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Development of Fuzzy Inference System for Nitrogen Requirement in Grape Vineyard

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Abstract
The grape is one of the major important fruit crop of the Maharashtra. The high input used crop gives more profit through export as foreign exchange. However, at present, the input in the form of fertilizer (Nitrogen) requirement is being worked out through laboratory analysis in the specified range. In the present study, the soil samples are collected from different vineyards of the Maharashtra state and also from Karnataka. To decide the actual requirement of nitrogen, the Fuzzy Information System (FIS) is developed. The data obtained from the analysis of soil testing report from the laboratory isused for FIS and result is compared with the results of Fuzzy InferenceSystem. It is found that the nitrogen requirement of any grape garden is lessthan the laboratory suggestions. This can help to reduce the cost of production without affecting the yield level of the grape garden and to maintain the soil quality. Development of Fuzzy Inference Systemisbased on MATLAB Simulation GUI Tool.

Key Words: Nitrogen, Grapes, Soil, Fuzzy Inference System**,**Mat Lab.

I. Introduction

Grape is one of the major important fruit crop of the country grown on an area of about 1.19 lakhhectare with an annual production of 25.85 lakh m tones (National Horticulture Database, India 2015). In Maharashtra, it is grown on an area of 90,000 hectare with production of 21.60 lakh M tones (National Horticulture Database, India 2015). The vine is pruned twice in a year i.e., once after the harvest of fruits during April (back pruning) and again for fruits during October (forward pruning). During each pruning, the nutrient requirement for soil is different and it varies from grapes variety to variety. Nitrogen is one of the major nutrients supplied to the vineyard for vegetative growth as well as all the major physiological processes are dependent on nitrogen requirement at this stage.

Nitrogen (N) is most critically needed by grapevines during the period of Rapid Shoot Growth in the spring through bloom and early Berry Development. The need for N reduces from midsummer to senescence (Christensen et al., 1978 and Winkler et al., 1974). The excess use of nitrogen may impart more vigour. The ultimate results of this will be the reduction in fruit yield as the vegetative growth and fruitfulness are negatively correlated. Nitrogen inputs from irrigation water, crop residues, and mineralization of soil organic matter must be considered when determining N fertilizer requirement.

Presently, the nutrient requirement of grapevine is assessed by the farmer which is based on the soil test report from laboratory. It has been experienced that the analysis of the major nutrients from the same vineyard may vary from laboratories. The nutrient requirement of each vineyard is fixed and based on the nutrient status of each garden. The method used for analyzing the nutrient in a given sample varies from laboratory tolaboratory. This shows the vagueness in treatment. There is also vagueness in the interpretation of the test results. In the San Joaquin Valley, time of fertilization, using isotopically labeled N, was studied in mature, furrow irrigated, "Thompson Seedless" vineyards (Peacock et al, 1989).To avoid this we can suggest the fuzzy logic for analysis and nitrogen requirement.Fuzzy logic technique in assessing the requirement of nutrients in the vineyard during each season may help to save the input andincrease the efficiency of vine in betterway. Theprincipal contributions of fuzzy logic - is its high power of precision. Fuzzy logic is much more than a logical system having many facets. Most of the practical applications of fuzzy logic are associated with its relational facet.Considering this,experiments areconducted for the developmentof the Fuzzy Inference System (FIS) to suggest the nitrogen requirement of grape vineyard based on the soil test report.Designing of the inference system for requirement of Nitrogen includes the Fuzzification, Knowledge Representation (Data base and Rule Base), Inference Process, Defuzzification and Surface Viewer. The objective of the study is to rectify the discrepancies using fuzzy logics flexibility and avoid the vagueness in nitrogen treatment to soil.

