Fuzzy Inference System for productivity and fertility of soil

[1]Miss Maya V. Mawale, [2]Dr. Vinay Chavan

[1]Researcher Department of Computer Science, Adarsha Science J.B.Arts and Birla Commerce, Mahavidyalaya Dhamangaon Rly-444709 (India) M.S

[2]Associate professor, Dept. Of Computer Science &IT, Seth Kesarimal Porwal College, Kamptee, Nagpur M.S.

***Abstract* - An assimilated approach to precision agriculture system is used for prediction of soil productivity and soil fertility using expert knowledge as one of its components for achieving sustainability. This prediction system is implemented with the help of fuzzy logic theory. Methodolgy consist of selection of dependent and independent soil parameter, fuzzification, fuzzy inference rule,memebership function and defuzzification process. This work shows that fuzzy inference system is an efficient method to demonstrate defuzzification of expert knowledge using fuzzy inference process. The paper developed a fuzzy logic model using mamdani fuzzy inference system The inference rules are framed using expert knowledge in the form of IF...THEN structures. FIS tool in Matlab is used for building a prediction model. Fuzzy model is used for the prediction of soil productivity using essential soil parameter in percentage.**

***Keywords* - Defuzzification,Fuzzification,Fuzzy inference system, Fuzzy logic controller,Multiple input single output,Soil productivity,Soil ferility.**

I. INTRODUCTION

Fuzzy set theory and concept of a linguistic variable is derived values of variables and made its use for expanded application area. Fuzzy logic makes conversion of imprecise information to precise one, consists of capability to design rational decisions containing imperfect information. Uncertainty, imprecision, incompleteness, risk management, partial true and vice versa is an attribute of information in Fuzzy systems[1]. Fuzzy inference systems (FIS) have been successfully applied as control system in different area such as automatic control, data classification, decision system, expert systems etc. Because of its multidisciplinary nature, FIS are associated with fuzzy rule-based systems, fuzzy expert systems, fuzzy modeling, fuzzy associative memory, fuzzy logic controllers, and simply fuzzy systems[2].

Fuzzy logic is used to provide way of importance of precision and the application of fuzzy set theory to many control problems. Concept of fuzzy logic is widely used in control system, precision system, and prediction system for design, development and decision making. Real system is very complex system hence prediction related yield and production is always done with uncertainties. Fuzzy logic design is the best approach to get precise, accurate result and conclusions[3].

Soil productivity profiles of the any region can be used for by developing proposed fuzzy logic system[4]. Prediction system using fuzzy inference system model for soil fertility helps and tests the fertility and fertilizer requirement and productivity yield[5,6]. An evaluation of Soil fertility was proposed using soil organic carbon, potassium, phosphorus and salinity factors by fuzzy logic [7]. Neuro-Fuzzy Modeled was proposed for crop yield prediction[8] and soil quality assessment by using fuzzy modeling[9]. Fuzzy logic model can be used to combine soil and crop growth information for estimating optimum N rate for corn[10].Decision support system for soil using prediction, modeling for suitability of crop can be develop for soil properties using weighted average model and linear regression [11,12].

The researcher wants to develop a computer model and simulates using fuzzy logic that helpful in finding solution for MIMO system and its productivity, suitability, requirement analysis. The model will work on existing properties of the system by mapping the knowledge and experience used in the traditional and scientific method and applying it to different application areas. The model will determine essential components useful for productivity, suitability and requirements analysis of the application area which will helps in profitability, productivity, and quality.

The present study of computer modeling and simulation for complex analysis of soil mensuration is based on fuzzy data sets and fuzzy logic. The model use to predict the cumulative solute in the soil profile for different scenarios such as soil fertility, productivity, crop suitability, and fertilizer requirements in the region.

As soil fertility represents crop productivity and soil productivity suitable for crop choice, fertilizer requirement to fulfill its deficiency hence MIMO system is a necessity of current design. Same model gives prediction of lots of problem and save development time. Previous studies on soil productivity do not consider all nutrient levels of soil properties and soil parameter which are useful for soil productivity, accuracy. Present study considers most of the parameters and nutrients deficiencies. As soil properties is highly variable spatially and temporally, measuring these properties both time consuming and expensive and hence researcher has chooses a soil parameters and its properties for the evaluation and testing of design model.

