Various Diseases Detection of Tomato Leaf Using Soft Computing Techniques:A Review

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***Abstract*—** Agricultural production is a crucial component of the economy, but plant diseases can have severe impacts on crop yield and quality. Early detection and proper care are necessary to prevent these negative effects. Tomato plants are susceptible to leaf diseases, such as little leaf disease, which can be particularly dangerous. Soft computing methods, such as fuzzy logic, artificial neural networks (ANN), and genetic algorithms, can help automate the detection of these diseases, reducing the amount of manual observation required in large-scale farming operations. In this paper, we present a procedure for using these methods to detect tomato leaf diseases, using the Plant Village dataset for training and testing. We also review other disease classification methods that could be applied to this task. By identifying symptoms at an early stage, these techniques can help farmers take action to protect their crops and ensure a healthy harvest.

Keywords*—Tomato Leave Diseasease; Soft Computing; PlantVillage Dataset.*

I. INTRODUCTION

India strongly depends on the farming segment for a common of the people. India's utmost general vegetable is the tomato. Tomatoes are sources of the three important anti-oxidants, vitamin E, C, and beta-carotene. Tomato is one of the most common potatoes developed globally and is a great revenue foundation for agriculturalists. They are a great source of potassium, outstanding strength an identical major mineral. The farming district of tomato production in India covers roughly 3, 50,000 hectares. The developed measures around 53, 00,000 stacks, manufacturing India as the third-biggest tomato manufacturer throughout the world. The sensitivity of harvests fixed through weather circumstances has prepared illnesses common in the tomato harvest throughout its growth. Plant life impacted by the illness develops around 10-30% of the whole yield harm. Physically monitoring vegetable and fruit infections is a tough task due to its composite environment and is a slow procedure [1]. Indian economy is governed by agricultural science and a wide-ranging population depends on cultivated agriculture. Plant disease life in Fig. 1 and harvests source the decrease in qualitative and quantitative yield.

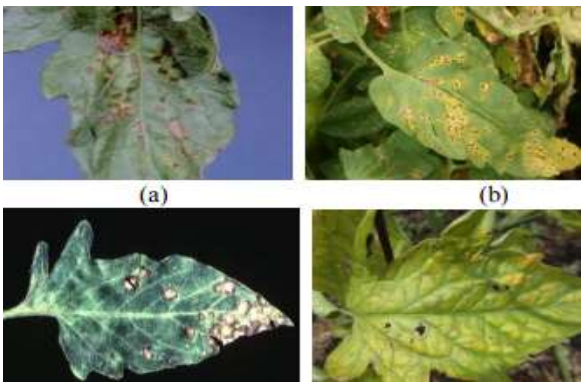

Fig1. Diseased Tomato Leaf [2]

So, the challenging process is to classify plant leaf illness very precisely. Syndrome-attacking portions are plants' leaves, branches, and fruits. Perfect quantification of sicknesses through necked discrimination is very challenging. Therefore considering detailed and precise image outlines is difficult currently. In organic learning, a massive amount of imagery accomplishment is caused through distinct trials and these imageries additional can be recycled for classification. Therefore, environmentalists must analyze and abstract the precise insides for additional classification [3]. Several types of tomato diseases are predicted in existing research. Various diseases and disorders disturb tomatoes during the increasing period. The symptoms and supervision of major problems originate in gardens and conservatories. Septoria leaf spot, early blight, Verticillium wilt, Bacterial spot, late blight and Powdery mildew etc. The Sectorial leaf spot, produced through the fungus Sectorial lycopersici, is the peak collective foliar infection of tomatoes in Iowa. It majorly seems as minor, water-soaked spots that rapidly become rounded spots with different dimensions. The lesions progressively grow grayfish snowy centers with dark boundaries. The light-colored centers of these spots are the most distinctive symptom of Septoria leaf spots. When circumstances are favourable, fungal crop fruit procedures appear as little black specks in the centers of the spots. Micro-organisms are supper to novel plants using splashing rain. Greatly diseased plants turn into yellow, wither, and eventually fall off. Lower leaves are infected first, and the disease progresses upward if the rainy climate perseveres. Defoliation exists simply after periods of protracted warm, rainy climates. Early blight is also a form of tomato disease, instigated through the fungus

