International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.7 September - October – 2023
DOI:10.46647/ijetms.2023.v07i05.021 ISSN: 2581-4621

Revolutionizing Fertilization Strategies with Machine Learning-Driven Nutrient Prediction

Mrs. J. Porkodi[1], Dr. B. Karunai Selvi[2], Mr. A. Nagavaratharajan[3]
[1]*Head and Assistant Professor, Department of Computer Applications (UG), V.V.Vanniaperumal College for Women, Virudhunagar, Tamilnadu*
[2]*Head and Associate Professor, Department of Botany, V.V.Vanniaperumal College for Women, Virudhunagar, Tamilnadu*
[3]*Associate Professor of Commerce with Computer Applications, V.H.N.Sentikumara Nadar College, Virudhunagar, Tamilnadu*
Orcid ID : 0009-0005-9609-8931

ABSTRACT
In the pursuit of sustainable agriculture, the effective management of fertilization strategies stands as a critical imperative. This abstract explores the transformative potential encapsulated within "Revolutionizing Fertilization Strategies with Machine Learning-Driven Nutrient Prediction." Traditional agricultural practices often grapple with imprecise fertilization, leading to inefficiencies, overuse of resources, and environmental ramifications. This study introduces an innovative approach that integrates advanced Machine Learning (ML) techniques with agronomic insights to accurately predict plant nutrient requirements. By harnessing comprehensive datasets encompassing soil properties, crop categorizations, and historical growth data, an intricate ML model is formulated. Employing sophisticated algorithms such as Random Forest, XG Boost Classifier the model uncovers intricate interdependencies shaping nutrient absorption. Through an iterative process of training, validation, and optimization, the model attains the capability to anticipate nuanced nutrient demands across diverse growth stages and crop typologies. By supplying real-time, data-informed intelligence on nutrient requirements, farmers are empowered to tailor fertilization approaches with precision, curbing resource wastage and diminishing nutrient runoff. Additionally, this ML-Centered methodology aligns seamlessly with the ambitions of sustainable agriculture, channelling efforts toward resource efficiency and environmental stewardship.
Keywords— Sustainable agriculture, Fertilization strategies, Nutrient prediction, Random Forest classifier, XG Boost Classifier.

1. Introduction

Agriculture is the production of food, feed, fiber, and other goods by cultivating plants and livestock. It is one of the most important economic activities in the world, and it plays a vital role in human society. Agriculture is essential for food security, which is the availability of safe, nutritious food to all people at all times. Agriculture provides the food that we need to survive and thrive. It also provides jobs, income, and foreign exchange for many countries. Fertilization is a critical practice in agriculture, as it helps to ensure that plants have the nutrients they need to grow and thrive. However, traditional fertilization methods can be inefficient and wasteful, as they often apply fertilizer in excess of what is actually needed. This can lead to environmental pollution and financial losses for farmers.

Machine learning is a rapidly developing technology that has the potential to revolutionize fertilization strategies. Machine learning algorithms can be trained on large datasets of data, such as soil test results, weather data, and crop yield data. This allows them to identify patterns and correlations that would be difficult to detect using traditional methods. Combined with nutrient prediction, machine learning can be used to develop highly precise fertilization recommendations. This can help farmers to reduce fertilizer use, improve crop yields, and protect the environment.

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.7 September - October – 2023
DOI:10.46647/ijetms.2023.v07i05.021 ISSN: 2581-4621

