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CROWN CHOKING DISORDER IN COCONUT PALMS: A REVIEW OF MACHINE LEARNING APPROACHES FOR EARLY PREDICTION

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ABSTRACT

Coconut is an important plantation crop in tropical regions, and crown choking is a serious physiological disorder that restricts leaf emergence, affects crown development, and reduces yield. The disorder is mainly associated with micronutrient imbalance, particularly boron deficiency, and is influenced by soil and climatic conditions. Early diagnosis is difficult because visible symptoms often appear at later stages. Machine learning has emerged as an effective approach for early prediction by analyzing soil, environmental, and plant-related data. This review examines studies applying machine learning techniques to predict crown choking and related nutrient stress conditions in coconut and similar perennial crops. Reported results show that Logistic Regression models typically achieve accuracies of 70–80%, Support Vector Machines reach 80–88%, and ensemble methods such as Random Forest and Gradient Boosting achieve 85–92% accuracy. Deep learning models, particularly convolutional neural networks using crown images, report accuracy levels above 90% under controlled conditions. The study highlights that prediction performance depends on data quality and field variability, emphasizing the potential of machine learning for early intervention and sustainable coconut plantation management.

KEYWORDS: Crown choking disorder, Coconut palms, Machine learning approaches, early prediction.

INTRODUCTION

Coconut (*Cocos nucifera* L.) is a major perennial crop cultivated in tropical regions, providing food, oil, fiber, and income to millions of small-scale farmers (Arumugam T & Md Hatta M. A**,** 2022). Crown choking is a physiological disorder that negatively affects palm growth and nut yield. It is characterized by narrow, twisted leaves, poor crown expansion, and compact crown formation (Indian Coconut Journal, 2024). The disorder is primarily caused by micronutrient imbalance especially boron deficiency along with poor soil conditions, moisture stress, and climatic variability. Traditional diagnosis relies on visual observation and soil testing, which often detect the problem only after significant damage. Recent developments in data-driven agriculture have introduced machine learning as a tool for early prediction, capable of processing soil, environmental, and plant data to identify hidden patterns that cannot be detected through conventional methods. This review presents a comprehensive overview of crown choking disorder and examines the effectiveness of machine learning techniques in its early prediction.

SURVEY METHODOLOGY

This review follows a survey based methodology workflow given in Figure 1, focusing on crown choking and machine learning structure of coconut palms.

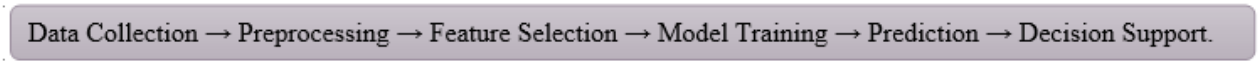

Figure 1: Machine Learning Workflow for Crown Choking Prediction.

Studies included data from (Dey B, Ferdous J & Ahmed R 2024).

- Soil and nutrient parameters (boron, pH, organic carbon)
- Environmental factors (temperature, rainfall, humidity)
- Morphological traits of coconut palms
- Image data of crown and leaves

RESULTS AND DISCUSSION

CROWN CHOKING DISORDER OVERVIEW

Crown choking disorder affects coconut palms features are shown in Table 1, by restricting leaf growth, twisting leaves, and forming a compact crown, often leading to reduced yield. It

is mainly caused by boron deficiency and influenced by soil and climate conditions. Symptoms usually appear late, making early detection difficult with traditional methods. The complex interaction of nutrients, environment, and palm morphology makes this disorder well-suited for machine learning approaches, which can detect subtle patterns and support timely intervention to sustain productivity (Anand V & et al., 2025).

Table 1. Characteristics and Causes of Crown Choking Disorder.

Aspect	Description
Nature of disorder	Physiological (non-pathogenic)
Primary cause	Micronutrient imbalance, mainly boron deficiency
Visual symptoms	Narrow, twisted, and poorly emerging leaves
Crown appearance	Compact and choked crown
Impact on yield	Reduced nut production and poor palm vigor
Detection difficulty	Symptoms appear at later growth stages

MACHINE LEARNING TECHNIQUES

Several machine learning algorithms have been applied to predict crown choking disorder in coconut palms, each showing varying levels of accuracy depending on the type and quality of data used (Singh P & et al., 2024)**.** Traditional statistical models given in Figure 2, such as Logistic Regression, are generally applied to soil and nutrient data and provide baseline prediction accuracies of 70–80%. Supervised learning methods like Support Vector Machines, which utilize soil, environmental, and morphological parameters, tend to achieve higher accuracies ranging from 80–88%.