II. MATERIAL AND METHODS

Data analysis is carried out on soil sample collected from Krushi Vighan Kendra Ghatkhed Amravati. Laboratory analysis is carried out through soil testing process. Preliminary data analysis is carried out for data preparation in which classification of whole data is carried out on village wise.

Statistical analysis is done by calculating mean, standard deviation, skewness and coefficient of variance.The standard deviation, in conjunction with the mean, provides a better understanding of the data.In statistical analysis, regression analysis is used for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable.Regression analysis is used for prediction and forecastingand also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships.

A field study is carried out to collect information for assessing soil parameter. Soil parameters analysis is done on 902 soil samples collected from Krushi Vighan Kendra, Ghatkhed, Amravati. The values of C, N, P, K, Mg, C, Fe, Cu, Zn, B, Mo, Lime, Saline, CEC, Mn, OM and pH of soil sample collected for the year 2011-2012 and 2012-2013 and these soil parameters are considered as a dependent and independent parameter (as per expert knowledge) that have direct/indirect effects on productivity.

Macronutrients are elements required in larger quantities and micronutrients are elements required in smaller quantities. This division does not mean that one nutrient element is more important than another, just that they are required in different quantities and concentrations. Developed FIS is based on Mamdani inference system consist of FIS editor, Membership function, rule editor, surface generation. Different defuzzification methods are used to calculate soil productivity as output. Methodology is used for model development of FIS with mathematical formula. Membership function is used in FIS is specified by combination of fuzzy clustering and expert knowledge. Model is validated by comparing prediction output with actual output. Model working is also tested on testing data other than training data using regression analysis.

