IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Fuzzy Logic Based System To Grade Pomegranate Leaf Disease

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Abstract

Present paper is an attempt to automatically grade the Bacterial Blight disease on the leaf of a Pomegranate plant. This innovative technique would be a boon to many and would have a lot of advantages over the traditional method of grading. There has been a an enormous change in the mindset and the effort put down by the agricultural industry by adapting to the current trends & technologies for e.g. using Precision Agriculture. Presently, plant pathologists follow a tedious technique that mainly relies on naked eye prediction and a disease scoring scale to grade the disease. Manual grading is not only time consuming but also does not give precise results. Hence the current paper proposes an image processing methodology to deal with one of the main issues of plant pathology i.e disease grading by employing Fuzzy Logic. The results are proved to be accurate and satisfactory in contrast to manual grading and hopefully take a strong leap forward in establishing itself in the market as one of the most efficient and effective process.

General Terms Leaf diseases, disease grading, image processing, disease management

Keywords Percent Infection, K-means clustering, color image segmentation, Fuzzy logic, Precision agriculture

Introduction

Plant diseases can cause significant reduction in crops and lead to poor quality of agricultural products[2]. Research in agriculture is aimed towards increase of productivity and food quality at reduced expenditure and with increased profit [2]. Although there is an industrial recognized corresponding standard to grade the leaf spot disease[5-8], the naked eye observation method is mainly adopted in the production practice. With the advent of new technologies and superior techniques, adopting these means would indeed help this sector to outperform in the coming days. Precision agriculture aims to optimize field-level management and also provides farmers with a wealth of information to build up a record of their farm; improve decision-making; foster greater traceability; enhance marketing of farm products; enhance the inherent quality of farm products.

Grading of the samples is a daunting task, one of the major reasons being the difference of personal knowledge and practical experience, the same samples are classified into different grades by different experts. Therefore, the result is usually subjective and it is impossible to measure the disease severity precisely as the outcomes may vary and could be misleading. The diseases that affect pomegranate plant are bacterial blight (Xanthomonas *axonopodis* pv *punicae*), antracnose (*Colletotrichum gloeosporoides*) and wilt complex (*ceratocystis fimbriata*), the major one being bacterial blight.

Present Grading Method: Manual Grading

Plants are bound to have diseases. The infected plants are diagnosed and treatment is suggested to cure the disease. To treat the disease chemical pesticides are used. Pesticides are substances or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. Chemicals are continually becoming a more intricate part of modern society. The rampant use of these chemicals, under the adage, “if little is good, a lot more will be better” has played havoc with human and also on agricultural products. Use of these toxic chemicals can only be minimised when the disease is identified accurately along with the stage in which the disease is observed.

Presently, a disease scoring scale is used by the plant pathologists to grade the disease. This is shown in Table 1.

Percent Infection	Disease Grade
0-0.999	0
1-5.999	1
6-15.999	2

16-25.999	3
26-35.999	4
36-45.999	5
46-55.999	6
56-65.999	7
66-75.999	8
76-100	9

Table1: Disease scoring scale for pomegranate leaves

From the table 1, it is observed that the grade of the disease is assigned based on the percent-infection i.e., if the infection percent is about 7 then the grade is 1.
Grid paper analysis is presently used to calculate percent-infection. The main disadvantages of using this method are that it is time consuming and burden of repetitive tasks. To add to the list since human intervention is involved, it is prone to errors which an area of concern.
Due to the ill effects of these methods, present paper suggests a solution to overcome the problems. Machine vision is one such way to grade the disease which can be a boon to the agronomists.

Approach

The proposed method presents a system that will grade the disease of pomegranate leaves.
The flow chart of the process is presented in figure 1.
The system is divided into the following steps: (1) Image acquisition (2) Image Pre-processing (3) Color image segmentation (4) Calculating A_T and A_D (5) Disease grading by Fuzzy Logic.