Alternaria solani, is also recognized as Alternaria foliage spot or target spot. Like Septoria leaf spot, early blight is common in Iowa tomato plantings, and the two diseases may attack the same plants. Premature loss of lower leaves is the most obvious symptom of the disease. Brown to black spots, with one-fourth or half-inch thick through dark boundaries, seems on inferior plants. Spots frequently syndicate, founding asymmetrical spots. Dark concentric rings repeatedly perform in leave spots, resulting in the board arrival suggested by the common name. Leaves turn yellow and dry up as soon as only a few spots are present. The mildew infrequently occurrences fruit at the branch end, producing large, gaunt parts with concentric rings and a black, velvety presence. Warm, wet weather favours the rapid spread of early blight. A. solani also can infect potatoes leaf. Like the Septoria leaf spot, early blight can blight vegetation at any period throughout the growing season, but usually, developments most fast after florae have established fruit [4] [5]. Early blight, Verticillium wilt, Bacterial spot, late blight and Powdery mildew etc. The Sectorial leaf spot, produced through the fungus Sectorial lycopersici, is tomatoes' peak collective foliar infection in Iowa. It majorly seems as minor, water-soaked spots that rapidly become rounded spots with different dimensions. The lesions progressively grow grayish snowy centers with dark boundaries. The light-colored centers of these spots are the most distinctive symptom of Septoria leaf spots. When circumstances are favourable, fungal crop fruit procedures appear as little black specks in the centers of the spots.

Various existing method for plant leaf illness detection is naked eye surveillance through specialists complete which credentials and exposure of plant illnesses are completed. For performance, a large group of professionals and continuous plant monitoring is mandatory, which expenditures are very great for large farms? In some countries, agriculturalists do not have good accommodations or even the knowledge to interact with experts because consulting experts is expensive and time-consuming. In such circumstances, the recommended method shows to be valuable in observing large fields of yields. Automatic detection of illnesses by unbiased sighted plant leaf indication varieties is informal and inexpensive. It also funds machine vision to offer image-based programmed development control, assessment, and automation direction. Soft computing approaches, for example, artificial neural networks (ANN), and fuzzy logic, are used as another technique for modeling the composite behavior of tools such as grapheme. These processes involve input preparation statistics for solving complications. These soft computing methods effectively solve complex optimization complications based on input. In various models, the 3-layered feed-forward system is used. The root-mean-square error (RMSE) technique can regulate the different neurons in the hidden layer. Tabu examination is a meta-heuristic search technique that uses recycled local examination methods for accurate optimization. Local examinations pick up a resolution to a future problem and pattern its direct neighbors, i.e., similar solutions except for some minor details, intending to find an improved result [6]. Local search approaches have a tendency to grow stuck in sub-optimal regions or on plateaus where several resolutions correspondingly fit. If any potential resolution has been visited earlier in a short period or does not fulfill a rule, it is noticeable as taboo. The procedure does not reflect the possibility of repetition.

Jagadeesh Basavaiah et al., [7] projected four main tomato leaves sicknesses as bacterial spot, Septoria spot, mosaic virus and yellow curl, using several feature extraction approaches. Also, the illnesses are classified with decision-tree and random-forest classifiers through 90% accuracy for the DT classifier and 94% for the random forest (RF) classifier, respectively. The results show that the RF classifier is further accurate than the DT classifier.

The rest of the paper is a literature survey regarding detecting tomato leaf illnesses using soft computing in sec 2 and the plant village dataset described in sec 3. Further, several soft computing methods are represented in sec 4. Finally, the conclusion are considered in Sec 5.

II. RELATED WORK

Detection has been considered in tomato plants, disease or infection. Soft computing methods such as ANN, Fuzzy logic and genetic algorithm methods were applied to solve tomato leaf infection because of their dominance in processing imageries. The initial detection and classification of illnesses affecting tomato plants can assist farmers in avoiding expensive yield insect killer and growth food manufacture. A lot of the existing research concentrations not only on model strategy on the other hand also on pre-processing developments, classification forms, and operative stages are described as; **L. Vijayalakshmi et al., (2022) [8]** described the research that was completed to associate twofold processes that recognize tomato diseases. The authors mainly constructed to categorize and distinguish the plant's infections mechanically for on the whole the tomato plant infection. The projected scheme recycled the ResNet CNN design by hybridizing the fuzzy-c-means and edge detection procedure in the fully connected layer (FCL) to distinguish the tomato infections. As an outcome, a few infections that generally happened in tomato plants such as gray spots, bacterial cancer, and late blight were distinguished. As a result, the projected technique attained an accuracy of 97.01% which was moderately adequate than the earlier recognized formal methods. **Iftikhar Ahmad et al., (2020) [9]** described vegetable and fruit plants simplify nearly 7.5 billion individuals from place to place in the globe, playing a critical part in supporting the lifespan of the world. Vegetable and fruit plants facilitate around 7.5 billion people around the globe, playing a crucial role in sustaining life on the planet. The rapid growth in the practice of chemicals, such as fungicides and antiseptics, to decrease plant illnesses was harmful to the agro-ecosystem. The higher-scale occurrence of illnesses in crops disturbs the construction quantity and excellence. Solving the difficulty of identifying or analyzing illnesses by manipulating rapid and reliable technique benefits agriculturalists. The authors focused on organizing and identifying tomato leaf illnesses using CNN methods. For this

