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Incremental Techniques based on Machine Learning for Crop Yield Prediction

Vishruth B Gowda[1], Sanjana.R[2], Sanjana S.S[3], Sriranjini. R.Vasista[4], Varshitha B.R[5]

Assistant Professor, Dept. of ISE., SJB Institute of Technology, Bengaluru India[1]

U.G Students, Dept. of ISE., SJB Institute of Technology, Bengaluru India[2,3,4,5]

ABSTRACT: It's a known fact that agriculture is the backbone of the Indian economy. As per examined research, it still suffers from a large number of setbacks such as climate change, unpredictable monsoon, droughts, floods, migration of farmers towards the cities to lead risk-free and profitable jobs, and more, which leads to poor crop production eventually resulting in economical decline, inflation, starvation, etc. Forecasting or predicting the crop yield quite ahead of its harvest time would benefit the authorized strategists and farmers in taking suitable measures for selling, storage, and also for the next sowing period. Accurate prediction of the same plays an important role in 'crop production management' hence being of support to the allied industries for strategizing the logistics of their business. Hence, we've come up with a project that aims to show practical and experimental results to improve the crop yield production thus resulting in profitability to the farmers. The statistical agricultural dataset is pre-processed and classified into training and testing data. Then suitable algorithms like Random Forest Regressor and Back Propagation are applied. On comparing the respective accuracies, the yield of a crop is predicted based on weather and soil parameters. The amount of fertilizer to be used for better growth is also determined i.e the amount of potassium, phosphorus, and nitrogen required**.**

KEYWORDS: Crop Production, Random Forest Regressor, MLP Regressor.

I. INTRODUCTION

From the historical period, agriculture is considered the main tradition practiced in India. Ranking second biggest manufacturer of fruits and vegetables within the world, now it's the most vital sector of the Indian economy which provides employment to nearly 1/2 the population of the nation. Humans concerned in agriculture are the least to be looked after, even if they may be the one who feeds the whole human race. India's agricultural region is beneath disaster for almost many years now leading to increasingly more suicidal instances in farmers. This issue lies in the lack of proper information and the mundane techniques followed in farming. Also, because of the invention of recent innovative technologies and techniques the agriculture subject is slowly degrading. Due to those abundant inventions, human beingsare getting into cultivating synthetic products which might be hybrid unhealthy products. Various seasonal, economic and biological styles affect crop manufacturing., at the end leading in extraordinary loss to farmers. Those dangers can be averted or at the least.

With institutions failing to guide agriculture in terms of imparting loans and farmer welfare schemes, the time has come for the generation to take over the alternate. Information Science(/Data Science) is one such principal answer. Data analytics can help farmers display the health of plants in actual time, create predictive analytics related to yields and assist farmers to make properly knowledgeable aid control choices primarily based on the results acquired. Any farmer is interested in understanding how a lot yield he is can anticipate. The yield prediction is the primary trouble that stays to be solved based on to-be-had data. Data mining techniques are thus preferred for this purpose. Different Data Mining techniques are used and evaluated in agriculture for estimating the future year's crop production. In the olden days, yield prediction was done by considering farmer's experience in respective fields and crops. Data is the need for industries and hence, data science is one such beneficiary. After revolutionizing industries like IT, Banking, Healthcare, etc it is now time to benefit the agriculture industry. Thus we've adopted one such main topic i.e amount of crop yield using incremental techniques based on Machine Learning.

A negative yield can result in a devastating season for farmers, as well as all those entities that rely on the crops. [12] In computer science, incremental learning is a method of machine learning in which input data is continuously used to extend the existing model's knowledge i.e. to further train the model. Algorithms that can facilitate incremental learning are known as incremental machine learning algorithms.

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The motive here is to build an efficient model to predict the yield of the crop by applying multiple algorithms and compare them to know which one has less error or more accuracy and finally implementing the most accurate one for further analysis.

Noticeably in the further sections we use the dataset collected from various websites spanned over multiple states and multiple crop types. The dataset includes all crop information collected from previous years. After data collection, we extract valuable in- formation. Next as per requirement, we classify data into 2 groups - training data and testing data. Then feature extraction is done as the statistical data obtained is redundant and too large to be processed, it is first transformed into a reduced number of features. Then we train the model by applying the algorithms to the training dataset and then evaluate the testing dataset. On comparison of accuracy scores of different algorithms, the most accurate one is chosen for the main prediction model where the user will be inputting the values of temperature, rainfall, and soil pH.