II. Laboratory Data Base

The data is collected from the fields ofSolapur, Sangli, Nasik, Pune, Belgaon, Bijapur,and Gulbarga. The soil samples have been collected from different vineyards of the farmersin these districts. The soil samples areprepared in the soil testing laboratory of Maharashtra Rajya Draksh Bagaitdar Sangh, Manjri Farm, Pune (Maharashtra).During the season(2013-14 and 2014-15), 230 samples of different grape vineyards and from different locations are collected and analyzed in the laboratory using laboratory standard methods.The Mat lab software was used to develop FIS using Mamdani approach for fuzzification and Centroid for de-fuzzification (Table 1).

Table 1: The data base used developed for input and output parameters in grape vineyard

Ob.No.	INPUT (Kg/acre)	OUTPUT		
		ORGANIC NITROGEN (Kg/acre)	INORGANIC NITROGEN	
			0 days (Kg/acre)	0 - 30 days (Kg/acre)
	Nitrogen	Natural Nitrogen	Artificial Nitrogen 1	Artificial Nitrogen 2
1	0 – 60	54	2	52
2	60 – 100	45	2	44
3	100 – 140	40	2	38
4	140 – 180	36	2	35
5	180 – 220	36	2	35
6	220 – 260	32	2	31
7	260 – 300	29	2	28
8	300 – 340	25	2	25
9	340 – 380	22	2	21
10	380 – 1000	18	2	17

Note: N: Nitrogen, NL: Natural, AN1: Artificial Nitrogen 1, AN2: Artificial Nitrogen 2.

From the table 1, it is seen that as the nitrogen levelin the soil increases,the requirement of additionalnatural fertilizer through the soil goes on decreasing.The same trend was also observed during the growth stage of 0-30 days after back pruning. However, during the initial stage of vine growth (0 days after back pruning), use of artificial nitrogen remains constant.

The fuzzy system represents structured information in the form of a fuzzy structure (FS). The input and output universe are modeled using FS [13, 17-19]. It consists of fuzzy domains such as: MOL (Most Low), VL (Very Low), JL(Just Low), ML (Moderate Low), L(Low),N(Normal),H**(**High), MH(Moderate High),JH (Just High),VH(Very High),MOH(Most High).The geometrical representation of a function operating on Fuzzy System is known as Fuzzification.

Nitrogen domain is used as input for FIS which may carry out the fuzzification for suggestion of nitrogen to the soil. The suggestion of nitrogen varies in the range of 0kg/acre to 1000 kg/acre.

Table 2: Membership functions for input variable Nitrogen measured from soil

Sr.No.	Nitrogen Measured (Membership Function)	Fuzzy sets for Nitrogen (kg /acre)
1	μ_{MOL}	L (0, 0, 60)
2	μ_{VL}	Λ (0, 60, 100)
3	μ_{JL}	Λ (60, 100, 140)
4	μ_{ML}	Λ (100, 140, 180)
5	μ_{L}	Λ (140, 180, 220)
6	μ_{N}	Λ (180, 220, 260)
7	μ_{H}	Λ (220, 260, 300)
8	μ_{MH}	Λ (260, 300, 340)
9	μ_{JH}	Λ (300, 340, 380)
10	μ_{VH}	Λ (340, 380, 1000)
11	μ_{MOH}	⅃(380, 1000, 1000)

Depending upon the nitrogen value in the soil of individual garden, the doses of nitrogen through organic and inorganic grades are to be supplied. The linguistic values for suggested nitrogen are chosen as:

