ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 9, September 2015

Nutrient Management System for Paddy Based on Multi Linear Regression

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Abstract: Rice is the most important food crop of India, extend over one-fourth of the total cropped area and providing food to about half of the Indian population. Fertilizers are an important input for producing sufficient supplies of rice to meet increasing demands. Excess application of fertilizers can have deleterious effects on environment. Therefore, optimum amount of fertilizers should be used. The optimum fertilizer management of a crop depends on crop yield. The quantity of fertilizer application is determined by the target yield and the amount of nutrients required by the crop. In the proposed method, extension agents and farmers are provided with an advice on crop and nutrient management, matching their particular farming conditions by predicting the target yield. Multi linear regression algorithm is used to forecast the crop yield.

Keywords: Multi linear regression, Nutrients, Fertilizers, Nutrient Management System.

I. INTRODUCTION

In olden days, agricultural practices are good enough for getting high quality of yield according to environment available in those days. But, in modern days it is very difficult for farmers to attain same quality yield due to biased environment like scarcity of water, pollution in air and usage of inorganic fertilizers. To get maximum yield, farmers have to choose modern practices like selecting a variety of crop, seed based on soil conditions and providing the required amount of nutrients and water. Selecting variety of crop and seed based on soil condition are field specific. Source of nutrients taken up by paddy are soil, crop residues and manures, irrigation water and fertilizers. Fertilizers bridges the gap between nutrients needed by crop and actual supply. If there is an adequate supply of nutrients in the soil, plants are likely to grow well and produce high yields.

Therefore, Farmers must tailor their fertilizer management to match the nutrient requirements of their crop in order to achieve high and profitable yields. This requires using the right combination of fertilizer sources, timing of application for their field-specific conditions. Tailoring fertilizer management to a specific field can require complex decision making for farmers. Therefore, a major principle of Nutrient management system is to prevent the over-application of nutrients. In this paper, a novel approach is presented for predicting the target yield. Based on the target yield, amount of nutrients needed by crop can be predicted [1]. This model is based on Multi linear regression (MLR) [3] that leads to an accurate forecasting model.

Soil type, crop variety, season, irrigated water supply, rainfall, weed elimination, nursery planning, crop establishment, line spacing are used as input parameters of the forecaster model. Synthetic data collected from various agricultural offices and farmers are used as input data for suggested model to forecast the target yield.

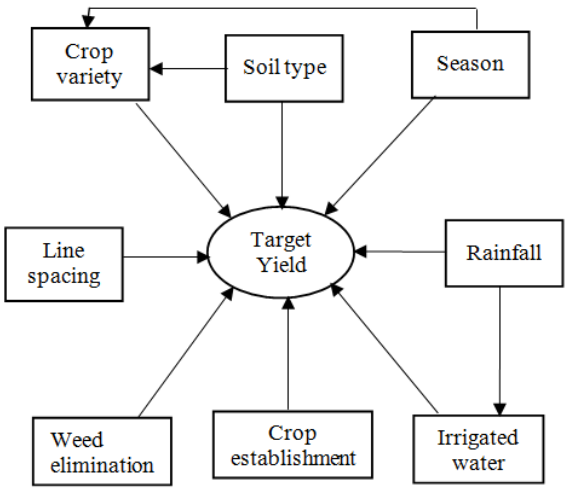

Fig. 1 Target yield and corresponding yield factors.

In Fig 1, soil type, crop variety, season, rainfall, irrigated water, crop establishment techinques, weed elimination, line spacing are the factors which affects the target yield. Raindfall and irrigated water are proportional to each other. Crop variety depends in season and soil type.

II. RELATED WORK

Agricultural offices maintain huge amounts of information regarding the rice crop by performing the field trails. With domain knowledge and experience, extension workers make use of the collected data and recommend required amount of fertilizers to the crop and time of application of fertilizers. Factors such as soil types, rice variety, season, water availability, climatic conditions, crop management techniques etc. effect the rice yield production. Considering these factors to forecast the yield manually is challenging to the experts. But, however they follow the traditional principles to recommend fertilizers to the rice crop.

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There is no computerized system to predict the target yield till now. In this paper, our proposed method uses Multi linear regression model to forecast the target yield.

III.PROPOSED METHOD

A. Nutrient Management System for Paddy

Nutrient management system for paddy (NMSP) enables farmers to dynamically adjust fertilizer use, by supplying optimum amounts of nutrients at critical time points in the crops growth to produce high yields.

The following are steps [2] in NMSP

1) *Establish an Attainable Target Yield*: Identify estimated yield based on location and season. Consider factors such as climate, rice varieties, soil types and crop management. The yield target determines the total amount of nutrients that must be taken up by crop.

In the proposed method, MLR is used to predict the target yield by considering all the parameters.

Multi Linear Regression Model

In general, regression model attempts to forecast variations in some variable of interest, the dependant variable, on the basis of variations in a number of other factors, the independent variables.

In other words, target yield could be predicted by the fallowing set of candidate variables as inputs to the regression model:

$$\begin{bmatrix} X_{11} & X_{12} & X_{13} & \dots & X_{1n} & Y_{11} \\ X_{21} & X_{22} & X_{23} & \dots & X_{2n} & Y_{21} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ X_{m1} & X_{m2} & X_{m3} & \dots & X_{mn} & Y_{m1} \end{bmatrix}$$

(m x n) (m x 1)

Where matrix X is collection of independent variables and matrix Y is collection of dependant variables.