Image acquisition

The first stage of any vision system is the image acquisition stage.
The digitization and storage of an image is referred as the image acquisition. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks required today. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement.
All the images are saved in the JPEG format. For the purpose of image acquisition, author has visited and captured images from several pomegranate farms in Rahuri, Ahmednagar district , Maharashtra, India.

Image Pre-processing

Preprocessing images commonly involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images[1]. Image preprocessing is the technique of enhancing data images prior to computational processing.
Image processing is a form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image[1].
Preprocessing uses the techniques such as image resize, filtering, segmentation, cropping, etc.
Initially, captured images are resized to a fixed resolution so as to utilize the storage capacity or to reduce the computational burden in the later processing. Noise is inevitable during image acquisition or transmission[1]. Noise would disturb the segmentation and the feature extraction of disease spots. So they must be removed or weakened before any further image analysis by applying an appropriate image filtering operation. In the present work, author has considered Gaussian filter to filter out the input images.

Image segmentation

Image segmentation refers to the process of partitioning the digital image into its constituent regions or objects so as to change the representation of the image into something that is more meaningful and easier to analyze. The level to which the partitioning is carried depends on the problem being solved i.e. segmentation should stop when the objects of interest in an application have been isolated [5]. In the current work, the very purpose of segmentation is to identify regions in the image that are likely to qualify as diseased regions. There are various techniques for image segmentation. *K-means clustering* method has been used in the present work to carry out segmentation. K-Means Clustering is a method of cluster analysis which aims to partition *n* observations into *k* mutually exclusive clusters in which each observation belongs to the cluster with the nearest mean.
When the segmentation is completed, one of the clusters contains the diseased spots being extracted. This image is saved and considered for calculating A_D

Calculating A_T and A_D

In image processing terminology area of a binary image is the total number of *on* pixels in the image[1]. Hence, the original resized image is converted to binary image such that the pixels corresponding to the leaf image are *on.* From this image total leaf area (A_T) is calculated. Similarly, the output image from color image segmentation, containing the disease spots, is used to calculate total disease area (A_D)[1].

Disease grading by Fuzzy Logic

Once A_T and A_D are known, the percent-infection (PI) is calculated by applying the formula (1).

$PI = (A_D / A_T) * 100$ . . . (1)

Now that, the Grade of the disease has to be determined from PI. , Fuzzy Logic has been employed for this purpose.

FlowChart of the complete Process[1] is shown in figure 1

Flowchart :