2. Experimental Methods or Methodology

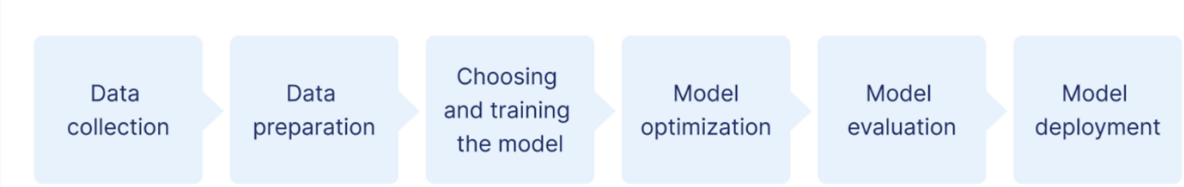


Fig 1. Machine Learning process flow

This article addresses the importance of correct amount of fertilizer for the better growth of plants and to improve the agriculture. Random forest is a type of ensemble learning algorithm that combines multiple decision trees to improve the accuracy of predictions. It is a popular machine learning algorithm that is used forclassification. Random forests work by building a large number of decision trees on different subsets of the training data. Each decision tree is trained to make predictions independently of the other trees. When a new data point is presented to the random forest, each tree makes a prediction. The final prediction is made by averaging the predictions of all the trees. Random forests are effective at reducing overfitting, which is a problem that can occur when machine learning models are trained on too much data. Overfitting occurs when the model learns the training data too well and is unable to generalize to new data. Random forests are often more accurate than other machine learning algorithms, especially for complex problems. This is because random forests are able to reduce overfitting by training a large number of trees on different subsets of the data. Hyperparameter tuning, also known as hyperparameter optimization or hyperparameter search, is the process of selecting the best combination of hyperparameters for a machine learning model. Hyperparameter tuning is done by grid search. Involves defining a grid of possible hyperparameter values and exhaustively trying all possible combinations. "XGBoost" stands for "Extreme Gradient Boosting," and it is a powerful machine learning algorithm. XGBoost is an advanced implementation of the gradient boosting algorithm that offers high performance, efficiency, and flexibility. It is commonly used for classification tasks. XGBoost is based on the gradient boosting framework, which involves combining weak learners (typically decision trees) into a strong predictive model. XGBoost includes regularization techniques to prevent overfitting, such as L1 (Lasso) and L2 (Ridge) regularization on the leaf weights.

3. Results and Discussion

3.1 Dataset

The dataset consist of the following features such as temperature, humidity, moisture, soil type, crop type, nitrogen, potassium and phosphorous .These are the independent variables and the fertilizer is the variable to be predicted. The fertilizers are to be classified into 6 categories based on the above mentioned features.

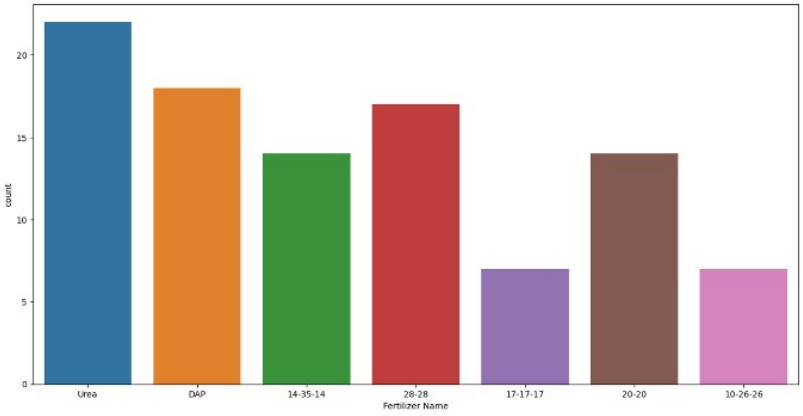


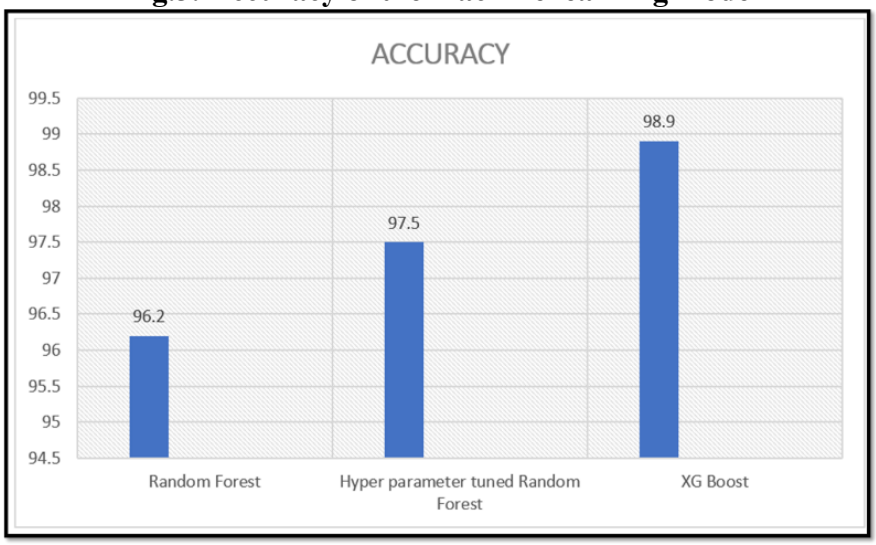
Fig. 2. Histogram of Fertilizer types

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.7 September - October – 2023
DOI:10.46647/ijetms.2023.v07i05.021 ISSN: 2581-4621

3.2 Performance metrics

Performance metrics are used to evaluate the performance of machine learning models. They are used to determine how well a model is able to make predictions on new data. The performance metrics used in this paper is accuracy and precision.

Fig.3. Accuracy of the machine learning model



The Random Forest classifier gives the accuracy of 96.2 %, Hyper parameter tuned Random Forest gives the accuracy of 97.5% and finally the XG Boost gives the accuracy as 98.9%. The classification report is analysed and the performance metrics for each machine learning algorithm is compared and finally for this data set XGBoost algorithm performs well compared to other machine learning algorithms.

Conclusion

As per preceding research and findings, the amount of fertilizer used in the plant is vital for the best growth of the plant. the integration of machine learning-driven nutrient prediction into fertilization strategies has the potential to revolutionize agriculture and address the challenges posed by traditional methods. The marriage of advanced data analytics and agricultural practices holds promise for optimizing nutrient management, increasing crop yields, and ensuring environmental sustainability.

