Prediction of Sugarcane Yields from Field Records using Regression Modeling

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Abstract: Prediction Of Sugarcane Crop Yield Benefits The Farmer To Get Best Possible Decision Regarding Sugarcane Crop Cultivation. The Purpose Of This Work Is To Identify Possible Relationship Between N, P, K Fertilizer, Water Resource And Planting Densities. The Algorithm Used Is Multiple Regression. The Paper Focuses On The Generation Of Multiple Regression Models For The Dataset Of Sugarcane Crop For Season Adasali, Suru And Preseasonal Method. The Intercept And Slope For Variables Are Calculated And Equation For Each Model Is Generated. Sample Of N,P,K And Other Are Considered For A Period Of 7 Years From 2012 To 2018. Data Of Experimentation Is Collected For Arid Region I.E Pandharpur, Maharashtra State.

Keywords: Prediction, Crop Yield, Regression Analysis

I. INTRODUCTION

As we know India is the land of agriculture, approximately 70% of population constitutes farmers. As in last few years the extensive boost of population raises the question of fulfillment of food requirement. So the slope of production needs to be at increasing order. Due to technological enhancement in agriculture practices which results in increased in production for initial certain years. But after some years usage of fertilizer and unpredictable weather conditions has make production of crop as challenging issue. So the improvement in crop production to contribute to national income is needed. So prediction of yield and recommendation of fertilizer will surely help the farmer for getting good output yield. The multiple regression algorithm considers parameters such as N, P, K to predict yield and try to find out the relationship with the input parameters and output parameters. The data is visualized with respect to different parameters using juypter, python. As it will help to make clear parameters dependencies with output and other variable. There are four methods of Sugarcane cultivation in Maharashtra. Maharashtra is the second largest producer of sugarcane in India. The research for increasing sugarcane production will be helpful to gain more production. The fertilizer recommendation for sugarcane crop can be done by considering N, P, K parameters as well as Ph value of soil. This will surely help in cost cutting of fertilizer usage and more production as well as land fertility can kept intact.

The following table shows the sugarcane production of Maharashtra. Sugarcane is also identified as one of the major cash crop.

Table 1: Sugar production of Maharashtra (Courtesy: indianexpress.com/article/india)

| Production Year | Production of Sugar (Lakhs Ton) | Recovery of sugar(percentage of sugarcane crushed) |
|-----------------|--------------------------------|-----------------------------------------------|
| MH | UP | MH | UP | |
| 2011-12 | 89.96 | 69.74 | 11.67 | 9.07 |
| 2012-13 | 79.87 | 74.85 | 11.41 | 9.18 |
| 2013-14 | 77.12 | 64.95 | 11.41 | 9.26 |
| 2014-15 | 105.14 | 71.01 | 11.30 | 9.54 |
| 2015-16 | 84.15 | 68.55 | 11.33 | 10.62 |
| 2016-17 | 42.00 | 87.73 | 11.26 | 10.61 |
| 2017-18 | 107.21 | 120.50 | 11.24 | 10.84 |
| 2018-19 | 98.45 | 81.77 | 11.14 | 11.27 |

From the above table we get to know that India is producing Sugarcane as the highest contribution to national income. Also the recovery of sugar is also high for Maharashtra.

II. LITERATURE SURVEY [2, 3]

Table 2: Literature survey

| Author and publication | Techniques applied | Variables considered | Area o grow |
|------------------------|--------------------|----------------------|-------------|
| Saeed Khaki, 2019      | deep neural network | genotype, environment | black box property |
| Mrs.K.R.Sri Preethaa, 2018 | Bayesian algorithm | Parameters of soil, fertilizer used, duration of crop and humidity | Suggestion of pesticide for different type of disease |
| Dr. A. Senthil Kumar, P. Arun, 2017 | K nearest neighbor, Artificial neural network and data mining techniques | Comparative study | - |
| E. Manjula, 2017      | data mining technique based on association rules | Year, District, Crop, Area, Tanks, Bore Wells, Open Wells, | Need to check with other algorithm |
III. METHOD

6 completed crop cycles records from 80 fields are taken into consideration. These records are extensively edited to provide figures appropriate for statistical analysis and electronic manipulation. Observations that are not representative were disqualified from the exploration using 3 prior criterion:

a. elimination of all observations with no fertilizer (N,P,K) records;

b. rejection of records which differ by more than 10% duplication.

c. Excluded observation made on mixed varieties of sugarcane which contribute less than 15 records.

The experimental data from 80 farmers were collected. The data cleaning and analysis is performed on data. Missing values are filled using mean method. Some observations are ignored as its giving very high error due to scattered of data.

