



## Early Detection of Coconut Black-Headed Caterpillar Using Machine Learning Techniques

S.T PAVITHRA DEVI<sup>1</sup>, Dr.V.MANIRAJ<sup>2</sup>

<sup>1</sup> Research Scholar, Department of Computer Science, A.V.V.M Sri Pushpam College (Autonomous), Poondi, Thanjavur-613503, Affiliated to Bharathidasan University, Thiruchirappalli, Tamil Nadu.

<sup>2</sup> Associate Professor & Research Supervisor, Department of Computer Science, A.V.V.M Sri Pushpam College (Autonomous), Poondi, Thanjavur-613503, Affiliated to Bharathidasan University, Thiruchirappalli, Tamil Nadu.

### Article Info

#### Article History:

Published: 14 Feb 2026

#### Publication Issue:

Volume 3, Issue 2  
February-2026

#### Page Number:

223-226

#### Corresponding Author:

S.T PAVITHRA DEVI

### Abstract:

Coconut (*Cocos nucifera* L.) cultivation supports millions of farmers in tropical regions and plays a significant role in agricultural economies. However, coconut productivity is severely affected by the black-headed caterpillar (*Opisina arenosella*), a destructive leaf-feeding pest that reduces photosynthetic efficiency and nut yield. Conventional pest monitoring methods rely on manual inspection, which is labor-intensive and often fails to detect infestations at an early stage. This study proposes a machine learning-based framework for early detection of black-headed caterpillar infestation in coconut palms. The system integrates image-based leaf analysis and environmental parameters such as temperature and humidity. Supervised machine learning algorithms including Support Vector Machine (SVM), Random Forest, and Convolutional Neural Network (CNN) were implemented and evaluated using standard performance metrics. Experimental results indicate that CNN achieved the highest accuracy in detecting early-stage infestations. The proposed approach offers a scalable, cost-effective, and sustainable solution for intelligent pest monitoring in coconut plantations.

**Keywords:** Black-Headed Caterpillar, Coconut Pest Detection, Machine Learning, Early Infestation Prediction

## 1. Introduction

Coconut is a vital plantation crop cultivated widely across tropical and subtropical regions. It contributes significantly to food security, rural employment, and agro-based industries. Despite its economic importance, coconut production is threatened by several pests and diseases, among which the black-headed caterpillar (*Opisina arenosella*) is one of the most damaging defoliators (Kamilaris, A., & Prenafeta-Boldu, F. X. 2018). The pest feeds on the green tissues of coconut leaflets, forming silken galleries and causing progressive drying of leaves. Severe infestations lead to reduced photosynthesis, poor nut development, and substantial yield loss. Traditional detection methods depend on visual observation, which is often delayed and subjective. Recent advancements in artificial intelligence and precision agriculture provide opportunities for automated pest monitoring. Machine learning algorithms and deep learning (LeCun Y & et al., 2015), can analyze visual and environmental data to identify early symptoms of infestation. Therefore, this study focuses on developing a machine learning-based early detection system to enhance coconut pest management.

## 2. Literature Review

Recent advancements in precision agriculture have demonstrated the significant potential of machine learning (ML) and deep learning (DL) techniques in plant disease and pest detection. Several studies have focused on image-based crop monitoring systems to detect visible symptoms of infections and infestations at early stages.

Studies by Mohanty et al. (2016) and Ferentinos (2018) demonstrated the effectiveness of deep learning in image-based crop monitoring. Convolutional Neural Networks (CNNs) have been widely used for plant leaf disease classification due to their strong feature extraction capability. Research on crops such as rice, tomato, and maize has shown high accuracy in identifying leaf diseases using deep learning models trained on large image datasets. Similarly, Cortes, C., & Vapnik, V. (1995), Support Vector Machines (SVM) and Random Forest algorithms (Breiman, L. 2001), have been effectively applied in agricultural prediction tasks where structured environmental and climatic data are involved.

In the context of coconut cultivation, studies have primarily focused on diseases such as root wilt, stem bleeding, and bud rot using image processing and machine learning approaches. However, limited research has addressed automated detection of coconut insect pests, particularly the black-headed caterpillar (*Opisina arenosella*). Traditional monitoring methods remain manual and reactive rather than predictive.

Recent developments in AI-based pest monitoring systems integrate image data, humidity, temperature, and seasonal patterns to forecast pest outbreaks. These systems enable early intervention and reduce dependence on chemical pesticides. Despite these advancements, there is still a need for a dedicated machine learning framework specifically targeting early detection of black-headed caterpillar infestation in coconut plantations.

This study attempts to bridge this gap by proposing a robust and scalable ML-based detection model tailored to coconut pest management.