Multi linear regression is used for yield forecasting.

Equation specifies the process:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_p X_{ip} + \mathcal{E}_i$$

Where Y_i is the output in the i^{th} trail with $i = 1, 2, \dots, n$, where n is the sample size, the values $X_{i1}, X_{i2}, \dots, X_{ij}$ are observed values of the j^{th} of p, that $j = 0, \dots p$ independent variables associated with i^{th} output, the non-observable random variables $\mathcal{E}_i, \mathcal{E}_{2, \dots, n} \mathcal{E}_n$ are random error terms with $E\{\mathcal{E}_i\} = 0$ and variance $\sigma^2\{\mathcal{E}_i\} = \sigma^2$ and β_j are unknown parameters to be estimated. The process modelled by

$$\hat{Y}_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_p X_{ip}$$

A variety of methods exist to find regression coefficient β_j, the most popular method is ordinary least squares (OLS). By using OLS, the regression coefficient estimations are achieved by expressing the measurements in the matrix form, for convenience, $(P + 1)$ is written as $P`$. The equation that give the least square estimate β` of the parameter set.

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} = \begin{bmatrix} 1 & X_{11} & X_{12} & X_{13} & \dots & X_{1p} \\ 1 & X_{21} & X_{22} & X_{23} & \dots & X_{2p} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & X_{n1} & X_{n2} & X_{n3} & \dots & X_{np} \end{bmatrix} \text{X} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_p \end{bmatrix} + \begin{bmatrix} \mathcal{E}_1 \\ \mathcal{E}_2 \\ \vdots \\ \mathcal{E}_n \end{bmatrix}$$

(n X 1) (n X P^1) (P^1 X 1) (n X 1)

$$\hat{\beta} = (X^T X)^{-1} X^T Y$$

Where X^T is transpose of matrix X. X^{-1} is inverse of the matrix X.

To assess the validity of the regression model, R-square test is adopted. The quantity r-square (r^2) [5] expresses the degree of which the linear relationship between set of predictors and a variable can explain the variance in the variable. The coefficient of determination ranges between 0 and 1.

- 0 indicates the model explains none of the variability of the response data around its mean.
- 1 indicates the model explains all the variability of the response data around its mean.[6]

$$r^2 = \sum_{i=1}^{n} (\hat{Y}_i - \bar{Y})^2 \Big/ \sum_{i=1}^{n} (Y_i - \bar{Y})^2$$

Where, $\bar{Y}$ is the average value of Y_i's and $\hat{Y}_i$ is the predicted value for Y_i.

2) *Effectively Use Existing Nutrients:* Indigenous nutrients that come up from the soil, along with organic materials, crop residues, manures and irrigation, need to be managed properly to achieve optimal crop nutrient uptake.

3) *Apply Fertilizer to Fill the Deficit between Crop Needs and Indigenous Supply:* Major fertilizers such as Nitrogen, potassium and phosphorus are applied to supplement nutrients. The quantity of application is determined by the target yield and amount of nutrients needed by the crop.
Proposed method calculates fertilizer quantities based on the forecasted target yield. In proposed method we follow some rules to calculate accurate amount of nutrients. They are,

- Rice crop takes around sixteen kg Nitrogen per ton of grain yield.
- Three kg phosphorus per ton of grain yield and
- Sixteen kg potassium per ton of grain yield.

B. Timing of Fertilizer Applications

Proposed method gives exact time points of application of fertilizers. For optimum results, fertilizers should be applied to the soil at three points in the crop cycle

1) The Basal Application: Just prior to transplanting, one third of fertilizer should be broadcasted and puddled into the field.

2) Active Tillering Stage: Approximately two weeks after sowing. Fertilizer should be broadcasted which promotes tillering and helps strengthen the plants against disease attack.

3) Panicle Initiation Stage: After the panicle initiation stage, fertilizer should be once again be broadcasted and puddled into the soil. Amount of fertilizers may vary according to the duration of the variety.

Our work includes, sources of nutrients in the fertilizers. Source of nitrogen is Urea (46% N), source of potassium is Muriate of potash (MOP) which consists of 50% K, sources of phosphorus di-ammonium phosphate (DAP) and single super phosphate (SSP) which consists of 17% P.

DOI 10.17148/IJARCCE.2015.4996

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IV. RESULTS

In order to compute performance of the proposed model, R-Square (R^2) fit is **0.84**. Table 1 shows performance of proposed approach and also demonstrates performance of the proposed method compared to multilayer perceptron model.

TABLE 1:PERFRORMANCE COMPARISON

Method	**Mean absolute error [6]**	**Root mean squared error [6]**	**Relative absolute error (%)**	**Root relative squared error (%)**
Multilayer perceptron	175.64	207.46	49.7	50.0
Proposed MLR method	129.39	163.5	36.6	39.4

V. CONCLUSIONS

In this study, a MLR approach is presented for forecasting the target yield of the paddy crop. The error of the proposed method is 36.6 by using MAE, which describes the high accuracy of the prediction compared to the multilayer perceptron model. By using the forecasted target yield, amount of nutrients taken up by the crop can be calculated.

ACKNOWLEDGMENT

We thank Department of computer science and systems engineering for their constant support. We would also like to thank the anonymous reviewers for their constructive comments.

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