The method of least squares is used for linear regression analysis. It is used to found a functional relation between the variables. The model which is generated using the formula:

Regression Line = Minimize (∑ (Y - (β₀ + β₁X₁ + β₂X₂ + ... + βₙXₙ)))²

Where we need to get function which will generate low bias.

The dependent parameter i.e. Y which is yield in our multiple regression model. The independent variables are values of N, P, and K fertilizer. The model generated on three season dataset.

We found in most of the model N and P parameters are affecting yield parameter in the model as compared to K parameter. As we tried to generate the model by considering more features or parameters but due to very few records are available and which is scattered also it gives very high error. Due to this the error generated is very high and prediction is not up to the mark. So we have not considered maximum parameters but limit the dataset.

IV. EXPERIMENT AND RESULTS

A. Multiple Regression Model for Adasali Sugarcane

Adasali sugarcane is 18 months crop. Its sowing time is till June to August. The Multiple regression method will consider one dependant variable that is crop yield and remaining variables such as N, P, K, water variables, planting densities, energy usage.

After applying the multiple regressions on train data set we will get the following Model. We will only consider coefficients

| Parameters | Coefficients | P-value |
|------------|--------------|---------|
| Intercept  | 85.50959     | 0.001555|
| N          | 0.149396     | 0.000226|
| P          | 0.176014     | 0.043106|
| K          | 0.178363     | 0.010977|

And intercept for building a model. The P value of the variable is greater than 0.15 is not considered for prediction. So according to result at Table 1 our Model is as shown below

Equation 1:

\[ \text{Predicted } Y = 85.5095232 + 0.149396062 \times \text{value of } X_1 + 0.176013688 \times \text{value of } X_2 + 0.178363252 \times \text{value of } X_3 \]

For the problem in linear regression we try to find the predicted value of Y:

\[ Y = \beta_0 + \beta_1 X \]

To find the values for the coefficients i.e. β₀ and β₁ which minimize the objective function we take the partial derivates of the objective function (SSE) with respect to the coefficients. Set these to 0, and solve.

\[ \beta = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2} \]

\[ \beta = \frac{\sum y - \beta \sum x}{n} \]

For multiple regression for n multiple variables we have formula,

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \]

Where \( \beta_0 \) is constant which is intercept in our formula, \( X_1,X_2, \ldots X_n \) are the values of N, P, K from the dataset and \( \beta_1, \ldots , \beta_n \) are the slopes used for getting predicted value Y.

Graph 1: Actual yield Vs Predicted Yield for Adasali

So for our model the error of prediction is 12.52.

The square of error is 1.043333333.

B. Multiple Regression Model for Pre-Seasonal Sugarcane

Preseason Sugarcane is of 16 months crop. Its sowing time is from October to November. After performing multiple regressions analysis on the data gathered from farmer. We got the following calculation

From the table the Model we get as follows, Equation 3

Predicted \( Y = -31.2418932 + 0.663990431 \times \text{value of Variable } N - 0.77497584 \times \text{value of Variable } P \)
1.144635649*value of Variable K

Table 4: Multiple Regression Model for Preseasonal Sugarcane

| Parameters | Coefficients     | P-Value  |
|------------|------------------|----------|
| Intercept  | -31.2418932      | 0.68513154 |
| N          | 0.663990431      | 0.023323571 |
| P          | -0.77497584      | 0.036496118 |
| K          | 1.144635649      | 0.047619227 |

So the error of prediction for our model is -47 and the standard error of estimate is -2.043478261.

C. Multiple regression Model for Suru/Seasonal Sugarcane

Crop duration is of 12 months. Sowing time for crop is January to February. The following is the result obtained for Multiple Regression on the data.

Table 5: Multiple Regression Model for Suru

| Parameters | Coefficients     | P-Value  |
|------------|------------------|----------|
| Intercept  | 190.5184576      | 0.000317 |
| N          | -0.121734273     | 0.564733 |
| P          | -0.193451256     | 0.568065 |
| K          | 0.013255739      | 0.973154 |

So our model of regression is Equation 4

Y Pred = 190.5184576+N*0.121734273+P*0.193451256 + K*0.013255739

So the error of prediction for our model is 76.71594 and the standard error of estimate is 7.671594.

Graph 2: Actual yield Vs Predicted Yield for Preseasonal sugarcane

As from the graph it shows that the regression model of season Suru gives low error of prediction and estimate. This shows that the Crop prediction given by this model is more accurate compared to other models.