Within the further section, we also see the fertilizer amount estimation. Fertilizer is an important aspect of meals production, it's far essential that fertilizer be used successfully to decrease food manufacturing charges and conserve natural resources. Consequently, green fertilizer use pertains to principles on uptake of nutrients from the soil by way of plant roots to efficient use of vitamins delivered as fertilizers. The simple and most important minerals include nitrogen, potassium, and phosphorus. If the quantity of fertilizer used is greater or less than the desired quantity, it is able to have a bad effect on the fertility of the soil, and then the crop won't supply the anticipated yield.As a result, fertilizer also counts as the first-rate component in crop yield. Consequently, weestimate the amounts of nitrogen,potassium and phosphorus to be used by collecting the preceding data. We employ the backpropagation set of rules for the same which is an idea under artificial neural network(ann).

Finally, to show the results obtained in a user-friendly manner, a simple GUI is developed using Tkinter. The crop yield estimation and fertilizer estimation have both been given separate GUIs. The output i.e yield/amount of fertilizer respectively will be printed on the same screen.

II. RELATED WORK

In paper [1] by AruvanshNigam,SakshamGarg,ArchitAgrawal,Parul Agrawal-This paper focuses on the practical application of machine learning algorithms and its quantification. The work presented here also takes into account the inconsistent data from rainfall and temperature datasets to get a consistent trend. Crop yield prediction is determined by considering all the features in contrast with the usual trend of determining the prediction considering one feature at a time.

In [2] Short Term Forecasting of Agriculture Commodity Price by Using ARIMA**:** Based on Indian Market (Anil KumarMahto, Ranjit Biswas, and M. Afshar Alam).They've used ARIMA framework to visualize the time series data. On the basis of visualization they've analyzed that whether the series is stationary or non-stationary as ARIMA model works with stationary series only. The second step of ARIMA is to stationarize the series. A series is stationary or not that depends upon expectation, var- iance and co-variance. The they've found the optimal parameter p, d, q for ARIMA and made predictions.

In [3] Crop yield prediction using machine learning: A systematic literature review (Thomas van Klompenburga ,AyalewKassahuna , CagatayCatal): To get an overview of what has been done on the application of ML in crop yield prediction, they've per- formed a systematic literature review (SLR). A Systematic Literature Review (SLR) shows the potential gaps in research on a particular area of problem and guides both practitioners and researchers who wish to do a new research study on that problem area. Their approach has been split up into three parts: plan review, conduct review, and report review.

In [4] A Survey On Crop Yield Prediction Using Machine Learning (Pooja Sachin Ji- rage ,Pratiksha Rajendra Patil , Sarika Surendra Mali, Mayuri Prakash Koshti , Snehal Sunil Kandekari , P. K. Akulwari) : Crop selector method has been implemented to minimize losses of crop when unfavorable conditions occur and they claim this selector could be used to maximize the crop yield rate when potential exists for favorable grow- ing conditions.

In [5] Performance Evaluation of Machine Learning Techniques for Mustard Crop Yield Prediction from Soil Analysis (Vaishali Pandith ,HaneetKour , Surjeet Singh , Jatinder Manhas , and Vinod Sharma): The main objective of their research work is to predict mustard crop yield from soil analysis using machine learning techniques. Aftergaining

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insight of problem domain, discussion with farmers and soil chemists and re- viewing literature; research problem has been framed out.

In [6] by Petteri Nevavuorib , Nathaniel Narraa , TarmoLipping.The main objectives are crop and weed detection, biomass evaluation and yield prediction. . In this study Convolutional Neural Networks (CNNs) – a deep learning methodology showing out- standing performance in image classification tasks – are applied to build a model for crop yield prediction based on NDVI and RGB data acquired from UAVs.

In[7] In the proposed approach by S.Nagini,Dr. T. V. Rajini Kanth,B.V.Kiranmayee, initially the raw data set was taken and it is subjected to preprocess for noise reduction and imputation methods and do refinement of data. It is further subjected to Feature selection and converted to the required format. Then it is subjected to various Regres- sion techniques and predictive models will be developed. The performances of them were compared and tested.

