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A Fuzzy based Decision Support System for Agriculture Support System

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Abstract - A fuzzy logic based decision support system (DSS) for agriculture support system is presented. The primary focus is on the algorithm used to correctly predict how much water should be poured to the agriculture for the optimal growth of the crops. Over-watering as well as under-watering has always been a big problem in farming. The proposed system uses three input parameters; namely field moisture, field humidity and field temperature. However, for predicting the proper amount of water so as to get the optimized best growth of the crop, few more parameters also play a vital role but in this work for simplicity purpose we have taken these three parameters as input. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine is used to deduce from the input parameters. Design of the proposed system is given with the fuzzy logic controller and simulation is being done using MATLAB (Matrix Laboratory) for solving the water irrigation issue.

Keywords - Fuzzy logic, Decision Support Systems, Agriculture support, Rule base

I. INTRODUCTION

India has the highest percentage of land under cultivation in the world where farming contributes to about 12.5% to the total domestic production. India suffers comparatively a low production of farming which depends mainly on monsoon rain. Low production is also due to the use of old cultivation methods in India. There are many factors which affects outcomes from the farming, like quality of seeds, land preparation, time of sowing, weed management, diagnosis of insect, disease and nutritional disorders etc. Farmers usually keep a watch on irrigation timetable, different for different crops and dependent on type of soil and other parameters. This process sometimes consumes more water or sometimes water reaches late due to which crop gets dried. An automatic irrigation system based on sensing technology with rule based control system requiring computer's computing, is required to reduce the labor cost and to give uniformity in water application across the field. Water has been always a very vital issue in farming. Farmer need advance expert knowledge to take different decisions related to farming. A rule based fuzzy controlled system can give a good approximation of the water needs for various crops. This paper focusses on this issue.

Rest of the paper is organized as follows. Section 2 gives the related work done by earlier researchers in the said field of decision support system for agriculture using fuzzy logic. Section 3 gives the general Structure of Fuzzy Logic based Decision Support System. Design of the proposed system is given in section 4. Section 5 gives the surface viewer. Finally work is concluded in section 6.

II. RELETED WORK

Rule based fuzzy systems have been applied to the decision making system of various agriculture related issues as early as 1980s. These rule based fuzzy systems have been developed by various Agricultural Research Institutes and researchers from different countries. Objective of these is to assist the farmers for plant-disorder diagnosis, management and other production aspects for agriculture [1]. These systems manipulates encoded knowledge to solve problems in a specialized domain that normally requires human expertise [2]. For integrated pest management, authors in [3] have proposed a rule based fuzzy expert system SOYPEST (Soybean pest Expert System) by dividing the identification and diagnosis into four phases. A comparison study on various rule based expert systems in agriculture is done in [4]. In [5] authors have discussed how fuzzy logic imitates the logic of human thought. Origin, theory and the application of decision support system in agriculture using rule based fuzzy logic has been given in [6]. In [7] authors have presented a report on the use of decision support system in agriculture. In [8] authors have covered the irrigation water quality for sugarcane crops. An automated water irrigation system in Nepal is proposed by the authors in [9]. In [10] various types of decision support systems along with the usage of linguistic variables and values in DSS has been presented.

III. GERERAL STRUCTURE OF FUZZY LOGIC BASED DECISIONSUPPORT SYSTEM

The general structure of fuzzy logic based decision support system is shown in figure 1. During fuzzification sub-process all three crisp inputs are changed to fuzzy inputs with the use of membership functions. For properly adapting the output fuzzy inference sub-procedure uses if-then rules during fuzzy inference. These rules determine the output. During aggregation, sub-procedure minimum of membership function of all inputs is determined for each rule. Results of aggregation sub-procedure are used for composition. A membership function for each region of the output parameter is calculated using the rule base and the values determined in the aggregation step. Min-max procedure is used for composition. During defuzzification subprocedure, the fuzzy output values are converted into real numbers. The defuzzification method used in this work is Weight-of-Average-Formula.

