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Research Article

Crop Recommendation On The Basis Of Soil

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ABSTRACT

The project integrates machine learning algorithms, expert systems, and decision-making models to provide accurate, data-driven recommendations. By suggesting appropriate crops and varieties according to region and season, the system aims to increase crop productivity, reduce costs, and support sustainable farming, ultimately contributing to economic growth.

INTRODUCTION

Crop recommendation involves suggesting suitable crops for a specific field in a particular area or farm based on factors like types of soil and properties, climate and weather conditions, market demand and economic viability, pest and disease management, irrigation and water availability.

This study proposed a soil-based system for crop recommendation that used Machine Learning techniques to predict suitable crop for a given soil type. The system utilizes soil type. Our results show that the proposed system achieves 90% in recommending crop. The system can be used to support precision agriculture initiative, enabling farmers to provide information to take decisions about crop selection and soil management.

This technology i.e crop recommendation system based on soil for agriculture to help the farmers for increase the crop production by suggesting a best crop according to their farming land condition with the help of selecting season or soil type from web portal.

In recommending a suitable crop to the farmers, proposed hybrid recommender model is found to be more effective. Value of crop yielding production has a positive practical significance for assisting agricultural production and notifying the changes in the crop market.

The purpose of this paper is to implement the method of crop selection so that it can helps in solving problem of many farmers related to their agriculture field. This can help in increasing the

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growth rate of our Indian economy by maximizing the crop production rate.

This study proposed SVM algorithm which was trained and evaluated on comprehensive dataset including historical data with diverse feature like season, soil type. The data was further classified on the basis of season such as month to provide crop recommendation tailored to specific frame of time. Crop Recommendation system technology helps the farmers for agriculture to increase the production of crop by recommending a suitable crop for their land according to their type of soil and the season.

There are some common approaches to crop recommendation like Machine learning algorithms, Statistical models, Expert systems, Decision support systems.

2. Importance of Crop Recommendations

Lack of knowledge about the crop in various season and soil is the main challenge faced in agriculture sector. For crop yielding each crop has its own climatic and soil features. This system is very helpful for optimizing agricultural practices by assisting in choosing the most suitable crops for their specific season and soil, leading to increased crop production and improved resource efficiency. With the help of precise farming techniques, it can be handled.

2.1 Importance of soil types for crop growth:

Soil is very important for crop production because it provides essential nutrients, water, and physical support for plants, enabling them to grow and thrive. It also a habitat for beneficial microorganisms and helps regulate the climate by isolation of carbon.

In the field of farming the main problem faced by the farmers are to decide the suitable crops for soil present in their field in a particular season. So that they can grow the crop in a high quantity and this result is not obtained without sowing the suitable crop in particular soil in a particular season. So, the knowing of soil type for a particular crop for a particular season is very important for growing the best crop.

3. Facing challenges in selection of crop in specific soil in a particular season

Farmers face significant challenges when selecting suitable crops for specific soil types and seasonal conditions. Soil characteristics such as pH level, nutrient content, moisture retention, and texture directly influence crop growth, but many farmers lack access to proper soil testing facilities. Without accurate knowledge of soil health, crop selection often depends on traditional practices or guesswork, which can lead to poor yields and financial losses.

Seasonal variations further complicate crop selection. Changes in rainfall patterns, temperature fluctuations, and climate uncertainty make it difficult to determine the right crop for a particular time of year. Inadequate access to timely agricultural information and expert guidance increases the risk of selecting unsuitable crops, ultimately affecting productivity and farm income.

LITERATURE REVIEW

[1] Smart Farming: Crop Recommendation using Machine Learning with Challenges and Future Ideas.

Author: Devendra Dahiphale, Pratik Shinde, Koninika Patil

In this chapter author uses machi

ne learning algorithm to predict suitable crop, based on soil composition and climate data. It achieves near perfect accuracy over 95% with the highest accuracy 99.5%. Machine leaning models is used for examine data from satellite images, drone footage and soil sensor to craft maps of crop growth, nutrients level and moisture content. This technology can help farmers to identify best crop, based on environmental feature and market demand.

Methodology Used: The author used soil and historical crop data to train machine learning models. The technique which are used in this paper are - Wrapper-PART Grid approach, MLP (Multilayer perception) and Decision Tree.

[2] Agricultural Crop Recommendation Based on Productivity and Season.

