An Expert System for Detection of Nutrient Deficiency Diseases of rice plant (With special reference to BTAD, Assam).

PRASENJIT NATH, MCA, UGC-NET.
Department of of B.Voc(IT),
B.N.College, Dhubri,Assam
Email: prasenath@gmail.com

ABSTRACT:

In Recent time Expert systems have been an area of research for computer scientist as well as agricultural scientists for application in a variety of information development and transfer situations. They can be easily used in the field of agriculture. Expert Systems can be designed to simulate one or more of the ways that an agriculture expert uses his or her knowledge and experience in making any diagnosis and forward the necessary recommendation regarding use of fertilizer, pesticide, etc. For High crop yields micro-nutrients plays an important role around the world. Deficiency of micro-nutrients like Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mg), Boron (B), Molybdenum (Mo) and Sulphar (S) has been notice in the soils of India. In this paper researcher like to discuss about Expert system and the basic structure of an Expert System as well as how one can develop an Expert system for detecting nutrients Deficiency diseases using Fuzzy Logic.

Key Word: Expert System (ES), Fuzzy Logic, Nutrient Deficiency disease, Bodo Territorial Area Districts (BTAD).

(I) INTRODUCTION:

Rice is the major food crop of Bodo Territorial Area Districts (BTAD) of Assam, mainly in terms of production and consumer preferences. India is the second largest producer as well as consumer of rice in the world after china. In BTAD, cultivation fields are available, but the farmers do not have the proper knowledge of soil preparation, fertilizer management, etc. Proper soil testing facility is not available in the rural areas of BTAD. Rice plant often shows nutrient deficiency symptoms diseases in the four districts of BTAD area. Very few studies have been done on the relationship between available nutrients in the soil and various rice plant diseases in low land area like BTAD of Assam. The recent development in computer science and Technology can help to upgrade the whole agriculture fields so that to get high yield.

In several countries for farming activities they start applying advanced technologies like Expert Systems. The reason behind the use of ES is that, they can be easily used in the field of agriculture. Farmer can get expert advice without having to meet with the Agriculture Experts who would take more time and cost. Some ES advice many solutions such as diagnosis and identification of plant diseases and suggestion for the way to the right treatment based on symptoms of diseases. But the symptoms of disease vary according to the different geographical conditions. So there is always a need to develop a new expert system for a different geographical region or states, even for different countries.

The main concern of the proposed study is to design and development of an Expert System which give suggestion about nutrient deficiency and fertilizer management based on soil testing data. This Expert System would analyses different rice plant disease and find out the proper nutrient disorder as well as generate information regarding the type and amount of fertilizer needs as a remedy of the diseases. This proposed Expert System would assist farmer to understand soil nutrient disorder so that they can increase the rice production by taking strong decision related to utilization of fertilizer.

(II) Origin of Research Problem:

In India, Agriculture is the backbone of the county's economy and it is primary sector of the county. India is one of the world's largest producers of white rice and brown rice, accounting for 20% of all world rice production. Rice is Indian's pre-eminent crop, and is the staple food of the people of the eastern and southern parts of the country. Farmers needed expert knowledge to take decision during soil preparation, seed selection, fertilizer management, etc. to increase their rice production. But in the rural areas like BTAD, agricultural experts are not always available when farmer needed. In this regard Expert System would be a powerful tool with extensive potential in Agriculture, mainly for rural areas like BTAD. Expert Systems are cheaper compared to human experts in the long-term scenario. However, Expert Systems are relatively costly to design and develop but easy and can operate at very low cost. An Expert System can also automate many tasks that is not possible by a human expert to control effectively.

(III) Review of Literature:

Application of Expert System in the field of Agriculture is not new. Numerous researches are being carried out. In Agricultural domain, applications of Expert System are mainly found in the area of diseases diagnosis and pest controls.

