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A Systematic Literature Review on the Detection and Classification of the Maize Leaf Diseases

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Agriculture plays a vital role in the economy of India. India is experiencing a rise in food demand due to the increasing population. Therefore, there is a need to enhance the total production of food items. Diseases caused by bacteria, viroid, infectious agents, weather fluctuations, fungi, etc. impact crop yields. Based on past research this research paper presents a pedagogical study on the maize crop because maize is the second most commonly grown crop in the world. According to the Indian Institute of Maize Research, India is the 3rd-largest creator of maize. The diseases in the plant need to be detected and treated at an early stage. This research aims to detect and identify disease in maize plants making use of leaves, as the plant reveals early signs on leaves. It is observed that the methods like Machine Learning and computer vision will help to identify and classify the disease. The conventional method of diagnosing diseases takes a long time and is not feasible for large yield areas. This paper presents a detailed survey of review of relevant literature by analysing more than 25 research papers. This study also provides technical support for the Maize plant disease classification.

This research will help in timely detection of Maize plant leaf diseases and to assist the farmers in the cultivation process, thus directly increase in maize production output.

Keywords: Maize Crop, Machine Learning, Image Processing, Deep Learning, CNN, State-of-art.

1. Introduction

India's economy is primarily based on agriculture. Therefore, enhancing agricultural output is essential for the nation's sustainable growth. India is facing tremendous food demand due to the increased population. However, because of the challenges that farmers are facing, the majority of the people are hesitant to engage in farming. As a result, many of the people from rural areas are moving to urban areas in search of greater opportunities of income. The average Gross Domestic Product of India in agriculture was 16% (Dongre & Wagh, 2016). The United Nations' global goals estimate that zero hunger will be achieved by 2030 (Keeling, et al., 2019) . Plant growth is the main factor that influences agricultural production. And the growth is mainly affected by significant variables like weather fluctuations, temperature, light, humidity, water conditions, minerals, and nutrients. Leaf metrics like leaf area length and width, leaf margins, leaf texture, leaf color, and leaf perimeter are all useful in plant development and output rate. The leaf area is the one-sided portion of any leaf which is usually irregular in shape. Leaf area is one of the metrics used by agricultural researchers, particularly by agronomists. It is the portion of the leaf that helps in photosynthesis. Photosynthesis is a process by which food can be generated.

Plant Disease is a normal phenomenon in nature. It is a disruption in a plant's normal state that changes its vital functions. Plant growth is affected by numerous conditions like bacteria, viroid, infectious agents, weather fluctuations, fungi, etc. and hence it will automatically impact total crop yield. So in order to get rid of diseases, one needs to identify and control them. The researcher decided to focus on the study of Maize plant leaves because maize is the second largest widely grown crop. After wheat and rice, maize is the third-most important cereal crop in India (IIMR, n.d.). India has been cultivating 9.89 million hectares of maize land and it ranks 4th in the world since 2005. (IIMR, n.d.). The only cereal crop that can be cultivated in a variety of seasons is maize. It can be grown in kharif as well as in rabbi season. It is one of the most significant cereal crops that is grown all over the world. Because of its exceptionally high yield, maize is referred to as the "Queen of Cereals" worldwide.

The word "Maize" comes from the Araguaco. Cristopher Columbus revived the name Maize back to the world (Organization, n.d.). The word Maize is derived from the word ‘Mahiz’ from Caribbean islands. A wide variety of maize species can be found in India. Among them, a few species are cultivated in the nation. According to (IIMR, n.d.) , there are 50 traditional species exist. The genus ‘Zea’ consists of various species including –

Table 1: Species from Genus ‘Zea’ (Kumar, Karjagi, Jat, Parihar, & Singh, 2012)