FIS Model

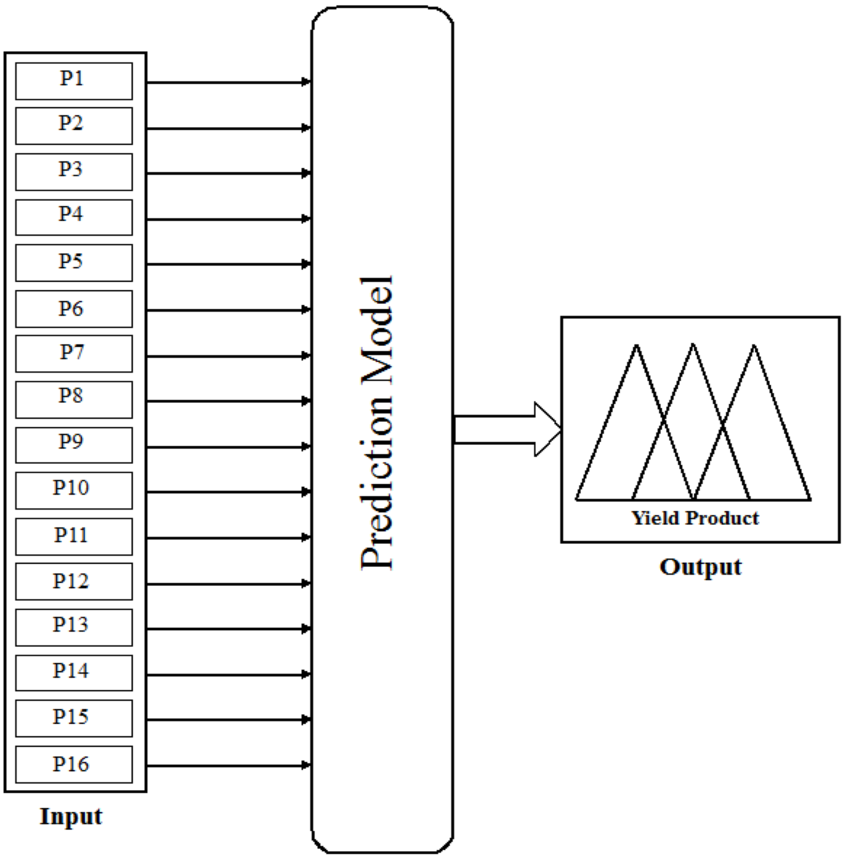


Fig 1 Design architecture of Fuzzy inference system

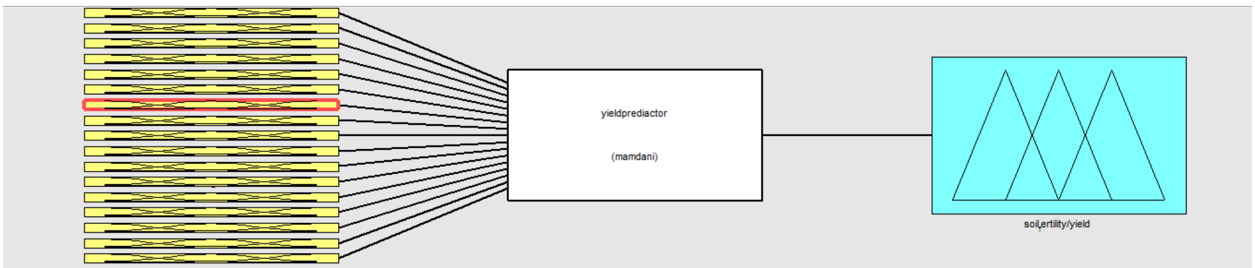


Fig 2 Developed Fuzzy Inference System

Mambership Function

Membership function are specified for all 17 input and one output soil parameter,few of them are presented as below.

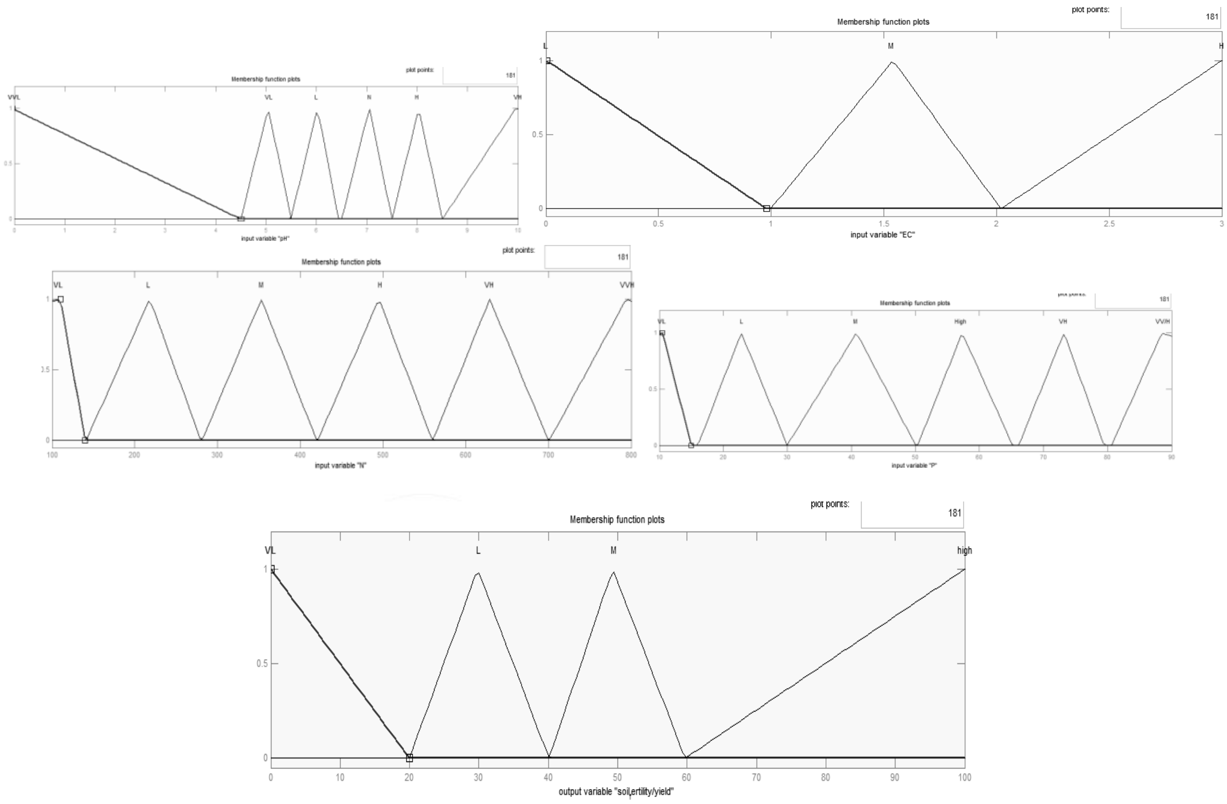


Fig 3 Membership function for input and output parameter

Rule Editior

Rules are created with the help of Expert knowledge.Total number of rules are 207.