YANG and OKRENT (1991) said that the most successful application of Artificial Intelligence in decision making so far in the development of Decision Support System, particularly Expert System. Expert Systems are computer program that can arriving at particular decision like human experts on of his particular expert domain.

Pinaki Chakraborti, Dr. Dilip Kumar Chakraborti (2008)[9] explain the success of Expert System for management of Malformation disease of Mango.

Harvinder S. Saini, Raj Kumar and A.N. Sharma92002),discussed about a web base fuzzy expert system for integrated pest management in Soybean in International Journal of Information technology(Vol. 8, No. 2,2002)[7].

G.N.R. Prasad, Dr. A. Vinaya Babu(2006)[9], are discussed about various agricultural expert systems. According to them, the modern farmer often approach to agricultural experts and advisor for decision making information. But expert help or assistance from agricultural specialist is not available all the time when farmer needs it. In this regard expert system help were identified as powerful tool with extension potential in agriculture. They also discussed about some more expert systems.

A.J. Castro and Garcia – Torres (1995) [10], explains an expert system SEMAGI. An interactive microcomputer program named SEMAGI has been developed for sunflower to evaluate the potential yield reduction from multispecies weed infestations and from the parasitic weed broomrape and to determine appropriate selection of herbicide. It combines relational database on herbicides, weed and their interactions. SEMAGI provides an economic study of any herbicide treatment selected or introduced by the user, based on herbicide treatment cost, expected production increase from the weed control treatment and sunflower selling price.

(V) METHODOLOGY:

In order to develop an Expert System in agriculture, knowledge has to be extracted from agricultural expert or domain expert. This knowledge is then converted into a computer program. While developing it, engineer must perform task of extracting the knowledge from the domain expert, so it can produce knowledge base.

Sampling sites will be selected randomly from various rice fields of kokrajhar, chirang, Baksa and Udalguri districts of BTAD. Soil samples will also collected from various rice fields randomly for testing nutrient status in soil.

As for the primary data, published and unpublished books, journals, articles will be consider by the researcher. Researcher would also consider on-line journals and articles about expert system as well as agricultural information regarding soil nutrient and rice plant diseases as a source of primary data.

As for the secondary data, the researcher would select about 50 big rice fields and about 200 farmers in random basis from various rice fields of different districts of BTAD area.

Fuzzy Expert system:

The most important application of fuzzy logic is in uncertain issues. Fuzzy logic is deals with the problems that have dynamic problem behaviour. First step of fuzzy expert system designing is determination of input and output variables. After that the researcher would design membership function of all variables. These membership functions would determine the membership of objects of fuzzy sets. It uses a collection of fuzzy membership functions and rules to facilitate reasoning. Since it uses rules, it falls into the category of rule-based expert systems. Rules can easily demonstrate human thinking as they are easily formulated. Fuzzy expert systems are used to provide non experts with some expert's skills. The method to be used for data collection from rice fields about soil nutrients and various rice plant disorders should have high degree of accuracy. To balance the soil nutrient status, it is very important that the amount of fertilizer to be used in soil would be determined accurately.

According to [11] fuzzy expert systems are categorized into two types. First type is the fuzzy control systems. Which are accepts inputs as numbers. The input number is then translated into a linguistic term. In fuzzy control systems the application domain is defined. The second type is fuzzy reasoning. Which are the systems that attempt to emulate human thinking where the domain is not defined. Such systems deal with numbers and linguistic variables.

The group of rules in a fuzzy expert system is called knowledge base or rule base. Such rule has the form of **If** x is low and y is high then z=medium, where low is a fuzzy set defined on x, high is a fuzzy set defined on y and medium is a fuzzy set defined on z. The part of the rule that follows **If** is called the "*antecedent*" and the part that follows **then** is called the "*consequent*". The antecedent consists of tests need to be made on the data. The consequent consists of actions to be made if the data passed the test [11][30].

