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Knowledge Based System Using Fuzzy Logic for Soybean Crop with Special Reference to Nutrition Management

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Abstract :Knowledge Based System is an application program that makes decisions or solves problem in particular area such as Finance, Medicine, Agriculture etc., by using knowledge and analytical rules defined by experts in that area.[8.2.1] Knowledge Based System is often called as Rule Based Expert System.[8.2.2]This paper deals with research work made to develop prototype Knowledge Based System using Fuzzy Logic which will accept symptoms of nutritional deficiency and identifies nutritional deficiency depending on symptoms and suggest necessary Nutrient application. This system will identify nutritional deficiency depending upon the symptoms observed on leaves. It also suggests necessary Nutrient application to control deficiency which ultimately helps Soyabean growers to increase yield. According to traditional binary logic where variable may take value, either True or False, one can't depict exact nutrient deficiency. So to depict deficiency, fuzzy logic is used. Basically Fuzzy Logic is multivalve logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high / low, etc. So one can put that symptoms appeared on leaves are in very high or high or medium or low.
Keywords: Knowledge Based System, Fuzzy Logic, Soybean

I. INTRODUCTION

A. Agriculture in India

India is Agricultural country. Today, India ranks second worldwide in the farm output. It was key rise of sedentary human civilization. More than 70% population in our country depends upon agriculture. During 1950s, India relied on imports and aid to meet domestic requirement. After 1966, India reformed its agricultural policies an adapted significant one to focus on a goal of food grain self sufficiency – Green revolution. It began with the decision to adapt superior yielding, in combination with better farming knowledge to improve productivity. As a result, India becomes second, worldwide in farm output and third largest producer of tomatoes, peas and beans.

B. Soybean Crop

Soybean or Soybean is a species of legume native to East Asia, widely grown for its edible bean which has numerous uses. The plant classed as an oil seed rather than pulses by the UN Food and Agricultural Organization (FAO). [8.3.3]. It contains 20% oil and 40% high quality protein.. In addition it contains good amount of minerals, salts and vitamins (thiamine and riboflavin) and its sprouting grain contain a considerable amount of Vitamin C, Vitamin A. A large number of western dishes such as bread, chapatti, milk, meal, sweets etc can be prepared with soybean. As an agricultural use, Soybean built up soil fertility by fixing large amount of atmospheric nitrogen through the root nodule and also leaf falls on ground at maturity. So because of these numerous uses Soybean sometime called as a 'wonder crop'. As a result, Soybean is important global crop, providing oil and protein. During World War II, soybeans became important in both North America and Europe chiefly as substitutes for other protein foods and as a source of edible oil. In the 1960-61 Dillion round of the General Agreement on Tariffs and Trade (GATT), the United States secured tariff-free access for its soybeans to the European market. In the 1960s, the United States exported over 90% of the world's soybeans. In 2005, top soybeans exporters are Argentina (39% of world soybean exports), United States (37%) and Brazil (16%), while top importers are China (41% of world soybean imports), European Union (22%), Japan (6%) and Mexico (6%). [8.3.1].The U.S., Argentina, Brazil, China and India are the world's largest soybean producers and represent more than 90% of global soybean production. The U.S. produced 75 million tons of soybeans in 2000, of which more than one-third was exported. In the 2010–2011 production years, this figure is expected to be over 90 million tons. Other leading producers are Argentina, Brazil, Paraguay, China, and India. According to world statistics, India contributes 4% of total world production. Soybean production in year 2011 is shown in following Fig.1[8.3.4]