1. If (P is VL) then (soil_fertility/yield is VL) (1)
2. If (pH is N) and (P is VL) then (soil_fertility/yield is L) (1)
3. If (pH is VVL) then (soil_fertility/yield is VL) (1)
4. If (pH is VL) then (soil_fertility/yield is L) (1)
5. If (P is L) then (soil_fertility/yield is L) (1)
6. If (P is VL) and (K is VL) then (soil_fertility/yield is VL) (1)
7. If (pH is VH) and (OM is H) and (Lime is M) and (Saline is M) then (soil_fertility/yield is high) (1)

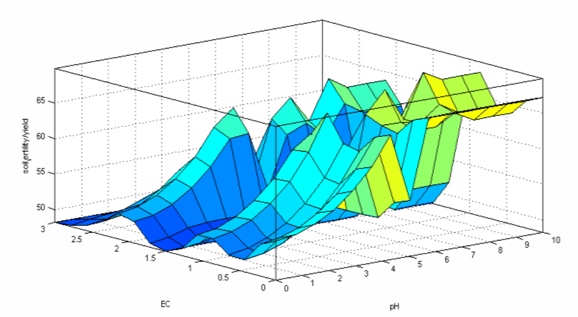
If (pH is L) and (OM is L) and (Lime is L) and (Saline is L) then soil_fertility/yield is L) (1)

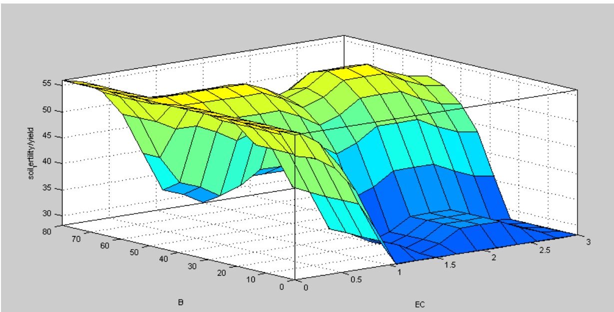
If (pH is L) and (OM is H) and (Lime is M) and (Saline is M) then (soil_fertility/yield is high) (1)

If (pH is L) and (OM is M) and (Lime is H) and (Saline is H) then (soil_fertility/yield is high) (1)

3D Surface Viewer For FIS

The Surface Viewer is use for presenting the mapping from two inputs to one output. This capability allows keeping the calculation time reasonable for complex problems three dimension view.





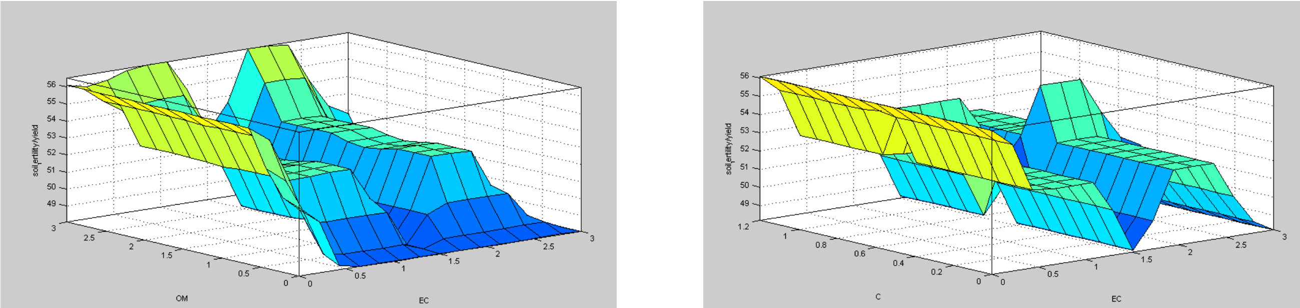


Fig 4

The Rule Viewer allows you to interpret the entire fuzzy inference process at once. The Rule Viewer also shows how the shape of certain membership functions influences the overall result.

