Chapter 1

Introduction to Plant Disease Detection System

1.1 Introduction

Agriculture plays vital role in Indian economy. Agricultural Image processing is nowadays one of the main and growing research area of Image processing. Images of agricultural field or plants captured through cameras, satellites, etc. used as input, processed and analysed using various image processing techniques. One can use image processing in agricultural applications for several purposes that includes:

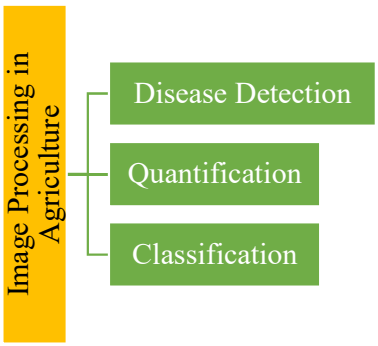


Figure 1.1: Image Processing in Agriculture

- Disease detection – on leaf, stem, fruits and on other organs of plants
- Quantification – Measuring total area affected by disease
- Classification – define the disease based on color, size & shape of the affected area.

1.1.1. Application areas of Agricultural Image Processing

Applying image processing techniques to the domain of agricultural images has many applications such as

- Food quality assessment, sorting and grading
- Crop and agricultural land assessment
- Nutrient deficiencies detection
- Pest management
- Plant Identification and Classification
- Crop/Plant Disease Detection

1.2 Crop/Plant Disease Detection

Crops are grown plants.

- Cash crops are those marketable crops that are directly sold in the market after its cultivation. Generally, they are not used by farmers directly.
- Food crops are used as food and are used by farmers as well as for sale commercially.
- Leaf Vegetables like lettuce, Parsley and spinach are those vegetables whose leaves can be consumed directly.
- Cereals are a type of grass that produces eatable grains like rice, wheat, and maize.
- Legumes are a type of crop that produces dry grain seeds. Some of them are used for oil extraction also. They grow in a pod organ of a plant.

Figure 1.2 represents classification of various crops. Here legume category is selected for research study.

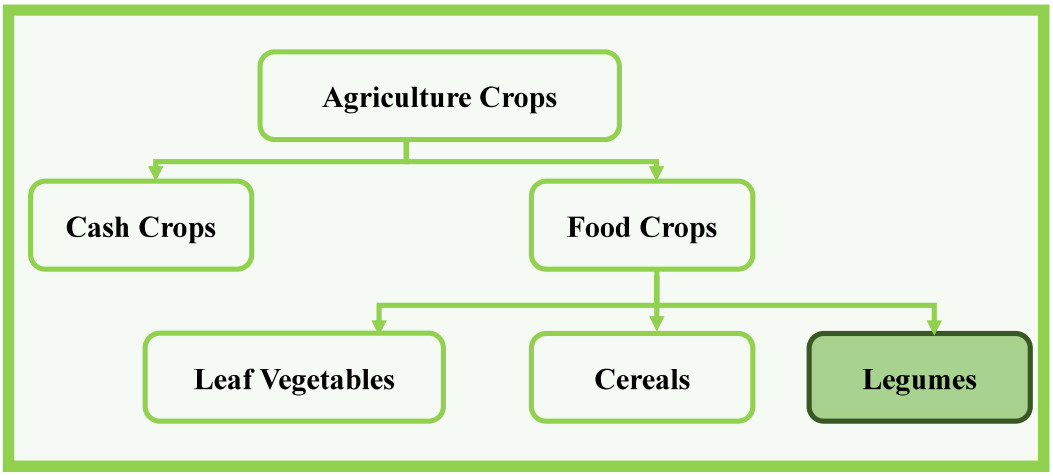


Figure 1.2: Crop Classification

Plants have distinctive organs like roots, stem, leaves, veins, and reproductive organs like a flower. Figure 1.3 shows different plant organs.