projected work, VGG_19, VGG_16 Res_Net, and Inception_V3. Also, feature extraction and parameter-tuning were utilized to detect and categorize tomato leaf illnesses. The fundamental representations were on twofold datasets, a laboratory-based dataset and self-composed statistics from the field. The authors detected performance that all designs accomplished well by using laboratory-based datasets as compared to field-based statistics through the presentation of several metrics screening alteration in the series 10–15%. The inception_V3 model was recognized as the best-performing process on together datasets. **Hasan Ulutas et al., (2023) [10]** described the Initial analysis of plant infections considered dynamic significance as the reason for common, environmental, and financial damages. So, it was extremely difficult and caused too much workload and time loss. The authors deployed around nine tomato plant leaf illnesses and strong ones were categorized with DL by novel ensemble designs. Also, an overall of 18.160 images were recycled for this development. The projected twofold new CNN models and four other recognized CNN models such as Mobile_Net_V3 Small, Efficient_Net_V2_L, Inception_V3 and Mobile_Net_V2 models, were used. A refinement technique was realistic to the novel projected CNNs models and then hyper-parameter optimization was completed by the PSO method. Earlier, the weights of these models had been optimized completely network search method, triple and quintuple ensemble prototypes were generated and the datasets were categorized using the five-fold cross-validation. The investigational outcomes determined that the projected ensemble representations stand out with their fast preparation, challenging time, and greater classification presentations through accuracy of 99.60%. The investigation supported by specialists enabled the initial detection of plant diseases simply and quickly and prevented the development of novel infections. **Syaiful Anam et al., (2022) [11]** described early blight considered a major syndrome that infected tomato leaves. The tomato leaf infection originated a decline in the construction of tomato plants. The earlier detection of this infection was very significant in preserving tomato construction. Monitoring tomato plants' fitness physically in a large range was an appropriate inefficient and disorganized. Drones and computer-vision tools were an alternative to explaining this difficulty. One of the significant stages in sensing tomato foliage illness constructed on computer vision was the segmentation zone of the tomato leaf into the well and unwell tomato leaf. The k-means clustering method was an image segmentation technique that was simple, fast, and mechanism unsupervised. The PSO method was utilized as a resolution of several problems. The performance of the PSO was dependent on the particle rapidity of the PSO. The particle ratio was not determined exactly but the PSO method was meeting too early. Fuzzy Adaptive Turbulence (FAT) with Particle Swarm Optimization (PSO) offered an adaptive least rapidity mechanism of the PSO particles to eliminate the previous conjunction difficulty in the PSO method. The authors proposed the FAT-PSO model to perceive the tomato leaf infection. The fitness function of FAT-PSO utilized an objective function of the K-means method and also delivered better performance results. **Siti Zulaikha Muhammad Zaki et al., (2020) [12]** described tomato as a red-colored eatable vegetable or fruit made in the American area. There was an allocation of vegetable diseases related to tomatoes for example, leaf mold, late blight, and mosaic virus. Tomato was considered a significant vegetable collection that funds the world carefully. In spite of fantastic determinations in vegetable supervision, biological infections were, especially hard to the mechanism and eliminate entirely. So, accurate and earlier recognition of plant infections was desirable to moderate the difficulty at the primary phase. A computer-vision method was projected to recognize the infection by catching the leaf imageries and sensing the syndromes' prospects. A DL classifier was employed to generate a strong resolution that protects a wide range of leaf forms. Dense DL construction, which was Mobile Net V2, was modified to detect three categories of tomato infections. The process was verified on 4,671 imageries from the Plant Village dataset and the outcomes demonstrated that Mobile_Net_V2 could detect the illness with an accuracy of 90%. **Kyamelia Roy et al., (2023) [13]** described the progress of DL and Computer-Vision in the cultivation field had originated to be an active tool in sensing damaging plant syndromes. Classification and recognition of well and unwell products play an actual critical role in influencing the ratio and feature of construction. The authors projected a novel technique of perceiving Tomato leaf diseases using DNNs to support agro-based activities. The existing innovative structure was employed with a grouping of the classical ML model PCA method and a customized DNN which had called as P.C.A. Deepen model. The hybridized structure similarly contained Generative Adversarial Network (GAN) intended to procure a decent combination of datasets. The recognition was accepted with the Faster Region-Based CNN (F-RCNN) and achieved an accuracy of 99.60% and a precision of 98.55%.