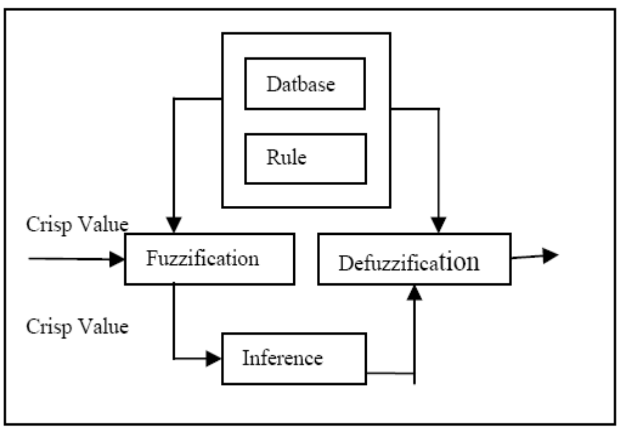

Figure 1: General Structure of Fuzzy Logic based Decision Support System

IV. DESIGN OF THE SYSTEM

Fuzzy decision support system designing, membership functions, fuzzy rule base, fuzzification and defuzzification are described in this section. In the proposed system a total of three inputs are chosen which determines the output. Figure 2 shows the fuzzy logic based irrigation control system.

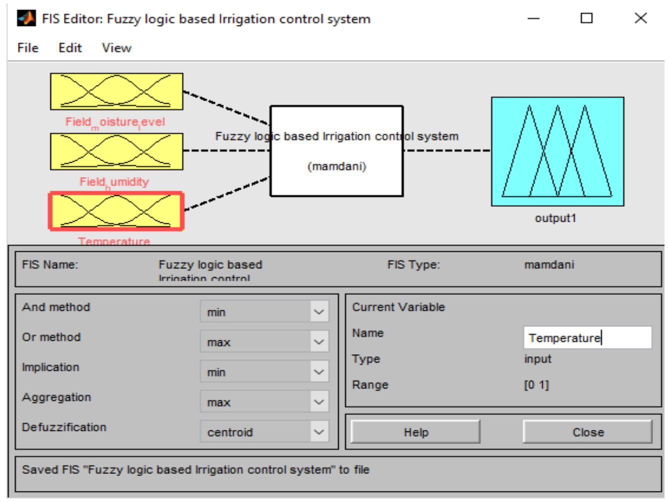

Figure 2: Fuzzy logic based irrigation control system

4.1 Input Variables

1. Field Moisture

The field moisture content of the soil is an important factor to be considered for watering the crops. In our case, we have taken four ranges of this parameter; standard, adequate, normal and dry. Fuzzy sets for input variable field moisture are shown in Table 1. Figure 3 shows the membership function of this input.

Table 1: Fuzzy sets for Input variable Field Moisture

Linguistic variable	Range	Fuzzy sets
Field Moisture	0-12	Saturated
	8-22	Adequate
	18-35	Normal
	More than 30	Dry

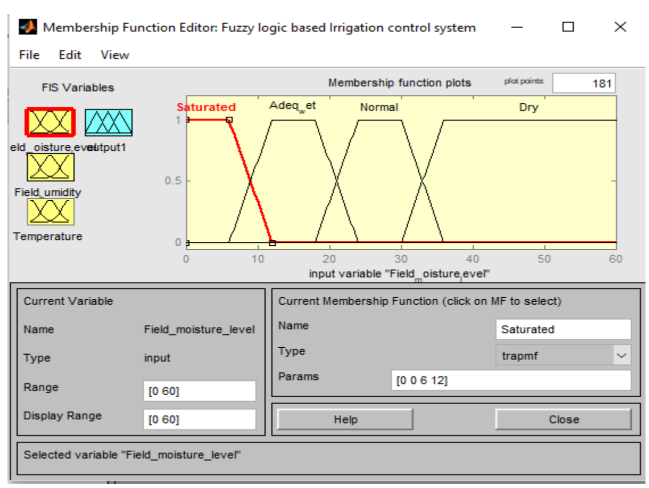

Figure 3: Membership function of the input variable Field Moisture

2. Field Humidity

It is well known that most of the crops can easily tolerate humid level if below 25%, however all crops grow best with relative humidity of over 50%. Relative Humidity is expressed as percentage of moisture in the air around the soil surface. In our case, we have taken four ranges of this parameter; low, medium, high and extremely high. Fuzzy sets for input variable field humidity time are shown in Table 2. Figure 4 shows the membership function of this input.

