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Decision Support System for Fertilizer Recommendation

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Abstract-: **India is known as an agricultural country, where the recommendations for use of fertilizers are given by traditional methods. At present, recommendations for farmers are based on communication between farmers and experts and different experts have a variety of recommendations. The proposed work uses past agricultural activities as a data for providing the recommendation to the farmers. The objective is to develop a decision support system for optimizing fertilizer used for agriculture, enabling farmers to maximize crop yields, save cost and increase their profits. In the proposed system, data mining is applied to recommend fertilizers which are interpreted from different soil test results. C4.5 can be used to effectively classify training data and use that training data to recommend fertilizers. The proposed system accepts nutrients and crop as an input and recommends organic, inorganic fertilizers and remark as a result. The farmers get access to an easy-to-use interface that eliminates the guesswork and minimizes the uncertainties involved in making fertilizer management decisions.**

***Keywords*: Agriculture, C4.5 Algorithm, Classification, Data Mining, Farmers, Fertilizers Recommendations.**

I. INTRODUCTION

Agricultural soils support plant growth by providing structure and a medium for water, nutrient, and gas exchange. The physical, chemical, and biological properties of a particular soil affect the ability of plants to grow. In simple terms soil quality means "the capacity of soil to function". So soil quality is a human construct that depends on the intended purpose for a particular soil. There is natural variability in soil parameters across the landscape and this variability becomes important as it affects crop yield or the environment.

Maintaining the health of the soil is very important for future crop yield because soil is an important entity in crop productivity. Crop yield depends on soil water and energy management with no adverse effect on the health of the plants, soil and environment. Thus, to maintain the soil health and to increase the sustainability of farming, there is a need of giving guidelines to the Farmers about the fertilizers and quantity of the fertilizers based on the soil test results. Also there is a need to give fertilizer recommendations for a whole calendric year cropping sequence based on different soil parameters.

Currently the farmers physically submit the soil sample to local agricultural research centers for testing. The test results are also to be collected from the same center after a week. However, the process of generation of report and handing over the report to the farmer is manual which is time consuming and tedious. There are some systems existing where the delivery of the reports is through mail. However, the local farmers do not understand how to access the mail and see the reports. So there is a need of mobile based application which is in vernacular medium to deliver the reports.

A. Objectives

The objective is to develop a decision support platform for optimizing fertilizer use for agriculture, enabling growers to maximize crop yields, save costs and increase their profits. This system uses data mining algorithm [1], [2] to recommend fertilizers which are interpreted from various soil test results.

The proposed system accepts nutrients and crop as an input and recommends organic, inorganic fertilizers & remark as a result.

II. LITERATURE REVIEW

There are many researches on the fertilizer recommendation systems. But the applications are more complicated and they cannot be easily understood by the farmers. For example [3], [4], [5] are all recommendation systems based on various applications. The work presented in [3] is similar to this paper except that they have many services, at least to say. It is more complicated system. Also this system is in English and European language. It is desktop application & not suitable for Indian farmers. In [4] only inorganic fertilizers are recommended based on NPK value. It generate soil report. But this system has some drawback that it checks only NPK values, has predefined list of crops, recommends only inorganic fertilizers and didn't have any mobile application. The research work in [5] presented by Kiran Shinde, Jerrin Andrei, Amey Oke provides recommendations to farmers for crops, crop rotation and identification of appropriate fertilizer. The system can be used by farmers on web as well as on smart phones. It has the drawback that micro level parameters are not used. Also it is in single language.

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Soil test may refer to one or more of a wide variety of soil analyses conducted for one of several possible reasons. Possibly the most widely conducted soil tests are those done to estimate the plant specific available concentration of nutrients, in order to determine fertilizer recommendations in agriculture. Soil testing may be done in laboratories.

Laboratory tests often check for plant nutrients in three categories [7]:

- Major Nutrients: Nitrogen N, Phosphorus P, and Potassium K.
- Secondary Nutrients: Sulphur, Calcium, Magnesium
- Minor Nutrients: Iron, Manganese, Copper, Zinc, Boron, Molybdenum, Chlorine

Nutrient deficiencies cause symptoms such as leaf yellowing or browning, sometimes in distinctive patterns shown in Fig. 1. This may be accompanied by stunted growth and poor flowering or fruiting. This will affect the production and profit of farmers. The system is designed to increase the production of agriculture by providing proper organic, inorganic fertilizer recommendation & an advice in farmer's local language.

