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Grading of Soybean Leaf Disease Based on Segmented Image Using K-means Clustering

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ABSTRACT

Traditional method used for disease scoring scale to grade the plant diseases is mainly based on neckaed eye observation by agriculture expert or plant pathlogiest. In this method percentage scale was exclusively used to define different disease severities in an illustrated series of disease assessment keys for field crops.The assessment of plant leaf diseases using this aaproach which may be subjective, time consuming and cost effective.Also aacurate grading of leaf diseases is essential to the determination of pest control measures. In order to improve this process, here we propose a technique for automatically quantifying the damaged leaf area using k means clustering, which uses square Euclidian distances method for partition of leaf image.For grading of soybean leaf disese which appear on leaves based on segmented diseased region are done automatically by estiamting thae ratio of the unit pixel expressed under diseased region area and unit pixel expressed under Leaf region area.For experiment purpose samples of Bacterial Leaf Blight Septoria Brown spot, Bean Pod Mottle Virus infected soybean leaf images were taken for analysis.Finally estiamated diseased severity and its grading is compared with manual scoring based on conventional illustrated key diagram was conducted. Comparative assessment results showed a good agreement between the numbers of percentage scale grading obtained by manual scoring and by image analysis The result shows that the proposed method is precise and reliable than visual evaluation performed by patahlogiest.

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1. INTRODUCTION

Soybean Leaf diseases like Bacterial Leaf Blight, Septoria Brown Spot, and Bean Leaf pod Mottlle are cause significant reduction in yield loss and lead to affect quality of soybean Products [1], thus influence economy and farmers life. An effective way to control soybean foliar diseases is by applying fungicides.To test the method for disease assessment, black and white drawings from a manual of disease assessment keys showing foliar diseases with different disease severities [2].Although there is an industrial recognized corresponding standard to grade the leaf spot disease [4-7], the naked eye observation method is mainly adopted in the production practice.Because of 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 extent precisely. Although grid paper method can be used to improve the accuracy, it is seldom used in practice due to cumbersome operation process and time-consuming. Therefore looking for a fast and accurate method to measure plant disease severity is of great realistic significance. Since the late 1970s, computer image processing technology is applied in the agricultural engineering research, such as agricultural products quality inspection and classification, the crop growth state monitoring, plant disease and insect pest's identification, and other agricultural robot [8, 9]. With the recent development in the field of image processing and pattern recognition techniques, it is possible to develop an automation system for disease asseesment of plant leaf based on the visual symptoms on leaf image.

The plant disease scoring is important procedure to develop diagnostic plant and investigate resistant varieties to the disease.Conventionally, plant pathologists score the disease level based on their own discretion using illustrated diagram key for particular disease.The various researchers investigated their methods for assessment key of disease severities for different plant diseases which are outlined as follows:

W. CIive James[3] developed method for series of assessment keys for plant diseases in which percentage scale was exclusively used to define different disease severities in an illustrated series of disease assessment keys for cereal,forage, and field crops. The standard area diagrams were accurately
prepared with an electronic scanner. Procedures for assessing the different diseases are outlined in order to achieve some degree of standardization in disease assessment methods.Paul Vincelli and Donald E. Hershman [4] developed a diagram key for classifying the severity of soybean leaf disease into 10 levels. In his work he had investigated procedure for rating disease in Corn, Soybean, and Wheat.Shen Weizheng and Wu Yachun [5] developed method for segmentation methods to analyse spot disese of soybean in which thresholding is done by Otsu method and disease spot regions were segmented by using Sobel operator to examine disease spot edges. Finally plant diseases are graded by calculating the quotient of disease spot and leaf areas.

Sanjay patil and Dr.Bodhe [6] developed Histogram based triangular segmentation methods to analysis Brown spot disease on sugarcane plant leaf symptoms was shown on it. Thus Sugarcane Leaf, disease svevrity are assessd by calculating the quotient of lesion area and leaf areas. Evy Kamilah Ratnasari & others [7] developed model for segmentation methods in which thresholding a* component of color independent L*a*b color space to analysis Brown spot disease on sugarcane plant leaf symptoms was shown on it. Kittipong Powbunthorn & others [8] developed segmentation methods for assessment of brown leaf spot Disease in Cassava in which thresholding is done by Otsu method and disease spot regions were segmented by analysis of the histogram based on HSI color space. Thus the plant diseases are assessed by calculating the quotient of disease spot and leaf areas. Jayme Garcia and Arnal Barbedo [9] developed model for segmentation methods in which thresholding based on ROI in CMYK-XYZ color space to analysis whiteflies symptoms disease on soybean leaves was shown on it.The objectives of this work is to develop an image analysis technique for estimating the severity level [11]of soybean disease based on diseased area as well as to compare the results with manual scoring using kentucky [10]diagram key.

2. CLASSIFICATION PRINCIPLE

The severity extent of the plant leaves diseases is commonly measured by the ratio of disease area and leaf area ratio. Adopting image processing method to measure can be expressed as the following formula. [3]

$$\mathbf{DS} = \frac{A_d}{A_l} = \frac{P\sum_{(x,y)\in R_d} 1}{P\sum_{(x,y)\in R_l} 1} = \frac{\sum_{(x,y)\in R_d} 1}{\sum_{(x,y)\in R_l} 1} \qquad \text{----------------} \ \mathbf{(1)}$$

A_d——Disease Region Area;
A_l——Leaf Region Area;
P——Unit Pixel Expressed Area;
R_d——Disease Region;
R_l——Leaf Region.