III. PLANT VILLAGE IMAGE DATASET FOR TOMATO LEAVE DISEASE DETECTION SYSTEM

Plant Village Image Dataset is used or composed huge quantity of statistics and it has around 50,000 pictures of fourteen yield classes and twenty-six infections. Around 9,000 tomatoes leave pictures. This dataset consists of 7 types of unhealthy pictures, including –

Class (0) Bacterial Spot
Class (1) Early Blight
Class (2) Healthy
Class (3) Septoria Leaf Spot
Class (4) Leaf mold
Class (5) Yellow Leaf Curl Virus
Class (6) Late Blight, and
Class (7) Tomato Mosaic [14]

The Plant Village dataset is an exposed repository that covers 54,323 imageries of 14 crops and 38 kinds of plant illnesses. From this dataset, only imageries of tomato leaves were

mined. Figure 2 displays a sample of every experimental class [10].

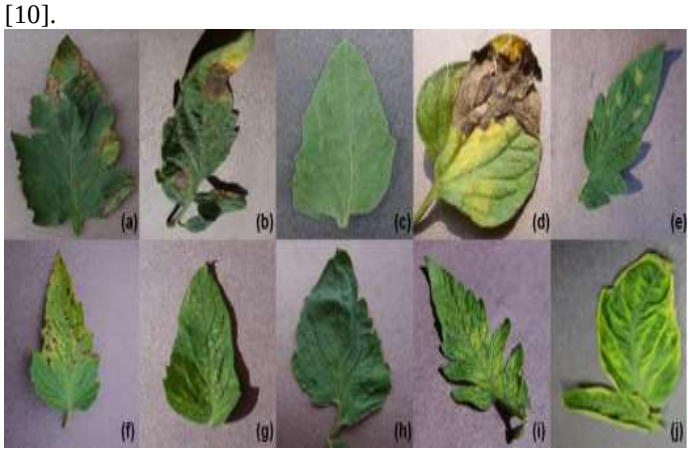

Fig 2. Plant Village Dataset [15]

IV. SOFT COMPUTING METHODS

Soft computing is an effective method of supervisory such composite plants. Soft computing (SC) is not a particular technique; on the other hand, it is a permutation of various approaches, such as fuzzy logic, neural networks (NNs), and genetic algorithms (GA). All these approaches are not inexpensive. However, matching each other and recycled collected to resolve a specified problem. It can be said that soft computing aims to solve complex problems by exploiting imprecision and uncertainty in decision-making developments. Fig 3 shows the soft computing of the plant under investigation is available and traditional mathematical methods are used to solve the problem. This figure shows a soft computing method where only an approximate model of the plant is accessible, and the solution depends upon estimated reasoning methods.

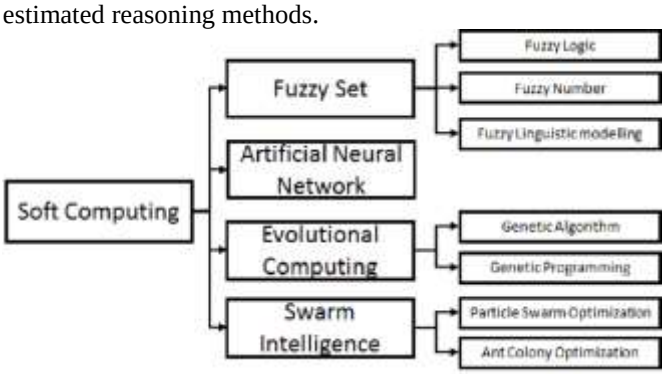

Fig 3. Soft Computing Categories [23]