Fig. 1: Yellow Tomato Leaves

Table I: Ranges of Nutrients

PH	**Value**	<6.5	6.5-7.5	>7.5			
	Remark	Acidic आम्लयुक्त जमिन	Neutral चागंली जमिन/सर्वसाधारण	Alkaline विम्लयुक्त जमिन/किंचीत क्षारयुक्त			
EC	**Value**	<1	1-2	2-3			
	Remark	Good for Crop Growth सर्वसाधारण	Affects Germination adversely साधारण पिक उगवणीस हानीकारक	Affects adversely growth of salt susceptible crops साधारण पिक उगवणीस हानीकारक			
Lime stone	**Value**	<0.5	0.6-1.25	1.26-2.50	2.51-5	5.1-10	>10
	Remark	चुनखडी विरहित	अत्यल्प चुनखडीयुक्त	अल्प चुनखडीयुक्त	मध्यम चुनखडीयुक्त	चुनखडीयुक्त	अति चुनखडीयुक्त
Organic Carbon	**Value**	<0.20	0.21-0.40	0.41-0.60	0.61-0.80	0.81-1.0	>1.0
	Remark	अंत्यत कमी	कमी	मध्यम	थोडे जास्त	जास्त	अंत्यत जास्त
Nitrogen	**Value**	<140	141-280	281-420	421-560	561-700	>700
	Remark	अंत्यत	कमी	मध्यम	थोडे जास्त	जास्त	अंत्यत जास्त

		कमी					
Phosphorus	**Value**	<7	8-14	15-21	22-28	29-35	>35
	Remark	अंत्यत कमी	कमी	मध्यम	थोडे जास्त	जास्त	अंत्यत जास्त
Potassium	**Value**	<100	101-150	151-200	201-250	251-300	>300
	Remark	अंत्यत कमी	कमी	मध्यम	थोडे जास्त	जास्त	अंत्यत जास्त
Fertilizer Recommendation		शिफारशीत खत मात्रेपेक्षा 50% जास्त	शिफारशीत खत मात्रेपेक्षा 25% जास्त	शिफारस खतमात्रा	शिफारस खतमात्रा	शिफारशीत खत मात्रेपेक्षा 25% कमी	शिफारशीत खत मात्रेपेक्षा 50% कमी

III. EXISTING SYSTEM:

At present, soil test report which contains available nutrients from soil, recommended organic, inorganic fertilizer & an advice in local language is given by manual process to the farmer. Manual process is time consuming; it may take a week to generate soil test report. This process is explained below. The soil is tested in KVK center's laboratory. Laboratory test finds available nutrients in the soil. Based on this nutrient value, remark is given by using Table I which indicates that whether the available nutrients are minimum, average or maximum. Now for recommending organic, inorganic fertilizer & for advice they refer Krushidarshani [6]. Krushidarshani contains information related to land requirement, crop species and required fertilizers.

Consider that farmer is taking Pomegranate crop. For recommending organic and inorganic fertilizers they perform following steps.

1. Organic fertilizers are recommended from Krushidarshani [6].
2. Recommended doses for fertilizers that is inorganic fertilizers for the given crops are N=625gm, P=250gm and K=250gm [6].
3. Above doses are given based on available nutrients.
4. Suppose available N in soil is 189.2 gm, then from Table 1 inorganic N should be 25% more than recommended fertilizer i.e. 25% more than 625=125%
   Recommended N= (625*125)/100=781 gm (1)
   which is to be given in two equal doses.

5. Suppose available P in soil is 9.94 gm, then from Table 1 inorganic P should be 25% more than recommended fertilizer i.e. 25% more than 250=125%
   Recommended P= (250*125)/100=312.5 gm (2)
6. Suppose available K in soil is 258 gm then from Table 1 inorganic K should be 25% less than Recommended Fertilizer i.e. 25% less than 250=75%
   Recommended K= (250*75/) 100=187.5 gm (3)
7. For calculating Uria U, Super Phosphate SSP and Murate of Potash MoP, first coefficient factor for NPK is calculated.