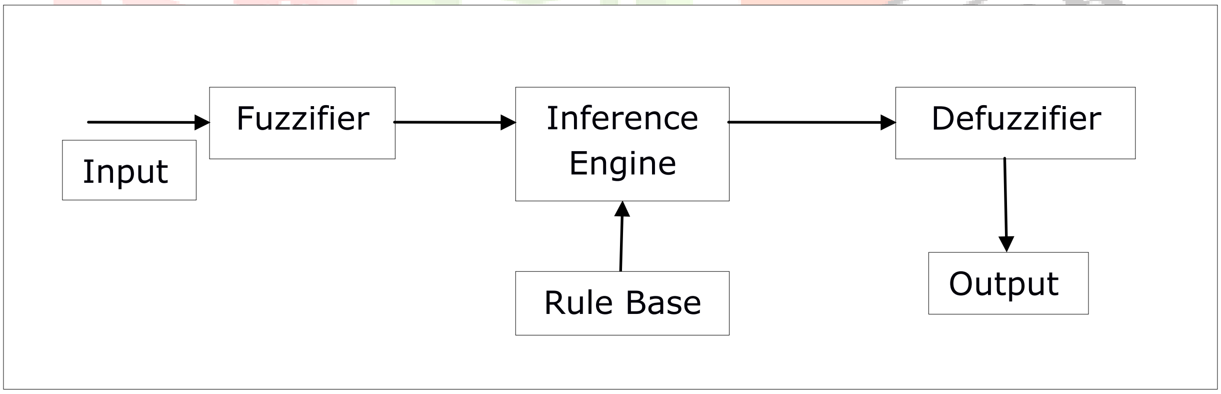

Figure 1: A fuzzy expert system architecture

Basically a fuzzy logic system consists of the following five steps:

Fuzzification: Converting the crisp inputs to membership functions which comply with intuitive perception of system status.

Rules Processing: Calculating the response from system status inputs according to the pre-defined rules matrix (control algorithm implementation).

Inference: Evaluating each case for all fuzzy rules

Composition: Combining information from rules

De-Fuzzification: Converting the result to crisp values.

Building Systems with the Fuzzy Logic Toolbox

Although it's possible to use the Fuzzy Logic Toolbox by working strictly from the command line, it is easier to build the system using graphical user interface. There are five primary GUI tools for building, editing, and observing fuzzy inference systems in the Fuzzy Logic Toolbox: the Fuzzy Inference System or FIS Editor, the Membership Function Editor, the Rule Editor, the Rule Viewer, and the Surface Viewer. The FIS Editor handles the high level issues for the system: for the number of input and output variables and also their names. The Membership Function Editor is used to define the shapes of all the membership functions associated with each variable. The Rule Editor is for editing the list of rules that defines the behavior of the system. The last two GUIs are used for looking at, as opposed to editing, the FIS. The Rule Viewer is a MATLAB-based display of the fuzzy inference diagram. Used as a diagnostic, it can show which rules are active, or how individual membership function shapes are influencing the results. Surface Viewer can display how one of the outputs depends on any one or two of the inputs- that is, it generates and plots an output surface map of the system.

The five principal GUI editors all exchange information, if appropriate. Any one of them can read and write both to the workspace and to the disk. For any fuzzy inference system, any or all of these five editors may be open. If more than one of these editors is open for a single system, the various GUI windows are aware of the existence of the others, and will, if necessary, update related windows.

To find the Nutrient deficiency (Nitrogen) disease of Rice plant:

The principal investigator developed the proposed expert system using the graphical user interface (GUI) tools provided by the Fuzzy Logic Toolbox. Although it's possible to use the Fuzzy Logic Toolbox by working strictly from the command line, in general it's much easier to build a system up graphically. There are five primary GUI tools for building, editing, and observing fuzzy inference systems in the Fuzzy Logic Toolbox: the Fuzzy Inference System or FIS Editor, the Membership Function Editor, the Rule Editor, the Rule Viewer, and the Surface Viewer. These different GUIs are all effectively siblings in that you can have any or all them open for any given system.