Ruler Viewer

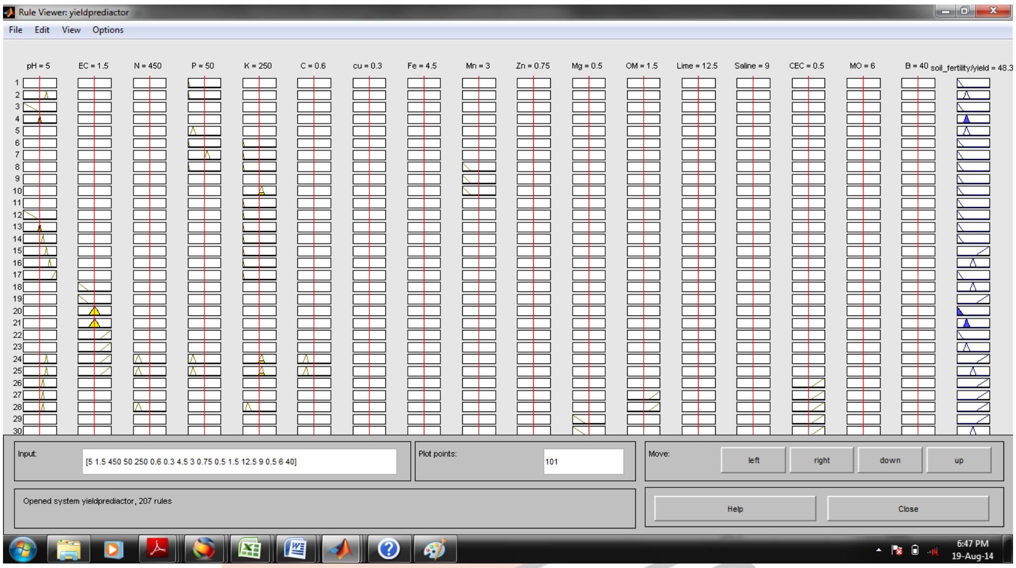


Fig 5

III. DEFUZZIFICATION ANALYSIS

Model development is for calculating productivity profile of different types of soils present in Krushi Vighan Kendra Ghatkheda Amravati region using a fuzzy logic system, on the basis of the mean analysis values of dependent variables and independent variables. Despite the fact that factors which are related with environment and soil structure which are effective for soil productivity, the system is structured to accept only the values of independent variables salinity, lime, organic matter and CEC, dependent variables EC, N, P, K, C, Cu, Fe, Mg, Mn, B and Mo content factors as input data. Complex analysis is performed over different soil types were entered as input data into the Seventeen input and one-output so as tocalculate productivity values. Productivity values were obtained as a percentage and varied between 42.23% and 51.63%. Village Salanapur soil is found to be the most productive soil (51.63%).

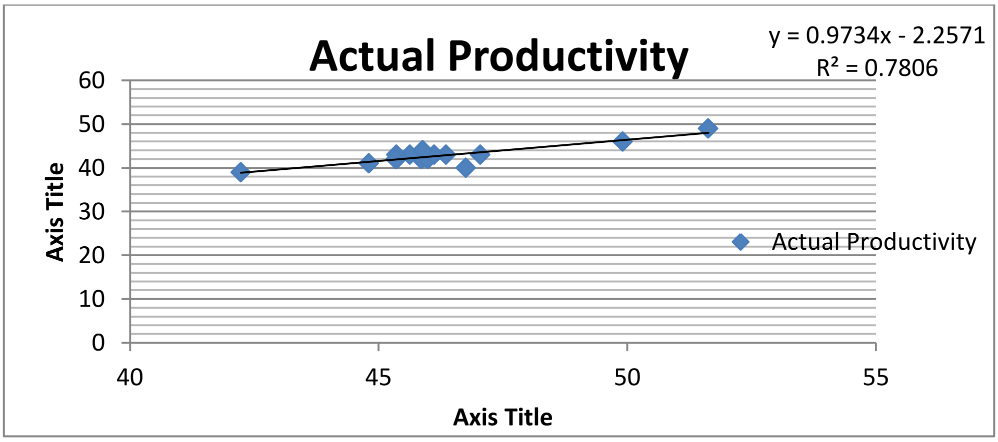


Fig 6

The relationship between actual and predicted soil productivity are shown in figure and the coefficient of correlation between actual and predicted soil productivity is R=0.78.