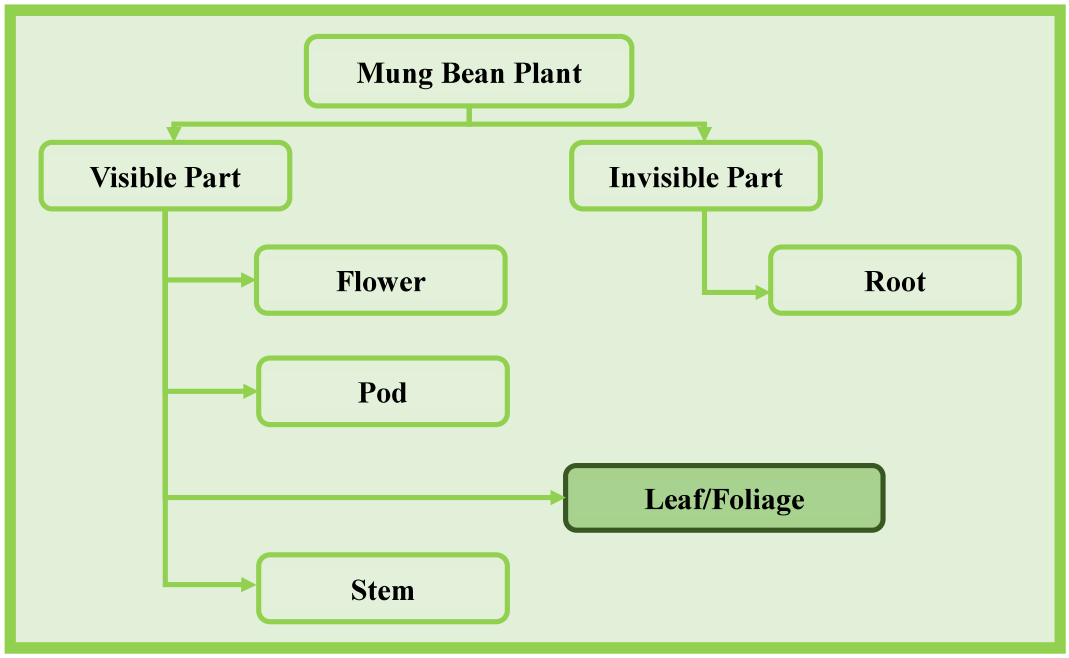


Figure 1.3: Plant Organ Selection

- Leaves are flat 2D surfaces which enables them to absorb more light. They are the lifeline of a plant because it collects sunlight and makes food for them.
- Flower is a reproductive organ of a plant that allows it to produce new plants from them.
- Stem hold the plant in an upright direction so they can get enough sunlight and air.
- Vein provides support to the leaf and also transport water and minerals through leaf and plant.
- Pod protects developing seeds from pests and other possible threats.

1.2.1 Legume Leaf Diseases

Leaves are the key part of the plant. Deficiency of nutrient, diseases, pests, floods, improper sunlight etc. can deteriorate or damages the leaves. Disease damages the leaf most and results in drop of various functions of leaf such as Photosynthesis, transpiration, pollination, germination, etc. of the plant. Early detection of disease can reduce the effect of disease on crop yield. Bacteria, Fungus, and Viruses are major disease – triggering agents. This agents are responsible for loss in crop yield. The

common diseases that occur on leaves are Cercospora Leaf Spot, Early blight, Late blight, Leaf curl, Powdery Mildew, Yellow Mosaic Virus, etc. the list of some of the common diseases and their symptoms on Mung bean crop are shown in Table 1.1.

Name	**Type of Disease**	**Symptoms of Disease**
Bacterial Brown Spot	Bacteria	Small oval, necrotic lesions on leaves.
Common Blight	Bacteria	Water Soaked brown spots with lemon-yellow margins.
Halo Blight	Bacteria	Water-soaked spots that eventually develop surrounding yellow margins
Cercospora Leaf Spot	Fungus	Circular/sub circular to broadly irregular shape on leaf, the central area turn reddish brown and grey centre surrounded by a dark brown margin.
Leaf spot cooletotrichum	Fungus	Circular, black, sunken spots with dark center and bright red orange margins on leaves and pods.
Powdery Mildew	Fungus	White powdery spots at early stage. Finally cover the entire leaf.
Yellow Mosaic	Virus	Intense yellow and green mottling of the leaves.
Leaf Curl	Virus	Downward curling in leaves
Mosaic Mottle	Virus	Irregular light green patches alternating with normal green areas. The size of leaf gets reduced and the margins show upward rolling

Table 1.1: Diseases of Mung bean plant

1.3 Introduction to Image processing

Image processing is a technique that perform various operations on an image either to extract useful information from image or to enhance the image. In this process image is given as input and output may also be an image or features related with that image. Image processing improves the quality of an image and alter image for future use. The

altered image is then used in various applications in form of enhancement, segmentation, feature extraction, classification, etc.

In image enhancement process the brightness of image is adjusted, the color tone has been changed, noise removal and improvement of image is done. Image segmentation divides the image into several parts to perform object identification in images. Various methods available to perform segmentation that includes color based, threshold, and texture based etc. Feature extraction efficiently reduces the dimensionality to characterize area of interest of an image as a compact feature vector. This method is very useful when size of image is large. Labelling of images into predefined categories is done in Image classification. Classification will be done in supervised or unsupervised manner. Image processing mainly focuses on enhancement of image information for human interpretation, storage, transmission, and depiction for independent machine perception.

1.3.1 Digital Images and Image processing techniques

An image commonly read as a two-dimensional array and can generally represented by various patterns such as color, shape, and texture. To process an image using computer, the image is converted to a sequence of numbers. Each number known as pixel signifies a particular location's brightness value. After digitizing the image, the image is enhanced, restored, or compressed by applying various operations on it.

Image processing techniques includes several fundamental steps and sub-steps.

- Image Acquisition – in this step images are captured using digital cameras. This step may also include some pre-processing steps such as resizing etc.
- Image Enhancement and Restoration – this step highlights the hidden details of an image or spot the certain features such as, brightness, contrast etc. and improves the image appearance.
- Image Preprocessing – the quality of an image is enhanced and noise removal is done in this step by using several image processing techniques such as, Color Image Processing, Wavelets and Multiresolution Processing, Morphological Processing etc.
- Segmentation – segmentation is a process that divides the image into several parts and helps to identify the area of interest from image.

