



# Smart Fertilization Advisor For Farmers Using Deep Learning And Expert Insights

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**Abstract:** Crop diseases are significant problems to agricultural productivity and farmer livelihoods, requiring early and accurate diagnosis for effective management. Early and accurate detection of crop diseases is essential for effective treatment and minimizing losses. Traditional methods often face challenges in early detection and accurate disease classification. Deep learning, a subset of AI, has demonstrated significant potential in agricultural image analysis, providing enhanced accuracy for crop disease detection and prediction. This review explores deep-learning models applied to crop disease detection, focusing on convolutional neural networks, recurrent neural networks, and ensemble methods. In addition to automated detection, the system integrates a dedicated portal for agricultural experts to provide farmers with personalized advice and actionable recommendations. Timely notifications and expert suggestions are delivered via farmer's preferred communication channels, enhancing disease management, crop health, and decision-making.

**Keywords:** Crop disease detection, Deep learning, image processing, Convolutional Neural Networks, expert recommendations, real-time monitoring.

I.

## INTRODUCTION

Crop diseases are one of the biggest challenges to agriculture productivity and farmers' welfare globally. The proper identification and diagnosis of such diseases are important in minimizing yield losses and ensuring food security. However, the traditional methods for disease detection through manual inspection and laboratory analysis are often slow, laborious, and prone to human error. This problem is worsened in extensive farming systems where rapid intervention is crucial to contain the spread of the diseases. In recent years, deep learning (DL) has emerged as a transformative technology for the analysis of images, offering significant improvements in detection and classification. Their ability to learn independently, and extract complex patterns from raw image data makes them a crucial tool in crop disease detection and classification. This project aims to design a system using deep learning and image processing algorithms for the precise detection and forecasting of crop diseases from images. In addition, the system will have a special portal for agricultural specialists to provide specific guidance and practical recommendations to farmers. This system deals with technical as well as practical issues related to disease management and ensures timely alerts and informed decision-making through the integration of automated detection with expert knowledge. While deep learning models offer transformative potential for precision agriculture, they also present challenges such as handling diverse and high-dimensional image data, managing class imbalances due to the varying prevalence of diseases, and ensuring model

interpretability for practical use. This project will explore how advanced techniques like transfer learning, attention mechanisms, and multimodal data fusion can address these challenges and enhance the system's predictive power. Given the mounting challenges posed by climate change and the expanding global population, this system aims to equip farmers with advanced tools designed to safeguard their crops, boost productivity, and enhance sustainability. This introduction elucidates the project's aims, significant obstacles, and prospects, emphasizing the revolutionary effects of deep learning within contemporary agricultural practices.

## II. RELATED LITERATURE WORK

### A. Literature Survey

Deep learning has emerged as one of the most transformative technologies in the agricultural sector, particularly in the areas of crop disease detection and classification. Convolutional Neural Networks (CNNs) [6] are among the most significant deep learning models, known for their intuitive ability to learn hierarchical features from agricultural images. This capability makes them exceptionally effective at recognizing patterns that indicate plant health or disease. This section reviews some of the key contributions made in the realm of crop disease detection, focusing specifically on the development of deep learning models and techniques used in precision agriculture. This section reviews the key contributions in this field, focusing on various deep learning models and techniques used for crop disease detection.

- 1) Crop disease recognition through leaf images using deep learning techniques. Inception\_v3 neural network [1] which introduced transfer learning, to extract robust features in images that may indicate the diseases. It achieves this by decomposing  $3 \times 3$  convolution kernels into  $1 \times 3$  and  $3 \times 1$  convolutions, which accelerates computations and reduces overfitting. The model architecture consists of 46 layers, including convolutional layers, pooling layers, Inception modules, dropout layers, and a softmax classifier.
- 2) Earlier efforts in crop disease detection relied heavily on traditional machine learning techniques, such as k-nearest neighbors (KNN), support vector machines (SVM), and decision trees [5] These methods utilized handcrafted features from images to classify crop diseases. For example, image filtering and clustering techniques were used to preprocess data and extract features. However, these approaches faced significant challenges, including their inability to generalize across diverse datasets and their reliance on manually designed features, limiting their scalability and accuracy.
- 3) CNNs achieved an accuracy of 99.53% in classifying healthy and diseased crop images using a dataset of 87,354 images [2]. Similarly, variants of ResNet-152 and InceptionV3 achieved accuracies of 97.81% and 99.10%, respectively, in detecting diseases in rice and corn crops [3].
- 4) Through such segmentation techniques, leaf diseases of brinjal, tomato, and green chili were identified, which helped farmers take targeted actions to reduce the damage [6]. These models highlight the necessity of identifying specific areas affected by pests and diseases for better decision-making in agricultural management [2].
- 5) The newest advancement in the crop disease detection field has involved attention mechanisms and their integration with CNN architectures. Detection accuracy increases for attention-based models, as these models concentrate the most important interest areas within a crop image [4]. Hybrid models consisting of a combination of CNNs and LSTM networks have also been used to extract spatial and temporal dependencies in sequential data from agriculture fields, achieving very high early detection.