In[8] by Shivam Bang, Akshay Kumar Dixit ,et al. Their proposed method uses Auto Regressive Moving Average and Seasonal ARIMA models to predict temperature. A time-series created from the dataset is fed into the model to predict temperature. Simi- larly, ARMA and ARMA with exogenous variables (ARMAX) models are used to pre- dictrainfall.They've used the ARMAX model in case of rainfall so that other factors such as cloud cover, temperature and evapotranspiration can also be taken into account. They've used a fuzzy logic system to predict yield. The fuzzy model takes in the pre- dicted values from the model with least errors and gives the yield for that season. Auto Regressive Moving Average with exogenous variables(ARMAX) models are applied to the remodelled rainfall dataset. Similarly, ARMA and Seasonal Auto Regressive Integrated Moving Average (SARIMA) models are applied to the temperature data to predict rainfall and temperature.

In [9] by Karan Chaudhary, Prof. Farhana Kausar -They've tried and achieved to pre- dict crop yield by using Artificial Neural Network algorithm which is based on the human brain's biological neural network Artificial Neural Network Consist of three different layer such as Input Layer, Hidden Layer, Output Layer. Input layer is very beginning layer of neural networks that takes the input and serves that input to the sub- sequent layer of neural network. Input layer feeds the output to input of the hidden layer, and the output of which is connected to the output layer.

In [10] by Sudarshan Dutta, Somsubhra Chakraborty, et al. The problem in yield gap of maize in eastern India is considered a complex interplay of climatic variations, soil fertility gradients, differential management intensities and farmer socioeconomics. This study has drawn upon a host of complex interacting yield determining factors, using machine learning approaches like PSR, C&RT, RF, SVM, and ANN to identify important biophysical, socio-economic, and crop management factors for explaining maize yield.

III. PROPOSED METHODOLOGY

A. *Data Set description:*

The data in Table I is data used to predict crop yield based on 9 attributes. These 9 attributes are state, district, year, season, crop, temperature, humidity, soil moisture, and area, production. Using this data we can apply a machine learning model as well as train it and can predict the yield/production. From Table II we can estimate the amount of fertilizer to be used to get the proper yield. The input parameters are the quantity of nitrogen, phosphorus, and the output is the amount of the respective fertilizer that should be used. Here in the input parameters very high, high, above average, below average, low, and very low quantity present in the soil are de- noted as 1, 2, 3, 4, 5, 6 represents the respectively.

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State_Name	District_Name	Crop_Year	Season	Crop	Temperature	humidity	soil moisture	area	Production
Andhra Pradesh	ANANTAPUR	2014	Kharif	Arhar/Tur	36	35	45	37562	4845
Andhra Pradesh	ANANTAPUR	2014	Kharif	Bajra	37	40	46	1752	1028
Andhra Pradesh	ANANTAPUR	2014	Kharif	Brinjal	36	41	50	320	7596
Andhra Pradesh	ANANTAPUR	2014	Kharif	Cabbage	37	42	55	10	123
Andhra Pradesh	ANANTAPUR	2014	Kharif	Cashewnut	36	40	54	19	7
Andhra Pradesh	ANANTAPUR	2014	Kharif	Castor seed	34	45	52	10320	5903
Andhra Pradesh	ANANTAPUR	2014	Kharif	Coriander	34	55	62	162	84
Andhra Pradesh	ANANTAPUR	2014	Kharif	Cotton(lint)	35	50	59	73734	103779
Andhra Pradesh	ANANTAPUR	2014	Kharif	Cowpea(Lobia)	25	55	55	982	410
Andhra Pradesh	ANANTAPUR	2014	Kharif	Dry chillies	36	35	45	2799	11848
Andhra Pradesh	ANANTAPUR	2014	Kharif	Grapes	37	40	46	309	6886
Andhra Pradesh	ANANTAPUR	2014	Kharif	Groundnut	36	41	50	550794	148714
Andhra Pradesh	ANANTAPUR	2014	Kharif	Horse-gram	37	42	55	3692	1658
Andhra Pradesh	ANANTAPUR	2014	Kharif	Jowar	36	40	54	13189	4234
Andhra Pradesh	ANANTAPUR	2014	Kharif	Lemon	34	45	52	416	3618
Andhra Pradesh	ANANTAPUR	2014	Kharif	Maize	34	55	62	16839	42687
Andhra Pradesh	ANANTAPUR	2014	Kharif	Mango	35	50	59	11278	70939
Andhra Pradesh	ANANTAPUR	2014	Kharif	Mesta	25	55	55	15	106
Andhra Pradesh	ANANTAPUR	2014	Kharif	Moong(Green Gram)	36	35	45	2428	2994
Andhra Pradesh	ANANTAPUR	2014	Kharif	Onion	37	40	46	1969	35214
Andhra Pradesh	ANANTAPUR	2014	Kharif	Other Kharif pulses	36	41	50	25	2