Machine learning algorithms have demonstrated their ability to process vast amounts of data from various sources, such as soil samples, weather patterns, crop types, and historical yield data. By extracting meaningful patterns and correlations, these algorithms can generate accurate predictions about the nutrient requirements of crops. This predictive capability empowers farmers with actionable insights, enabling them to apply fertilizers more precisely and efficiently. The benefits of such a revolution in fertilization strategies are manifold. Firstly, it can lead to a significant reduction in resource wastage. Over-fertilization, a common practice with conventional methods, can lead to nutrient runoff, soil degradation, and groundwater contamination. By tailoring nutrient application to the exact needs of crops, machine learning-driven approaches can mitigate these negative environmental impacts. Secondly, optimizing nutrient delivery can directly translate into increased crop productivity.

Fine-tuning nutrient levels based on predictive models can enhance crop health, accelerate growth, and boost yields. This is especially critical as the global population continues to grow, placing greater demands on agricultural output. Moreover, the economic benefits cannot be overlooked. Precision fertilization can lead to cost savings for farmers by minimizing excess fertilizer expenditures. Additionally, the enhanced yields resulting from optimized nutrient management can contribute to increased profitability.

DOI:10.46647/ijetms.2023.v07i05.021 ISSN: 2581-4621

References

1. Dorijan Radocaj, "The Role of Remote Sensing Data and Methods in a Modern Approach to Fertilization in Precision Agriculture," Remote Sensing for Water Resources Assessment in Agriculture, 2022.

2. Andavar Suruliandi, Kharla Andreina Segovia-Bravo, Soosaimarian Peter Raja, "Predicting the suitable fertilizer for crop based on soil and environmental factors using various feature selection techniques with classifiers," Expert Systems, 13 July 2022.

3. Alicia Hernandez-Mora , Walter W. Wenzel , "Improving the prediction of fertilizer phosphorus availability to plants with simple, but non-standardized extraction techniques," Science of The Total Environment, September 30 ,2021.

4. John E. Sawyer, Javed Iqbal, Aaron M. Sassman, Renuka Mathur, "Role of sulfur mineralization and fertilizer source in corn and soybean production systems," SOIL FERTILITY & PLANT NUTRITION, 31 March 2022.

5. Michela Battisti, Barbara Moretti, Dario Sacco, "Soil Olsen P response to different phosphorus fertilization strategies in long-term experiments in NW Italy," Soil Use and ManagementVolume 38, Issue 1 p. 549-563,2021

6. Laasya Kanuru; Amit Kumar Tyagi; Aswathy S U, "Prediction of Pesticides and Fertilizers using Machine Learning and Internet of Things", IEEE 2021 International Conference on Computer Communication and Informatics (ICCCI -2021), Jan. 27-29, 2021

7. Jeevaganesh R; Harish D; Priya B ,"A Machine Learning-based Approach for Crop Yield Prediction and Fertilizer Recommendation", 2022 IEEE 6th International Conference on Trends in Electronics and Informatics (ICOEI), 28-30 April 2022.

8. S. Bhanumathi; M. Vineeth; N. Rohit ," Crop Yield Prediction and Efficient use of Fertilizers", 2019 International Conference on Communication and Signal Processing (ICCSP) ,25 April 2019.

9. K P K Devan; B Swetha; P Uma Sruthi; S Varshini ," Crop Yield Prediction and Fertilizer Recommendation System Using Hybrid Machine Learning Algorithms", 2023 IEEE 12th International Conference on Communication Systems and Network Technologies (CSNT), 31 May 2023.

10. G. Elizabeth Rani; Ede Venkatesh; Karnam Balaji," An automated prediction of crop and fertilizer disease using Convolutional Neural Networks (CNN)" 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE),18 July 2022.

11. Hongjian Zhang; Chunbao Xu ," Fertilizer Strength Prediction Model Based on Shape Characteristics" , IEEE Access (Volume: 9), 23 March 2021.

12. K Monika; Balakrishnan Ramprakash; Sankayya Muthuramalingam; K Mirdula"Crop Fertilizer Prediction using Regression analysis and Machine Learning algorithms", 2022

13. Krutika Hampannavar; Vijay Bhajantri; Shashikumar. G. Totad ," Prediction of Crop Fertilizer Consumption", 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA) ,25 April 2019.

14. O. Rama Devi; P. Naga Lakshmi; S.Naga Babu ," Fertilizer Forecasting using Machine Learning", 2023 International Conference on Inventive Computation Technologies (ICICT), 01 June 2023.

15. Sai Yasehwanth Chaganti; Prajwal Ainapur ," Prediction Based Smart Farming", 2019 2nd International Conference of Computer and Informatics Engineering (IC2IE), 27 December 2019.