- Feature Extraction – the output of segmentation step, typically pixel information is considered as input for Feature extraction, which creates boundary of a region. This will create the base which differentiate the objects from one class to another.
- Object Identification - Object identification is done in this step by assigning labels to objects based on their descriptors.
- Classification – various classifiers can be used to classify an image.

1.3.2 Application Area of Image Processing

Digital image processing plays important role in a wide variety of disciplines and fields in science and technology as well as our daily life too. Various fields uses digital image processing includes:

- Space Images (Images collected from telescope etc.)
- Computerized Image capturing (Photoshop etc.)
- Medical Image (Microscopic images, X-ray images, etc.)
- Remote Sensing (satellite and aerial images, etc.)
- Character Recognition (licence plate, zip code interpretations etc.)
- Biometric Images (Irish, Fingerprint, face recognition etc.)
- Industrial Applications (Sorting, inspection etc.)
- Pattern Recognition (disease detection, handwriting recognition, identification of images in agriculture field, etc.)

1.3.2.1 Pattern Recognition

Plant disease detection system is an area of pattern recognition. Pattern recognition is the discipline of creating inferences from perceptual data based on either a statistical data or on previous knowledge (FOLDOC, n.d.).

1.4 Plant Disease Detection using Image Processing

Crop disease classification and identification plays major economical and technical importance in the Agricultural Industry. In traditional practice, farmers try to evaluate

the diseases by their past experience. Or in other cases, the expert observes the plant organs like leaves and stems for any diseases. It is a very time-consuming and costly method because it requires continuous monitoring by an expert in large fields. Universal lack of expert has additional increased the demand for automatic tools that would let non-botanical persons to carry out valued field work of recognizing and classifying plants. These tools are of importance in numerous fields including forestry, agriculture, and pharmacological science (Cotton Incorporated USA, 2009). Early identification and treatment will help farmers to reduce the overall loss. We require a fast approach to protect the crop from diseases. A brief methodology for identification of symptoms using image analysis techniques is explained by below figure 1.4.

Leaf disease detection and classification includes several basic steps such as image acquisition, pre-processing, feature extraction and disease detection and classification. These steps are as below in Figure 1.5.

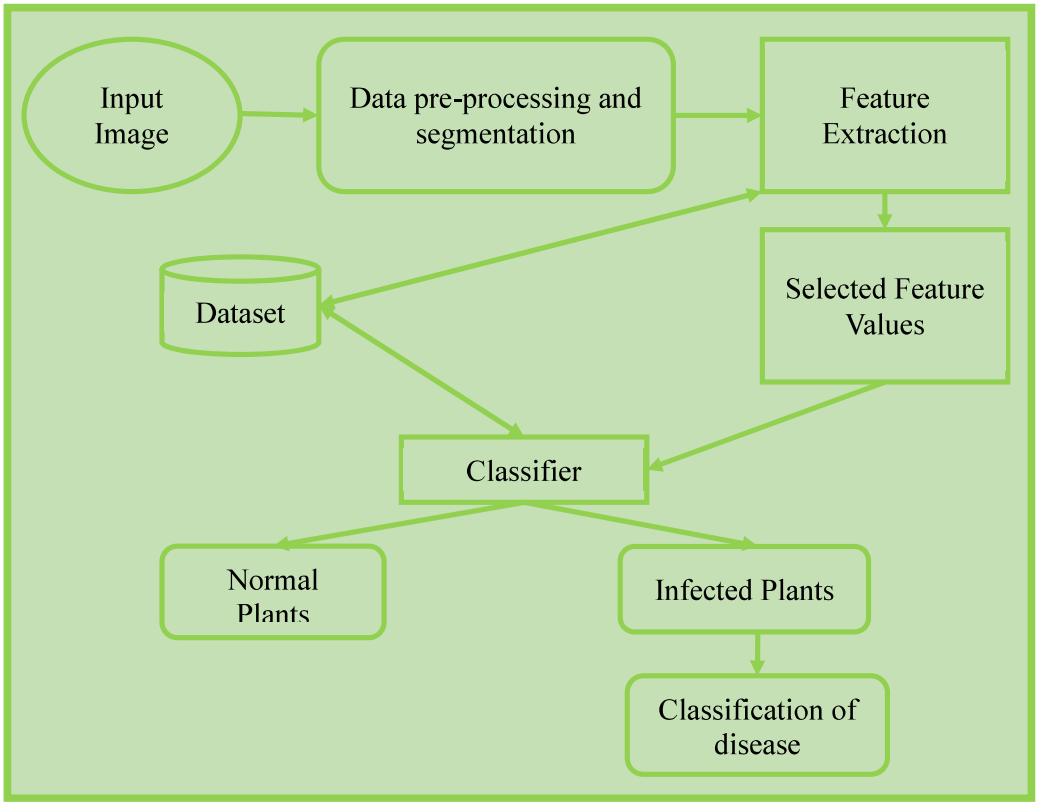


Figure 1.4: A brief methodology for identification of symptoms using image analysis techniques