### **3. Methodology**

#### **3.1 Data Collection**

- Coconut leaf images (Healthy & Infested)
- Environmental data (Temperature, Humidity, Rainfall)
- Field-level and open-source datasets

#### **3.2 Data Preprocessing**

- Image resizing and normalization
- Noise removal
- Feature extraction
- Data labeling

#### **3.3 Model Implementation**

- Support Vector Machine (SVM) – Binary classification
- Random Forest (RF) – Ensemble-based classification
- Convolutional Neural Network (CNN) – Deep image feature extraction

#### **3.4 Evaluation Metrics**

- Accuracy
- Precision
- Recall
- F1-score
- Confusion Matrix

### **4. Results and Discussion**

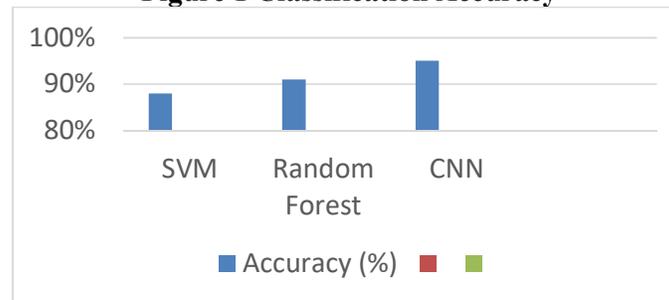
Among the implemented algorithms, the Convolutional Neural Network (CNN) demonstrated superior performance due to its strong capability in automatic feature extraction from leaf images. Traditional machine learning algorithms such as Support Vector Machine (SVM) and Random Forest also produced satisfactory results but were comparatively in Table 1 less effective in identifying subtle early-stage infestation symptoms. The CNN model achieved the highest classification accuracy is given Figure1, indicating its effectiveness in distinguishing between healthy and black-headed caterpillar-infested leaves. The confusion matrix analysis revealed that misclassification mainly occurred in very early infestation stages where visual symptoms were minimal.

The integration of environmental factors such as humidity and temperature further improved prediction reliability, as pest outbreaks are strongly influenced by climatic conditions. These findings highlight the importance of combining image-based detection with environmental data for improved early warning systems. The dataset was divided into training (80%) and testing (20%) sets. Among the implemented models, CNN achieved superior performance due to its deep feature extraction capability. The CNN model effectively identified early-stage infestations with minimal misclassification. Integrating environmental parameters improved prediction reliability.

**Table 1** Performance Evaluation of Machine Learning Models

Algorithm	Accuracy (%)	Precision	Recall	F1-Score
SVM	88%	0.87	0.86	0.86
Random Forest	91%	0.9	0.89	0.89
CNN	95%	0.94	0.93	0.93

**Figure 1** Classification Accuracy



## 5. Proposed System Architecture

Figure 2 shows, integrates coconut leaf images and environmental parameters, which are preprocessed and analyzed using machine learning algorithms for classification. The model then predicts whether the leaf is healthy or infested and generates an early warning alert for timely pest management.

**Figure 2** workflow of the proposed system

Input (Leaf Image + Environmental Data) → Preprocessing → Feature Extraction → Machine Learning Model → Classification (Healthy / Infested) → Early Warning Alert

## 6. Conclusion

The early detection of black-headed caterpillar infestation is essential for protecting coconut yield and ensuring sustainable plantation management. This study proposed a machine learning-based framework that integrates image processing and environmental data to identify early-stage pest attacks.

Among the evaluated models, the Convolutional Neural Network (CNN) achieved the highest performance, demonstrating its suitability for automated pest detection systems. The results confirm that artificial intelligence can significantly enhance agricultural monitoring practices by enabling timely intervention and reducing economic losses.

The proposed system can be further expanded into a mobile-based application or IoT-enabled monitoring system to provide real-time alerts to farmers. Future research may focus on expanding the dataset, improving model generalization, and integrating drone-based image acquisition for large-scale plantation monitoring.

This research contributes to the growing field of smart agriculture and supports sustainable coconut farming through data-driven pest management solutions.

## References

1. Mohanty, S. P., Hughes, D. P., & Salathé, M. (2016). Using deep learning for image-based plant disease detection. *Frontiers in Plant Science*, volume 7, Article 1419, pp.no 1–10.
2. Ferentinos, K. P. (2018). Deep learning models for plant disease detection and diagnosis. *Computers and Electronics in Agriculture*, 145, 311–318.
3. Kamilaris, A., & Prenafeta-Boldu, F. X. (2018). Deep learning in agriculture: A survey. *Computers and Electronics in Agriculture*, 147, 70–90.
4. Padi, B., & Baloch, G. M. (1973). Studies on the biology and control of *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae), a pest of coconut palm. *Indian Journal of Agricultural Sciences*, 43(9), 798–802.
5. Nair, C. P. R., & Nambiar, M. C. (1975). Biology and management of black-headed caterpillar in coconut. *Journal of Plantation Crops*, 3(1), 15–20.
6. Breiman, L. (2001). Random forests. *Machine Learning*, 45(1), 5–32.
7. Cortes, C., & Vapnik, V. (1995). Support-vector networks. *Machine Learning*, 20(3), 273–297.
8. LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, 521(7553), 436–444.
9. Savary, S., Willocquet, L., Pethybridge, S. J., Esker, P., McRoberts, N., & Nelson, A. (2019). The global burden of pathogens and pests on major food crops. *Nature Ecology & Evolution*, 3(3), 430–439.
10. FAO. (2021). *Coconut production and pest management practices*. Food and Agriculture Organization of the United Nations, Rome.