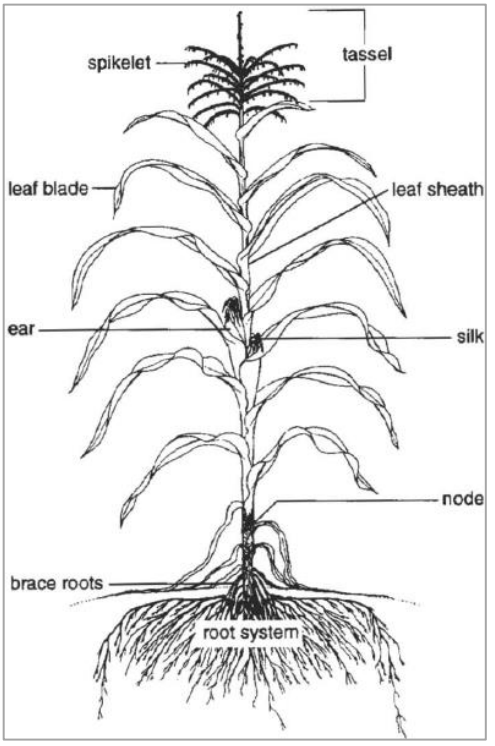
1	Zea mays (Maize or Corn)	the most widely cultivated species
2	Zea diploperennis (Perennial Corn)	a perennial species native to Mexico
3	Zea perennis (Perennial Teosinte)	a perennial species native to Mexico
4	Zea luxurians (Luxuriant Teosinte)	an annual species native to Central America
5	Zea nicaraguensis (Nica Teosinte)	an annual species native to Nicaragua
6	Zea mays subsp. parvifolia (Small leaf Corn)	a subspecies of Maize

The maize plant is a member of the grass family. It has a moderate height varying between one and four meters. It has one stem. Because the stem is encased with layers of tissues, it is sturdy and solid. The stem contains the number of nodes. There is only one leaf per node, and it grows on the opposite side of the stem. Typically, maize plants are monoecious, it means they yield both male and female flowers on the same plant. (K, Kling, & Edmeades, 1996)

Maize Morphology-

Plant morphology is the study of the physical and external features of a plant.

Figure 1: Morphology of a Maize Plant (K, Kling, & Edmeades, 1996)



Taxonomy of Maize-

Taxonomy is the scientific study of naming, characterizing, and grouping all living organisms based on common traits.

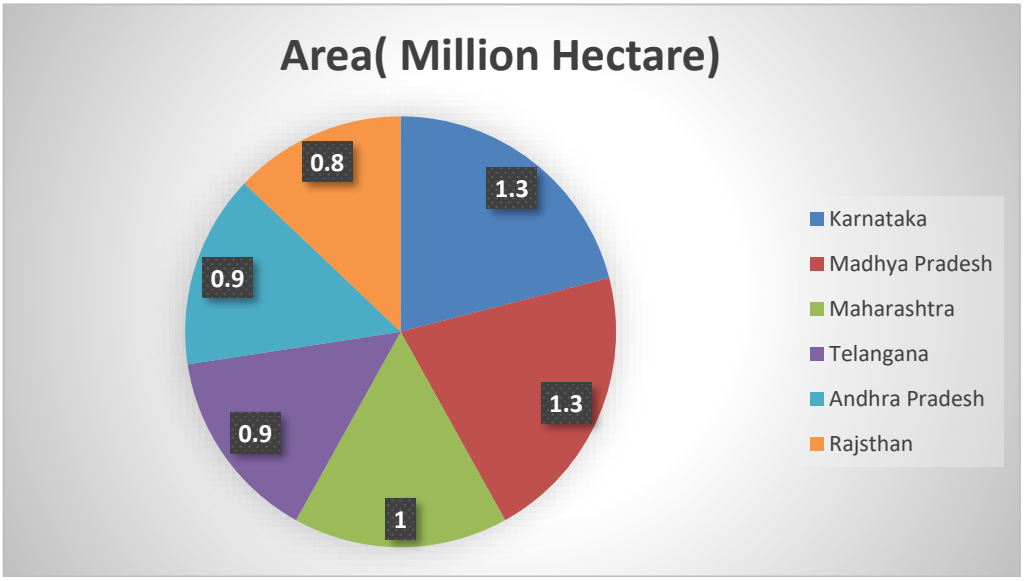
Table 2: (Biotechnology, Govt. of India, & Govt. of India, 2011) (Rashid & Shrivastav, 2021)

Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Poales
Family	Poaceae
Genus	Zea
Species	mays

Maize Utilization-

Corn is another name for maize. It has various potential uses like food, feed, seeds, cooking, ornamental, biofuel and ethanol. Also, young maize silk is used in herbal medicines. Also, numerous products like starch, corn syrup, sweeteners, oil, drinks, glue, and alcohol are made from maize (Awata, Tongoona, Danquah, & Ifie, 2019).

Figure 2 : Principal Maize Growing States in India (IIMR, n.d.)



Commonly Observed Diseases in Maize Plants –

Table 3 : Predominant diseases of maize across all over India (IIMR, n.d.)

Sr.No.	State/Union territory	Predominant disease
1.	Jammu & Kashmir	Turcicum leaf blight
2.	Himachal Pradesh	Banded leaf and sheath blight, Bacterial stalk rot and Turcicum leaf blight
3.	Punjab	Maydis leaf blight, Banded leaf and sheath blight and Charcoal rot
4.	Uttarakhand	Turcicum leaf blight, Banded leaf and sheath blight and Bacterial stalk rot
5.	Rajasthan	Curvularia leaf spot Non-Insect pest- Cyst Nematode , Fusarium stalk rot, and Rajasthan downy mildew
6.	Haryana	Common rust, Banded leaf and sheath blight and Maydis leaf blight
7.	Bihar	Maydis leaf blight, Banded leaf and sheath blight and Turcicum leaf blight
8.	Maharashtra	Charcoal rot
9.	Delhi	Banded leaf and sheath blight, Maydis leaf blight
10.	Karnataka	Turcicum leaf blight, Polysora rust, Charcoal rot, Common rust, and Sorghum downy mildew
11.	Telangana	Charcoal rot
12.	Andhra Pradesh	Banded leaf and sheath blight and Turcicum leaf blight
13.	Tamil Nadu	Charcoal rot
14.	Sikkim	Turcicum leaf blight
15.	Meghalaya	Turcicum leaf blight
16.	Manipur	Turcicum leaf blight
17.	West Bengal	Turcicum leaf blight

The above table highlights the predominantly occurring diseases throughout India. Farmers can identify these by their open eyes, but physical circumstances like as eyesight, weariness,

and light variations can have an impact on the outcomes. If these conditions led to an error, the outcome would be incorrect. As a result, it's necessary to diagnose the illnesses with an automated system that can produce accurate results. They may additionally contact agricultural experts to identify them, although this can be costly and time-consuming (Awata, Tongoona, Danquah, & Ifie, 2019). Early detection is an essential measure to avoid major yield loss. In order to circumvent the shortcomings of conventional methods and to obtain accurate results expeditiously, the researcher concentrated on employing digital image processing to detect diseases in the leaves of maize plants. Conventional methods have some shortcomings, so to avoid it and to get proper results quickly the researcher focused on detecting diseases in maize plant leaves by using digital image processing. Leaf disease detection and classification involves the use of image processing techniques such as image acquisition, image filtering, image pre-processing, image segmentation, feature extraction, and disease classification.

The next section presents, various strategies for leaf disease identification and detection for maize plant leaves, which are surveyed in the literature. Several researchers have conducted studies on the identification and classification of leaf diseases. The relevant literature overview of works on the subject is provided below. The remaining work is arranged into distinct but connected subsections.

2. Literature Survey -

This section reviews the literature pertaining to the detection, and classification of maize leaf diseases using machine learning and image processing approaches. The subsequent section delves into different kinds of maize diseases also.

(Kaur & Kukreja, 2024) concluded a review that, Detecting diseases in maize leaves quickly is crucial for preserving food safety. Researchers followed a cycle of activities that involved data collection, model architecture design, training, and evaluation. DenseNet model is used to identify the diseases on the maize leaf. The author uses a few learning rates and optimizers with names like Adam and SGD. The Adam optimizer resulted in 96.53% accuracy in training and 97.43% accuracy in testing. These results indicate that the model is effective in correctly diagnosing the disease.