V. FERTILIZER RECOMMENDATION DEPENDING ON SOIL PARAMETER

The equations which can be used for determination for fertilizer recommendation are as follows:

Table 6 :Suru Hungama (WITHOUT COWDUNG FERTILIZER)

| Parameters | Coefficients     | P-Value  |
|------------|------------------|----------|
| N          | 4.76*Production expectation-1.34*AVILABLE N OF SOIL | 0.000317 |
| P          | 1.24*Production expectation-1.55*AVILABLE P OF SOIL | 0.564733 |
| K          | 2.73*Production expectation-0.21*AVILABLE K OF SOIL | 0.568065 |

Table 7 :Purva Hungama (WITHOUT COWDUNG FERTILIZER)

| Parameters | Coefficients     | P-Value  |
|------------|------------------|----------|
| N          | 3.79*Production expectation-1.16*AVILABLE N OF SOIL | 0.000317 |
| P          | 1.53*Production expectation-2.61*AVILABLE P OF SOIL | 0.564733 |
| K          | 3.67*Production expectation-0.73*AVILABLE K OF SOIL | 0.568065 |

Table 8: Khodava (WITH COWDUNG FERTILIZER)

| Parameters | Coefficients     | P-Value  |
|------------|------------------|----------|
| N          | 3.89*Production expectation-0.94*AVILABLE N OF SOIL-0.94*cowdung Fertilizer | 0.000317 |
| P          | 1.12*Production expectation-1.66*AVILABLE P OF SOIL-40* cowdung Fertilizer | 0.564733 |
| K          | 3.06*Production expectation-0.58*AVILABLE K OF SOIL-1.04 *cowdung Fertilizer | 0.568065 |

Table 9: Khodava (WITHOUT COWDUNG FERTILIZER)

| Parameters | Coefficients     | P-Value  |
|------------|------------------|----------|
| N          | 4.47*Production expectation-1.08*AVILABLE N OF SOIL | 0.000317 |
| P          | 1.56*Production expectation-2.32*AVILABLE P OF SOIL | 0.564733 |
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### Table 10: Purva Hungama (COWDUNG FERTILIZER)

| Variable | Equation |
|----------|----------|
| N        | 3.73*Production expectation-1.14*AVILABLE N OF SOIL-3.09*cownud Fertilizer |
| P        | 1.49*Production expectation-2.54*AVILABLE P OF SOIL-2.24*cownud Fertilizer |
| K        | 3.15*Production expectation-0.63*AVILABLE K OF SOIL-1.15*cownud Fertilizer |

### Table 11: Adasali Hungama (WITHOUT COWDUNG FERTILIZER)

| Variable | Equation |
|----------|----------|
| N        | 4.39*Production expectation-1.56*AVILABLE N OF SOIL |
| P        | 1.62*Production expectation-4.56*AVILABLE P OF SOIL |
| K        | 1.86*Production expectation-0.37*AVILABLE K OF SOIL |

VI. OBSERVATION

Following are the observations of models generated for Adasali, Suru and preseasonal.

Firstly the dependent variable in the model is sugarcane yield which basically depends on N, P, K and other variable whereas water resource need to be treated important, but sometime it will behave unexpectedly as we know that agriculture is very uncertain branch. When so to build model on area like agriculture need to consider each and every minute parameter to reach to the accuracy expected , but it again depend on the real parameters and accurate static data. Data from Indian government on agriculture will really help the researcher to contribute for farming through technologies. Secondly, sometime many of the parameters considered are really independent on each other and which surely affects the performance of the model. So simple multiple regression is not going to give the desired result as well as accuracy for the output variable. The output of our model is generally helpful to managers for planning and resource allotment required for achieving certain desired yield. The appropriate and ample amount of data and technologies like neural network along with function activation and weight adjustment may solve the purpose. This may give the desired result.

VII. VALIDATION

For predicting future sugarcane production there is need of the sugarcane crop dataset at least 6 to 8 months in advance to take decision on parameters. This is required to analyze and visualize the relationship with each variable. From the models generated the results for yield prediction does not fit appropriate for all the future data.

The accuracy of the model is very low while error generated is very high. So model generated with multiple regressions using available data is very poor.

The cross validation method might help to improve model accuracy and may give better result for unseen data.

VIII. CONCLUSION

The area of study on which the model is applied is restricted to arid region of Maharashtra; Pandharpur. The model is trained and tested with the input values given by 80 farmers. The model can be undertaken for more number of records and need to train accordingly.

The model recognized and executed focuses on parameters which were treated important initially. The supplementary research is required to find out the association and patterns between dependent and independent variable.

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