The FIS Editor handles the high level issues for the system The Membership Function Editor is used to define the shapes of all the membership functions associated with each variable. The Rule Editor is for editing the list of rules that defines the behavior of the system. The last two GUIs are used for looking at, as opposed to editing, the FIS. They are strictly read only tools. The Rule Viewer is a MATLAB-based display of the fuzzy inference diagram shown at the end of the last section. , or how individual membership function shapes are influencing the results. It's a very powerful window full of information. This tool can display how one of the outputs depends on any one or two of the inputs- that is, it generates and plots an output surface map for the system. Some of the GUI tools have the potential to influence the others. For example, if you add a rule, you can expect to see the output surface change.

Fuzzy nutrient deficiency diagnosis:

The proposed expert system uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data. The general structure of the proposed expert system can be summarized in the following steps, carried out in order:

(i) **Fuzzification:** the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise.

(ii) **Inference:** the truth value for the premise of each rule is computed, and applied to the conclusion part of each rule. This result in one fuzzy subset to be assigned to each output variable for each rule.

(iii) **Composition:** all of the fuzzy subset assigned to the output variable are combined together to form a single fuzzy subset for each output variable.

(iv) **Deffuzification:** is an optional step which is used when it is useful to convert the fuzzy output to a crisp number

The developed fuzzy expert system prototype would query the user for the relevant symptoms of rice plants. The strength of each single symptom is specified by a fuzzy value such as low, moderate, and high for those symptoms that cannot be measured quantitatively like Leave colour or Field colour.

The prototype proceeds through the above-mentioned inference process and provides a percent value for the certainty of presence for each one of the considered nutrient deficiency.

Fuzzy Knowledge Representation:

The experience of the expert system physician regarding the set of considered diseases D is captured in a set of fuzzy tables, each of which specifies the profile for nitrogen deficiency disease. The principal investigator consider three fuzzy sets Yes, May Be, and No as shown in figure 6.1 to represent the certainty of disease presence. Entries in the disease profile tables would be selected from these fuzzy sets.

After designing the Fuzzy inference system by using Mamdani inference method of MATLAB, the principal investigator use GUIDE of MATLAB for developing user interface from where user access the expert system for input the scale of various symptoms, like field colour, Leave colour, Plant colour, etc. The user interface is looking like as show in figure 6.2.

Fuzzy expert system works in the following manner:

a) **Fuzzification:** The inputs given by the user are fuzzified using the triangular function and fuzzy sets for plants health, leave colour, field colour, tellering etc.

b) **Inference engine:** The inference engine contains the knowledge base (KB) of the system. The knowledge base is created from the data gathered from domain expert, farmers, published literature, internet search, books, and agriculture consultant's annual reports. The inference engines also contain the rule based in which rules are constructed in consultation with domain experts.

c) **Defuzzification:** The defuzzification is done by the centroid method and the output is converted into crisp value.

The proposed Fuzzy based methodology is implemented in MATLAB 7.9.0(R20096) MATLAB (Matrix Laboratory) environment is one such facility which lends a high performance language for technical computing. Fuzzy inference is the process of formulating the mapping from a given inputs to an output using fuzzy logic. The mapping is used to provide a basis from which decisions can be made.

After selecting the membership functions, the rules are also generated using the Rule-Editor. Then the rules can be viewed using the Rule-Viewer. In Fuzzy Inference Systems, based on the knowledge provided by the Domain Experts (Agricultural Experts and Farmers), decisions are made and outputs are generated. While collection of this type of knowledge generates a fuzzy knowledge based system, which is basically collection of some fuzzy IF-THEN rules is generated by consulting various Domain Experts.