The research was focused on constructing an MResNet model that could effectively identify maize leaf diseases. Researchers (Liu, et al., 2024) worked with the PlantVillage and PlantDoc datasets and gathered a total 4188 images build a new dataset for a study. The dataset is classified into 4 types of leaves, namely Common rust, Gray spot, Blight, and Healthy. Data preprocessing techniques such as cropping and resizing, segmentation, image enhancement employing contrast and sharpness, image augmentation, and so on were applied. MResNet was made up of two residual subnets of varying sizes, which exploited residual blocks to enhance the functionality of deep neural networks. A hybrid feature weight optimization method was also devised to improve and integrate the weights of two subnets.

(Khan, Sohail, Madsen, & Khare, 2024) carried out an extensive survey on comparative analysis of the disease detection model. They used 4 deep learning frameworks,

VGGNET, InceptionV3, ResNet50, and InceptionResNetV2. Data was collected from the ImageNet dataset. The paper discusses 9 types of maize diseases like Maize Bacterial Leaf and Sheath Blight, Maize Brown Spot, Maize Common Rust, and so on. The total research was carried out in 6 stages – data collection, image augmentation, image resizing, batch normalization, obtaining the best model, and validation. After assessing the performance of four transfer learning models, the author came with a conclusion that ResNet50 architecture is a superior performer as it achieved 87.51 % accuracy (highest among others).

To address the challenge of early detection of crop diseases, the researchers (Kumar & K, January,2024) have implemented 10 different modified DCNNs from ALexNet to EfficientNet-b0. The current study make a comparison among different DCNNs (AlexNet, SqueezeNet, ResNet-50, VGG16, GooLeNet, DarkNet53, DarkNet-19 etc.) and the simple CNN, with the help of two different datasets that is Kaggle and a manually created dataset. The results of the study showed that modified DCNNs outperform simple CNNs in terms of accuracy. Among the other DCNNs, ShuffleNet and ResNet-50 achieved the highest accuracy of almost 98%. Sigmoid, LeakyReLu, and Linear rectified unit (ReLu) have been employed as activation functions.

(Siam, Hossain, Hossain, & Rahman, March,2024) elaborated on a meticulous analysis of maize leaf disease detection using deep learning models. Comparing the performance of different pre-trained deep learning models (VGG16, VGG19, ResNet50, MobileNetv2 and Inceptionv3) with the proposed model is the goal of this study. Augmentation strategies are used to enlarge the dataset and to enhance the generalizability. As the attention mechanisms play a significant role in enhancing the capabilities of neural networks, the researcher integrated a Squeeze and Excitation (SE) block into the ResNet50 and VGG16 models. After evaluating the two models' respective levels of efficiency, it was discovered that, out of the two proposed models, VGG16 and SE had the highest accuracy i.e. 93.17%.

(Lapates, June,2024) implemented the YOLOv8 algorithm for efficient and precise disease detection in corn crops. The study focuses on detecting diseases such as blight, common rust, and grey leaf spot. The authors concentrated on evaluating the YOLOv8 model's performance in aspects such as recall, accuracy, precision, and speed. After 25 epochs, the model began to learn automatically. Also, the study shows a comparative analysis of other Deep Learning image detection methods. YOLOv8 processes the whole image in one pass, also it has exceptional speed and accuracy.

(Zhou, et al., June,2024) brought the spotlight on replacing deep convolutional layers with max pooling layers for downsampling. The authors proposed a SNMPF model to recognize the maize leaf diseases which is based on a CNN, ShuffleNetv2. With the goal to achieve higher accuracy in recognition and to build a lightweight model, the model obtained 98.40% accuracy. ShuffleNetV2, ShuffleNetV2 + Max pooling (MP), ShuffleNetV2 + SimAM (SAM), and ShuffleNetV2 + Max pooling (MP) + SimAM (SAM) are the four models that are compared in the present study. The researchers found that the performance of the ShuffleNetv2 model is enhanced when both the max pooling layer and SimAM attention mechanisms are added to the model.