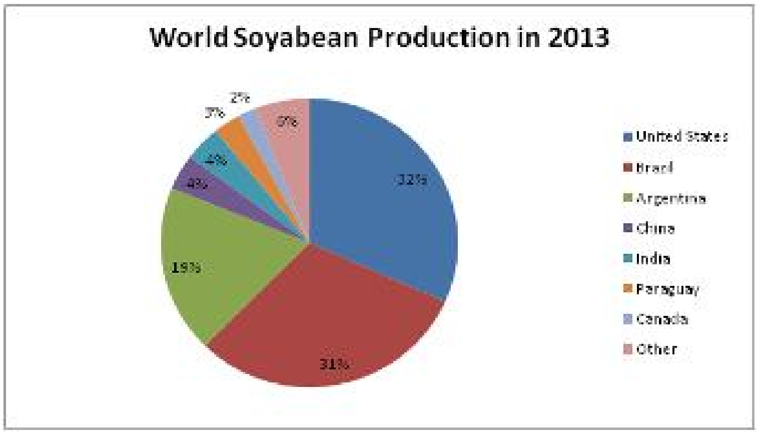

Fig 1 World Soybean production in 2013

C. Problem Faced by Growers

Considering the Soybean growers, in case of profit, maximum yield is only thing that is possible to them but they do not have any control on their product price. Government of India provides SMP or FRP to crops like Cotton, Sugarcane etc, but it is not applicable to crops like Soybean, tomato etc. So their price is depends upon demand and supply position of market. So profit is directly proportional to yield. So maximum yield is only solution to above mentioned problem.

But max yield is depending up on number of factors like water management, weed management, nutrition management, fertilizer management etc. Basically growth and yield is mainly depending upon Nutrition Management. Nutritional deficiency directly affects the yield. So it becomes necessary to provide required nutrition to crop to recover deficiency. One of the sources to identify deficiency is symptoms which are appeared on leaves. But most of the Growers of Maharashtra are unable to identify exact deficiency by observing leaves. So they need an expert advice. But one expert can't solve problems of number of Growers. So they need virtual expert.

Also in this information age, the available information from various sources is growing at phenomenal rate, and this information is primary requirement and considered as the heart of Precision Agriculture. Numerous researches are being carried out, new results are discovered at the research institutions and they continue to accumulate in the form of Reports and Dissertation. Most of these findings, recommendations do not reach to the farmers at implementation level. That is because there is lack of proper channel between researcher and farmers. The lack of proper decision support system to disseminate timely, relevant farming advice, has been observed as a major road block for adopting precision agriculture (Mc Bratneyetal. 2005).

To address this problem, Knowledge Based Systems can be used. Knowledge Based Systems are one computer program which will guide growers according to expert knowledge. Knowledge based Systems can be used to make decision at different levels in agriculture, Operational Level and Planning Level. On Operation Level, the extension workers in the villages, districts and /or Governorate can use the system to support him in making his decision in giving appropriate advice to Growers. On the Planning level, the decision makers can use expert system who predicates need of water, fertilizers and pesticides. (Rafea, 1996).

II. LITERATURE REVIEW

Peter B Goodell &other (1990) [8.1.1], have focused on integrated Expert system for Cotton production and management, developed in Egypt. CALEX is user friendly computer program that simulates human problem solving behavior. Growers can use this system to help manage crop production or predicts the effects of any one decision on subsequent events. In 1990, more than 100 cotton producers have taken advantage of the CALEX computer program. CALEX contains plant and pest simulation models to diagnose the pest.

Pinaki Chakraborti, Dr. Dilip Kumar Chakraborti (2008) [8.1.2], discussed the success of expert system for management of Malformation disease of Mango i.e. ESMMDM. This system considers variety of plant, the number of malformed shoots, climatic facts etc and prescribes suitable treatment package. It is interactive software tool with graphical user interface. Fadzilah Siraj&Nureize Arbaiy [8.1.3], proposed expert system Fuzzy X Pest, related to Rice crop since Rice is a staple food of Malaysia.

FuzzyXPest is proposed to provide information to farmers and researchers through the internet using fuzzy expert system. This system focused on pest activity on rice crop. Fuzzy logic approach is then used to forecast the pest activity level that will determine the damages caused by pests. This system has been verified by Malaysia Agriculture Research & development Institute (MARDI), Malaysia. Azizul Azar bin Ramil & Nur Suhallinbt. Suhaimi (2008) [8.1.4], discussed the development of an expert system for Oil-Palm disease control diagnosis(PEKA-SEWIT). It will perform diagnosis process for assigning an infected disease treatment solution and also the preventive control. Agricultural Officers and planters who involve directly with oil-Palm plantation may use this system as assistance for helping them in managing crop activities especially in disease control. G.N.R. Prasad, Dr. A Vinaya Babu (2006)[8.1.5], discussed various Agricultural expert system. They said that in order to remain competitive, the modern farmers often relies on agricultural specialist and advisor to provide information for decision making. Unfortunately agricultural specialist assistance is not always available when the farmers need it. In order to solve this problem, expert systems were identified as powerful tool with extensive potential in agriculture. In this paper, author discusses some more expert system. POMEE is an expert system for apple orchid management. POMEE advices growers about when and what to spray on their apple to avoid infestation. The system also provide advice regarding to winter injuries, drought control and multiple insects problems. UNU-AES is an expert system in agri forestry management. This system was designed to support land – use officials, research scientist, farmers and other individuals, for maximizing benefits from agri forestry management techniques. In 1991, Egypt started it's efforts to develop expert systems for different crops. They establish Central Laboratory for Agricultural Expert System (CLAES), by keeping the view that it helps growers for maximize food production. Numbers of expert systems were developed by CLAES. Some are described below. CUPTEX: This expert system is developed for cucumber crop production. It contains five subsystem First one is Disorder diagnosis, provides user with a disorder diagnosis which causes problem on plantation or verifies a user assumption. Second one is disorder treatment provides user with remediation of disorders. Third one is irrigation scheduling which provide an irrigation schedule for a plastic tunnel. An irrigation schedule demonstrates the water quantity related to each time instance. Forth one is Fertilizer scheduling to determine fertilization requirement for cucumber. Fifth one is plant care subsystem to predict from the last crop and plastic tunnel characteristics.