A. Fuzzy Logic

Fuzzy control has been in practice for completed twofold periods to resolve composite control difficulties. In accumulation, several arrangement difficulties are resolved by consuming fuzzy logic principles. NNs, though an original model, has used by numerous persons to resolve complex programmed control difficulties and complications. In addition to solving automatic control problems, soft computing has also been used in diverse applications such as intelligent speech recognition, communications, fields of signal processing, heavy current schemes, design and manufacturing, pattern recognition, and several additional applications. The fuzzy logic model is a technique for representative human facts that is inaccurate through the environment. The basic conformation of a fuzzy logic structure is in Fig 4. The fuzzification interface transforms the hard input assessment into a fuzzy morphological value. The fuzzification is constantly essential in a fuzzy logic scheme as the input values from current devices are permanently crisp mathematical standards. The inference machine precedes the fuzzy input and the fuzzy instruction base and generates fuzzy outputs.

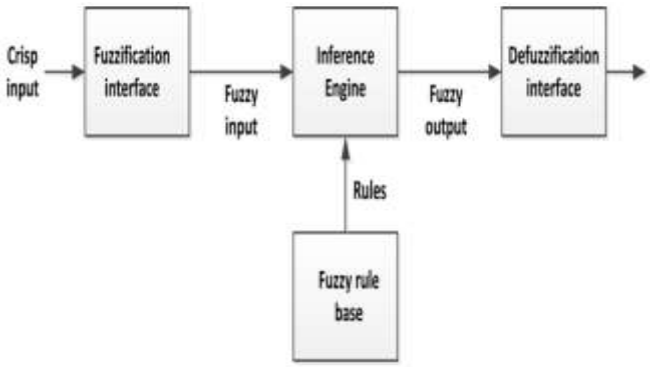

Fig 4. Fuzzy Logic Model [16]

B. ANN (Artificial Neural Network)

ANN or neural computing is one of the fast-budding fields of investigation, attracting investigators from various engineering corrections, such as electrical engineering, regulator engineering, and software engineering. ANNs are data processing structures that are encouraged through the method of the biological nervous scheme and the brain mechanism. ANNs are frequently organized for detailed presentations, such as pattern recognition, statistics recognition, image processing, stock market forecast, climate prediction, image compression, and safety and loan applications. NNs intend to bring traditional computers closer to how the human brain works. ANNs work superlatively if the association between the involvements and productions is non-linear. This method is extremely appropriate for solving difficulties where there are nope processes or specific conventional directions to be monitored to solve the problem.

A neural network is a large network of interconnected elements encouraged by human neurons. Each neuron performs little operations and the overall operation is the weighted sum of these operations. Fig 5 represents ANN model has to be proficient thus that a recognized set of inputs produces the desired outputs. Training is usually done by feeding teaching patterns to the network and letting the network change its weighting function according to some previously defined learning rules. The learning can either be supervised or unsupervised. In supervised learning, the system under investigation is trained by giving inputs and matching output patterns such as the results being recognized for precise inputs. In unsupervised learning, the network's output is proficient in responding to input patterns.

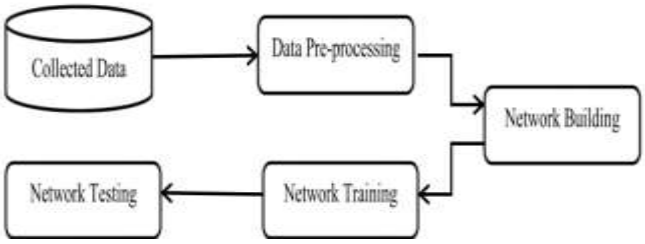

Fig 5. ANN model Flowchart [23]

C. GA (Genetic Algorithm)

GA is measures of artificial intelligence (AI) and fuzzy computing. They are generally recycled to resolve several optimization difficulties encountered in practical applications. The straightforward impression of a GA method is to simulate the natural collection in the environment to the invention a good selection for an application. GA method is a prototypical ML encouraged through the environment's development process. A GA method also detects solutions to complex search difficulties in engineering presentations. For instance, they can examine. Several schemes and mechanisms catch the greatest arrangement that products in improved economic development. GAs are currently used in many diverse arenas, such as climatology, the biomedical industry, code-breaking, control engineering, games theory, electronic design, and automated manufacturing and design.