Author: AV Senthil Kumar, Hakikur Rahman, Samrat Roy, I. Musirin,

This paper focuses on impacting the power of machine learning by utilizing agricultural crop recommendation system. It also focuses on productivity of crop & prevailing season as crucial factor. To aware of best climate and predict the most appropriate crop for cultivation author used SVM algorithm.

Methodology Used: Following steps have to be taken to complete this project.

1. Data Input

2. Data pre-processing

3. Selection of features

4. Crop recommendation using SVM (Support Vector Machine)

5. System testing

6. Implementation

[3] Crop Recommendation System for Growing Best Suitable Crop

Author: Yash Gupta & Garima Srivastava

This chapter, focuses on helping farmers to decide best crop plant based on various factors like soil properties, weather condition & Geographical factor. Machine Learning algorithm used to recommend suitable crop based on various factors. Random Forest, SVM, KNN machine algorithm has been used. Random Forest (RF) has shown high accuracy in crop recommendation, with some studied achieving up to 99.22% accuracy.

SVM is algorithm in crop recommend system, often achieving accuracy about 95%. K-Nearest Neighbor (KNN) is also used in this chapter which gives accuracy may vary depending on the dataset and implementation.

[4] Soil Classification and Crop Recommendation System.

Author: Ashwin John, Denzil Davis, Athulya Merin C Tom, Dibin Davis, Jasmi Davis

In this paper, author makes a soil classification and crop recommendation system. This project will help the farmers for test the quality of soil. And no need to go to laboratory for testing the soil.

Author uses image dataset and crop which is the main task of the project to collect the soil images. Training and testing the model for soil classification and crop recommendation system. After collecting the soil & crop data, next step is processing. In next step, this system can predict the soil type & its features and remains data will be used for testing the model which trained. They also used machine learning, image-based classification, hybrid approach for soil classification.

[5] Crop Recommendation System Machine Learning

Author: Dhruvi Gosai, Chintal Raval, Rikin Nayak, Hardik Jayswal, Axat Patel

This paper was published on 2021. In this paper author develop a crop recommendation system with the help of machine learning. It focuses on helping farmers to choose suitable crop based on environmental condition.

Author uses environmental factors such as humidity, soil type, PH, and temperature to optimize crop yielding and promote sustainable agricultural practices.

They used Decision Tree, SVM, Random Forest, Naïve Bayes algorithm. They applied Naïve Bayes approach in his model as:

1. Importing library Gaussian NB classifies from Sklearn.naive_bayes class
2. Create Naïve Bayes classifies object
3. At last Fit data

They also used comparative study about crops & its attributes.

[6] Cop Recommendation System

Author: Jangale Neha, Gawali Sayali, Tikole Snehal, Gandhale Pradnya, Prof. Sayyed J.I

This paper proposed a crop recommendation system to improve the crop productivity using Machine Learning technique.

Author proposed a model that predict the existing issues. This system is used to guide the farmers to maximize the crop yield as well as suggest the most profitable crop for the specific area. It would help to minimize difficulties faced by farmers in choosing a crop.

In this paper, Random Forest, Decision Tree, Logistic Regression algorithm has been used.

Methodology used: i. e Continuous learning and improvement, Model selection Trains the model, Model evaluation, Integration with IOT and season, Data Collection,

Preprocessing and Feature engineering, and Deployment.

There are some limitations of this systems i.e Data availability and Generalization,

Lack of domain expertise, Adoption and acceptance.

This system is divided in Fertilizer Recommendation System and Crop Recommendation System. Further Crop Recommendation System is classified in Best suitable crop that can be grown & Crops as per suitable condition.

[7] Multi Criteria Agriculture Recommendation System Using Machine Learning for Crop and Fertilizer Prediction

Author: Krupa Patel and Hiren B. Patel

In this research paper, a machine learning algorithm used which is based on crop and fertilizer recommendation is proposed by author. For predicting best crop in different seasons they design machine leveraging model which work on the basis of properties of soil, water level, MSP, farm size.

To envisage the soil, crop and fertilizer properties/details, they proposed another mechanism in which for a given pair of soil and crop, a combination of fertilizer has been used.

In this paper there are three matrix used i.e Land Matrix, Crop Property Matrix, Fertilizer Matrix. In Land Matrix soil health, land parameter values are contained. In Crop Property Matrix includes the require property values for crop along with Minimum Support Price (MSP). Fertilizer Matrix requires fertilizer with percent content properties.