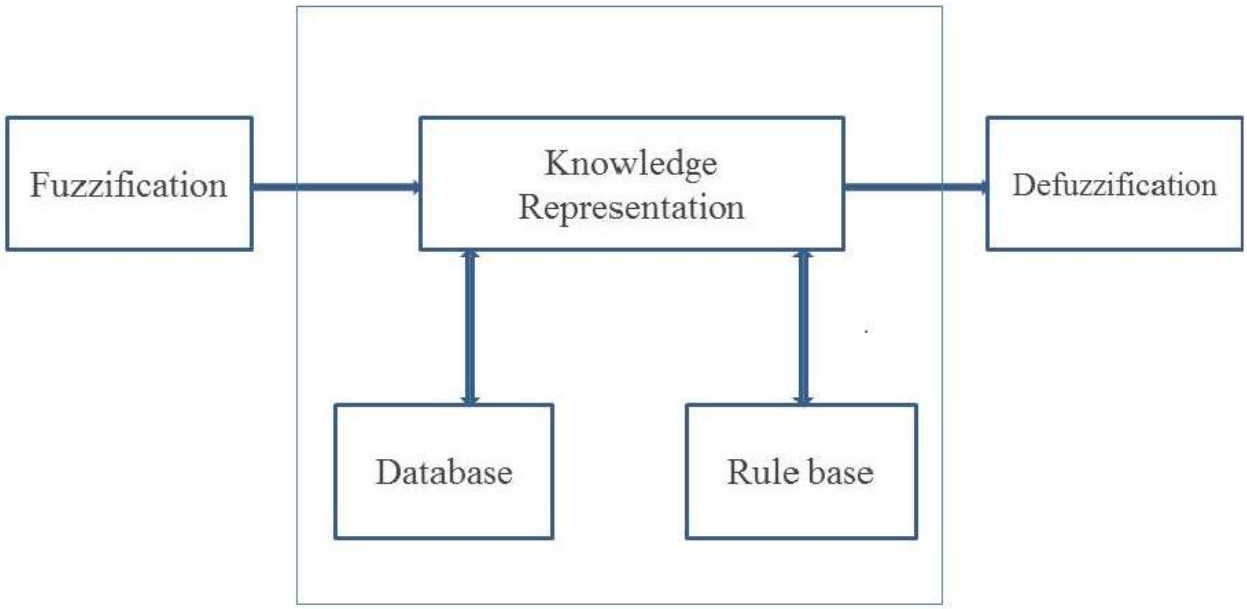
MOH (Most High), VH (Very High), JH(Just High), MH (Moderate High), H (High), N (Normal), L (Low), ML (Moderate Low), JL (Just Low),VL (Very Low), MOL (Most Low). The values of NL are within the range of 18-54 kg/acre. Here AN1 is constant as 2kg/acre, while AN2 range is fromfor 17-52 kg/acre.

III. Fuzzification

Table 3:Membership functions for output variables using organic and inorganic fertilizer

Sr.No.	Organic and Inorganic fertilizer(Membership Function)	Fuzzy set	
		Basal Organic before pruning(NL) (kg /acre)	Inorganic 30 days after pruning(AN2) (kg /acre)
1	μ_{MOH}	L(54, 54, 45)	L(52, 52, 44)
2	μ_{VH}	Λ (54, 45, 40)	Λ (52, 44, 38)
3	μ_{JH}	Λ (45, 40, 36)	Λ (44, 38, 35)
4	μ_{MH}	Λ (40, 36, 36)	Λ (38, 35, 35)
5	μ_{H}	Λ (36, 36, 32)	Λ (35, 35, 31)
6	μ_{N}	Λ (36, 32, 29)	Λ (35, 31, 28)
7	μ_{L}	Λ (32, 29, 25)	Λ (31, 28, 25)
8	μ_{ML}	Λ (29, 25, 22)	Λ (28, 25, 21)
9	μ_{JL}	Λ (25, 22, 18)	Λ (25, 21, 17)
10	μ_{VL}	Λ (22, 18, 16)	Λ (21, 17, 15)
11	μ_{MOL}	⅃(18, 16, 16)	⅃(17, 15, 15)

IV. Block diagram of Fuzzy Inference System



V. Fuzzy Inference System

For Fuzzy Inference System triangular membership functions are used for input and output variables. For Defuzzification, Centroid method is used. The system results are carried out by using MATLAB Software GUI tool.The fuzzy rule based table is developed as shown.