A. Citex: this expert system is developed for orange production. It contains four subsystems.

First one is Assessment of farm which is to evaluate new farm in a given location. Second one is Irrigation scheduling to produce schedule for irrigation of particular farm. Third one is fertilizer scheduling which determine fertilization requirement by considering aspects like fertilizer type, quantity, application method etc. Fourth one is Disorder diagnosis to conclude causes of user complaints. Fifth one is disorder treatments to provide a appropriate treatment for infected plant.

A. J. Castro and Garcia – Torres (1995) [8.1.6], 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 yield increase from the weed control treatment and sunflower selling price.

Harvinder S. Saini, Raj Kamal and A. N. Sharma (2002) [8.1.7], introduces Web based fuzzy expert system for integrated pest management in Soyabean i.e. SOYPEST. Objective of SOYPEST is to provide IPM decision support to the farmers through the internet. This has been used for the crops grown I different regions of India. It provides diagnosis of pest and its preventive and curative measures.

S.J. Yelapure, R.V. Kulkarni, (2012), [8.1.8], studied different expert system in agriculture and concluded that there is not any expert system available for Soyabeanin India which will guide farmers from soil preparation to harvesting. So there is need of such system, where growers get knowledge at one point.

By reviewing above literature, it is observed thatthere is wide scope for Expert Systems and Fuzzy Logic in Agriculture area. So Author hasmade an attempt to develop prototypeKnowledge Based System using Fuzzy Logic for Soybean with special reference to Nutrition Management.

III. METHODS OF DATA COLLECTION

For study the researcher has selected both primary as well as secondary data.

Primary data: This data has been collected by discussing with Agricultural Experts, Academicians, and Growers.

Secondary Data: The secondary data is collected by referring various books, websites, newspaper, research journals, articles, etc.

IV. FACTORS CONSIDERED IN THE PROCESS OF NUTRITION MANAGEMENT

A. Nutrient required for Soybean and their deficiency symptoms

Nutrient required for Soybean and their deficiency symptoms is shown in Table 1. [8.2.3]

Table 1: Nutrient required for Soybean and their deficiency symptoms

Nutrient Id	Nutrient	Deficiency Id	Symptoms Observed on leaves
N_1	Nitrogen	D_{11}	Younger leaves of plant become light green
		D_{12}	Older leaves of plant become yellow and shriveled.
N_2	Phosphorus	D_{21}	Older leaves become darker than normal
		D_{22}	Purple color spots appear on older leaves.
N_3	Potassium	D_{31}	Yellowing at tips and edges in younger leaves
		D_{32}	Yellow patches or spots develop on leaves
N_4	Zinc	D_{41}	Part of older leaves between two veins turns yellow
		D_{42}	Shrinking of leaves
N_5	Iron	D_{51}	Part of younger leaves between two veins turns yellow and veins remain green.
N_6	Magnesium	D_{61}	Part of older leaves between two veins turns yellow and veins remain green.
N_7	Manganese	D_{71}	Yellow or whitish spots appears on leaves
		D_{72}	Elongated hole between veins
N_8	Molybdenum	N_{81}	Younger leaves of plant become light green
		N_{82}	Older leaves of plant become yellow and shriveled
N_9	Boron	N_{91}	Brown spots occurs on upper leaves
		N_{92}	Shorten internodes and death of terminal growth
N_{10}	Sulphur	$N_{10\,1}$	Younger leaves of plant become light green
		$N_{10\,2}$	Older leaves of plant become yellow and shriveled
		$N_{10\,3}$	Chlorosys may be more apparent on younger leaves.
N_{11}	Copper	$D_{11\,1}$	Green splotches
N_{12}	Calcium	$D_{12\,1}$	New leaves misshapen or stunted and existing leaves remain green