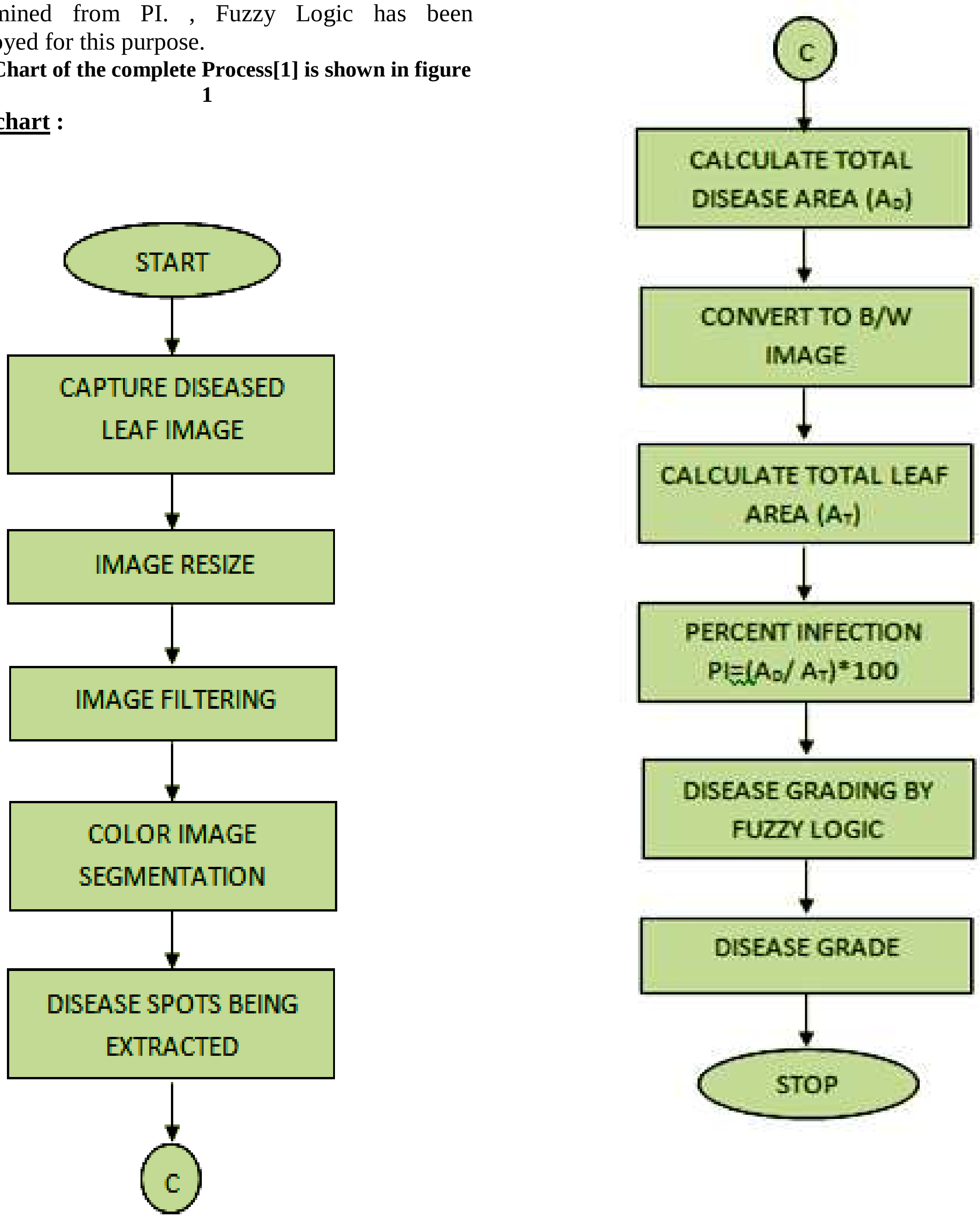


Figure1: Flowchart of the process

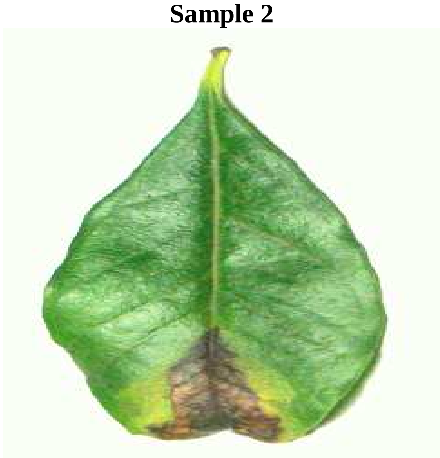
Result And Analysis

Image acquisition

Figure 2 shows the images of pomegranate leaf diseased by Bacterial Blight.

Sample 1

Sample 2



Sample 3

Sample 4

Figure 2: samples of Leaf Diseased by Bacterial Blight

Image Pre-processing

Resize

The image is resized to a resolution of [250 300].

Filtering

Gaussian filters are used to remove noise

Color Image Segmentation

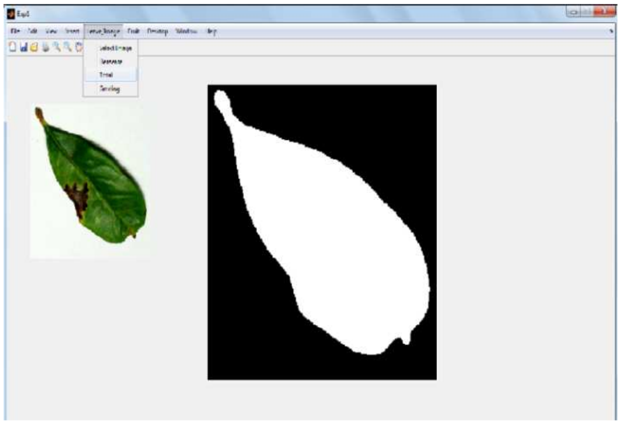
K-means segmentation algorithm requires users to select the value ‘k’. The correct choice of k is often ambiguous. Increasing k will always reduce the amount of error in the resulting clustering, to the extreme case of zero error if each data point is considered its own cluster (i.e., when k equals the number of data points, n). Intuitively then, the optimal choice of k will strike a balance between maximum compression of the data using a single cluster, and maximum accuracy by assigning each data point to its own cluster.