Table 4: FuzzyRule baseTable:

If N is	MOL	Then NL is	MOH	And AN1 is	C	And AN2 is	MOH
	VL		VH		C		VH
	JL		JH		C		JH
	ML		MH		C		MH
	L		H		C		H
	N		N		C		N
	H		L		C		L
	MH		ML		C		ML
	JH		JL		C		JL
	VH		VL		C		VL
	MOH		MOL		C		MOL

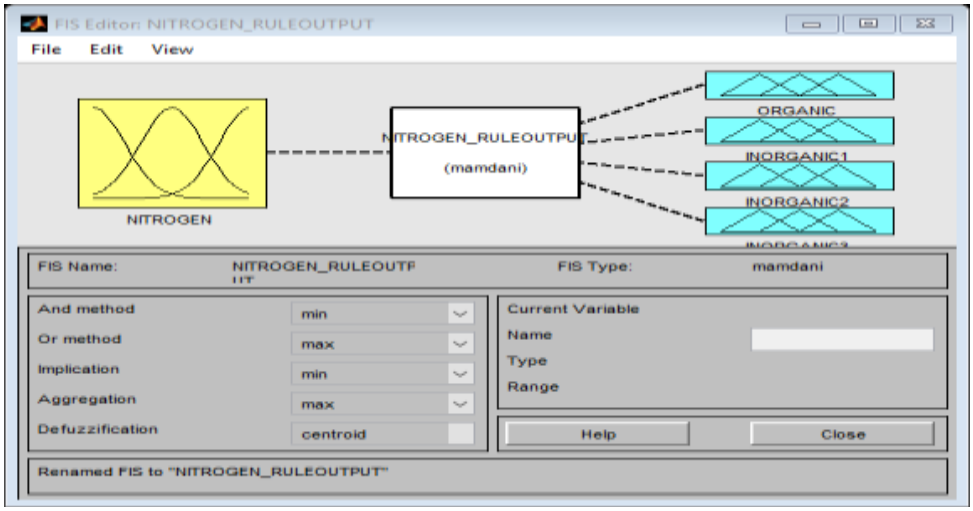
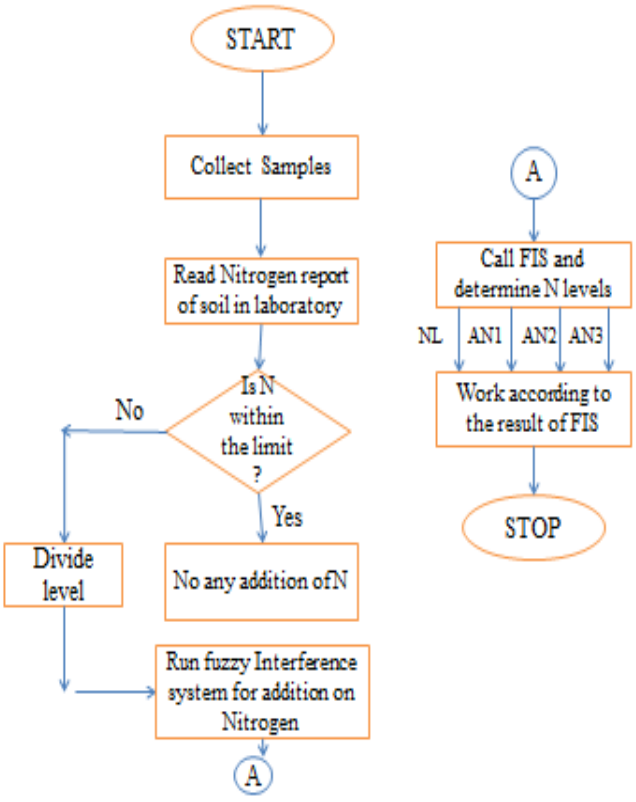