d) **Implementation:**

The proposed Fuzzy based methodology is implemented in MATLAB 7.9.0(R2009b) MATLAB (Matrix Laboratory) environment is one such facility which lends a high performance language for technical computing. Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping is used to provide a basis from which decisions can be made. Inputs are Crop health, Leave colour, Plant colour, Chlorotic at tip, Field colour and Tellering. The output is Nitrogen deficiency.

e) **Rule viewer:**

After selecting the membership functions, the rules are also generated using Rule-Editor. Then the rules can be viewed using the Rule-Viewer. In Fuzzy Inference Systems, based on the knowledge provided by the Domain Experts (Agriculture Experts), decisions are made and outputs are generated. While collection of this type of knowledge generates a fuzzy knowledge based system, which is basically collection of some fuzzy IF-THEN rules. In this proposed system, 51 such type of fuzzy IF-THEN rules is generated by consulting various Domain Experts (Agricultural Experts).

f) **Result Analysis:**

The output of this MRP is coming out to be more reliable and dependable as the principal investigator used the fuzzy approach to diagnose the nutrient deficiency disease in kokrajhar and chirang districts of BTAD area. Till date this is the single work done in this field was of " A new Intelligence-Based approach for computer-aided diagnosis of nutrient deficiency disease of rice plants" who had work upon the probabilistic model to predict the occurrence or the non-occurrence of nutrient deficiency disease of rice plant based on the symptoms generated.

g) **Conclusion:**

The result of the implementation suggests that an almost 100% accurate in predicting the type of nutrient deficiency (especially for Nitrogen). However it may not be the best result but it is sufficient to prove the working.

Fuzzy Expert systems are useful when the knowledge is complicated and little is known about the relationship between variables. In recent years Fuzzy logic getting more attention because it is easy to learn and understand. For developing Fuzzy logic based Expert system lots of software tools available in the market. As for example FuzzyClips is a fuzzy expert system shell. It is an extension to CLIPS (C Language Integrated Production System) and developed by the Integrated Reasoning Group of the Institute for Information Technology of the National Research Council of Canada.

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Figure3: Nitrogen (N) deficient crops have low yield.

Figure 4: Plants without and with Nitrogen.

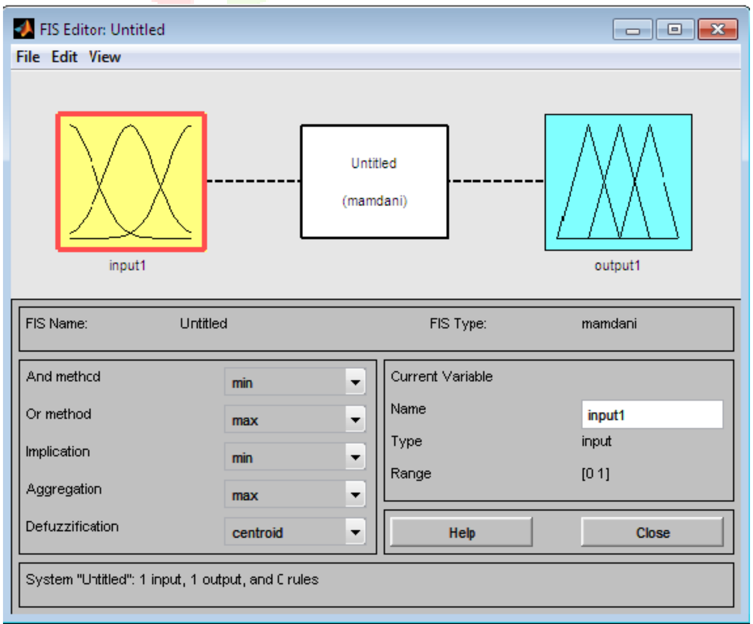

Figure 5: FIS Editor.