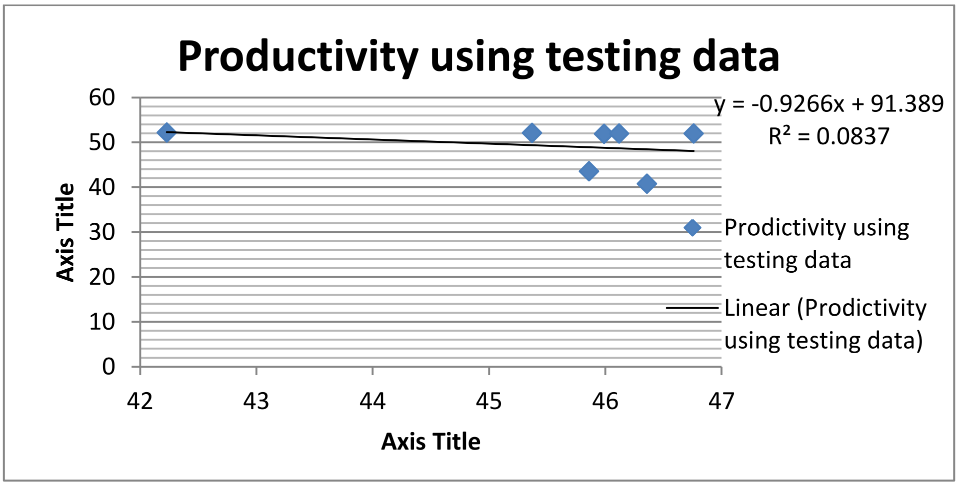


Fig 7

The relationship between actual and predicted soil productivity using data other than training data and termed as testing data are shown in figure and the coefficient of correlation between actual and predicted soil productivity is R=0.083. Accuracy of regression equation for the prediction of soil productivity using R2 and Root mean square Error (RMSE) is calculated