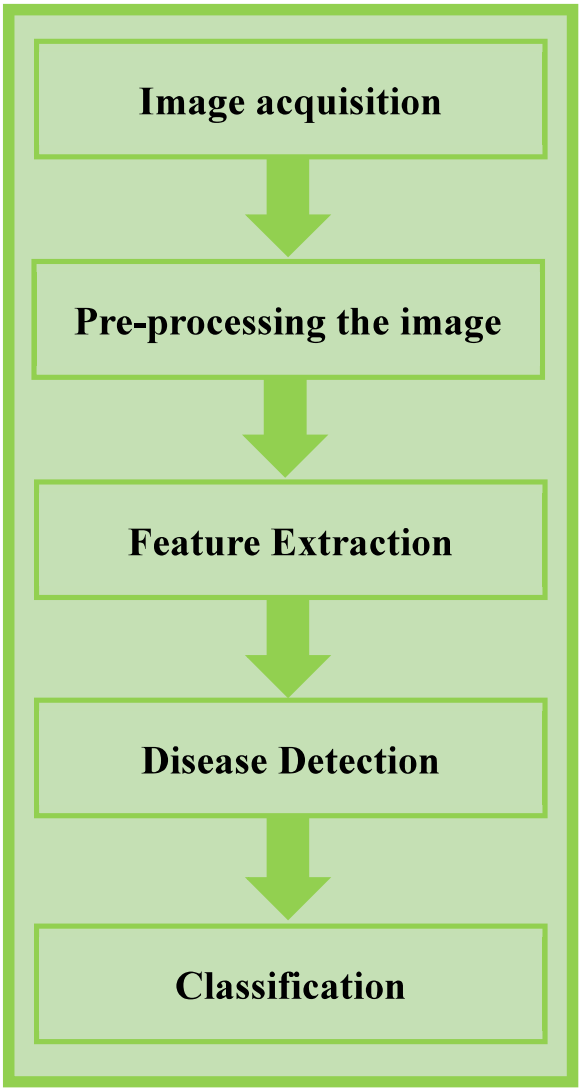


Figure 1.5: Leaf disease classification steps

1.4.1 Image Acquisition

Acquiring images from various sources is known as image acquisition. This step of image processing involves capturing of high quality images of plant leaves with disease and without disease on it to construct necessary database. The effectiveness of the model highly dependent on the quality of the database images. For this research work a self-created dataset is used by capturing images of mung leaf from various farm fields using smart phones. Images were captured in two different environments namely controlled and uncontrolled, where controlled environment image contains only a single mung leaf with white background and uncontrolled environment contains mung leaf images taken from farm field directly.

1.4.2 Image Pre-processing

After image acquisition the pre-processing phase takes place. In this phase image enhancement will be done. For this various operations carried out in a series: RGB image Acquisition and color transformation, normalization/ resize of image size, noise removal, masking green pixels, Segmentation and morphological operations and extracting ROI. This phase make changes in the image and make it appropriate for segmentation. For this work researcher applies various pre-processing steps on image like, resizing an image, converting image to gray scale, edge detection, augmentation etc.

1.4.3 Image Segmentation

During segmentation phase image will be divided into several segments so that the analysis process becomes easy. Segmentation is used for locating objects in the image and to detect bounding lines of the image, background subtraction. Various techniques are available for performing segmentation like region based, edge based, threshold based, model based, and feature based clustering, etc. Image segmentation is the first step in image analysis and pattern recognition it is a critical and essential step and is one of the most difficult tasks in image processing, as it determines quality of the final result of the analysis (Jagtap et al., 2014). This phase gives accurate classification of diseases. Initially two different segmentation methods namely HSV and grabCut were applied on image dataset. Both provide average results in controlled environment images, but failed to provide good results in uncontrolled environment images.

1.4.4 Feature Extraction

After segmentation Area Of Interest (ROI) will be extracted. In our case ROI is diseased part. Next significant features are extracted and used to decide the significance of given sample. Leaves are having mainly three types of features such as Color, texture, and shape. Researcher uses Histogram of Oriented Gradients (HOG) for object detection because they act as feature descriptors by focusing on the structure or shape of the object.

1.4.5 Classification

Classification is the phase where training and testing takes place. It is where the decision takes place using feature extracted from previous phase. Classification defines classifying an images to some group which is having unique characteristics. After classifying an image in particular group based on some local features extracted symptoms is identified to be one particular symptom. In this step machine learning or deep learning methodologies are used for the training and testing of image datasets. Initially researcher applied Support Vector Machine (SVM) and Custom Convolutional Neural Network (Custom CNN) for classification. Later on five other classifiers namely, KNN, AdaBoost, DTC, LogisticRegression and GaussianNB were also applied for classification with the same preprocessing steps as applied on SVM.