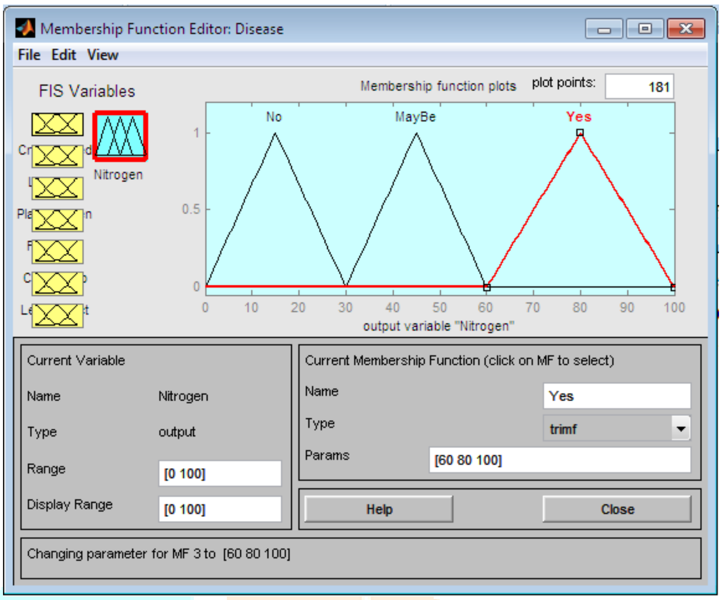

Figure 6: The Membership dialog

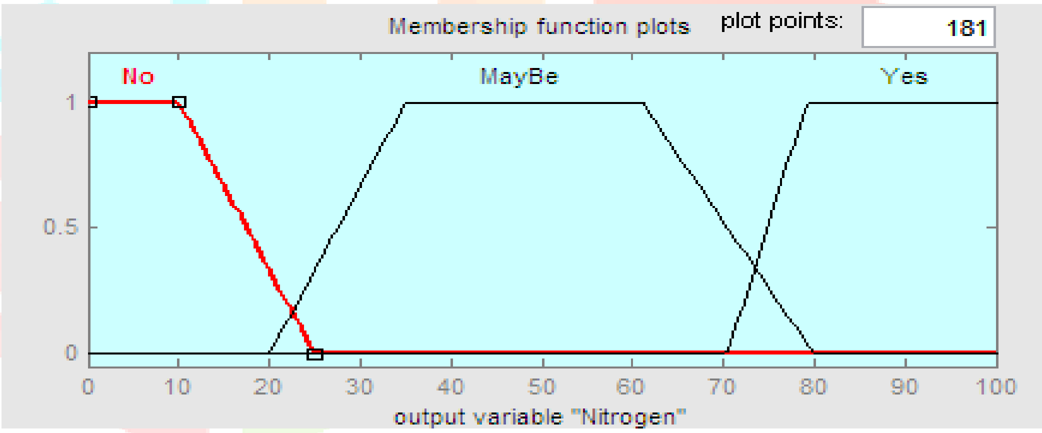

Figure 6.1: Fuzz sets for the certainty of disease presence.