Table 2: Fuzzy sets for Input variable Field Humidity

Linguistic variable	Range	Fuzzy sets
Left green time	0 – 12	Low
	10 – 40	Medium
	30 – 60	High
	50 and above	Extremely High

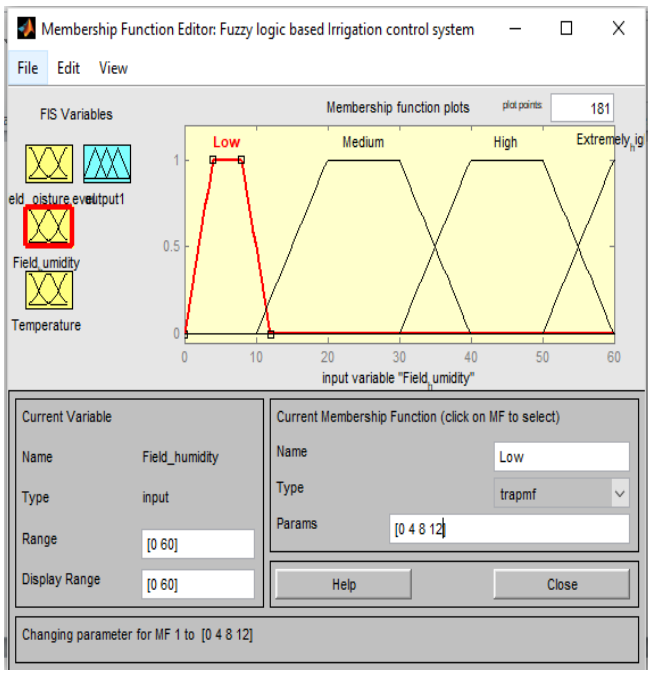

Figure 4: Membership function of the input variable Field Humidity

3. Field Temperature

For germination of the seeds, different crops grow at various levels of temperature. If field temperature is high, it will evaporate the soil moisture and visa versa. Temperature plays a vital role in farming. Temperature is expressed as degree Centigrade. In our case we have taken four ranges; very cold, cold, normal and high. Fuzzy sets for input variable field temperature are shown in Table 3. Figure 5 shows the membership function of this input.

Table 3: Fuzzy sets for Input variable Field Temperature

Linguistic variable	Range	Fuzzy sets
Field Temperature	0 - 15	Very Cold
	10 – 25	Cold
	20 – 35	Normal
	30 – 45	High

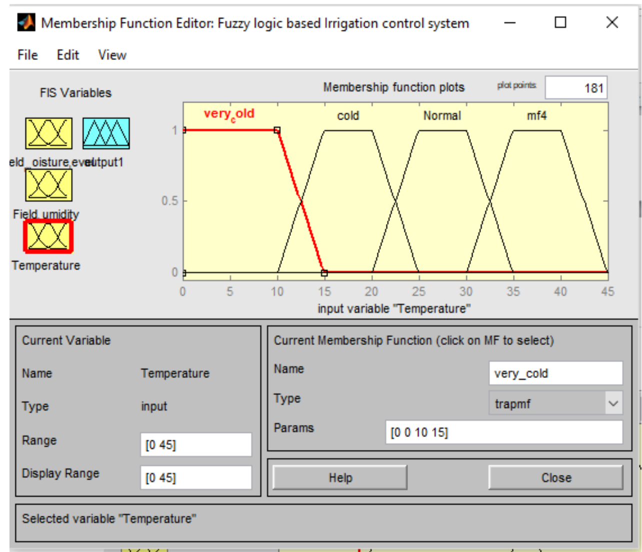

Figure 5: Membership function of the input variable Field Temperature

4.2 Output Variable

Aim of the present work is to correctly predict how much water should be poured to the agriculture for the optimal growth of the crops. The output variable has a value from 1 to 4; representing normal, deficit, medium deficit and high deficit. Figure 6 shows the membership function of the output variable.