100kg U contains 46% N,

then coefficient factor is 100/46=2.17 (4)

100kg SSP contains 16% P,

then coefficient factor is 100/16=6.25 (5)

100kg MoP contains 60% K,
then coefficient factor is 100/60=1.67 (6)

8. Afterwards they calculate recommended U, SSP, and MoP.
9. Then calculate recommended uria.
   Recommended U=2.17 * Recommended N
   =2.17 * 781 using (1) and (4)
   =1694.77 gm
10. Then calculate recommended SSP.
    Recommended SSP= 6.25 * Recommended P
    = 6.25 * 312 using (2) and (5)
    = 1950 gm
11. Then calculate recommended MoP.

Recommended MoP= 1.67 * Recommended K
= 1.67 * 250 using (3) and (6)
= 417.5 gm

12. Then the final recommended inorganic fertilizers as per calculation are given in Table II.

Table II: Results of inorganic fertilizers recommendation by manual process

Time of Fertilizer	Nitrogen	Uria	Phosphorus	SSP	Potassium	MoP
First Dose	391	848	313	1950	125	209
Second Dose	390	848	-	-	125	209
Total	781	1694	313	1950	250	418

IV. METHODOLOGY

A. Proposed Algorithm:

Classification is a form of data analysis that extracts models describing important data classes. Such models, called classifiers, predict categorical class labels. The classification problem is stated as below.

Given a database D={t1,t2,…,tn} of tuples and a set of classes C={C1,C2,…,Cm}, the classification problem is to define a mapping f:D → C where each ti is assigned to one class. A class, Cj, contain precisely those tuples mapped to it; that is, Cj= {ti | f(ti)=Cj, 1≤ i ≤ n, and ti ϵ D}.

Data Classification is two-step process consisting of learning step and a classification step. In the first step, a classification model is build based on previous data. In the second step, the model's accuracy is determined for acceptance, and if accuracy is acceptable, then the model is used to classify new data.

In this project data is collected from KVK, Solapur center. Around 3000 farmers' soil test record is present in database. In KVK center, farmer's soil is tested in laboratory & hard copy of soil test report is given to farmer which contains available nutrients of soil, recommended organic & inorganic fertilizer for given crop & an advice in local language.

The proposed application needs to classify that large amount of data on basis of nutrients and crop name to suggest optimal fertilizer suggestion along with advice in a local language to a farmer. The decision tree is required to build for classification of such big data. C4.5 developed by Ross Quinlan is an ideal algorithm to build decision tree and hence used for classification. Earlier, ID3 algorithm is developed by Quinlan for decision tree construction but as it does not guarantee an optimal solution; C4.5 is proposed and developed which is an extension of ID3 algorithm.

C4.5 builds decision tree from a set of training data in the same way as ID3, using the concept of information entropy. The training data is a set S=s1, s2… of already classified samples. Each sample si consists of a p-dimensional vector (x1,i, x2,i, …, xp,i), where the xj represent attribute values or features of the sample, as well as the class in which si falls.

At each node of the tree, C4.5 chooses the attribute of the data that most effectively splits its set of samples into subsets enriched in one class or the other. The splitting criterion is the normalized information gain (difference in entropy). The attribute with the highest normalized information gain is chosen to make the decision. The C4.5 algorithm then recurs on the smaller sub lists.

This algorithm has a few base cases as stated below.

Case 1: All the samples in the list belong to the same class.

C4.5 simply creates a leaf node for the decision tree saying to choose that class.

Case 2: None of the features provide any information gain.

C4.5 creates a decision node higher up the tree using the expected value of the class.

Case 3: Instance of previously-unseen class encountered.

C4.5 creates a decision node higher up the tree using the expected value.

A.1 Algorithm:

The general algorithm for building decision trees is:

1. Check for the above base cases.
2. For each attribute a, find the normalized information gain ratio from splitting on a.
3. Let a_best be the attribute with the highest normalized information gain.
4. Create a decision node that splits on a_best.
5. Recur on the sublists obtained by splitting on a_best, and add those nodes as children of node.