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B. Methods of Nutrient Application

There are number of methods of application depend upon nature of nutrients. Mostly Broadcasting, Placement and foliar spraying mostly used methods of nutrient application. But disadvantage of Broadcasting and Placement is Nutrients are not fully utilized by plant root, since utilization is fully depend upon factors like soil type, moisture available etc.

Foliar spraying is most effective, and the risk of scorch is minimized, if the spray droplets do not dry too rapidly, i.e. on cloudy days and in the early morning or late afternoon.

The advantage of foliar application is the direct uptake of nutrients into the metabolism of the plant tissues. Thus, with a very low consumption of energy for transportation within the plant, the uptake is virtually independent of environmental factors such as soil moisture. The disadvantage is the limited amount that can be applied at one time, due to the risk of leaf burn; but this is of less concern provided proper attention is paid to the relevant limits of concentration, especially when there are a number of split dressings. Another advantage is the opportunity to combine fertilizer application with that of pesticides and growth regulators, in many cases with beneficial synergistic effects. In arid conditions the high concentration of combined sprays reduces evaporation, and so reduces vaporization of the active ingredients, thus permitting a reduction in pesticide usage with resultant benefit to the ecosystem.

By considering advantages of Spraying, Foliar fertilizers become very popular. These fertilizers are in crystal or powder form and can dissolve into water very easily and can be apply using spraying. So in case of Soybean, according to Experts spraying of Foliar Fertilizer is best method to apply nutrient.

C. Growth stages of Soybean crop

Growth stages of Soybean crop are shown in Table 2.

Table 2.Growth stages of Soybean Crop

Name	Duration in days
Germination	4-6
Vegetative Growth	6-22
Grand Vegetative Growth	23-40
Flowering	41-60
Pod Formation	50-70
Pod Filling	70-90

Here Flowering stage may continue up to 70 days.[8.2.4] But according to expert, spraying of Nutrient or pesticides are not recommended before stage Flowering, since it is not so beneficial for plant. So according to spraying of Foliar Nutrient, Researcher considers only four stages of crop as shown in Table.3

Table 3.Growth Stages considered for Nutrition management

Stage Id	Name	Duration in days
S_1	Grand Vegetative Growth	23-40
S_2	Flowering	41-60
S_3	Pod Formation	50-70
S_4	Pod Filling	70-90

D. Primary and other Nutrition requirement of Soybean:

The total Primary Nutrition requirement of Soybean(Foliar gm per acer) is shown in Table 4. According to Fuzzy Logic, here total nutritional requirement is considered as weight of attribute.

Table 4. Primary Nutrition requirement of Soybean

Nutrient Id	Name	Total Nutrient required (gm / Acer)	Stage wise Nutrient required (gm/Acer)			
			S1	S2	S3	S4
N_1	Nitrogen	310	190	120	-	-
N_2	Phosphorus	1320	190	610	520	-
N_3	Potassium	1030	190	-	340	500

Mahatma Phule Krishi Vidhyapeeth, Rahuri recommended only Primary nutrients for Soybean. But according to Expert, for normal growth of Soybean, it also requires Secondary and Micro nutrients. So Growers have to spray Micro nutrients, two times from starting of stage S1 to ending of stage S2 . Government of Maharashtra specifies Micro nutrient mixture for spraying as shown in Table 5.

After spraying above recommended Micro nutrient, even though deficiency symptoms occurs on leaves then Grower have to spray above micro nutrient in additional manner. But for that , Grower must know total requirement of Micronutrient since extra spraying can badly affect the growth.

Table 5. Micro nutrient mixture for spraying

Nutrient Name	Ratio in W/V
Iron	2.50
Manganese	1.00
Zinc	3.00
Copper	1.00
Molybdenum	0.10
Boron	0.50

Also this requirement is depend upon number of factors like soil type, availability Nutrients in soil, plant uptake capacity etc. So generally Experts recommend following Micro and Secondary Nutrients with quantity gm per acer as shown in Table 6.