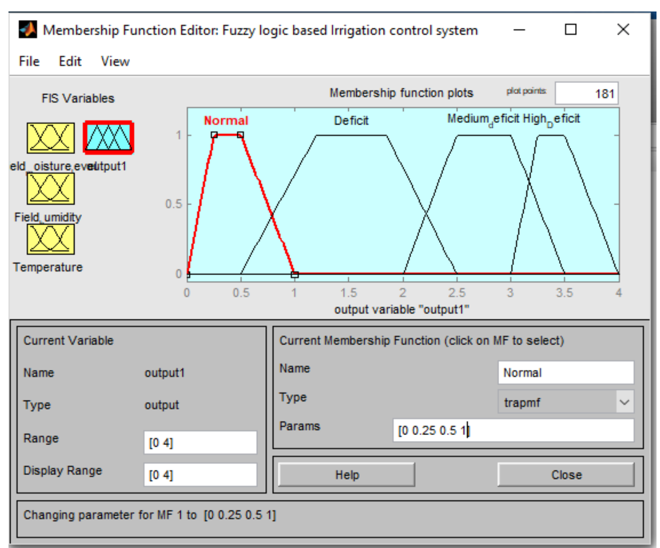

Figure 6: Membership function of the output variable

4.3 Fuzzy Rule Base

The rule base determine the extension, having five different values; more decrease, decrease, do not change, increase, and more increase. Figure 7 shows the Rule Viewer and sample of different if-then rules are shown in figure 8.