B. System Architecture:

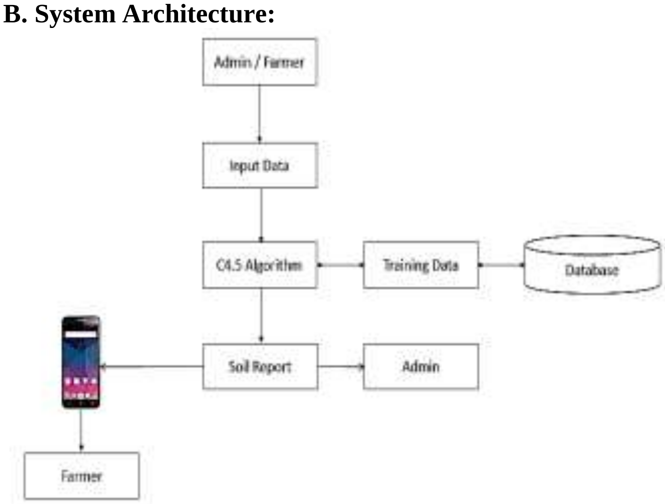

Fig. 2: System Architecture.

International Journal of Science, Engineering and Management (IJSEM)
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Fig. 2 shows the system architecture. It consists of user input, database, and related output. First raw data is provided to system, it will train the system and generate the decision tree. Admin or Farmers now can give the nutrients value and crop name as an input. System will apply the C4.5 algorithm and recommend the required fertilizers. These recommendations are generated in the form of soil report and this report can be given to farmer. Farmers can also use mobile device to generate the report.

V. RESULTS

For generating decision tree a large amount of historical data is used from KVK, Solapur. This data contains near about 3000 farmers soil test report. System consists of a website and mobile. The farmer may get fertilizers recommendation reports either from the website or from the mobile application. Fig. 3 shows input form for soil test report on website and Fig. 4 shows input form for soil test report on mobile application.

Fig. 3: Input for soil test report on website

Proposed algorithm is applied to the existing data, first it will train the large data and create decision tree. When training data is ready user can give the input in the input form. Then system will analyse the given decision tree and recommend the fertilizers & advice. Fig. 5 shows soil report which contains organic and inorganic fertilizer recommendation along with advice in local language. The result is highlighted by red box.

Fig. 4: Input form in mobile application

VI. CONCLUSION

Each and every sector is undergoing a dramatic change due to IT field. But, in agriculture field, till date not much work has been done. Various data mining technique used in agricultural field become the large sphere of research. The ultimate goal is to increase the crop yield of the agricultural field. This paper implements C4.5 algorithm which helps to find out the perfectly suitable fertilizer suggestion for a farmer based on soil condition and crop details. The suggestion is in local language which is easily understandable by farmers. The system will help farmers to download latest or old soil test report easily from their smart phones. Also farmers are able to download from online web based application.

