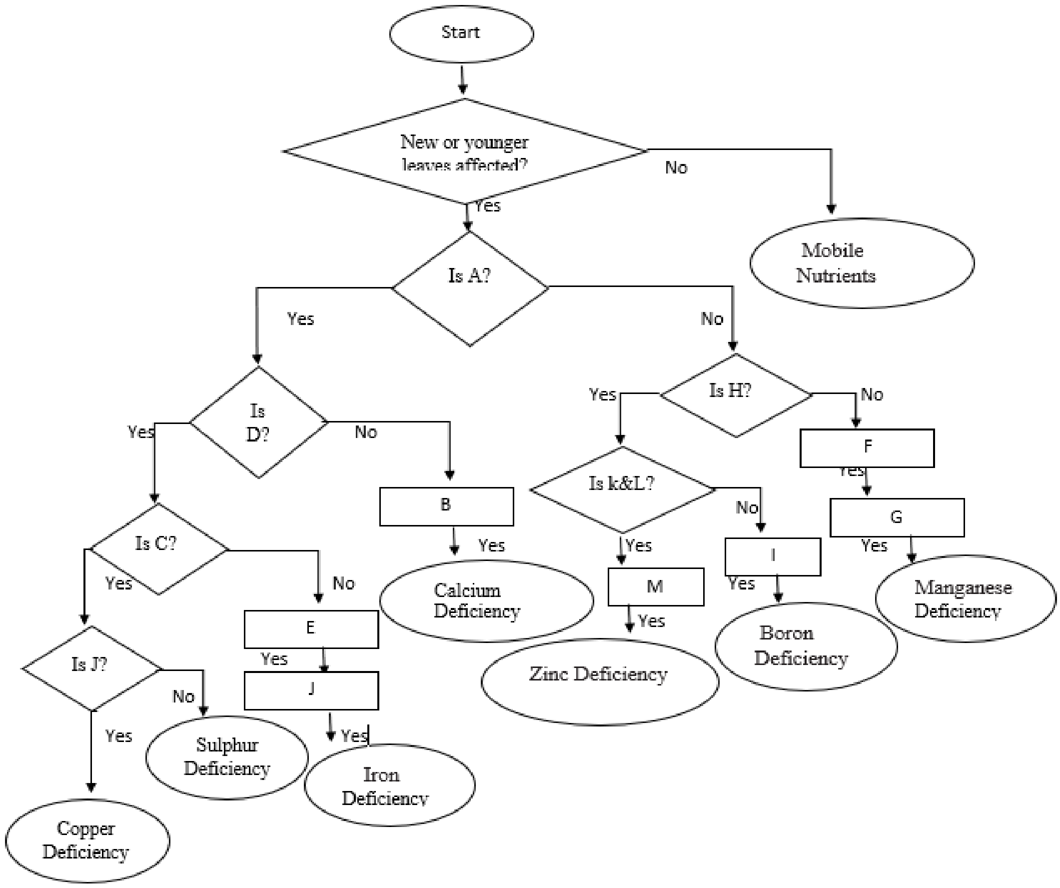

Figure 2: Decision Tree of Immobile Nutrient for Maize Crop

V. Proposed knowledge Base System Architecture

As shown in the figure3 the knowledge engineer acquired knowledge from domain expertise and accessing different documents from different sources like books, journal articles, technical reports, case histories and agricultural manuals. The acquired knowledge is represented in the form of If …Then rules to be coded in the knowledge base using prolog programming language by knowledge engineer. The knowledge base contains essential information about the problem domain which is the symptoms of the crop and was represented as facts and rules. The inference engine then provides a mechanism to derive new knowledge from the knowledge base and the information provided by the user based on the rules incorporated in the knowledge base. The inference engine is also used to allow the generation of new conclusions from existing knowledge in the knowledge base. When the usersinteract to the knowledge base system the user interface provides communication with end users and the explanation modules illustrates to the user how and why a particular solution was generated.