Fig. 1: Fuzzy Inference System



VI. Working flow of FIS

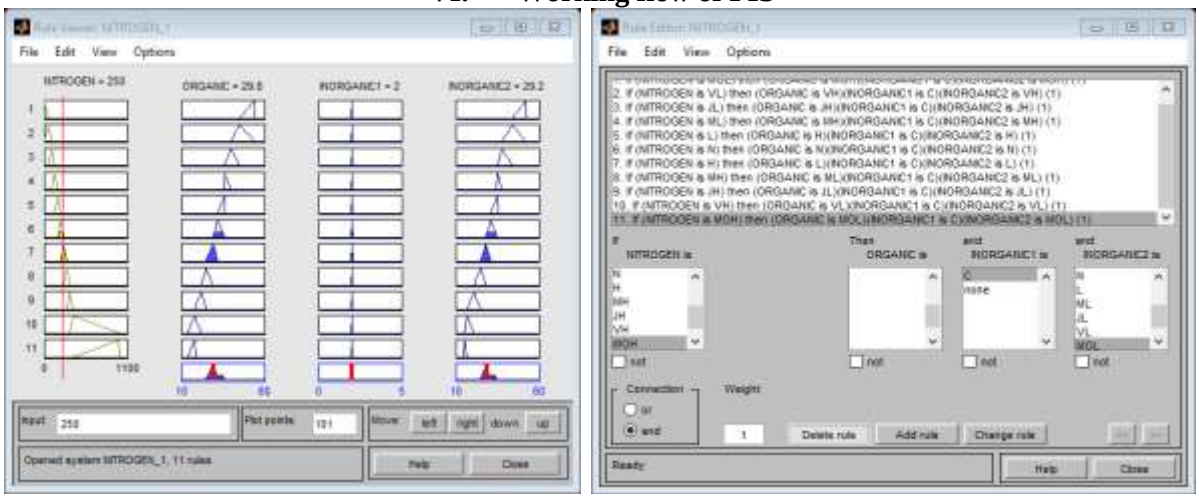


Fig. 2: Rule base for inference system

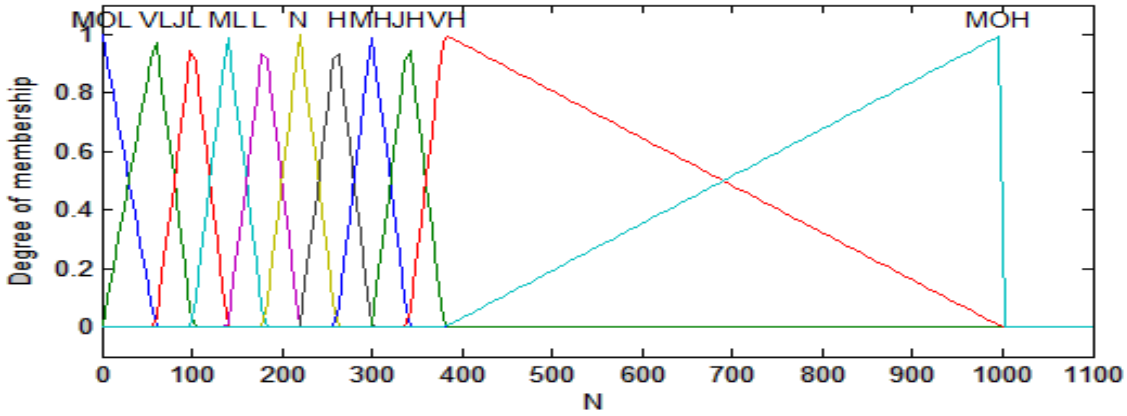


Fig.3: Fuzzy membership function for nitrogen range of a soil

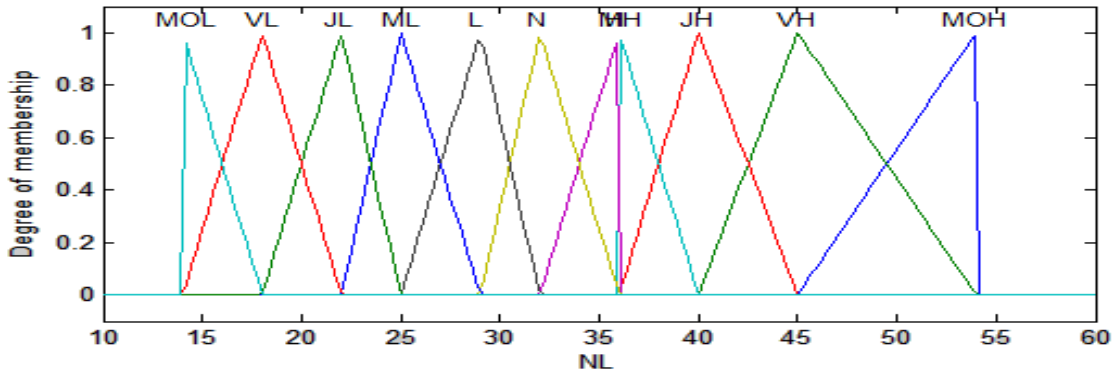


Fig. 4: Fuzzy membership function for Organic fertilizer range of a soil

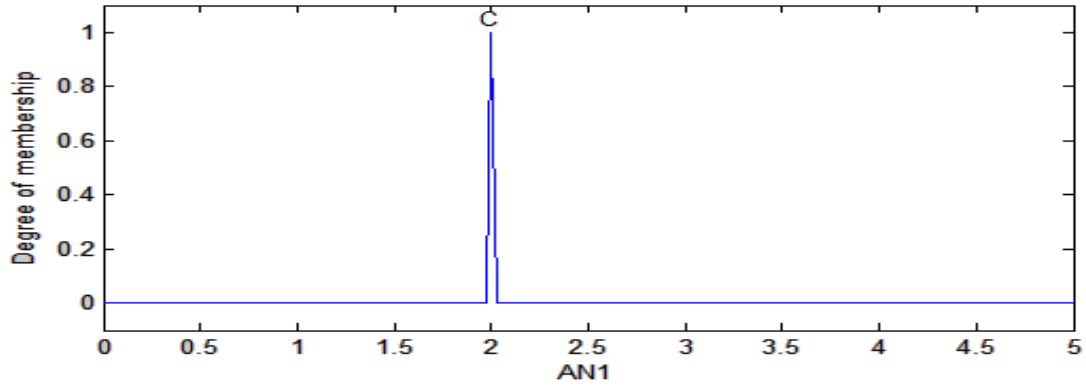


Fig. 5: Fuzzy membership function for Inorganic fertilizer range of a soil

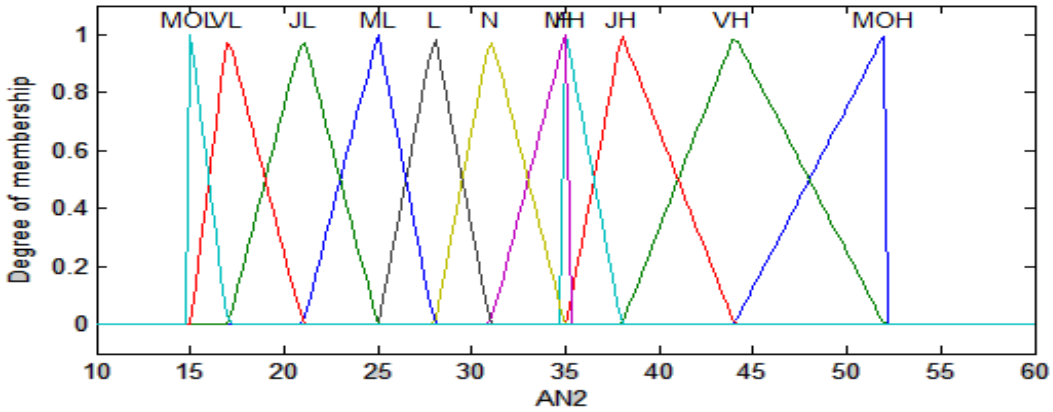


Fig. 6: Fuzzy membership function for Inorganic fertilizer range of a soil

VII. Practical Results for Suggestion of NL, AN1 and AN2

The data given in the table 5 shows suggested value for NL, AN1, and AN2 based on the status of nitrogen available in the soil sample analyzed in laboratory.The NL and AN2 vary significantly. The values obtained in the results obtained through laboratory are presented in the range. However, the data using FIS system gives requirement of exact quantity of particular fertilizer during the season. This can also helps in saving the cost involved in the use of fertilizer thus reducing the cost of production (Table 5).