(Zhu & Gao, July,2024) proposed a lightweight model MC-ShuffleNetv2

based on ShuffleNetv2, which is composed with Mish + Convolutional Block Attention Module + ShuffleNetV2. The researcher is destined to use this model due to its Network light weighting feature and the property of accurate feature extraction. The study concentrated on an excellent recognition of 6 types of maize leaf disease. The Mish activation function is employed to overcome the disadvantages of the ReLU activation function. The proposed model is less complex and gained a recognizable accuracy of 99.86%.

(Kanchanadevi & Sandhia, 2023) illustrated in their research that, early disease diagnosis is the preliminary step in disease control. The present research utilized the VGG19Net, ResNet152, InceptionV3Net, MobileNetV2, DenseNet201, and NASNetLarge models. The maize leaf dataset has been broken down into four classes: leaf rust, leaf blight, leaf spot, and healthy leaf. Each class holds 500 images. Out of the total 2000 images, 1800 were used for training, whereas 200 were used for testing. In this study, the researcher deployed six pre-trained models to construct a disease classification model. The pre-trained model went through 100 training epochs on the maize leaf disease dataset.

(Mazumder, Khan, & Khandaker, 2023) presented a new approach based on Biorthogonal Wavelet Transform to detect acute maize leaf diseases. The proposed methodology encompasses three steps: 1. segmenting maize lesions 2. Extracting features and 3. Classifying diseases. The researchers constructed a dataset of 1500 images obtained from the Plant Village dataset. Five different classifiers were used: ensemble, KNN, discriminant analysis, SVM, and decision tree. To detect the damaged region of the leaf, lesion segmentation was used.

(Bachhal, Kukreja, & Sachin, 2023) outlined that, to keep from crop loss, plant leaf diseases must be diagnosed early. Researchers deployed multiple pre-trained CNN classifiers, trained with Transfer Learning, including VGG16, VGG19, InceptionV3, and EfficientNetB7, to precisely identify maize leaf diseases. They stated that the EfficientNetB7 is the best model since it is superior to the other models with a higher precision of 98.77%. The 3810 image dataset has been divided 80:20 across training and testing sets. Studies show that the VGG16 gained 95.68%, the VGG19 reached 96.39%, InceptionV3 achieved 97.88%, and the EfficientNetB7 model exceeded a higher accuracy of 98.77%.

(Jasrotiaa, Yadav, Rajpal, Arora, & Chaudharya, 2023) used a model based on customized CNN. Pre-processing methods such as Contrast Limiting Adaptive Histogram Equalization, log transformation, and RGB to HSV conversion were applied. Maize leaf images were gathered from Plant Village Dataset and the authors used a Jupyter Notebook with Python 3.9.7 to execute experimentation. SVM and CNN were considered for classification. The performance has been evaluated using the Confusion Matrix, F1 Score, PPV, Accuracy, and True Positive Rate (Recall). The dataset of maize leaf comprises four categories namely, northern leaf blight, Cercospora leaf spot, Gray leaf spot, Common rust, and Healthy. The CNN model attained an accuracy of 96.76%.

(Dash, Sethy, & Behera, Maize disease identification based on optimized support vector machine using deep feature of DenseNet201, 2023) introduced a novel classification model that achieved 94.6% accuracy. The present study elaborated on detecting maize leaf diseases using SVM with DenseNet201. Four types of disease were

studied using a total of 4988 images collected from Plant Vilage and Kaggle datasets; out of them 80% were used for training and 20% were used for testing. The proposed model is a hybrid of DenseNet201, CNN, and SVM. The fusion of model gives 94.6% accuracy in identifying maize leaf diseases. The experiment was carried out in a series of activities, including pre-processing, feature extraction, hyperparameter tweaking, and classification.