Fig. 1. Sample dataset for crop data

n	p	k	amt of n	amt of p	amt of k
3	5	6	64	50	60
1	4	2	40	46	30
5	1	5	93	16	32
3	1	3	63	20	39
4	6	6	87	37	39
2	1	1	65	19	32
3	5	6	64	50	60
1	4	2	40	46	30
5	1	5	93	16	32
3	1	3	63	20	39
4	6	6	87	37	39
2	1	1	65	19	32
3	5	6	64	50	60
1	4	2	40	46	30
5	1	5	93	16	32
3	1	3	63	20	39
4	6	6	87	37	39
2	1	1	65	19	32
3	5	6	64	50	60
1	4	2	40	46	30

Fig. 2 Sample Fertilizer data

B. *Imported packages:*

- Numpy
- Pandas
- Matplotlib.pyplot
- Scikit-learn
- Jupyter

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The data related to the yield and fertilizer is stored in the csv/xlsx holding attributes state_name, district_name, crop_year, season, crop, temperature, humidity, soil moisture, area, production, and another data set containing level of nitrogen , level of phosphorus, level of potassium in the soil, amount of phosphorous, potassium, nitrogen to be used to enhance fertility of the soil.

C. *Architecture:*

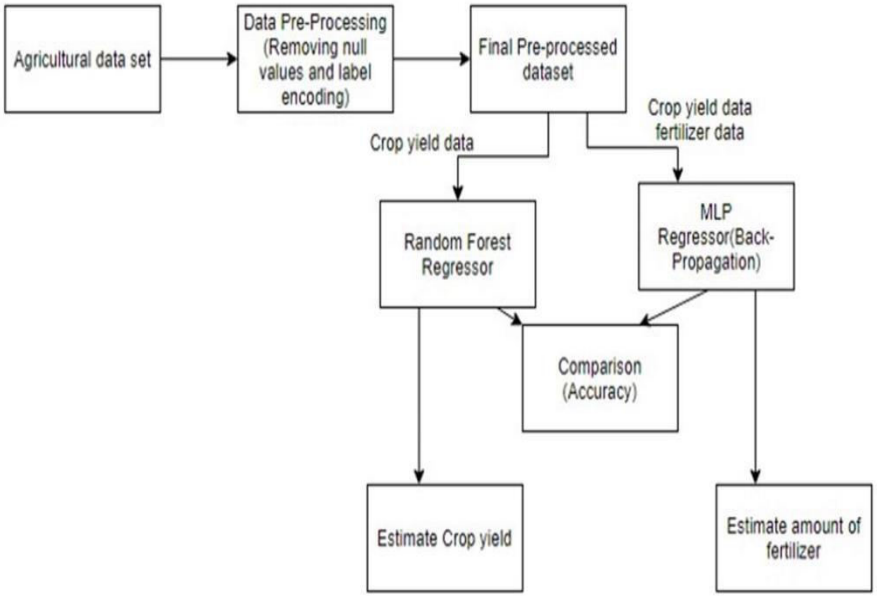

Fig. 3. Block diagram

D. *Data Collection:*

To predict the crop yield and the amount of fertilizers, the first step is to collect the datasets. We collected from various sources like Kaggle, GKVK, DES, agmarknet.gov.in and krishimaratavahini. These included information like temperature, humidity, area and yield of the previous years.

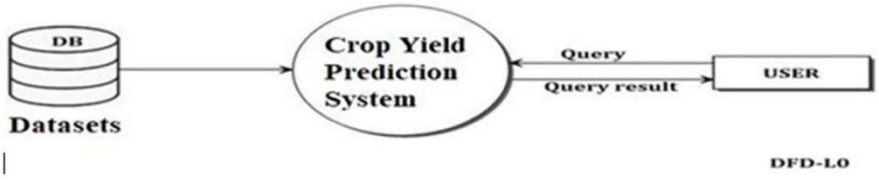

Fig.4.DFD of Data collection

The data used in the dataset are initialized with an integer for computation. For instance, the data of all the crops are initialized with a unique number. Similarly for season, crop, area and more.