Table 5: Suggestion of NL, AN1 and AN2

Ob. No.	Input Farmer Data	NL(kg/acre)	AN1(kg/acre)	AN2(kg/acre)
1	50	46.18	2	44.82
2	75	44.60	2	43.40
3	110	40.18	2	39.07
4	140	37.16	2	35.83
5	212	32.38	2	31.48
6	250	29.76	2	29.16
7	300	25.33	2	24.66
8	315	23.85	2	23.00
9	340	21.66	2	21
10	385	17.99	2	17.66
11	615	17.63	2	17.50
12	715	17.29	2	17.35
13	825	16.80	2	17.09
14	905	16.19	2	16.60
15	1000	15.16	2	15.50

VIII. Defuzzification

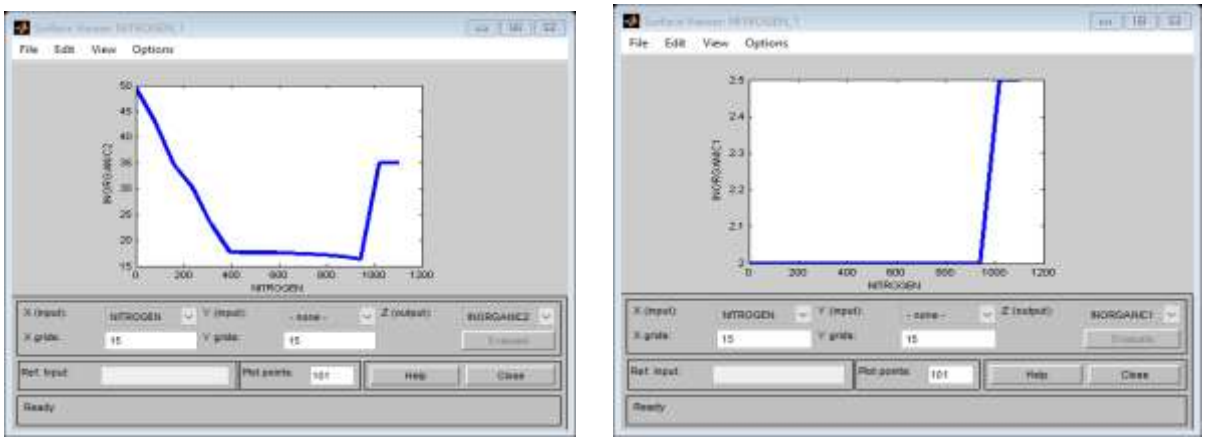


Fig.7: Surface viewer of the system

IX. Conclusion

The soil analysis laboratory does not indicate how much quantity of fertilizer to be used for increasing the quantity of use the nitrogen. The use of FIS system can help to suggest the accurate quantity of nitrogen to be used in the soil. This reduces the cost of production of grapes.

References

[1.] Christensen, L. P., A. N. Kasimatis and F. L. Jensen. 1978. Grapevine nutrition and fertilization in the San Joaquin Valley. 40 pp. Calif. Div. Sci. Publication 4087.

[2.] Winkler, A. J., J. A. Cook, W. M. Kliewer, and L. A. Lider.1974. General viticulture. 710 pp. University of Calif. Press, Berkeley and Los Angeles). Conradie W. J. Seasonal uptake of nutrients by Chenin Blanc in sand culture:I. Nitrogen. S. Afr. J. Enol. Vitic. 1:59-65 (1980).

[3.] Conradie, W. J. The uptake and distribution of N enriched nitrate by three rootstock cultivars grafted to Chenin Blanc. S. Afr. J. Enol. Vitic. 4:45-4l7 (1983).