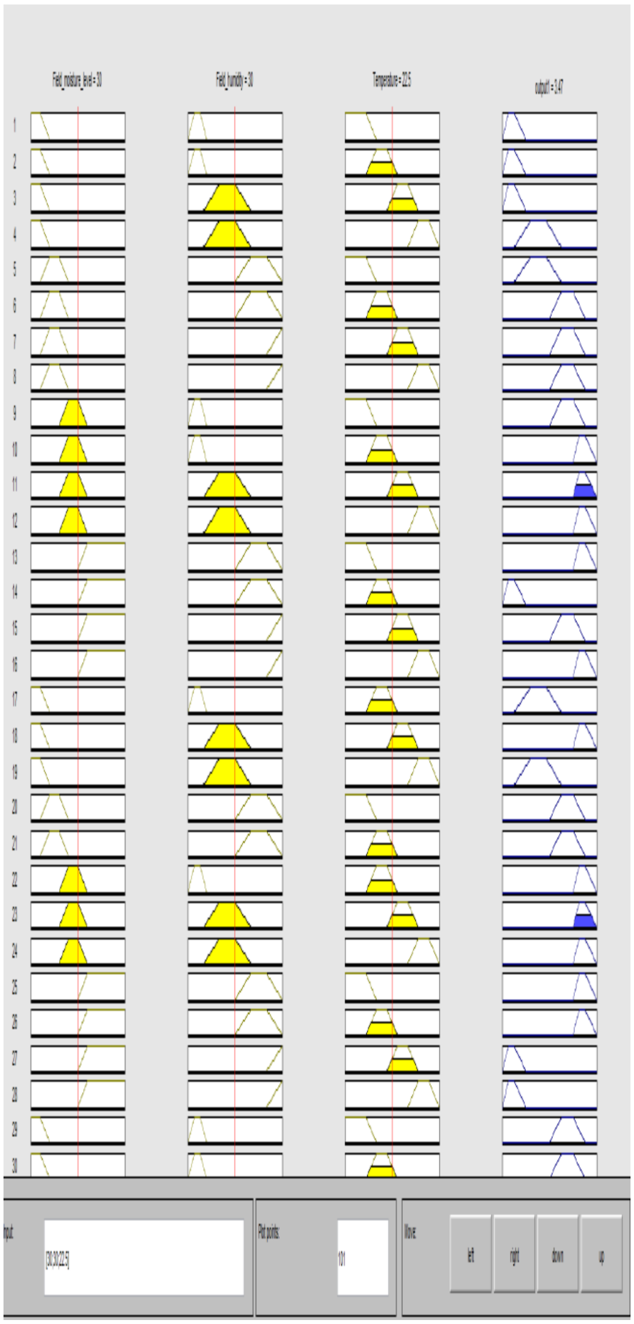

Figure 7: Rule Viewer

1. If (Field_moisture_level is Saturated) and (Field_humidity is Low) and (Temperature is very_cold) then (output1 is Normal) (1)
2. If (Field_moisture_level is Saturated) and (Field_humidity is Low) and (Temperature is cold) then (output1 is Normal) (1)
3. If (Field_moisture_level is Saturated) and (Field_humidity is Medium) and (Temperature is Normal) then (output1 is Normal) (1)
4. If (Field_moisture_level is Saturated) and (Field_humidity is Medium) and (Temperature is Hot) then (output1 is Deficit) (1)
5. If (Field_moisture_level is Adeq_wet) and (Field_humidity is High) and (Temperature is very_cold) then (output1 is Deficit) (1)
6. If (Field_moisture_level is Adeq_wet) and (Field_humidity is High) and (Temperature is cold) then (output1 is Medium_deficit) (1)
7. If (Field_moisture_level is Adeq_wet) and (Field_humidity is Extremely_high) and (Temperature is Normal) then (output1 is Medium_deficit) (1)
8. If (Field_moisture_level is Adeq_wet) and (Field_humidity is Extremely_high) and (Temperature is Hot) then (output1 is Medium_deficit) (1)
9. If (Field_moisture_level is Normal) and (Field_humidity is Low) and (Temperature is very_cold) then (output1 is Medium_deficit) (1)
10. If (Field_moisture_level is Normal) and (Field_humidity is Low) and (Temperature is cold) then (output1 is High_Deficit) (1)
11. If (Field_moisture_level is Normal) and (Field_humidity is Medium) and (Temperature is Normal) then (output1 is High_Deficit) (1)
12. If (Field_moisture_level is Normal) and (Field_humidity is Medium) and (Temperature is Hot) then (output1 is High_Deficit) (1)
13. If (Field_moisture_level is Dry) and (Field_humidity is High) and (Temperature is very_cold) then (output1 is High_Deficit) (1)
14. If (Field_moisture_level is Dry) and (Field_humidity is High) and (Temperature is cold) then (output1 is Normal) (1)
15. If (Field_moisture_level is Dry) and (Field_humidity is Extremely_high) and (Temperature is Normal) then (output1 is Medium_deficit) (1)
16. If (Field_moisture_level is Dry) and (Field_humidity is Extremely_high) and (Temperature is Hot) then (output1 is High_Deficit) (1)
17. If (Field_moisture_level is Saturated) and (Field_humidity is Low) and (Temperature is cold) then (output1 is Deficit) (1)
18. If (Field_moisture_level is Saturated) and (Field_humidity is Medium) and (Temperature is Normal) then (output1 is High_Deficit) (1)
19. If (Field_moisture_level is Saturated) and (Field_humidity is Medium) and (Temperature is Hot) then (output1 is Deficit) (1)
20. If (Field_moisture_level is Adeq_wet) and (Field_humidity is High) and (Temperature is very_cold) then (output1 is Medium_deficit) (1)