E. *Data preprocessing:*

Here we remove the unwanted attributes from the datasets. Feature extraction is done in order to extract only the attributes that affect the yield of a crop like rainfall, temperature, location, area, production, and yield. Label encoder is used to convert the attributes of non-numeric type to numeric. This is done to train the data easily and enabling machines to interpret the same.

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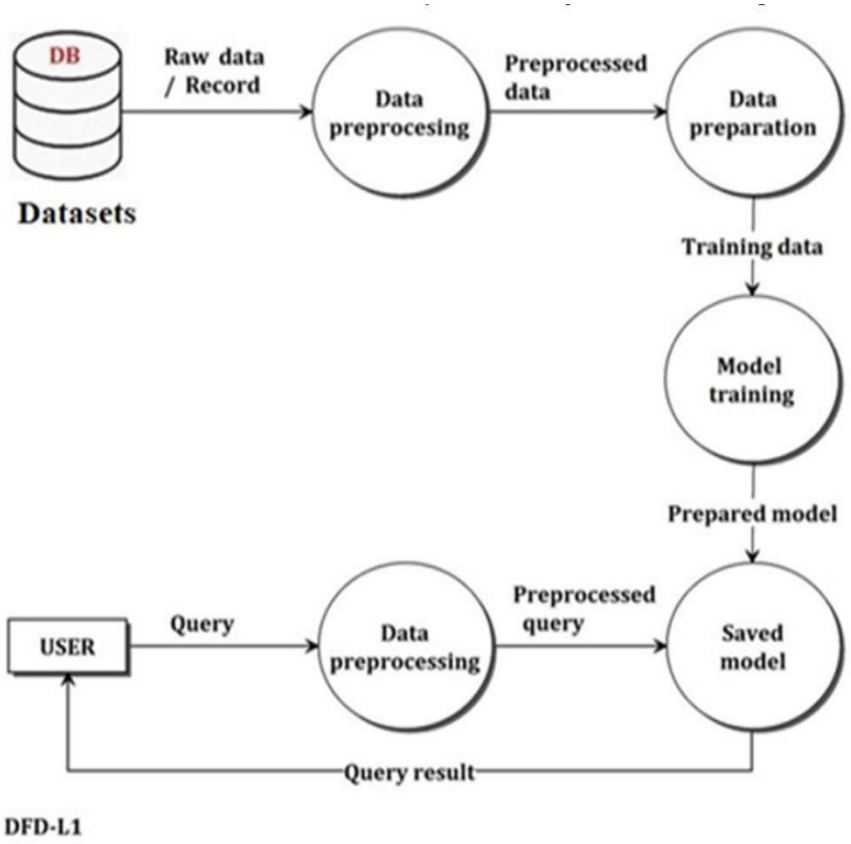

Fig. 5. DFD of Data Preprocessing

The data is split into train and test data. To do this, we need to import train_test_split which in the scikit-learn will help the pre-processed data to split the data into train and test according to the given weight given in the code. The division of the test and train is 20 and 80 percent respectively.

F. *Analysis and Prediction:*

The pre-processed data undergoes feature selection. It is the process of reducing the number of input variables when developing a predictive model. It is done to reduce thecomputational cost of modeling and to improve the performance of the model.

Patterns in the dataset are recognized, the percentage correlation between various factors affecting crop yield is determined. Various data visualization techniques are used to study the patterns in data and factors causing change. For this, both the training data and test data are considered. Algorithms like Backpropagation and Random Forest are used to predict crop yield. The accuracy of these algorithms is compared using mean absolute percentage error,r2 score, etc, thus helping us determine the most suitable approach for prediction. The backpropagation algorithm is used to predict the amount of fertilizer. From the above figure, it can be observed that after the data is prepared by removing unnecessary attributes and null rows, 80% of data is used as training data and the model is trained. The model is validated using 20% of the data. The value is analyzed and the model is saved. The saved model is then used to query the user's request and provide the result.