Table 6. Micro and Secondary Nutrients requirement

Nutrient Id	Name	Total Nutrient required (gm / Acer) W
N_4	Zinc	360
N_5	Iron	200
N_6	Magnesium	200
N_7	Boron	24
N_8	Manganese	224
N_9	Molybdenum	54
N_{10}	Calcium	191
N_{11}	Copper	254
N_{12}	Sulphur	200

V. DESIGN OF KNOWLEDGE BASED SYSTEM:

In this research, Author adapted fuzzy logic principles to identify exact deficiency of Nutrients depending upon symptoms occur on leaves of Soybean. Here, the Grower can specify exact symptoms, but can't specify percentage of symptoms like 10% or 20 %. But Growers can specify that, symptoms observed on leaves in very high, high, medium, low, or very low manner.

According to Fuzzy Logic, the variables that represents the gradual transition from high to low, true to false, is called Fuzzy variable and set containing these variables is called Fuzzy Set.

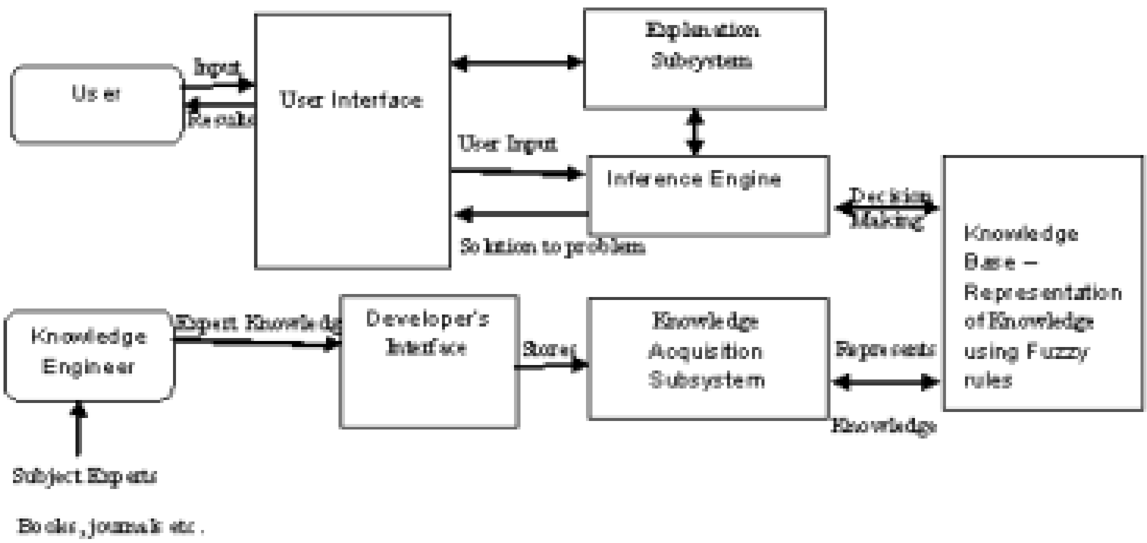

Fig 2 - Knowledge Base System Model

In this research, Author used the concept of Fuzzy set and membership function to map the linguistic characteristics of percentage of symptoms that can be ranked high, medium or low and degree of membership. The degree of membership in Fuzzy set is [1,0], where '1' represents highest membership and '0' represent no membership. A fuzzy variable set and membership values are shown in Table 7.

So by taking advantages of Fuzzy logic, author design a prototype Knowledge Based System to identify Nutrient deficiency depending upon deficiency symptoms, is shown in Fig 2 Here this system will accept values from user like stage of crop, symptoms observed on leaves and their occurrence ratio like very high, high etc. Also if Grower already applied nutrient then he have to specify it's details. After considering all input parameter, system will give the output in the form of advice.

Table 7 - Fuzzy variable and Membership values

Fuzzy Variable Id	Fuzzy Variable	Membership Id	Degree Of Membership
F_1	Very High	M_1	1.0
F_2	High	M_2	0.8
F_3	Medium	M_3	0.6
F_4	Low	M_4	0.4
F_5	Very Low	M_5	0.2
F_6	Null	M_6	0

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VI. RULE BASE DESIGN

In rules, abbreviations are used. So abbreviations and their meaning is given in Table 8

Table 8 : Abbreviations and their meaning

Abbreviations	Meaning
D	Deficiency
N	Nutrient
S	Stage of Crop
TN	Total Nutrient required by crop
F	Fuzzy Variable Id
M	Membership Id
AN	Already applied Nutrient