Table 1 represents the advantages and disadvantages of soft computing methods and Table 2 represents the comparative analysis of the different soft computing methods. Fig 6(i) and (ii) represent the comparative analysis with different soft computing methods and performance metrics.

Table 1. Advantages and Disadvantages of Soft Computing Methods

Techniques Name	Advantages	Disadvantages
Fuzzy Logic [17] [18]	• This method is strong and simple. • If the feedback structure flops in the method, it can be simply re-programmable.	• In this method, regular modifications are needed. • This method is absolutely to be subjective through human data and capability.
ANN [19] [20]	• This method is simply run on any machine. • It is an implementation process which is not required any programming.	• This method required additional preparation for processing. • Required extra time for running.
GA Method [21] [22]	• This method offers fast processing as compared to others. • This technique executes large variables simultaneously.	• The casual heuristics occasionally doesn't catch the optimal. • It is not an inclusive process because this method does not deliver relevant results.

Table 2, soft computing methods as fuzzy logic, ANN and GA method are considered with specific datasets and the final output is predicted for tomato leaf infection detection.

Table 2. Comparative Analysis : Results

Method Name	Dataset	Results
Fuzzy Logic [17] [18]	Plant Village maize data set	Accuracy= 95.63%
ANN [19] [20]	136 data samples.	RMSE = 0.095 MSE = 0.049
GA Method [21] [22]	Terahertz image dataset	Accuracy = 95%

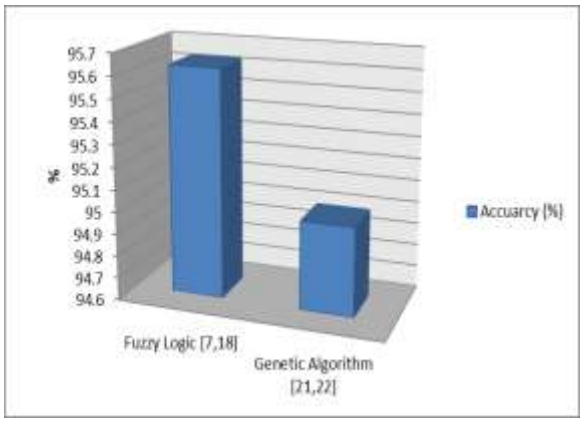

Fig 6 (i) Comparative Analysis with different soft computing methods (Fuzzy and Genetic): Accuracy (%)

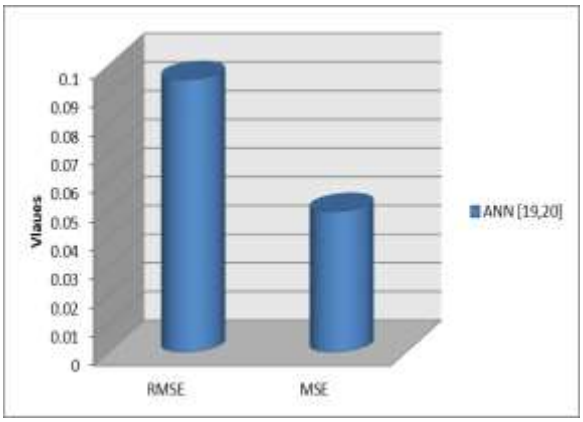

Fig 6 (ii) Comparative Analysis with different soft computing methods (Fuzzy and Genetic): RMSE and MSE

V. CONCLUSION

This article concluded that it offers tomato leaf disease detection by using soft computing methods. Several tomatoes leave diseases such as bacteria, septoria spots, mosaic virus, yellow curl, etc. These diseases badly affect the tomato plants and also degrade any country's economic growth because agriculture plays an important role in the economic sector of any country. In this paper, detection of Tomato plant leaf disease over soft computing methods such as fuzzy logic, ANN and genetic method. These methods are very beneficial to diminish the large observing work in large yield farms. At an early stage, it identifies the symptoms of syndromes when they act on plant leaves. This paper presents a procedure of soft computing methods such as fuzzy logic, ANN and genetic method for tomato leaf disease detection. The Plant Village dataset repeatedly perceives and categorizes plant leaf illnesses. Comparative analysis shows that the fuzzy logic method performs better than other methods. The fuzzy method has achieved 95.6% and genetic algorithm value of 95%.

In the Future, by using these methods, construct an efficient tool or method for detecting tomato leaf or other plant leaf diseases. Also, classifying several diseases through several species, refining the accuracy through soft computing methods.

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