In Phase II of AgriRec, all the three matrices and fertilizer recommendation system which are mentioned above. Cultivate recommend crops algorithm, find deficit properties by using equation:

Deficit % for L_i = (avg(prc_u-pr_d) – pr_{li}) /avg(prc_u-prc_l) x100

[8]. An AI – based Crop Recommendation System Using Machine Learning.

Author: Shraban Kumar Apat, Jyotirmaya Mishra, K Srujan Raju & Neelamadhab Padhy.

In this paper, For precision agriculture improve overall crop harvest quality and accuracy, AI system has been used. One solution like recommended system, using AI and a family of Machine Learning Algorithm proposed by this research Industry 4.0.

Methodology Used: Data Collection, Preprocessing, Feature extraction, Feature selection, Classification.

The modal is divided in two section:

Phase I- Data balancing technique

Phase II-Classification – Regression Boosting Model

Phase I - One of the most widely recommended techniques that is Data sampling which is used for dealing with an imbalanced data set. This study uses various specific data augmentation resampling techniques such as SMOTE.

Phase II-

To determine the best performance, Author used 14 classifies and evaluated six performance parameters.

4. Proposed System:

The proposed research introduces a different approach. Instead of relying solely on laboratory-tested N, P, and K values, this study utilizes a dataset that includes soil types, seasonal information, and crops along with their respective varieties. Based on this comprehensive dataset, the system will recommend the most appropriate crop suited to a particular season selected by the user or farmer.

This approach eliminates the need for laboratory testing of N, P, and K percentages, thereby reducing the cost of soil testing and making the system more accessible and cost-effective for farmers.

5. Methdology:

The proposed crop recommendation system is designed to suggest the most suitable crop based on soil type and seasonal conditions without requiring laboratory testing of soil nutrients. The methodology of the study is described as follows:

5.1 Data Collection:

The datasets consist of parameter like soil name and season name. The data have been obtained from Niche Agriculture, Chegg India websites. The dataset includes sixteen different crops such as Rice, Wheat, Maize, Sunflower, Pearl, Cotton, Tea, Mustard, Sugarcane, Jute, Tobacco, Barley, Coffee, Jute, Maize, Groundnut.

5.2. Input Data:

The data which are used for agricultural crop recommendation system consist from different

sources including websites [8] data which is selected by farmers/user to get their best crop from the system using internet. The input data included either Soil Type and Season or Crop name only.

5.3 Data Processing:

Dataset pre-processing is a fundamental step to gain the knowledge of models in preparing the entered information for teaching the computer. Data processing ensure that all the data which is entered by user is matched from database. If not matched to database, then show error.

5.4 Feature Selection:

Machine learning algorithm is transformed to corresponding algorithm because it cannot work on same dataset, for the specific algorithm to prepare the proper input to show the correct output. After matched the user data from database, features of soil have been selected.

5.5 Model Development

A suitable machine learning algorithm (such as Decision Tree, Random Forest, or K-Nearest Neighbors) is selected and trained using the prepared dataset. The model learns the relationship between soil type, season, and suitable crops.

5.6. System Implementation

A user interface is developed where the user or farmer selects: Soil type, Season.

Based on the selected inputs, the trained model predicts and recommends the most suitable crop along with its variety.

5.7. Model Evaluation

The performance of the model is evaluated using metrics such as: Accuracy, Precision, Recall

This ensures that the system provides reliable recommendations.

5.8. Cost Efficiency Analysis

Since the proposed system does not require laboratory testing of N, P, and K percentages, it reduces soil testing costs, making it more accessible and affordable for farmers.

6.Algorithm Design

The proposed algorithm recommends the most suitable crop based on soil type and season selected by the user.

6.1Algorithm: Crop Recommendation System

Input:

Soil Type (selected by user)

Season (selected by user)

Output:

Recommended Crop

Recommended Crop Variety

Step 1: Start

Step 2: Load Dataset

Load the dataset containing soil types, seasons, crops, and their varieties.

Step 3: Data Preprocessing

Remove missing values

Encode categorical variables (soil type, season, crop, variety)

Split dataset into training and testing sets

Step 4: Train Model

Select a suitable machine learning algorithm (e.g., Decision Tree / Random Forest / KNN).

Train the model using soil type and season as input features.