A. Rule 1: IF symptom is D_{ij}

THEN deficiency is of N_i

Where i= 1,2,…,12

J= 1,2,3

B. Rule 2: If stage is S_i AND deficiency is of N_j

THEN

Total N_j required by crop $T_{Nj} = \sum_{i=1}^{m} S_i$

Where i= 1,2,.,4

j= 1,2,3

C. Rule 3: IF Occurrence of observed deficiency on leaves are Fi

THEN Degree of membership is M_i

Where i= 1,2,..,6

D. Rule 4: IF Nutrient N_k already applied = ‘NO’ and stage is S_i

Then Apply Nk Nutrient to recover deficiency, in the ratio (T_{Nk} * M_j) gm / Acer. Also Soybean needs Micro Nutrients for regular growth. So with Nk, also apply Following Nutrient with ratio specified by Maharashtra State Government, during the stage S_i

Nutrient Name	Ratio / Acer
ron	2.50% w/v
Zinc	3.00% w/v
Manganese	1.00% w/v
Copper	1.00% w/v
Boron	0.50% w/v

Where i=2,3

j=1,..,6

k = 1,2,3

E. Rule 5: IF Nutrient N_k already applied = ‘NO’ and stage is S_i

THEN

Apply N_k Nutrient to recover deficiency, in the ratio (T_{Nk} * M_j) gm / Acer during The stage S_i.

Where i=1,4

j=1,..,6 k = 1,2,3

F. *Rule 6:* IF Nutrient N_k already applied = 'Yes' and stage is S_i
THEN
Apply N_k Nutrient to recover deficiency, in the ratio (T_{Nk} * M_j) - A_{Nk}gm/ Acer. Also Soybean needs Micro Nutrients for regular growth. So with N_k, also apply Following Nutrient with ratio specified by Maharashtra State Government, during the stage S_i

Nutrient Name	Ratio / Acer
Iron	2.50% w/v
Zinc	3.00% w/v
Manganese	1.00% w/v
Copper	1.00% w/v
Boron	0.50% w/v

Where i=2,3
j=1,..,6
k = 1,2,3

G. *Rule 7:* IF Nutrient N_k already applied = 'Yes' and stage is S_i
THEN
Apply N_k Nutrient to recover deficiency, in the ratio (T_{Nk} * M_j) - $A_N$kgm/ Acer during the stage S_i
Where i=1,4
j=1,..,6
k = 1,2,3

H. *Rule 8:* IF Nutrient N_k already applied = 'No' and stage is S_i
THEN
Apply N_k Nutrient to recover deficiency, in the ratio $W_k$gm/ Acer during the S_i
Where i=1,2,3
K= 4, ..,12

I. *Rule 9:* IF Nutrient N_k already applied = 'Yes' and stage is S_i
THEN
Apply N_k Nutrient to recover deficiency, in the ratio $W_k$gm / Acer during the Si
Where i=1,2,3
K= 4, ..,12

J. *For Eg.*
Case i) Input Parameters
Stage of Crop :Flowering
Symptoms :Younger leaves of plant become light green
Occurrence :High
Nutrition Already Applied: No
In this case i) Rule 1 will get execute and deficiency found is Nitrogen
Rule 2 will get execute and so total nitrogen required = 310 gm/ Acer
3 will get execute and so degree of membership (Occurrence of observed deficiency on leaves) =0.8
Rule 4 will get execute and will get output as - Apply Nitrogen to recover deficiency, in the ratio 248 gm / Acer. Also Soybean needs Micro Nutrients for regular growth. So with Nitrogen, also apply following Nutrient with ratio specified by Maharashtra State Government, during the Flowering stage

Nutrient Name	Ratio / Acer
Iron	2.50% w/v
Zinc	3.00% w/v
Manganese	1.00% w/v
Copper	1.00% w/v
Boron	0.50% w/v

VII. CONCLUSION

This paper explores application of Knowledge Based system using Fuzzy Logic in Agriculture sector. This prototype will helpful for Soybean Growers to identify Nutrient deficiency depending upon symptoms observed on leaves of crop. So Grower will take appropriate action which will increase yield. Using this prototype one may go for an advisory system into different domains like Fertilizer Management, Weed Management etc. Also this system can be proved an efficient mean to store Expert knowledge for long time and can be used as training tool for agriculture persons and Growers.

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