accurate results [7]. An automated plant disease detection is highly beneficial to farmers, since they know less about plant diseases.

In the current era, many works are ongoing in the domain of machine learning, which can be used effectively in the field of health monitoring, the identification of diseases in plants, etc. This kind of system provides reliable, precise results and reduces the time, cost and manpower for maintaining and ensuring quality in real-time applications. In the field of agriculture, there are a lot of opportunities for researchers to apply machine learning techniques in many aspects, such as the identification of plants, early detection of diseases, pesticide, nutrition requirement, etc. In this paper, we consider the diseases which occur on the leaves of the plant. Several machine learning techniques are discussed in this paper, which were proposed by different researchers based on color, shape, texture features and deep learning models for detecting diseases in plant leaves.

The automated detection of diseases in plants has been studied largely in recent times. The identification of diseases in plants requires accurate and precise information regarding the quantitative measurement of diseases [8]. In [9,10], the authors studied potato and tomato diseases and showed how these crops were affected by viruses. In [11], authors surveyed several papers on the classification of rice diseases and also considered different criteria such as the dataset used, disease classes, preprocessing and segmentation techniques along with the classifier used. Prajapati et al. [12] conducted a survey on the classification of cotton plant diseases using machine learning techniques. Iqbal et al. [13] surveyed the classification of citrus plant diseases using image processing. Kaur et al. [14] conducted a survey on the identification and classification of plant diseases through leaf images. These studies discussed in [11–14] are based on handcrafted features. To classify the diseases using handcrafted features, there is a need for the preprocessing, segmentation and extraction of features from the images, which is laborious and time-consuming.

With the technological advancements, machine-learning-based artificial intelligence has gained a lot of attention in the development of new techniques and models in computer vision [15]. Deep learning models are used in fields such as image recognition [16], voice recognition [17,18] and other complex applications such as self-driving cars, machine interpretation, etc. The application of deep learning in agriculture [19] and particularly in the plant disease detection [20] domain is very much new and limited. In [21], the authors surveyed the identification of plant diseases based on deep learning techniques and essentially focused on the data sources, models and preprocessing techniques used in the proposed CNN models. In [22], the authors reviewed research works on the identification of diseases using several types of deep learning techniques. In these papers, the authors discussed mainly the different CNN models used in plant disease identification. However, the comparative advantages and disadvantages were not clearly highlighted in these works.

In this work, we survey the different methodologies for the identification of plant diseases using both handcrafted-features-based and deep-learning-features-based identifications. We also discuss several segmentation techniques used in the identification of plant diseases along with their advantages and disadvantages. This paper aims to address the drawbacks of the existing works on the identification of diseases based on both handcrafted features and deep learning approaches. We also consider the recent works on the identification of plant diseases which are based on deep learning models. We point out some of the challenging issues in the identification of diseases along with the advantages and disadvantages of using deep learning models.

This paper is organized as follows: Section 2 provides the basic steps in the identification of plant diseases from leaf images. Section 3 represents a comprehensive review on the identification of plant diseases along with their relative advantages and disadvantages. In Section 4, we discuss the different techniques and advantages of deep-learning- over handcrafted-features-based approaches. Different challenges that are faced during the identification of diseases and the areas that need to be focused on are discussed in Section 5. Finally, Section 6, provides the conclusion and future directions in the classification of plant diseases.