Store the trained model.

Step 5: User Input

Accept soil type from the user.

Accept season from the user.

Step 6: Prediction

Convert user input into encoded format.

Provide input to the trained model.

Predict the most suitable crop and its variety.

Step 7: Display Output

Show the recommended crop.

Show the recommended crop variety.

Step 8: End

6.2 Pseudocode

BEGIN

Load dataset

Preprocess dataset

Train model using (Soil_Type, Season)

WHILE system is running

Read Soil_Type from user

Read Season from user

Encode input

Prediction = Model.predict(Soil_Type, Season)

Display Recommended Crop and Variety

END WHILE

END

6.3 Mathematical Model Representation

The crop recommendation system can be mathematically represented as a supervised classification problem.

1. Input Variables

Let:

St = Soil Type

S = Season

These are the independent input variables selected by the user.

2. Output Variable

Let:

Cr = Recommended Crop

Va = Variety of the Recommended Crop

The output can be represented as:

$Y=(Cr,Va)$

3. Dataset Representation

Let the dataset be represented as:

$D=\{(St1,S1,Y1),(St2,S2,Y2),\ldots\ldots,(Stn,Sn,,Yn)\}$

Where:

n = Total number of training samples

Each sample consists of soil type, season, and corresponding crop with variety.

4. Functional Mapping

The system learns a function:

f:(St,S)→Y

That means,

Y=f(St,S)

Where:

f is the trained machine learning model (e.g., Decision Tree, Random Forest, or KNN).

5. Model Objective

The objective of the model is to minimize the classification error:

$$\text{Error}= \frac{1}{n} \sum_{i=0}^{n} L(Xi, Yi)$$

Where:

Xi= Actual crop and variety

Yi=Predicted crop Variety

L = Loss function (e.g., 0–1 loss for classification)

6. Final Prediction

For a new user input ((St*,S*), the predicted output is:

Y'=f(St*,S*)

This output provides:

Recommended Crop

Recommended Variety

This mathematical model clearly shows that your system is a classification-based supervised learning model without dependence on N, P, K laboratory values.

Used Data Table:

TABLE – I.1 List of state wise soil

Id	Soil Type	State
6	Arid	Western Rajasthan, Southern Punjab, Northern Gujrat,
3	Alluvial	Uttar Pradesh, Punjab, Haryana, Arunachal Pradesh, Gujrat, West Bengal
4	Black	Uttar Pradesh, Gujrat, Maharashtra, Karnataka, MP, Andhra Pradesh
7	Laterite	Karnataka, Kerala, Tamil Naadu, Madhya Pradesh, Assam and hills of Odissa
8	Loamy	Uttar Pradesh, Karnataka, Telangana, Bihar, Tripura
9	Marshy	
10	Saline	Punjab, Haryana, Uttar Pradesh, Gujrat, Maharashtra
12	Red	
13	Mountainous	Assam, Jammu Kashmir, Himachal Pradesh, Manipur, Sikkim, Western Ghat of Karnataka, Keral, Tamil Nadu
14	Peaty	Sundarbans in West Bengal, Kerla, Uttar Pradesh, Bihar

TABLE – I.2 List of Season for crop yielding

Id	Type	Duration
1	Zaid Crop	Mar to June
2	Kharif Crop	June to Oct
3	Rabi Crop	Nov to March

5	Rabi Crop	October to November
7	Zaid Crop	May to June
8	Rabi Crop	November
9	Rabi Crop	January to February
10	Rabi Crop	December to January
11	Kharif Crop	June to July
12	Kharif Crop	January to December