21. If (Field_moisture_level is Adeq_wet) and (Field_humidity is High) and (Temperature is cold) then (output1 is Medium_deficit) (1)
22. If (Field_moisture_level is Normal) and (Field_humidity is Low) and (Temperature is cold) then (output1 is High_Deficit) (1)
23. If (Field_moisture_level is Normal) and (Field_humidity is Medium) and (Temperature is Normal) then (output1 is High_Deficit) (1)
24. If (Field_moisture_level is Normal) and (Field_humidity is Medium) and (Temperature is Hot) then (output1 is High_Deficit) (1)
25. If (Field_moisture_level is Dry) and (Field_humidity is High) and (Temperature is very_cold) then (output1 is High_Deficit) (1)
26. If (Field_moisture_level is Dry) and (Field_humidity is High) and (Temperature is cold) then (output1 is High_Deficit) (1)
27. If (Field_moisture_level is Dry) and (Field_humidity is Extremely_high) and (Temperature is Normal) then (output1 is Normal) (1)
28. If (Field_moisture_level is Dry) and (Field_humidity is Extremely_high) and (Temperature is Hot) then (output1 is Normal) (1)
29. If (Field_moisture_level is Saturated) and (Field_humidity is Low) and (Temperature is very_cold) then (output1 is Medium_deficit) (1)
30. If (Field_moisture_level is Saturated) and (Field_humidity is Low) and (Temperature is cold) then (output1 is Medium_deficit) (1)
31. If (Field_moisture_level is Saturated) and (Field_humidity is Medium) and (Temperature is Normal) then (output1 is Medium_deficit) (1)
32. If (Field_moisture_level is Saturated) and (Field_humidity is Medium) and (Temperature is Hot) then (output1 is Deficit) (1)
33. If (Field_moisture_level is Adeq_wet) and (Field_humidity is High) and (Temperature is very_cold) then (output1 is Deficit) (1)
34. If (Field_moisture_level is Adeq_wet) and (Field_humidity is High) and (Temperature is cold) then (output1 is Deficit) (1)
35. If (Field_moisture_level is Adeq_wet) and (Field_humidity is Extremely_high) and (Temperature is Normal) then (output1 is High_Deficit) (1)
36. If (Field_moisture_level is Adeq_wet) and (Field_humidity is Extremely_high) and (Temperature is cold) then (output1 is Normal) (1)
37. If (Field_moisture_level is Normal) and (Field_humidity is Low) and (Temperature is very_cold) then (output1 is Medium_deficit) (1)
38. If (Field_moisture_level is Normal) and (Field_humidity is Low) and (Temperature is very_cold) then (output1 is Medium_deficit) (1)
39. If (Field_moisture_level is Normal) and (Field_humidity is Low) and (Temperature is cold) then (output1 is Medium_deficit) (1)
40. If (Field_moisture_level is Normal) and (Field_humidity is Medium) and (Temperature is Normal) then (output1 is High_Deficit) (1)