### III. FUTURE WORK

The system will be expanded to support a wider variety of crops, including cereals, pulses, and cash crops, making it more applicable across diverse agricultural regions. Efforts will focus on improving accuracy and efficiency to provide reliable results. A mobile notification system will be introduced for timely alerts, enabling proactive disease management. Additionally, multimodal data fusion will combine image data with weather conditions, soil health reports, and historical patterns for a more comprehensive analysis. Multi-language support will also be implemented to ensure accessibility for farmers from different linguistic backgrounds.

#### A. Diversification of Agricultural Species

Future developments in the system will include scaling up the crop scope of the database to include cereal, pulse, and cash crops. This will widen the utility scope of the system and thereby make it beneficial to a wide range of farmers across the staple food crops critical for food security. Moreover, region-specific crops in the system will make it more applicable to different agricultural zones because of the specific disease challenges in the different geographical areas. More relevant and accurate disease detection and management strategies will be provided by the system with regard to regional agricultural requirements.

#### B. Improvement in Model Accuracy and Efficiency

To ensure that the system remains accurate and reliable, the overall accuracy and efficiency of the system will be enhanced by conducting initiatives. Continuing research in the field of data preprocessing, feature extraction methods, and optimization strategies will be essential in increasing precision in disease detection. The development will target false positives and negatives to make the recommendations given to farmers reliable. In addition, improving computational efficiency will allow for faster processing times, making the system more responsive and accessible, especially for those in less resource-rich environments.

#### C. Alert system through mobile notifications or SMS

The alert mechanism will be the most critical improvement in the system, informing the farmers of the diseases detected through mobile notifications or SMS. It is a preventive measure that will enable farmers to take swift action and, therefore, prevent possible crop losses and improve productivity. The notification system will give concise yet informative messages that guide farmers on the prevention measures and alternatives for treatment. These real-time alerts will be highly beneficial for farm producers in areas that are distant and lack ready access to agronomic specialists.

#### D. Multimodal Data Fusion

The multimodal data fusion merges image data and supplementary sources for weather conditions, soil health, and historical trends of diseases and ensure improvements in the efficiency and accuracy of the system. An integrated approach like this would generate a more holistic understanding of crop health due to all those factors. This will allow the system to give better predictions and recommendations on diseases and consequently enable farmers to make more informed decisions in the context of wider agricultural conditions.

#### E. Multi-Language Support

Multi-language support would be added, so the system could be accessed and used for farmers from any linguistic background. The interface, as well as the reports, will be provided in several languages. This will easily allow farmers coming from different parts of the country to interact and benefit from this system. With this feature, language barriers are removed, making advanced disease detection technology more easily accessible and more user-friendly for the farmers. The content will be localized and customized for particular

regions, further improving the system's overall efficacy.

#### IV. CONCLUSION

Deep learning has significantly transformed crop disease detection, offering improved accuracy and automation in analyzing agricultural image data, such as leaf images captured via mobile devices and drones. Modern techniques, including Convolutional Neural Networks (CNNs), transfer learning, and multimodal data fusion, have outperformed traditional methods in disease identification and classification [6]. The integration of diverse data sources such as weather conditions, soil health reports, and historical disease patterns provides further opportunities for enhanced predictive precision. However, challenges such as limited labeled datasets, variations in environmental conditions, and the need for real-time processing remain. Addressing these challenges, along with ensuring accessibility and usability for farmers through multi-language support and mobile notifications, is crucial for translating deep-learning advancements into practical agricultural solutions. Despite these challenges, deep learning holds great potential to revolutionize crop disease management, paving the way for smarter, more efficient, and sustainable farming practices.

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