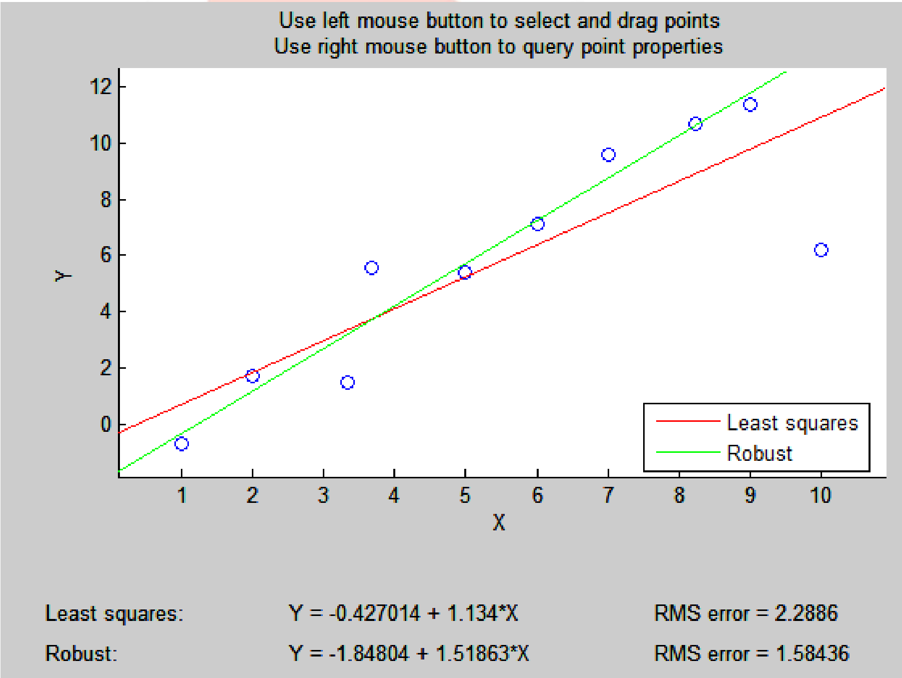


Fig 8

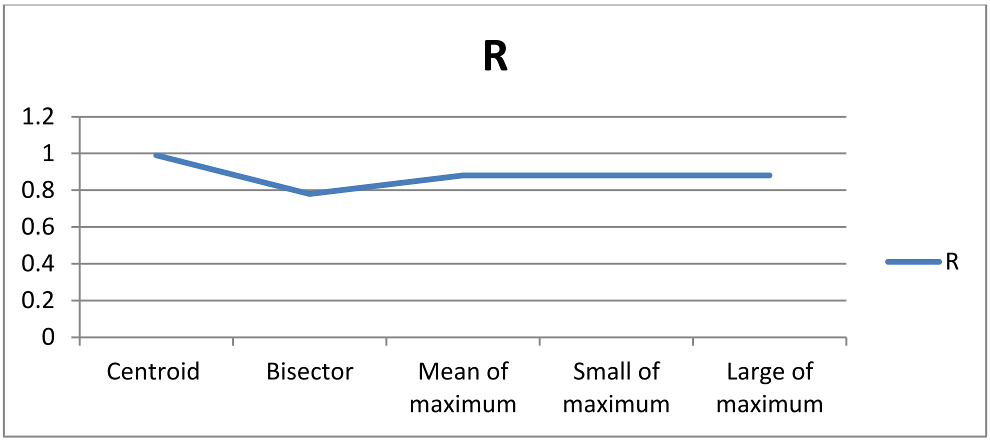


Fig 9

IV. CONCLUSION

The validity of the basic model is conducted. To make the model data driven, experimental data is used. The model is developed using MATLAB. The result of prediction is excellent, particularly with Centroid methods of defuzzification techniques. Furthermore, the average of error for prediction of the soil productivity is 8.2%. Finally it has been felt that application of fuzzy logic for prediction of soil productivity and fertility would work well for modeling of soil productivity. FIS based model is used to predict soil productivity by making use of available experimental data. These data are divided into training data and testing data. Training data are used in developing the (FIS) based model. In validating the (FIS) based model testing data are used. Validation of model is performed on testing data and training data. It is found that the model is successfully run on a training data as well as testing data. But it works well on testing data because regression analysis result of a testing data show R2=0.08. The result shows that the model is helpful in determining different output parameters used for decision making. The expert system predicts a productivity potential using testing data other than data use for model and uses a linear regression model to link the PP given predicted soil productivity to actual productivity (AP) by finding equation

Pp=0.085Ap+46.15 and $R^2 = 0.16$. Accuracy of regression equation for the prediction of soil productivity is calculated using R2 and Root mean square Error (RMSE) is 2.21 and its robustness error is 1.51. The results of prediction are excellent, particularly with Centroid of defuzzification techniques, average productivity is 46.29%. It gives better result than training data For FIS.

REFERENCE

[1] Kailan Shang, Zakir Hossen, Applying Fuzzy Logic to Risk Assessment and Decision-Making, November 2013.

[2] Sandeep Kaur, Gurpreet Bharti, Two Inputs Two Output Fuzzy Controller System Design using MATLAB, IJAEST Vol. 2 No. 3 Aug-Oct 2012 Vol. 2 No. 3, Aug-Oct 2012.

[3] Feng Qi, A-Xing Zhu, Mark Harrower, James E. Bur, Fuzzy soil mapping based on prototype category theory.

[4] Nevcihan Duru,a Funda D¨okmen,bMM, ucella Canbayc and Cengiz Kurtulus¸c, Soil productivity analysis based on a fuzzy logic system J Sci Food Agric, 90, pp 2220–2227,2010.

[5] Zainb Abd Alelah,Prediction of Land Soil Erosion using Fuzzy Inference System model(FIS),KUFA Journal of Engineering Volume 4 Number 1 pp 69-80,2012.

[6] Ehsan Bijanzadeh and Marzeieh Mokarram,The use of fuzzy AHP method to assess fertility classes for wheat and its relationship with soil salinity,AJCS 7(11):1699-1706,2013.

[7] Noredin salehi1, Mehdi Ghajar Sepanlou, Behnosh Jafari Gorzin3,An evaluation of Soil fertility using soil organic carbon, potassium, phosphorus and salinity factors for rice cultivation by fuzzy logic and AHP techniques,IJACS/2013/5-19/2233-2241, 2013.

[8] D.Stathakis I Savin and T.Negre, Neuro Fuzzy Modeling for crop yield prediction IAPRS,Vol.34,part XXX.

[9] H.A. Torbert E.Krueger and D.Kurtener,Soil quality assessment using fuzzy modeling, International Agro physicsvol. 22, nr. 4, pp. 365-370, 2008

[10] N. Tremblay1, M.Y. Bouroubi, B. Panneton, S. Guillaume, P. Vigneault and C. Bélec, Fuzzy logic to combine soil and crop growth information for estimating optimum N rate for corn, EFITA conference ’09 397-404,2009.

[11] Rajeshwar G Joshi Parag Bhalchandra,Dr.S.D. Khamaitkar, Predicting suitability of crop by developing fuzzy decision support system(DSS),IJETAE volume 3 Special issue Jan 2013.

[12] A Xing Zhu,Feng Qi,Amanda Moore,James E Burt,Prediction of soil properties using membership values Geoderma, 158, 199–206, 2010.