Using advanced technology like mobile phones, tablets, and similar devices farmers can input data in form of digital images and get an immediate response. That will result in crop productivity. Image processing techniques helps farmers in automatic detection and classification so that farmers take necessary action at early stage. Automatic detection process starts with digital color image of a diseased plant leaf.

1.5 Challenges and Issues

In controlled environment as leaf is on plain background it is easy to extract ROI where as in uncontrolled environment where image is captured from the field which has background having other leafs, land area, mud etc. which makes it difficult to identify the ROI.

When images are taken in uncontrolled environment, background contains several features that makes it challenging to perform precise segmentation and area of interest where the disease symptoms are visible. In uncontrolled environment image capture conditions are challenging to control, which makes disease identification and classification more challenging. Majority symptoms do not have distinct boundaries, rather slowly disappearing into normal tissue, which makes it difficult to define healthy and diseased regions.

1.6 Statement of the problem

Title of the present study is: “Design and development of a model to classify crop foliar diseases”.

Present study is focused on development of technique for early identification of Mung bean plant leaf disease of South Gujarat Region, Gujarat, India from digital images using Plant Disease Identification Model that uses various machine learning and deep learning techniques. The principal theme of the study is to develop a model capable of identifying diseased leaf from image. When image of Mung leaf is given as input Leaf disease detection will first detect whether the leaf is healthy or diseased and if it is diseased, next it will classify it to particular disease category. Present study focused on three different mung leaf diseases namely Cercospora Leaf Spot, Powdery Mildew, and Yellow Mosaic Virus.

1.7 Need of the proposed research

Agriculture has turn into simply a means to feed ever growing populations. Plants have become an important source of energy, and are a fundamental piece in the puzzle to solve the problem of global warming (Barbedo, 2013). There are several diseases that distress plants with the latent to cause devastating economical, social and ecological losses. Therefore, detecting diseases in an accurate and timely way is of the most importance task. In tropical countries like India, yields of agricultural crops are immensely affected by various plant diseases. Early identification of these diseases can be useful to abolish the effect of disease on crop yield. Empirical techniques of identification is time consuming and lengthy. It is noteworthy that most of the plant dieses produce different symptoms on the surface of the leaves. Most diseases, however, generate some kind of manifestation in the visible spectrum. Trained raters may be efficient in recognizing and quantifying diseases, however they have associated some disadvantages that may harm the efforts in many cases (Barbedo, 2013). Bock et al. (Bock et. al., 2010) list some of those disadvantages. However, these symptoms can be identified using various digital image analysis techniques. Image analysis techniques

can be useful to resolve this problem. A relationship between digital numbers in various pixels can be identified from the image. Pixel wise classification techniques can be applied to identify disease symptoms on the leaves of plant.

1.8 Objective of the study

Major objective of the proposed study is to create a "Plant Foliar Disease Identification Model" for recognizing Mung bean plant leaf diseases.

The objective of the proposed research is to analyze complexities involved in developing plant Leaf disease identification model that can detect diseased leaf and classify them. Other objectives are,

- Explore the diseases found in mung plant leaf.
- Analyze different signs and symptoms of the diseases
- Collecting mung leaf samples
- Creation of Dataset
- To Propose Plant Foliar Disease Identification Model (PFDIM) that classify and identify mung bean plant leaf diseases and develop components of PFDIM.
- Development of alternative techniques for identification of mung plant leaf diseases.
- Application of different analysis techniques for identification mung plant leaf diseases using digital images.
- Testing and performance evaluation by analyzing the result of recognition system engine.
- Designing interface which lets end user to identification of disease by providing suitable input.
- To works on controlled, uncontrolled (in-field) and combined environment (Controlled + Uncontrolled) dataset.
- Testing and performance evaluation by analyzing results of model.

1.9 Advantage of the study

Advantage of the proposed study is:

- Early recognition of disease in Mung plant leaf. Early identification of plant disease can decrease the effect of disease on crop yield.