Mahato P & et al., 2024 focused the Ensemble approaches, including Random Forest and Gradient Boosting, are particularly effective when handling heterogeneous datasets, combining multiple decision trees to improve robustness and accuracy, often reporting results between 85–92%. For image-based assessments of crown health, deep learning models, especially Convolutional Neural Networks, have demonstrated the highest performance, frequently exceeding 90% under controlled experimental conditions. Emerging hybrid approaches that integrate deep learning with ensemble methods, IoT sensor data, or GIS-based spatial analysis have also been explored, achieving high accuracy (88–92%) while offering better interpretability for practical field applications.

These findings highlight the importance of selecting the appropriate algorithm based on data type, feature complexity, and deployment requirements. The review analyzed supervised and

unsupervised learning models, ensemble and deep learning methods, and hybrid approaches. Reported metrics such as accuracy, robustness**,** and interpretability were emphasized.

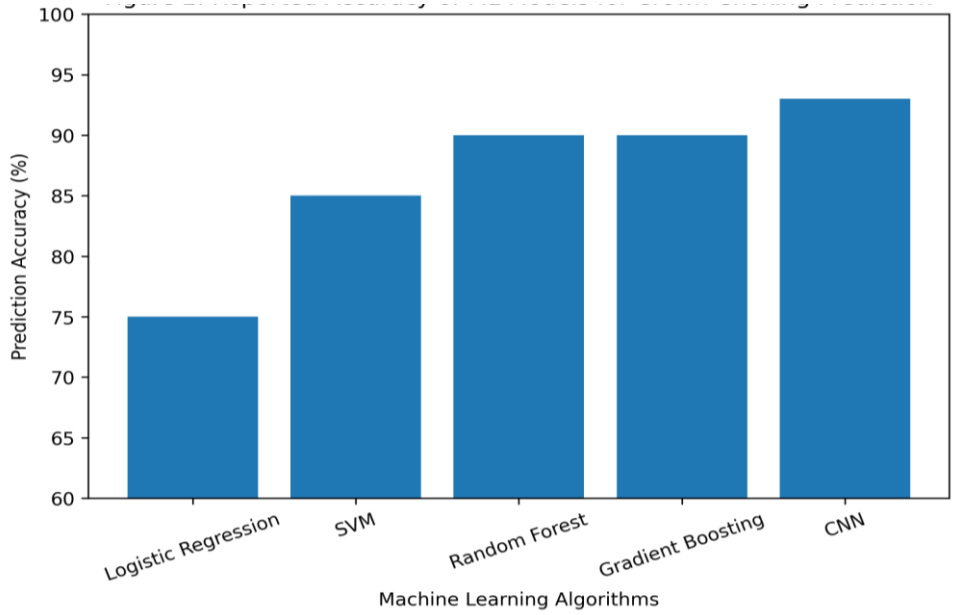

Figure 2: Reported Accuracy of ML Models for Crown Chocking Prediction.

LITERATURE INSIGHTS

Recent studies show that:

- Logistic Regression and LDA achieve moderate accuracy (70–80%)
- SVM improves accuracy to 80–88% with soil and environmental data
- Ensemble methods (Random Forest, Gradient Boosting) achieve 85–92%
- CNNs for crown image analysis exceed 90% under controlled conditions
- Hybrid approaches integrating IoT, GIS, and explainable AI are promising for field deployment

Hassan M. M & et al., 2025 highlights the Prediction performance depends on data quality, feature selection, and environmental variability**.**

CONCLUSION

Crown choking is a major challenge for coconut productivity. Machine learning has proven effective in enabling early prediction by analyzing soil, environmental, and image-based data. Ensemble and deep learning methods outperform traditional classifiers, achieving high accuracy and robustness. Hybrid and explainable approaches offer practical deployment potential for real plantations. Future research should focus on large-scale datasets, real-field

validation, and interpretability, to ensure sustainable coconut management and timely intervention.

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