After some trial and error method, for the current work, value of K is chosen as 6

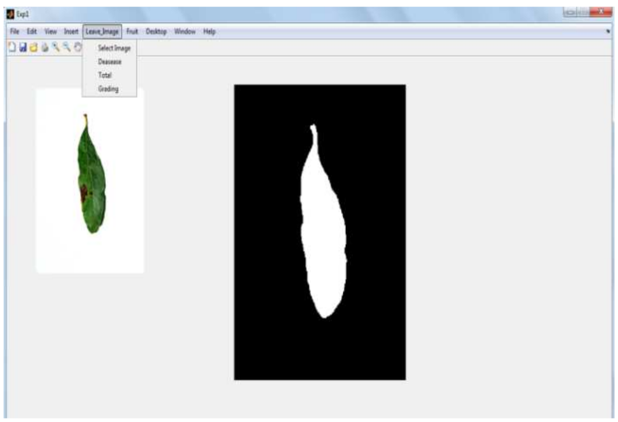
Calculating A_T and A_D

Total Leaf Area (AT)

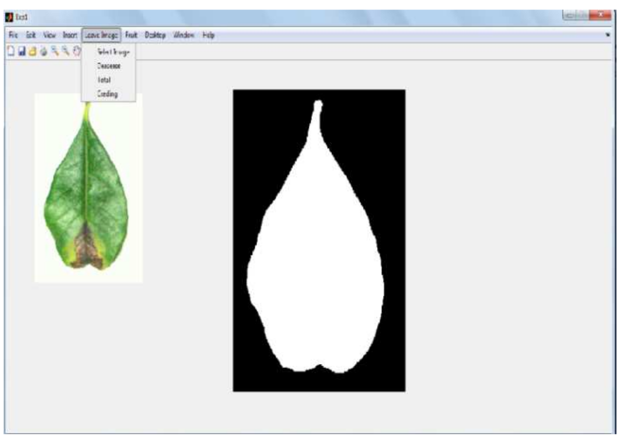
Figure 3 shows the binary images of the original resized image.