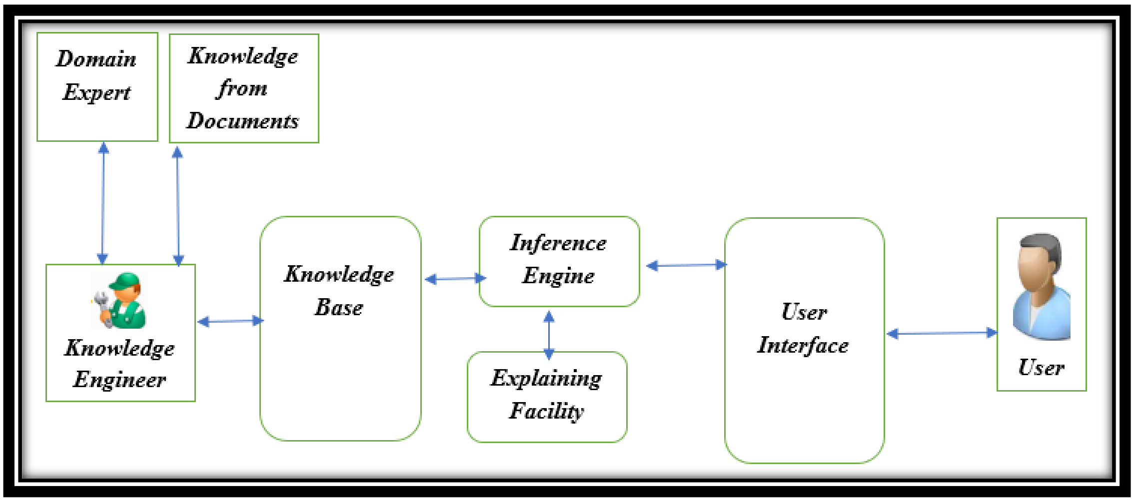

Figure 3: Proposed Knowledge base System Architecture

VI. Proposed System User Interface

The user interface enables user to communicate with knowledge base system. Since a set of facts and rules is found in the inference engine which is programed using prolog programming language, the inference engine provides information to the user through the user interface to produce result to the user through the user interface. The user interacts with the system by responding for the series of question as "yes" or "no" till the knowledge base system decided for conclusion. To display the main menu of the user interface, the user should open the SWI-Prolog and start by typing "go" followed by "."