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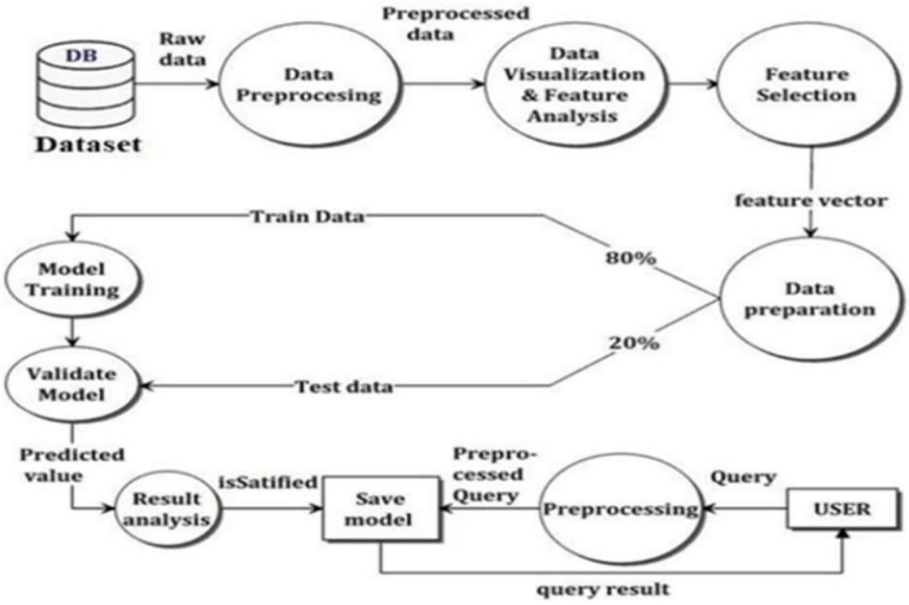

Fig. 6. DFD of Analysis and Prediction

IV. ALGORITHMS AND PSEUDO CODE

G. *Crop yield estimation using random forest regressor:*

[11]Random Forest Regression is a supervised learning algorithm that uses ensemble learning method for regression. Ensemble learning method is a technique that combines predictions from multiple machine learning algorithms to make a more accurate pre- diction than a single model. Random forest handles the missing values and handles the accuracy for it. Random forest is integrally random. For crop yield different climaticconditions, soil, hydro physical characteristics and crop management information are correlated to each other. We'll be considering crop yield as the response variable and remaining dataset parameters as the predictor variable.

[11] Workflow of Random Forest Algorithm:

1. Pick at random k data points from the training set.
2. Build a decision tree associated to these k data points.
3. Choose the number N of trees you want to build and repeat steps 1 and 2.
4. For a new data point, make each one of your N-tree trees predict the value of y for the data point in question and assign the new data point to the average across all of the predicted y values.

Import RandomForestRegressor from sklearn.ensemble
An instance of it is created and assigned to a variable.
The parameter n_estimators is passed to it which decides the number of trees in the forest.
Then the model is trained using fit() function.
After this, use the predict() function on test data to make predictions.
R2 score and MSE is also calculated to understand the accuracy of the model.
Random forest takes mean contribution for a variable across all trees in the forest to
determine the contribution of features and was found highly capable of predicting crop yields.

H. *Fertilizer prediction using back propagation:*

Any farmer will be interested to increase yield more than expected. By analysing the various relative attributes like location, temperature, pH value from which alkalinity of the soil is determined, soil fertility can be increased. Along with it, percentage of nutrients like Nitrogen(N), Phosphorous (P), and Potassium (K) is used and the temperature, soil moisture ,area ,soil composition can be determined. This is implemented through MLP Regressor.[13] Back propagation neural network is one of the most widely used ANNs.[17]The algorithm is used to effectively train a neural

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network through a method called chain rule. In simple terms, after each forward pass through a network, backpropagation performs a backward pass while adjusting the model's parameters (weights and biases).It has three layers:

- Input layer
- Hiddenlayer
- Output layer

Each layer is made up of units. The inputs are fed simultaneously into the units making up the input layer. These inputs pass through the input layer and are then weighted and fed simultaneously to a second layer of "neuronlike" units, known as a hidden layer.The outputs of the hidden layer units can be input to another hidden layer, and so on. The number of hidden layers is arbitrary, although in practice, usually only one is used. The weighted outputs of the last hidden layer are input to units making up the output layer, which emits the network's prediction .The network's actual output value is then compared to the expected output, and an error signal is computed for each of the output nodes. Since all the hidden nodes have, to some degree, contributed to the errors evident in the output layer, the output error signals are transmitted backwards from the output layer to each node in the hidden layer that immediately contributed to the output layer. This process is then repeated, layer by layer, until each node in the network has received an error signal that describes its relative contribution to the overall error. The Back- propagation algorithm looks for the minimum value of the error function in weight space using a technique called the delta rule or gradient descent. The weights that minimize the error function is then considered to be a solution to the learning problem.