(Dash & Sethy, Detection of Defected Maize Leaf using Image Processing Techniques, 2022) brought a spotlight on identifying early signs of diseases on maize leaves by leveraging techniques like computer vision and image processing. The researcher stated that their proposed model can detect defects in maize leaves caused by fungal, bacterial, or other diseases that are not covered in the experiment. The author presented a paradigm that works with techniques such as image processing. This research focuses on four types of maize leaf diseases: common rust, southern rust, northern leaf blight, and gray leaf spot. This experiment was carried out using MATLAB 2020a with 20 images of each disease. The proposed model works by removing the green channel from the red channel.

(Nunoo-Mensah, Kuseh, Yankey, & Acheampong, February,2022) put forth a comprehensive review of various state of art Deep Learning techniques used for detecting diseases in the maize leaf. The authors outlined several innovative, automatic disease detection techniques such as CNNs, Deep Learning methods, and transfer learning methods. The paper highlighted various modern architectures including GoogleNet, AlexNet, ResNet, VGGNet, DenseNet, EfficientNet, etc. The author specified the commonly used and successful activation function ReLU and its various derivates such as Parametric ReLU, Exponential ReLU, and Leaky ReLU.

(Haque, et al., 2022) proposed a deep learning-based approach for the identification of diseases in maize crops. The three diseases—Maydis Leaf Blight, Turcicum Leaf Blight, Banded Leaf, and Sheath Blight—were the center of the researchers' study. The proposed model achieved an accuracy of about 95.99%. The experiment was carried out with a well-known CNN - Inceptionv3 for disease classification. The research study was conducted in the following steps: building a database, classifying diseases with CNN, and training and testing the model.

(Ullah & Sayyed, April 2021) proposed a CNN model to detect and classify maize diseases. The model achieved 96.53% accuracy. Researchers discussed the stages for automatic detection such as pre-processing, feature extraction, comparison, and classification. They compare the performance of the proposed solution with two other solutions, KNN and Ensemble, in terms of accuracy. Ensemble gives 84.6 whereas KNN gives 80.2 percent accuracy. The study is carried out on 4 leaf varieties: Cercospora Leaf Spot Grey, Northern leaf blight, common rust, and normal leaf. In order to assess the effectiveness of the proposed model, the author has used both the accuracy and the loss parameter.

(Syarief & Setiawan, June,2020) tested 7 CNN models namely, AlexNet, VGG16, VGG19, GooLeNet, InceptionV3,ResNet50 and ResNet101. Used 3 classifiers: SVM, Decision Tree, and KNN. The author conducted an experiment with three distinct scenarios and seven CNN models that were classified using SVM, KNN, and Decision Tree. According to the experiment, the AlexNet architecture with the Support Vector Machine

classifier generated the best classification results, yielding 95% accuracy. The 10-fold cross-validation approach is employed for validation.

(Bonifacio, Pascual, Caya, & Fausto, 2020) developed a system to determine maize leaf diseases using grey level segmentation and edge detection techniques. The study employed the PlantVillage dataset, Raspberry Pi 3B – a portable device to classify images and obtained 92.50% accuracy. The study focused on classifying the common diseases found in the Philippines. A CNN is employed for classification, while gray-level segmentation to convert an image into gray scale and edge detection techniques were used to identify objects clearly, earlier in the pre-processing stage.

(Rocha, Rodrigues, & Mari, October,2020) evaluated the performance of 3 CNN architectures namely, AlexNet, ResNet50, and SquuezeNet. Experiments carried in this study are validated using the 5-fold cross validation method. The findings demonstrate that all the 3 CNN models examined achieved 97% of accuracy in classifying maize leaf disease. The study compared the performance of 3 state-of-art algorithms using parameters like accuracy, precision, F1 score and recall. According to the researcher, the important task is to find the optimal hyper parameters to train the CNN models, so Bayesian optimization is used. For conducting experiments Python 3.6 and a deep learning framework PyTorch 1.4 were employed.