Figure 8: Sample of different if-then rules

4.4 Fuzzification & Defuzzification

This system depends on Mamdani model for inference mechanism. Aggregation method between rules is maximum to combine output fuzzy set. Fuzzification method used is min-max and defuzzification method is centroid.

V. SURFACE VIEWER

Different surface viewer are shown in figure 9 – 11. Figure 9 shows the surface viewer of field humidity, field moisture and output parameter. Figure 10 shows the surface viewer of field temperature, field moisture and output parameter. Figure 11 shows the surface viewer of field temperature, field humidity and output parameter.

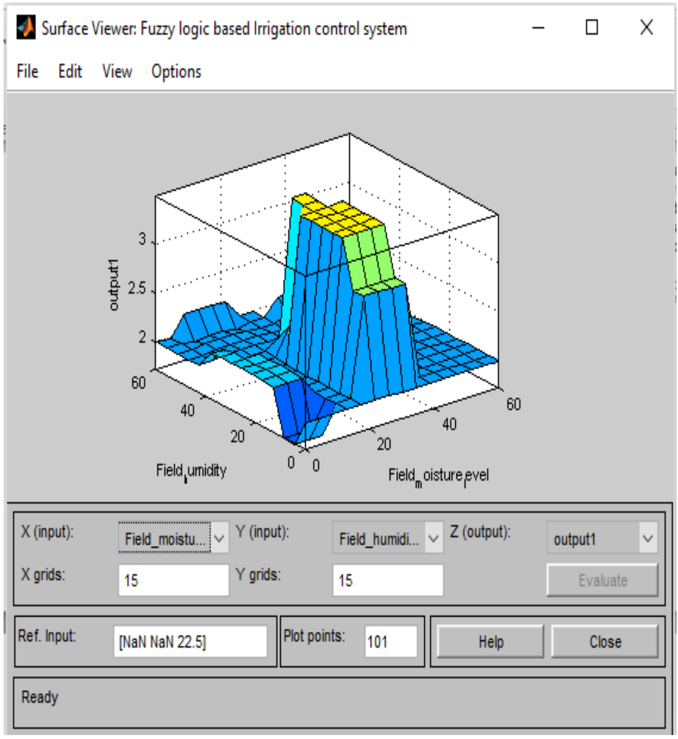

Figure 9: Surface viewer of field humidity, field moisture and output parameter

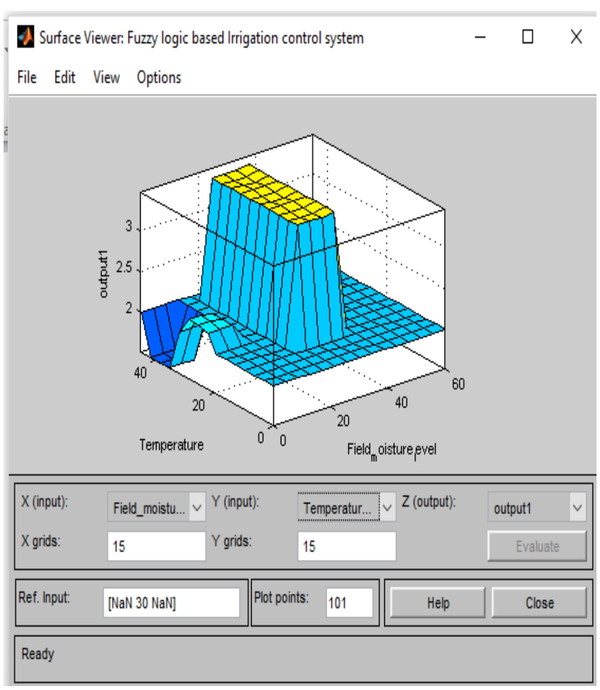

Figure 10: Surface viewer of field temperature, field moisture and output parameter

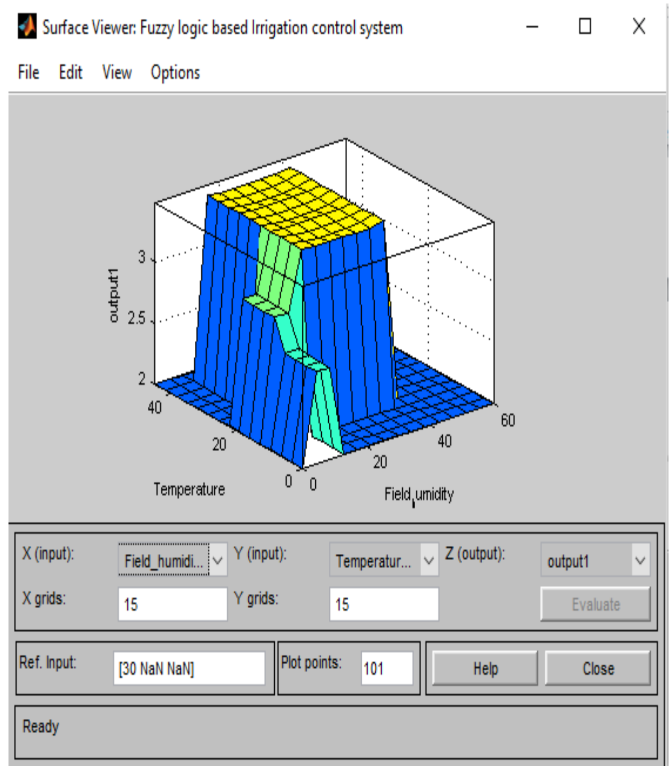

Figure 11: Surface viewer of field temperature, field humidity and output parameter

VI. CONCLUSION

In this paper, a fuzzy logic based decision support system (DSS) for agriculture support system was presented. The primary focus was on the algorithm used to correctly predict how much water should be poured to the agriculture for the optimal growth of the crops. Over-watering as well as under-watering has always been a big problem in farming. The proposed system used three input parameters; namely field moisture, field humidity and field temperature. However, for predicting the proper amount of water so as to get the optimized best growth of the crop, few more parameters also play a major role but in this work for simplicity purpose we have taken these three parameters as input. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine was used to deduce from the input parameters. Design of the proposed system was given with the fuzzy logic controller and simulation was being done using MATLAB (Matrix Laboratory) for solving the water irrigation issue.

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