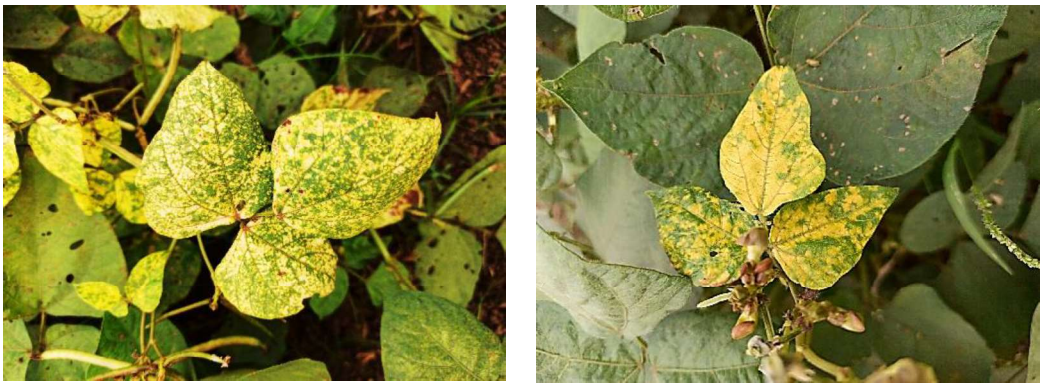
1.10 Disease of Mung bean plant leaf

Mungbean is the third most important crop in India with production of 1.71 million tonnes of grain with productivity of 498 kg/ha and 3.43 million hectares of area (Anonymous, 2012). It is commanding to improve the current global average productivity to meet global demand (Nair et al., 2012). The crop of mungbean is affected by numerous reasons (Grewal, 1988). Amongst numerous fungal, bacterial and viral diseases that attack different parts of mung bean plant, major ones are; Mung bean yellow mosaic virus (MYMV), Cercospora leaf spot and Powdery mildew. The account of diseases and their management practices are mentioned below:

1.10.1 Mung bean Yellow Mosaic Virus (MYMV)

Mungbean yellow mosaic virus disease (MYMVD) is one of the major destructive diseases of mungbean in India. It was first reported on Mungbean from India in 1940 (Nariani, 1960). When it is severe yield losses reach up to 85-90%. It's considered to be a potential threat to the cultivation of not only mungbean but also in other species like urdbean, cowpea, mothbean and soybean (Prabhakar et al., 2013). The MYMVD occur throughout the country wherever these crops are grown. It often assumes epiphytotic proportions in northern plains and central and south zones of the country. Symptoms first appear as small yellow flecks in young leaves. Subsequently emerging leaves and irregular yellow and green patches alternating each other. Leaf size is generally not much affected. Figure 1.6 shows yellow mosaic virus disease on leaf in controlled and uncontrolled environment.

(a)



(b)

Figure 1.6: Leaf with yellow mosaic virus in (a) controlled and (b) uncontrolled environment

1.10.2 Cercospora Leaf Spot (CLS)

CLS is the most wide spread and destructive fungal disease of mungbean. Cercospora leaf spot disease caused by Cercospora spp. The disease was first time reported in Delhi, India (Munjal et al.,1960). Cercospora leaf spot is also causing serious losses to mungbean crop. It 58% yield loss annually (Lal et al., 2001). The disease starts appearing about 30-40 days after planting. The leaf spots develop on infected leaves with a somewhat circular/subcircular to broadly irregular shape, the central area turn reddish brown and grey centre surrounded by a dark brown margin. Cercospora spp attacks the crop and the symptoms appear on leaves as water soaked spot with greyish borders. As the disease becomes severe cause death of the tissues of infected leaves. The petioles, stems and pods also get affected by the pathogen. During favourable condition the spots increase in size and at the time of flowering and pod

formation lead to defoliation in case of severe attack of Cercospora premature defoliation is also observed. Sometimes the leaves may become unshaped and wrinkled. Poor pod formation, late maturity and immature seed formation is also reported. Figure 1.7 shows Cercospora Leaf Spot disease on leaf in controlled and uncontrolled environment.

(a)

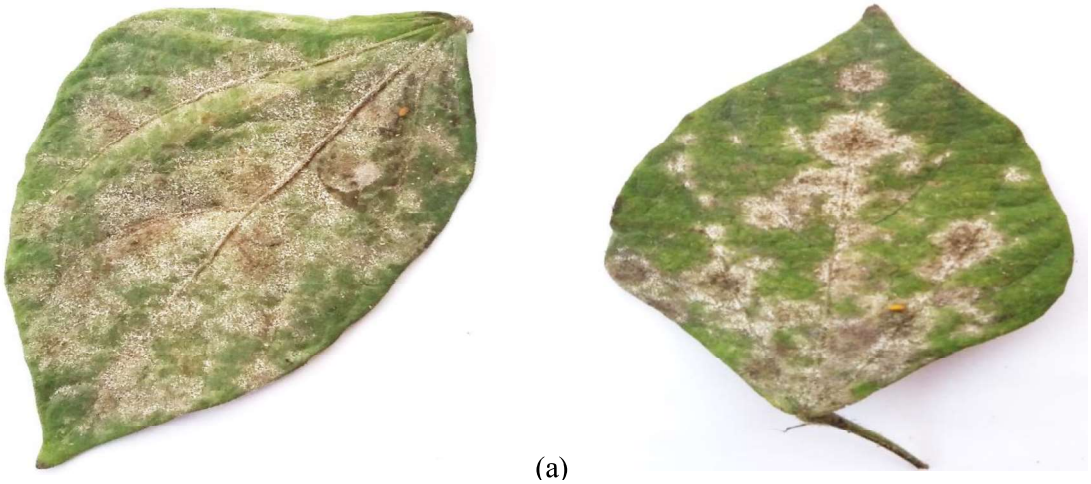
(b)

Figure 1.7: Leaf with Cercospora Leaf Spot in (a) controlled and (b) uncontrolled environment

1.10.3 Powdery Mildew

Powdery mildew diseases in mungbean by the fungal pathogen Erysiphe polygoni. Yield losses due to the disease were reported to be up to 20-40% at the reproductive stages (Fernandez and Shanmugasundaram, 1998), but the damage can be more serious when the epidemic starts at the reproductive stages it may reach up to 55% (Poehlman, 1991). Infected plants have a greyish-white powdery growth on the surface of leaves,

stems and pods. Late infections during the pod filling stage can cause leaf drop but do not appear to seriously affect yield. All above-ground part of the plant may be affected. The first symptoms are faint dark areas on the leaf that develop into small white powdery spots. These spots enlarge rapidly, coalesce and finally cover the entire leaf. Figure 1.8 shows Powdery Mildew disease on leaf in controlled and uncontrolled environment.