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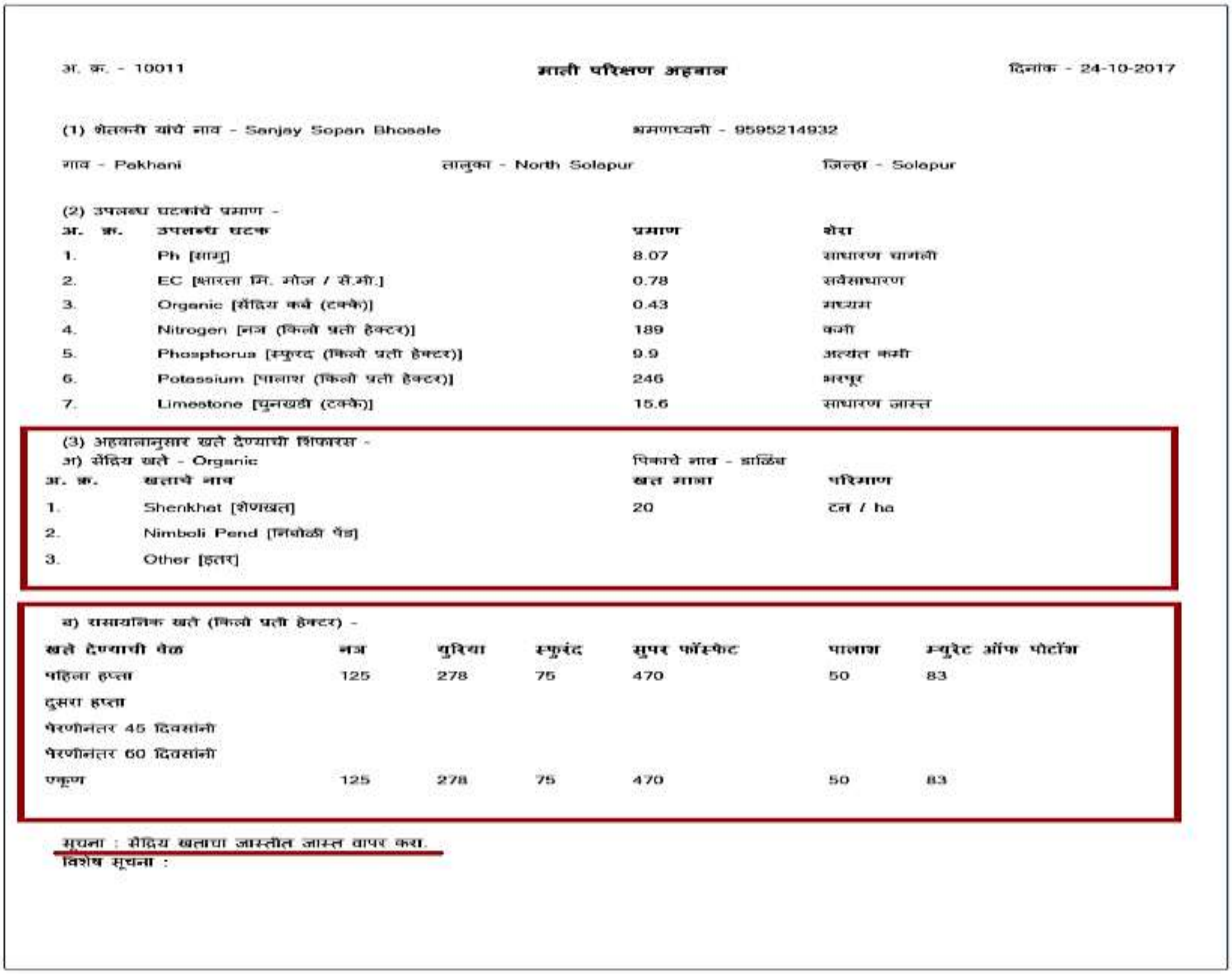

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(1) शेतकरी यांचे नाव - Sanjay Sopan Bhosale | भ्रमणध्वनी - 9595214932

गाव - Pakhani | तालुका - North Solapur | जिल्हा - Solapur

(2) उपलब्ध घटकांचे प्रमाण -

अ. क्र.	उपलब्ध घटक	प्रमाण	शेरा
1.	Ph [सामु]	8.07	साधारण चांगली
2.	EC [क्षारता मि. मोज / सें.मी.]	0.78	सर्वसाधारण
3.	Organic [सेंद्रिय कर्ब (टक्के)]	0.43	मध्यम
4.	Nitrogen [नत्र (किलो प्रती हेक्टर)]	189	कमी
5.	Phosphorus [स्फुरद (किलो प्रती हेक्टर)]	9.9	अत्यंत कमी
6.	Potassium [पालाश (किलो प्रती हेक्टर)]	246	भरपूर
7.	Limestone [चुनखडी (टक्के)]	15.6	साधारण जास्त

(3) अहवालानुसार खते देण्याची शिफारस -

अ) सेंद्रिय खते - Organic | पिकाचे नाव - डाळिंब

अ. क्र.	खताचे नाव	खत मात्रा	परिमाण
1.	Shenkhat [शेणखत]	20	टन / ha
2.	Nimboli Pend [निंबोळी पेंड]		
3.	Other [इतर]		

ब) रासायनिक खते (किलो प्रती हेक्टर) -

खते देण्याची वेळ	नत्र	युरिया	स्फुरद	सुपर फॉस्फेट	पालाश	म्युरेट ऑफ पोटॅश
पहिला हप्ता	125	278	75	470	50	83
दुसरा हप्ता						
पेरणीनंतर 45 दिवसांनी						
पेरणीनंतर 60 दिवसांनी						
एकूण	125	278	75	470	50	83

सूचना : सेंद्रिय खताचा जास्तीत जास्त वापर करा.

विशेष सूचना :

Fig. 5: Soil Test Report for Fertilizer Recommendation

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