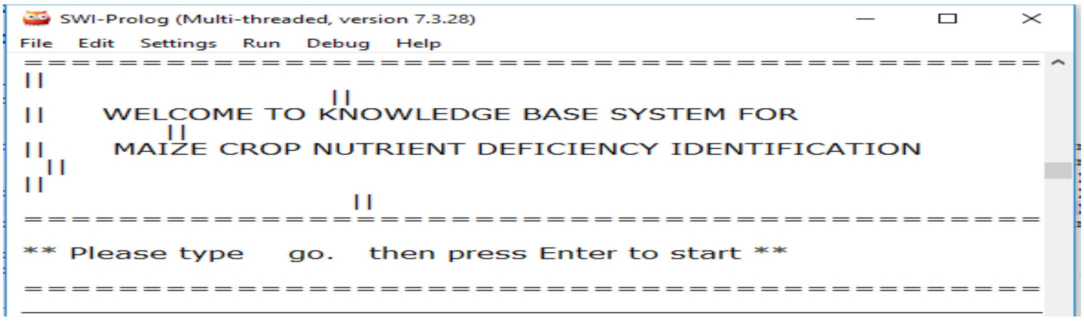

Figure 4: Main Menu for the proposed System User Interface

```
Do you want to diagnosis?(press y for yes and n for no followed by .
|:y.
Older or lower leaves affected
|:y.
Spindly stalk, weak stalk or purplish stalk, Stunted growth and retarded matured
|:y.
Small ear with fail to fill at tip
|:y.
Yellowing leaf tip
|:y.
Short internode and excessive lodging, leaf edges ragged
|:n.
Egdes remain green and yellowing leaf midrib
|:y.
V-Shapped yellowing start at the leaf,poor yield
|:y.
The result shows that the maize has Nitrogen Deficency
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Figure 5: Sample window with identified nutrient deficiency of maize crop

VII. Evaluation of the System

Testing is help us to assure the correctness of the System with domain expert prediction as well as user acceptance of the system requirement. To measure the performance of the system, Predictive validation method was used to assure the performance of the system against with human expertise decision. For evaluating the system performance, the model was tested 10 times with different test cases provided to the system, and the outputs were compared with the domain experts. Furthermore, to evaluate the proposed system during interaction of the user, the user acceptance techniques were carried out to check whether or not the potential user requirements was fulfilled. For these purposes, questionnaires were prepared by considering the system usability scale [9]. Table1 shows the confusion of the system compare to the expertise judgement for the selected test rules.

Table 1: Confusion matrix of the system performance

	System prototype outputs		
Domain expert Judgments		Correct	Incorrect
	Correct	5	1
	Incorrect	1	3

The column of the table 1 shows the system prototype evaluation output and the row of the table shows the domain experts' judgments result. From the table the first column shows that out of 6 test rules, the system correctly classified 5 test rules and incorrectly classified 1 test rules of nutrient deficiency disorder. Additionally, in the second column, the system classified 3 test cases as incorrect (False positive) and 1 test case is incorrectly classified. From this, the proposed system correctly classified 80% prediction but incorrectly classified 20%

To evaluate the proposed system during interaction of the user to ensure how well the system is acceptable and usable, user acceptance testing by expertise was investigated and the weight values were assigned for each closed ended question to made the evaluators response convenient to use.

Table 2: user acceptance evaluation result

No	Evaluation criteria	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Excellent (5)	Average
1	Efficiency of the System in time			1	1	3	4.4
2	Convenient to use the system frequently			2	2	1	3.8
3	Simplicity of the System		1	1	2	1	3.6
4	Easiness of system to use			1	3	1	4
5	Does not need the support of a technical person to be able to use the system			1	1	3	4.4
6	Adequate knowledge is integrated to identify nutrient deficiency.	1		1	2	1	3.4
7	Significance of the System in the domain area			1	1	3	4.4
8	The system produced consistence result			1	1	3	4.4
9	Users learn this system very quickly.				2	3	4.6
10	The confident for using the system		1		3	1	3.8
		Average					4.08

7.1 Discussion

Even though, the system performance was calculated as 80% and also the average evaluation result by the domain experts were 81.6% from user acceptance testing which resulted with an overall average performance of system 80.8, the system has some challenges that reduce its performance better.

According to the evaluation, the challenges of the proposed model was, the first one is some of the nutrient elements show similar symptoms because of the behavior of the nutrient element response for crop type and because of other environmental factors. The second was that insufficient parameters used to identify nutrient deficiency disorder for the maize crop, which again leads to reduction in the system performance. The third one was thatinteractivity nature of prolog programming language user interface design is used a command line interface to interact with it. This result implies that the simplicity and confidence parameters of the evaluation criteria leads to reduce the system performance.

VIII. Conclusion

In developing countries like Ethiopia, the availability of agriculture experts is low compare to the total number of farmers which practiced agriculture. Different factors are identified such as shortage of skilled manpower in the domain, the skill level of the experts, the distribution of experts per woreda, shortage of budget and the complexity of identifying nutrients deficiency.To address the aforementioned problems and the like, knowledge base system was designed which assists agriculture experts and computer users to solve problems effectively and efficiently. This leads to an attempt to identify nutrients deficiency disorder for maize crop to support experts.

After performing the knowledge base design process, the model was developed and produced a system performance of 80% accuracy and an average scored of 81.6% based on user acceptance evaluation which resulted with overall accuracy 80.8%.Generally, the study shows good results to identify the nutrients deficiency disorder of maize crop which achieved the objectives of the study. But further exploration and study has to be done to refine and produce a better model which can be used in nutrients deficiency disorder identification of maize crop.

Even though this study provides good result to achieve its intended objectives by providing advice mainly for agricultural expertise, the following recommendations has been forwarded for the betterment of the system performance and to bring it to the real-world application system.

In this study, some of nutrients show similar nutrient deficiency symptoms because of many environmental situations which is difficult to identify nutrient deficiency disorder. However, if researchers consider other mechanisms like integrating soil test result and crop tissue testing may enhance the performance of the proposed model to identify nutrient deficiency disorder.

In addition to this, in the study the actual crops image is not directly interacting to the modeled prototype. Therefore, if researchers integrating an image based diagnostic expert system that predicts the type of nutrients deficiency disorder based on the respond symptoms from the actual crop.

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