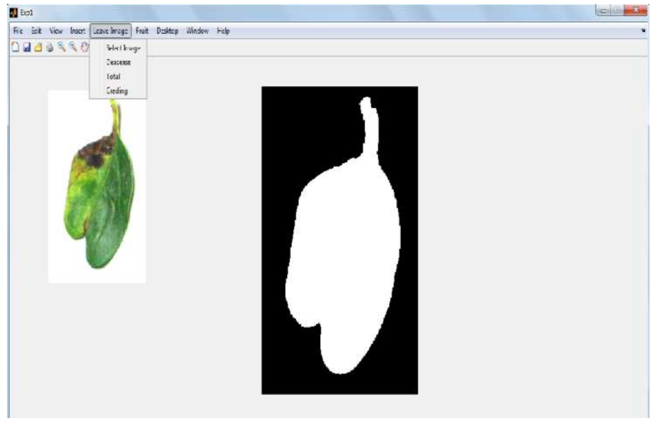
Sample 1



Sample 2



Sample 3

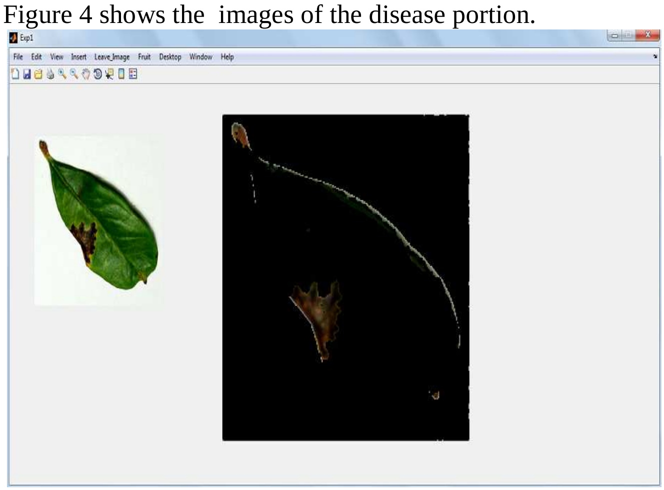


Sample 4

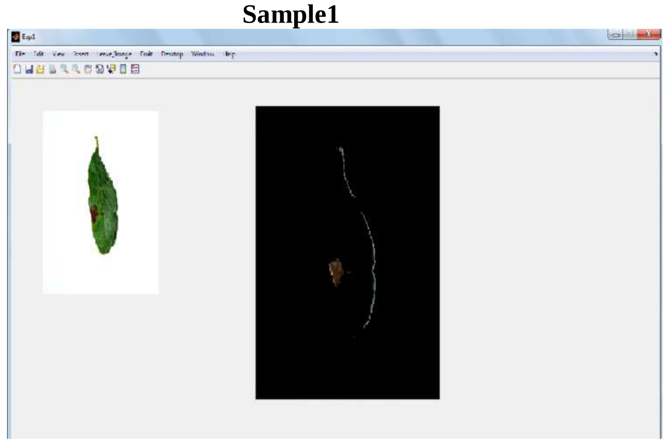
Figure 3: Black and white images of the different query image

Total Disease Area (AD)

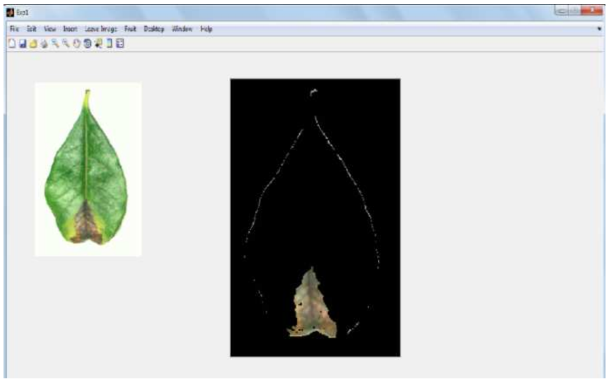
Figure 4 shows the images of the disease portion.



