

# Transfer Learning Boosts Ensembles for Precise Sugarcane Leaf Disease Detection

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## Abstract

The United Nations' Sustainable Development Goals (SDGs) are committed to ensuring that all individuals have access to sufficient, safe, and nutritious food by 2030, acknowledging that food security is a fundamental right of human survival. However, the exponential growth of the world population raises concerns about the threat of global food insecurity by 2050. An increase in agricultural output is inevitable to meet the growing demand for food. Maximizing agricultural output requires safeguarding crops against disease due to the scarcity of arable land. In the modern age of technology-driven agriculture, the traditional approach of visually detecting agricultural diseases, employed by skilled farmers, is susceptible to inaccuracies and can be a time-consuming process. Transfer learning achieves exceptional accuracy on a noise-free image dataset by using pre-trained CNN models for early crop disease detection. However, their performance significantly deteriorates on datasets with images with complex natural backgrounds. This paper describes an ensemble of transfer learning-based binary classifiers to detect multiple sugarcane leaf diseases using a binary classification tree. Our model successfully classified five distinct sugarcane leaf diseases, achieving an impressive overall validation accuracy of 98.12%, macro-average precision of 97.75%, Recall of 97.93% and F1-score of 97.84%. Moreover, a methodological approach derived from the empirical observations of experienced agricultural experts led to a significant reduction in the computational complexity of our model, transitioning from exponential to linear search space framework.

**Keywords:** Sugarcane Leaf Disease Detection, Transfer Learning, Ensemble Model, Computer Vision

## 1. Introduction

Sugarcane, a significant crop contributing to global sugar production and byproducts like syrups and bagasse, has the potential to achieve SDG 2 (Zero Hunger) and SDG 8 (Decent Work and Economic Growth) [1], [2], [3], [4], [5]. It is a cornerstone of modern civilization and crucial for providing necessary resources [1], [2]. The presence of infectious pathogens and extreme climatic conditions are the primary causes of plant diseases. Plant diseases can have a negative impact on the growth, function, and structure of crops, which can seriously affect individual's dependent on them. Reliance on traditional methods for identifying plant diseases can decrease agricultural productivity and increase losses due to their ineffectiveness in detecting diseases in their early stages. Agricultural productivity is a significant driver of economic growth. Agricultural industries rely on accurate identification and classification of plant diseases to improve productivity and economic outcomes [6], [7].

Conventional methods for detecting and categorizing plant diseases are time-consuming, error-prone, require experts, and negatively impact productivity [8]. Accurate classification of plant diseases can boost crop productivity and support various cultivation methods [9]. Researchers developed several image processing, machine learning (ML), and deep learning (DL) techniques to identify and classify plant diseases using plant leaf datasets. DL using Convolution Neural Network (CNN) for plant disease identification has gained attention [10], particularly after the release of the PlantVillage [11] dataset in 2015. Studies on leaf disease detection showed only 1% focusing on sugarcane, compared to 39% for tomatoes and 16% for rice [12]. This disparity highlights a notable gap in the existing academic research

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