TABLE – I.3 Crop details

Id	Crop Name	Variety	Condition
1	Pearl (Bajra)		
2	Cotton	Lohit, R.G.8, C.A.D-4, H.S.6, Vikas, H777, F846, R.S.810, RS 2014	
3	Sorghum (Jowar)		
4	Jute	JRC-321, JRC- 212, UPC-9(Reshma), JRac-688, Ankit (NDac), NDC-9102, JRO-632, JRO-878, JRao-7835, JRO-524, JRO-66	
5	Mustard	Pitambari, Narendra mustard-2, K-88	PH-6.0 to 7.5, Temp-10-to-25-degree Celsius, and 28-degree Celsius for germination, Rainfall- 625 to 1000mm
6	Pulses		
8	Paddy (Dhan)	Govind, Narendra-118, Shusk Samrat, Poosa-169, Narendra-80, Malviya, Sarju-52, Poosa-44, Poosa Basmati-1, Haryana-Basmati-1, Sambha Mansuri, Mahsuri, Basmati-10-9, Sugandh-4-3, Basmati-370, Usar-Dhan-1, Madhukar,	PH-5.5 to 6.5, soil- acidic, Water - 10 to 12 cm, High humidity with annual rainfall above 100 cm, Temp- 20-to-27-degree Celsius but 15 degrees for germination
9	Sun Flower	SS-56,CO-4,LS-11, Kanthi, DRSF-108,CO-1, Bahu,GAUSUF-15,CO-3,LSF-8,DRSF-113,PKVSF-9, SS-0808,Morden Surya,CO-5,EC-68415, CO-2, TAS-82	PH-6.0 to 7.5, Temp-21-to-26-degree Celsius
10	Sugarcane	CoJ.64, Co.sa-8436, Co.sa-88230,Hriday,UP-39,UP-0097,Pant-84212,Co.sa-92423	PH- 5 to 8.5, Good drainage, Rainfall- 2000 - 3000mm in tropical area, Temperature 21-to-27-degree Celsius, Humidity- 80 to 85%

11	Wheat	PDW215, PDW233, Raj1555, WH896, HI8498, Hi8381, GW190, GW273, Meghdoot,Vizga yellow, Sujata, HI-627	PH-5.5 to 7.5, Temp-21-to-24-degree Celsius, Water- 31 to 38 cm, Nutrients- Nitrogen, Potassium, Phosphorous, calcium, Zinc etc., Good drainage
12	Groundnut	GAUG-1, Prakash, BG-1, Chitra, Gaug-10, T-64, Amber, PG-1,Kadri-3,T-28, Kaushal,BG-2,Kuber, Chandra, Kadri-2	
13	Tobacco	1)Cigar and Cheroot-Mandival, Yerumaikappal, monnakappal 2)FCV tobacco-Jayasri,CTRI special,Godavari special and G 11. 3)Bidi tobacco- Anand 23,Keliu 20,Anand 119 and hunkumathiri, surati 20.	
14	Tea	BSS 1, Evergreen, BSS 2, Biclonal seed stocks and Grafts, BSS 3, Athrey, BSS 4, Brookeland, Pandian, Sundaram, BSS 5, Golconda, Jayram	soil- acidic, PH- around 5.0, well drained, Temp-15-to-23-degree Celsius, Max temperature- 16 to 32 degree Celsius, Rainfall-Adequate
16	Barley	NDB-1173, Geetanjali(K-1149), k-141,Haritima(K-560), Jyoti(K.572/10), Azad(K-125), RS-6, Lakhan(K-226)	
17	Maize	Priya sweet-corn, Buland, PMH-3, Deccan-105, Trisulta, K-H-5981, HQPM-1, Dhawal, Sharadmani, Shakti-1, J-1006	

7. Crop Recommendation System Results and Conclusion

Improved Production:

The implementation of advanced machine algorithm, including Expert System, resulted in improving crop yields in compare to rule-based approach. This system predicts the crop on the basis of soil and season.