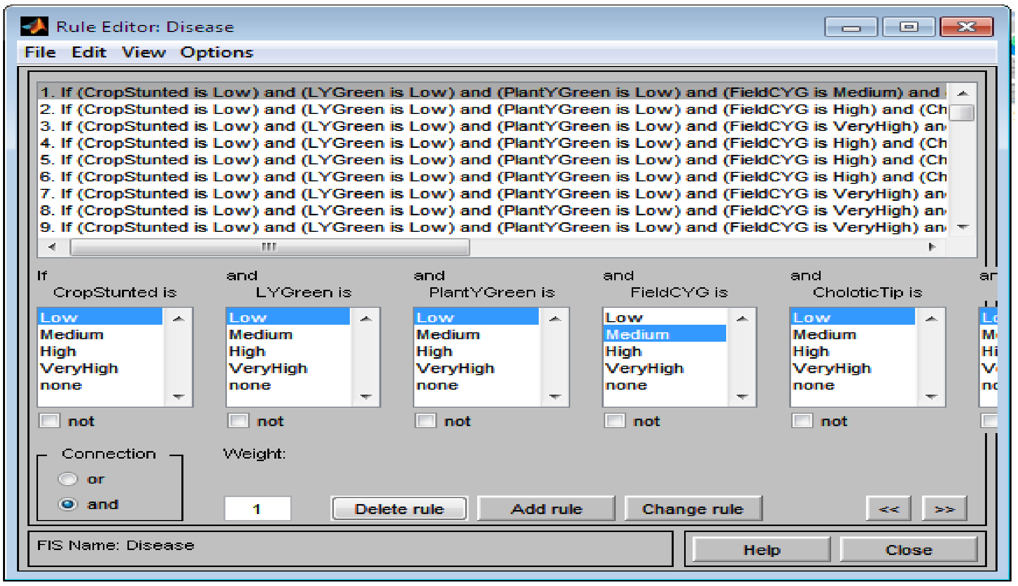

Figure 7: Rule Editor

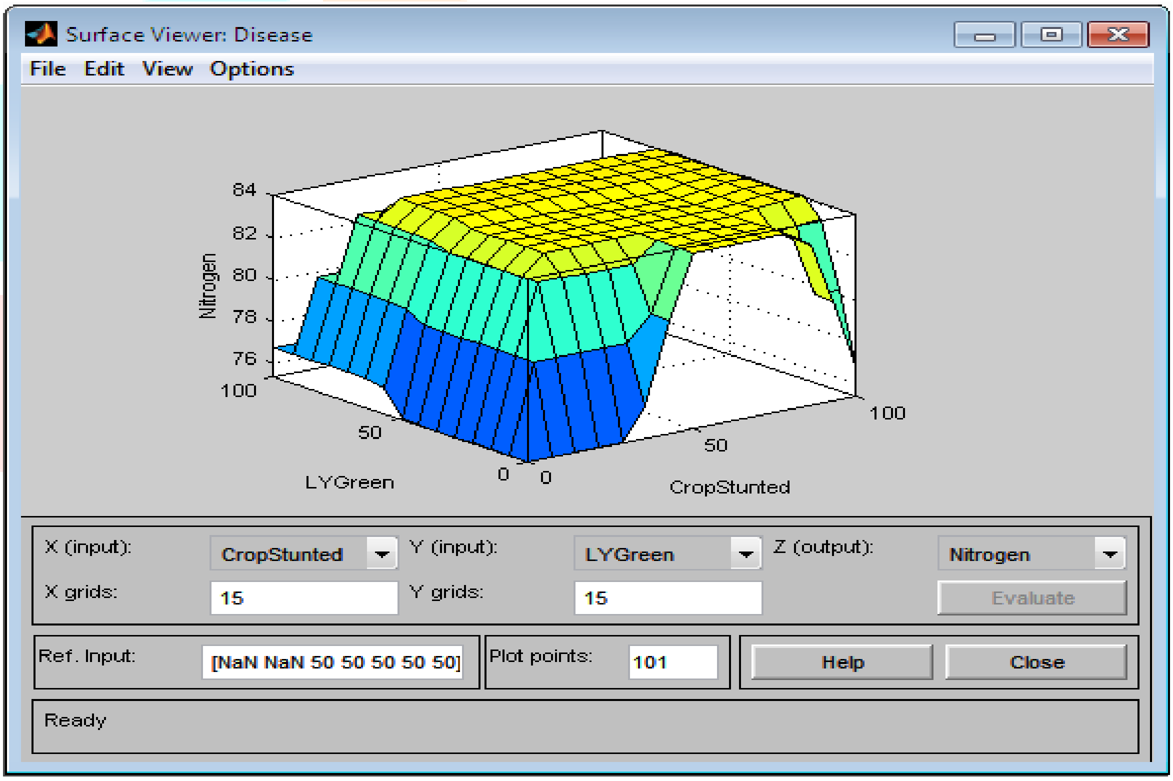

Figure 7: Surface Viewer