(Panigrahi, Das, Sahoo, & Moharana, January,2020) concluded the Random Forest achieved higher accuracy of 79.23% on corn leaf. The present study was centered on supervised machine learning technology such as Naïve Bayes, Decision Tree, KNN, SVM, and Random Forest for identifying diseases on corn plant leaves. The researcher intended to develop a model that can accurately detect and classify the diseases. Gray scale conversion and image size reduction are the two techniques employed in the pre-processing phase. Based on the data, the SVM produced an accuracy of 77.56%, Naïve Bayes produced 77.46%, KNN produced 76.16%, Decision Tree produced 74.35%, and Random Forest yielded a greater accuracy of 79.23%.

(Overbeek, Kaesmetan, & Twince Tobing, 2019) proposed a model to identify fungus-caused diseases in maize plant leaves. The researcher carried out this study in six stages: data gathering, pre-processing, feature extraction, model creation, evaluation, and implementation. The researcher recorded maize leaf images from a local farm in Bismarak village, Kupang District. He sorted the 140-image dataset into four classes: 34 healthy leaves, 34 southern leaf blight leaves, 35 northern leaf blight leaves, and 37 southern rust leaves. Feature extraction is done with the sobel operator. The model for classification was built using SVM. The proposed model emits accurate findings 92.225 % of the time.

(Sheikh, Mim, & Reza, July,2019) illustrated that the numerous farmers of Bangladesh will be helpful with the help of the proposed model. This study sought to identify leaf diseases in corn and peaches and offer a remedy for them. The model achieved over 99.28% accuracy. With phases like image acquisition, pre-processing, image augmentation, statistical analysis, and so on, the authors reflected the model's workflow. The contaminated portion of the leaf of the peach and corn plants is segmented and carefully examined using the CNN (convolution neural network) method.

(Dutta & Yadav, 2018) devised an automatic technology for spotting and segmenting the area of a maize leaf afflicted by rust disease. The infected section of the leaf sample was measured in order to estimate the extent of damage caused by the disease. The authors split the planned work into two stages – 1. Identifying disease presence in leaf samples. & 2. Calculating the contaminated area. The authors employed the Area Based Segmentation Method to remove noise, and Intensity Based Thresholding to convert an image to a binary image. The pre-processing is carried out by applying the LAB Color Space Method. The authors of this study made use of the plant village dataset. Out of a total of 120 images, 60 are healthy maize leaves and the other 60 are rusty maize leaves.

❖ Search Approach –

Plenty of keywords were used to locate the research papers for the present study, such as 'Maize Crop', 'Disease Detection', 'Machine Learning', 'Image Processing', 'Deep Learning', 'maize leaf diseases'. Prominent academic research databases such as PubMed, Springer, Elsevier, ResearchGate, Web of Science, IEEE Explore, and Google Scholar were reviewed for the acquisition of research papers. Furthermore, some information was obtained from reliable, reputable, and trustworthy sites like government-owned websites.

❖ Selection of Articles –

Papers that omitted any relevant data were eliminated.

Table 4 : Research Papers Selection Criteria

• Included papers published in years 2018–2024 • Included Papers that studies about Maize Plant Leaf • Included papers with diverse viewpoints • Selected papers that best suit the researcher's specific interests • Included Peer-reviewed journal articles, conference papers • Included papers that utilized Deep Learning, Machine Learning, CNN like approaches	• Excluded articles containing unattended studies • with unclear or irrelevant methodologies • Excluded papers that are too broad or lack specificity.

3. Conclusion –

This paper conducted a thorough literature review of recent research on maize leaf disease detection using machine learning and deep learning, as well as by using other fundamental techniques. The many latest machine learning techniques that were utilized for the identification of plant diseases were examined in the present study. Emerging technologies, especially machine learning, artificial intelligence, and image processing, have demonstrated promising outcomes in enhancing diagnostic accuracy as well as efficiency. It is also noted that such approaches aid farmers in raising productivity through the employment of such technologies. This review serves as a valuable resource for future researchers, providing essential insights and directions for advancing the field of maize leaf disease detection and

classification.

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