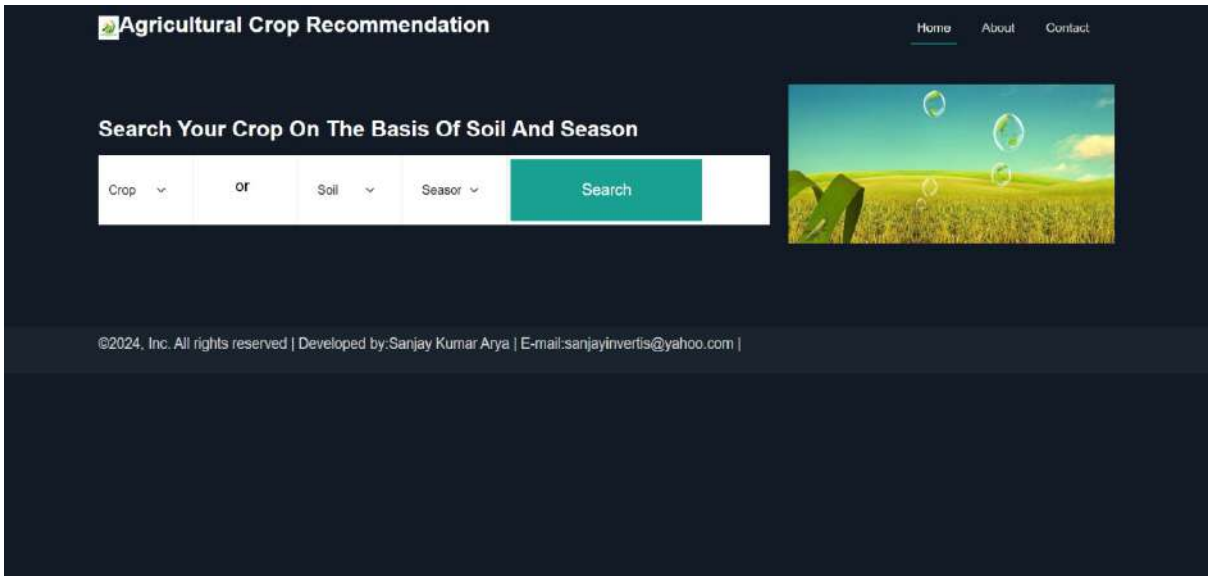
Economic Development:

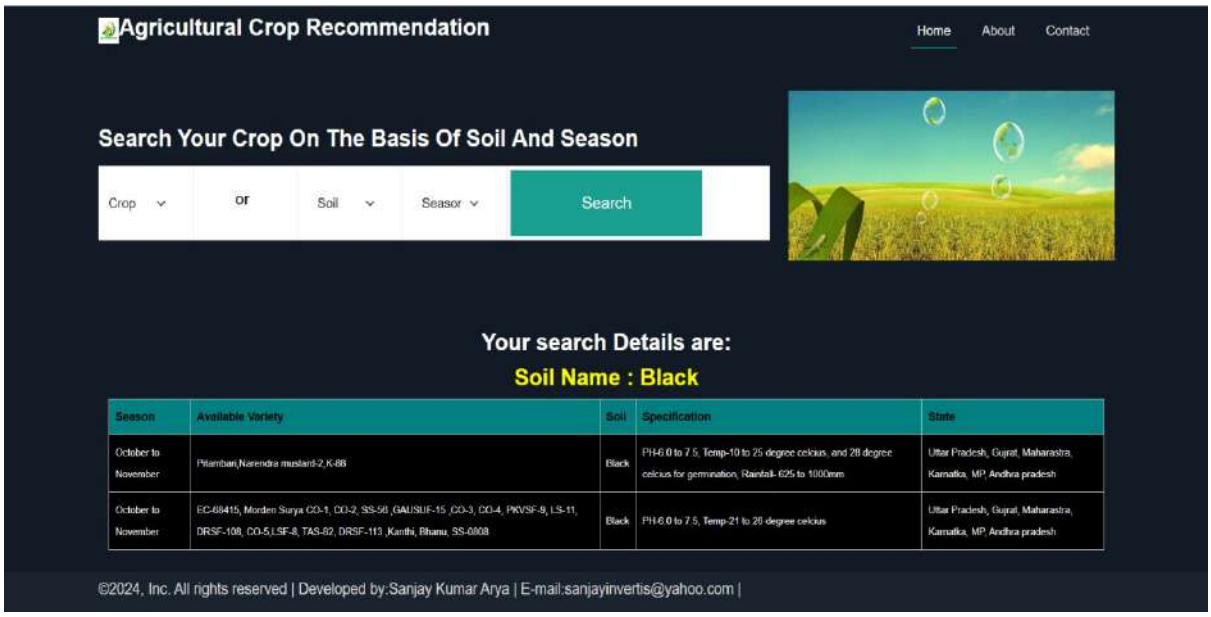
With the help of Crop recommendation farmers can get information about best crop in a specific season for a particular soil. Farmers will get the information about soil and crop variety also. By using and implementing the information about crop variety they can improved the crop production. If in our country crop production increased So, the economy of the country will automatically developed.

Cost Reduction:

Implementation of crop recommendation system will be reduced cost of farmers harvesting because there is no need to go to lab for soil testing. Expert system will suggest crop to farmers by selecting

soil type & season. So, Farmers can used their saved money to their other work.





CONCLUSION

The proposed soil based crop recommendation system will help to farmer for crop yielding on the basis of their soil and season.

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