[4.] Kliewer, W. M. Annual cyclic changes in the concentration of free amino acids in grapevines. Amer. J. Enol. Vitic. 18-126:137 (1967).

[5.] Peacock, W. L., L. P. Christensen, and F. E. Broadbent. Uptake, storage, and utilization ofsoilapplied nitrogen by Thompson Seedless as affected by time of application. Am J. Enol.Vitic. 40:16-20 (1989).

[6.] Bill Peacock, Pete Christensen, and Donna Hirschfelt,Best Management Practices for Nitrogen Fertilization of Grapevines,University of California Cooperative Extension, Pub. NG4-96).

[7.] Kwang H. Lee, First Course on Fuzzy Theory and Applications 2005. ISBN:3-540-22988-48. "Grapes and Their Management", Shruti Publication, Jaipur, Dr. T. V. Sathe, Dept. of Zoology, Shivaji University, Kolhapur, 2010.

[8.] Nutrition of Fruit trees, Kalyani Publisher, New Delhi, G. S. Nijjar, Panjab Agriculture University, Ludhinana, India, 1990.

[9.] R.G. Maiti, Fruit Crops of India, Kalyani Publisher, New Delhi, 2007.

[10.] Emily Hoover and etl.,Grape IPM Guide for Minnesota Producers Departments of Horticultural Science, University of Minnesota. Agrios, G.N. 2005, Plant Pathology, Fifth Edition, Elsevier Academic Press, pg. 483-484.

[11.] Wayne F. Wilcox, Professor, Department of Plant Pathology, Cornell University, NYSAES, Geneva, NY Grapevine Powdery Mildew Uncinula necator (Schw.) Burr. Disease Identification Sheet No. 102GFSG-D2, 2003.

[12.] Cultural Practices for Crimson Seedless Table Grapes, Nick Dokoozlian, Bill Peacock,

[13.] GRAPE NEWS, A Publication of National Research Centre for Grapes, Pune Vol. 9 (2), April – June, 2005.

[14.] A HISTORY OF GRAPE PRODUCTION AND WINEMAKING IN CANTERBURY, NEW ZEALAND, 1840-2002, Rupert Tipples, Research Report 1/2002, Farm and Horticultural Management Group Lincoln University, ISSN 1174-8796.

[15.] OVERVIEW OF THE FITZROY BASIN AND OPPORTUNITIES FOR OFFSET TRADING, RESEARCH REPORT No. 1, John Rolfe, Khorshed Alam and Jill Windle

[16.] Production Guide for Organic Grapes, NYS IPM Publication, No. 224, Integrated Pest Management, Cornell University, New York, 2010.

[17.] G.J. Klir and B. Yuan, "Logic Fuzzy Sets and Fuzzy," Prentice-Hall of India, New Delhi, ch.1-12, pp.11-338, 1997
[18.] Fuzzy System Basic, Zadeh.
[19.] T. Clifford, G.L. Bodhe and V.K. Kondawar "Towards Intelligent Control System Design: The Fuzzy Paradigm" Journal of .Instrument. Society of India. Vol-28(1), pp. 1-11, 1998.
[20.] Ibrahim, Fuzzy Electronics, PHI Edition, 2000.
[21.] Roll of Membership functions in Fuzzy Logic for Prediction of Shoot Length of aMustard Plant Based on Residual Analysis, World Academy of Science, Engineering and Technology14, 2008, Satyendra NathMandal, J. Pal Choudhury, Dilip De, and S. R.BhadraChaudhuri
[22.] Agro-Informatics and Precision Agriculture 2012 (AIPA 2012)
[23.] FUZZY LOGIC BASED IRRIGATION CONTROL SYSTEM USING WIRELESS SENSOR NETWORK FOR PRECISION AGRICULTURE PrakashgoudPatil, UmakantKulkarni, B.L. Desai, V.I. Benagi and V.B. Naragund