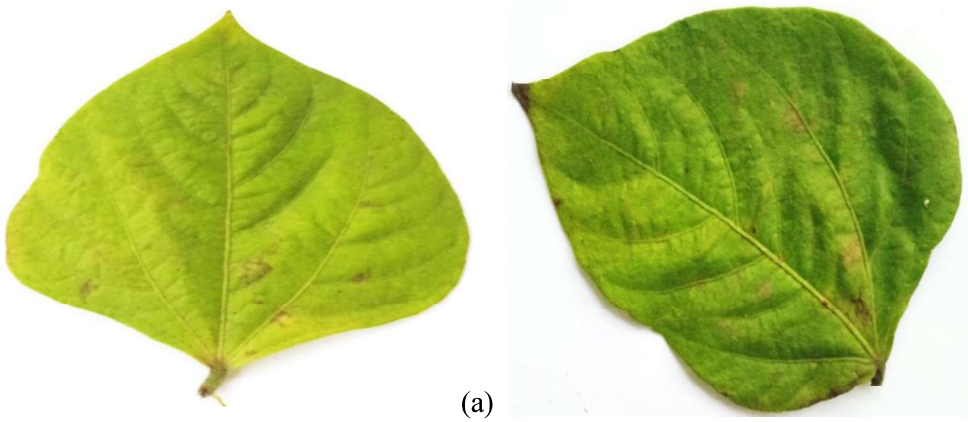
(a)

(b)

Figure 1.8: Leaf with Powdery Mildew in (a) controlled and (b) uncontrolled environment

1.10.4 Healthy

Apart from diseased categories proposed study also classify healthy leafs. The process of photosynthesis is an essential function of the green and healthy plants. Healthy leaf perform photosynthesis activity in plant. Leaves absorb sunlight, and make food for the plant by photosynthesis that utilized in cell activities. Figure 1.9 shows Healthy leaf in controlled and uncontrolled environment.



(a)

(b)

Figure 1.9: Healthy Leaf in controlled and uncontrolled environment

1.11 Experimental Images

Images of Mung bean plant leaf used in Dataset for this work are collected from the Navsari Agricultural University at Navsari, Gujarat and from various farms of Navsari district region. A pictorial assessment of the above-mentioned study sites are shown in Figure 1.10.