- The data set is divided into 80% for training data and 20% for the test data.
- Import MLP regressor
- Set hidden layer size=(5,2)
- Inputs X are the parameters such as nitrogen, phosphorus and potassium.
- Input is modeled using weights W.
- Calculate the output for every neuron from the input layer, to the hidden layers, to the output layer.
- Calculate the error in the outputs.
- Error= Actual Output – Desired Output
- Travel back from the output layer to the hidden layer to adjust the weights such that the error is decreased.
- Predict the fertilizer and display the same.

V. RESULTS

On applying both RF and BPN to crop dataset,we observe RF and BPN get 95.80 and30.28 percent respectively, resulting in choosing RF over BPN for crop production estimation. However BPN was useful in predicting the fertilizer amount.

Fig 7. From experimental results, random forest predicted higher accuracy compared to backpropagation on crop data set only. Both the algorithms were compared in predicting the crop yield and by various parameters with respect to the error rate. Accuracy scores of both the algorithms are predicted and a graph is plotted for the same.

Fig 8. We predict the crop yield by taking the input of the parameters like state, district, year, season, crop, temperature, humidity, soil moisture and area.

Fig 9. The fertilizer amount is calculated and the type of fertilizer obtained is predicted based on the amount by inputting the values of phosphorous, potassium and nitrogen.

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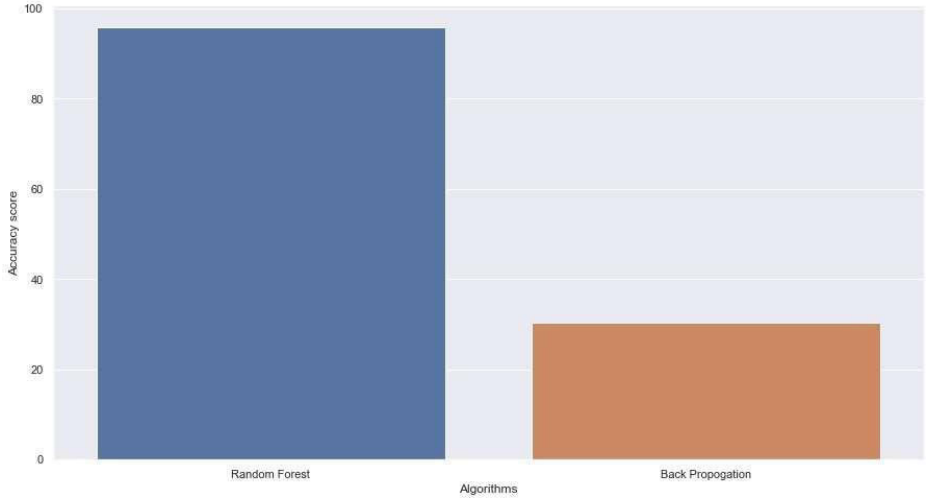