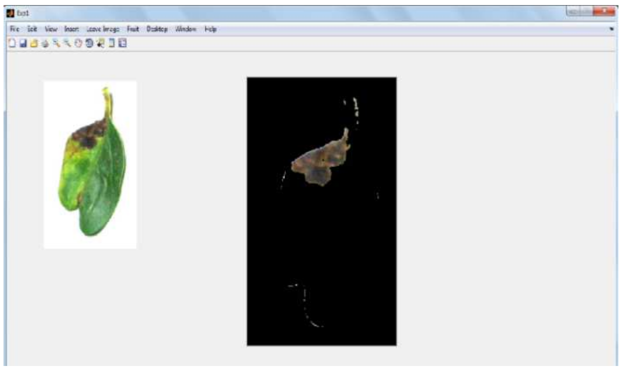
Sample1



Sample 2



Sample 3



Sample 4

Figure 4: Diseased portion of the different query image

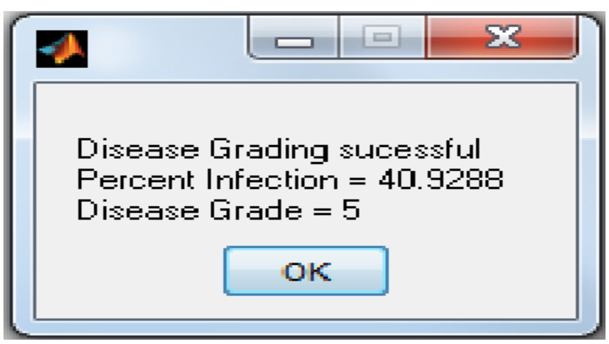
4.5 Disease grading by Fuzzy Logic

From (1), Percent-infection is given by

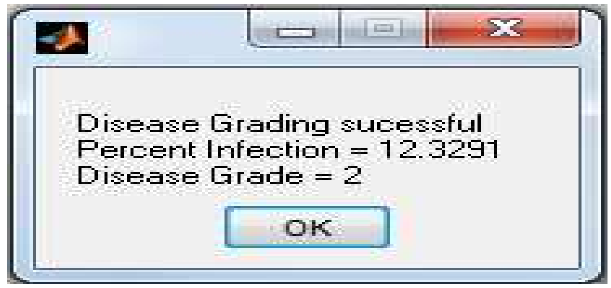
PI= (AD / AT) *100

= (72990/ 178334) * 100

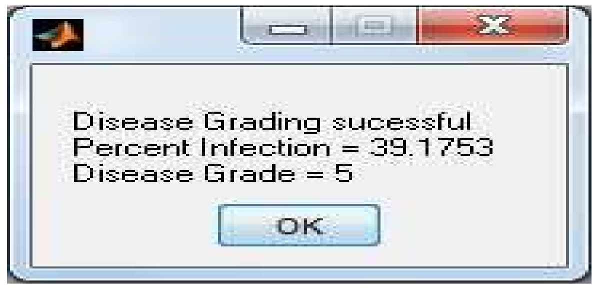
= 40.9288 %



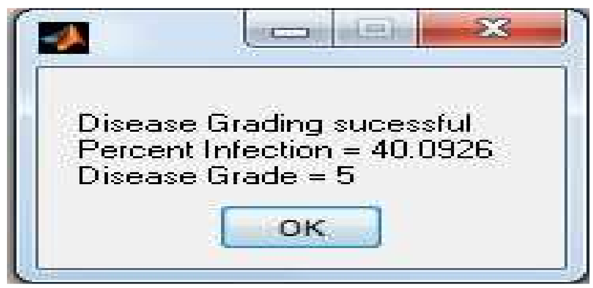
Sample 1



Sample 2



Sample 3



Sample 4

Figure 5: Grading Results of different Query images

A Fuzzy logic based System is developed for disease grading by referring to the disease scoring scale in Table1 triangular membership functions are used to define the variables and 10 fuzzy rules are set to grade the disease. Figure5 shows the result of grading for different images

From the result, it can be observed that the accurate values of percent-infection and disease grade are obtained with which a proper treatment advisory can be given thereby eliminating the above mentioned problems. Also chemical spray frequency can be minimised thereby reducing chemical residue in plant parts i.e. food or fodder parts.

Fuzzy Logic (FL)

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. It incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically.

FL was conceived as a better method for sorting and handling data but has proven to be a excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. It uses an imprecise but very descriptive language to deal with input data more like a human operator. It is very robust and forgiving of operator and data input and often works when first implemented with little or no tuning.

Conclusion

The main motive of this paper is to improve the efficiency and productivity through a robust system which can overcome the shortcomings of the manual process. Looking at the current scenario an approach to automatically grade the disease on plant leaves is very much essential. As discussed in the earlier sections Grading System built by Machine Vision and Fuzzy Logic is very useful for grading the disease or to measure the severity of disease. The disadvantages faced through the manual grading would be overcome once this system is adopted and will help the pathologists in terms of complexity and time. Through research and experiments it has been observed that the results found are precise, accurate and acceptable. Also it is observed that the bigger the bacterial blight spots, higher grade is obtained

Acknowledgment

We thank the Director of Research, Mahatma Phule Krishi Vidyapeeth Rahuri, Ahmednagar district, Maharashtra India for providing his support and giving directions to the proposed work.

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