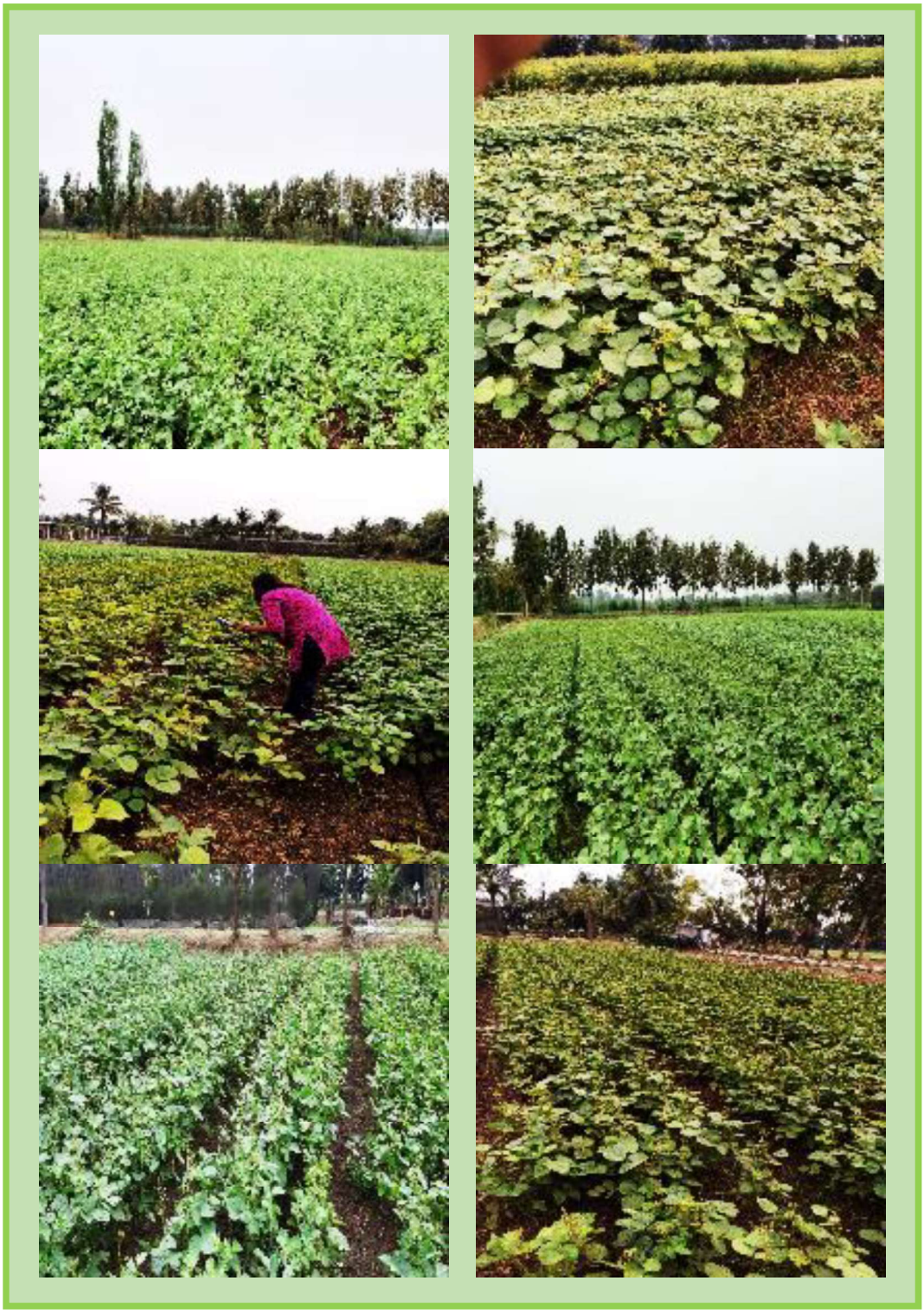


Figure 1.10: Study Site of Mung bean Plants

Leaves were digitally captured in a controlled environment using Oppo A5 13MP and MI Note 8 Pro 64MP smartphones. The images are collected and categorized under

four categories namely Cercospora Leaf Spot, Healthy, Powdery Mildew, and Yellow Mosaic Virus. The dataset primarily accounts for two different conditions: controlled environment and uncontrolled environment. An image from the controlled environment contains a single Mung leaf at its centre and a white background i.e. no noise. On the other hand, an image from the uncontrolled environment, along with the Mung leaf contains background noise like ground, stems, other Mung leaves etc. There are a total of 883 leaf images for controlled environments: Cercospora (224), Healthy (211), Powdery Mildew (225) and Yellow Mosaic (223). In an uncontrolled environment, there are a total of 322 images. Some sample images from dataset are shown in below Figure 1.11.

Controlled Environment **Uncontrolled Environment**

(a) Cercospora Leaf Spot

(b) Healthy

(c) Powdery Mildew

(d) Yellow Mosaic Virus

Figure 1.11: Sample images of mung bean leaf (Controlled Environment and Uncontrolled Environment)

1.12 Outcome of study

Empirical techniques of disease identification and detection is time consuming, laborious and expensive. Modern technique such as image analysis can provide easy and the handy tool for farmers. New image analysis techniques or developed algorithms can be applied through devices such as Mobile phone or tablets, so farmers can identify disease without the mediation of any expert.

1.13 Scope of the Study

Plant leaf disease detection is a challenging area for researcher. Here researcher has controlled the proposed study to achieve accuracy for the limited scope of the vast

domain where,

- Proposed study focuses on analyzing and recognizing mung bean plant leaf diseases from South Gujarat region of India.
- For experimental work research have identified three different diseases of mung leaf and a healthy leaf category.
- The study will help mung bean farmers who generally depend on the agricultural experts or advisors for the disease diagnosis.

1.14 Limitations of the Study

Current disease recognition model recognizes three most destructive diseases of mung bean plant leaves. In future other diseases of mung bean plant leaf can also be consider for classification.

1.15 Organization of the Thesis

Researcher has distributed complete work into five different chapters. Summary of the continuing chapters i.e. from chapter 2 to chapter 5 is as follow.

Chapter 2 Literature Review

This chapter presents literature review of existing studies carried out so far in the area of plant disease recognition for numerous plants and it's organs from numerous sources which consist of journal articles, conference articles, electronic documents, web resources.

Chapter 3 Plant Foliar Disease Identification Model

This chapter presents design of the foliar/leaf disease detection model. Several components and subcomponents of model are explained in detail in this chapter.

Chapter 4 Development of Plant Foliar Disease Identification Model (PFDIM)

This chapter presents explanation associated to component development of the model presented in chapter 3. Every component and subcomponent of model of "Plant Foliar Disease Identification Model" is developed and input and trial output of it is presented. In a task of identifying leaf disease from image for which numerous stages are employed as: developing mung leaf image dataset, preprocessing, feature extraction, and recognition.

Chapter 5 Results and Conclusion

This chapter converses result of the projected PFDIM model applied on mung leaf dataset collected to quantity the success of projected research work. Moreover this chapter presents conclusion of projected research work along with path for future scope in the present research space.

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