Fig 7. Accuracy of the algorithms

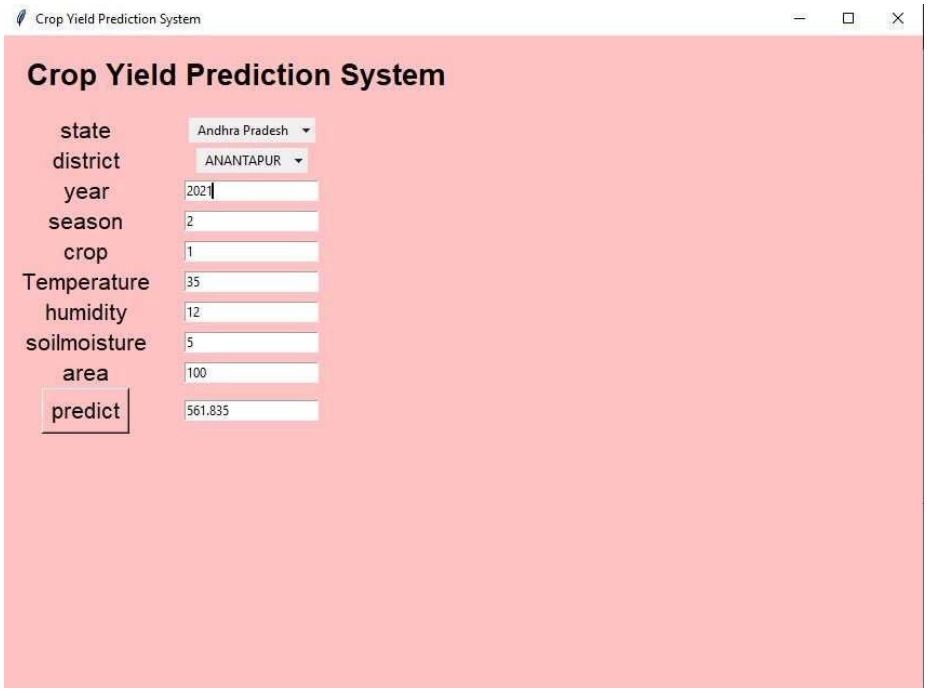

Fig. 8. Predicting the crop yield

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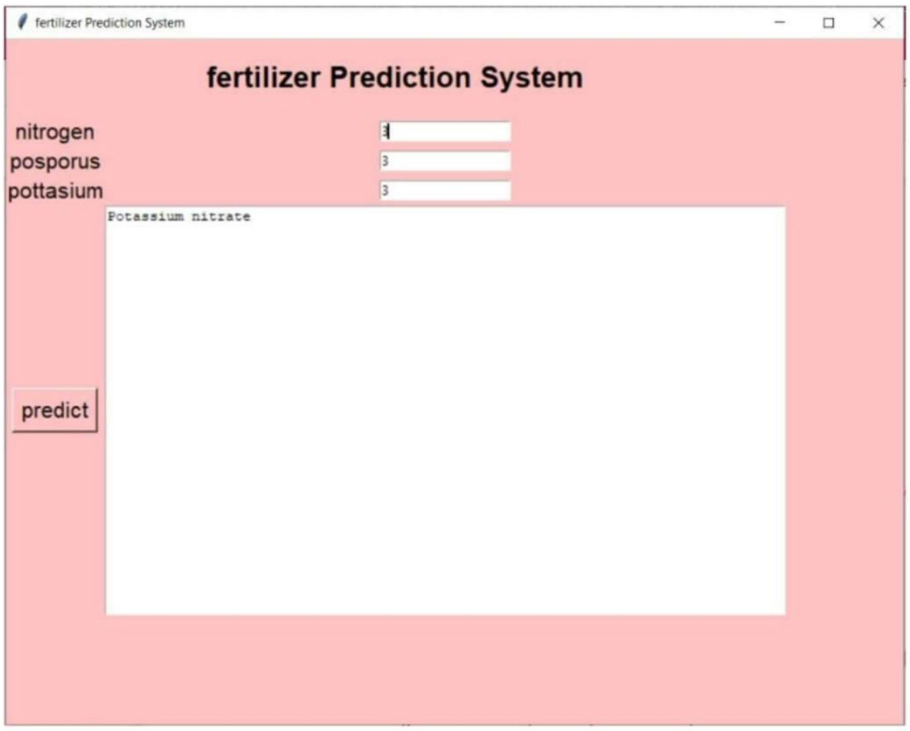

Fig. 9. Fertilizer prediction using back propagation

VI. CONCLUSION AND FUTURE WORK

This project is undertaken using machine learning techniques, evaluating the performance by using algorithms like Random forest and back propagation. In our proposed model among the two algorithms Random forest gives the better crop yield prediction as compared to other. So we analyzed that the proposed model has got more efficiency than the existing model for finding crop yield. However Back Propagation proved efficient in predicting the amount and type of fertilizer to be used on crops for enhanced growth. The implementation of the above system would help in better cultivation of the agricultural practices of our country. Further it can be used to reduce the loss farmers experience and improve the crop yield to get better capital in agriculture. The model can be improved by integrating this with other departments like horticulture, sericulture, and others towards the agricultural development of our country. An android application can also be built for a quick access as a part of future enhancement.

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