Unit pixel in the same digital image represente the same size, so ratio DS can be obtained by segmenting. Diseased region from leaf Region and Calculating pixel number $\sum_{(x,y)\in R_d} 1$ of diseased region and $\sum_{(x,y)\in R_l} 1$ of leaf region in the clusture image. Then according to disease classification standard consult table the final severity level can be achieved.

3. SEVERITY ASSESSMENTS BY AREA DIAGRAM KEY

Assessing the severity of soybean foliar diseases by using an area diagram key [4] [10] was categorized percentages of inflection of ten levels as show in Figure. 1. Each leaf image samples was visually assessed independently & then with image analysis methods upon to the discretion of the individual raters [11] were taken in to account for method validitation.

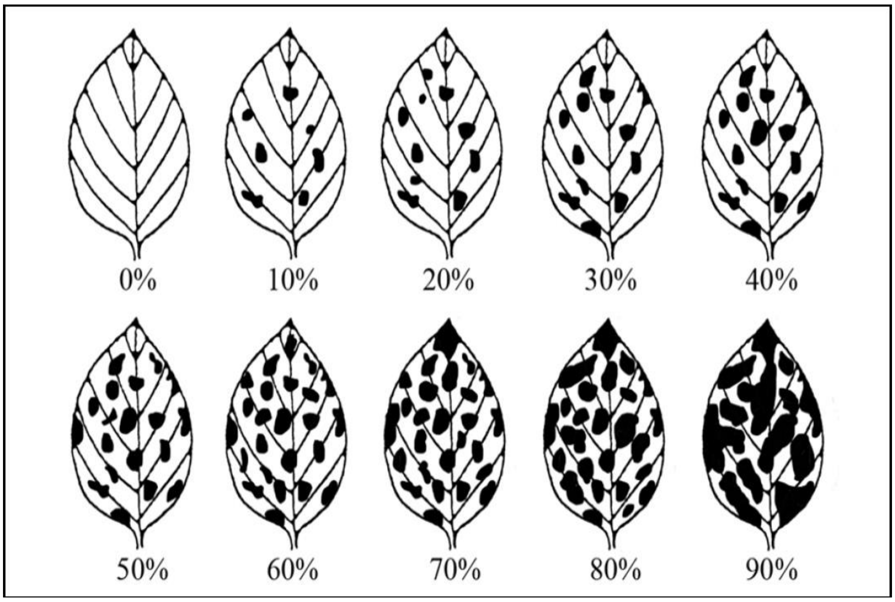


Figure 1. Diagram key for assessment of Foliear diseases of Soybean (Based on A figure in KENTUCKY Integrated Crop Manual for Soybeans IMP-3.2009.PG.3)

4. SEVERITY ASSESSMENT BY IMAGE ANALYSIS

4.1. IMAGE SEGMENTATION

Segmentation is the classifications of an image into meaningful data for easy analysis of the image. The existing methods for segmentation are thresholding, region growing and clustering. Thresholding is the simplest method of image processing. From an RGB image converted to the corresponding gray level intensity image [17], image can be partitioned by binary values, 1 and 0. The region above the threshold may be assigned 1 and that of below the threshold may be assigned zero. This histogram approach cannot be relayed upon for effective classification of the image information as the binary approach of classification limits the representation of image segments and further reduces proper detection[14][16][18] of the required area. Considering this limaitation k-means clustering method for leaf image segmentation is used in this paper.

4.2. PROPOSED CLUSTURING METHOD :

Segmentation approaches based on clustering has many advantages over other approaches as it provides an efficient classification of image information and can be implemented in many fields of humaninterest such as aviation, military and medical fields.The implementation of segmentation on agriculture has aroused the interest of many scholars for it paves an easy to implement and effective method for detecting various pathogens and it is harmless due to low consumption of artificial pesticides and herbicides

K-means clustering is used to partition the leaf image into four clusters in which one or more clusters contain the disease in case when the leaf is infected by more than one disease. K means clustering algorithm was developed by J.MacQueen (1967) and then by J. A. Hartigan and M. A. Wong [14]. The k-means clustering algorithms tries to classify objects (pixels in our case) based on a set of features into K number of classes. The classification is done by minimizing the sum of squares of distances between the objects and the corresponding cluster or class centroid. In our experiments, the K-means clustering is set to use squared Euclidean distances.

4.2.1. Description of Algorithm

The algorithm is very similar to Forgy's algorithm [19]. Besides the data, input to the algorithm consists of k, the number of clusters to be developed. Forgy's algorithm is iterative, but k-means algorithm makes only two passes through the data set.

1. Begin with k cluster centres, each consisting of one of the first k samples. For each of the remaining n-k samples, find the centroid nearest it. Put the sample in the cluster identified with this nearest centroid. After each sample is assigned, recompute the centroid of the altered cluster.
2. Go through the data a second time. For each sample, find the centroid nearest it. Put the sample in the cluster identified with this nearest centroid. (During this step, do not recompute any centroid) Addition of certain features in the existing k means algorithm improves the detection of the interested region effectively with minimum chance of faulty clustering. The first step in k-means clustering is the initialisation of cluster centres. Common methods for initialisation include randomly chosen starts or using hierarchical clustering to obtain k initial centres [19]-[20].

The initialisation steps can be explained as follows.

1. Convert n×p image matrix X to n× (p -1) matrix Z, where each row Zi of Z is the polar representation of the corresponding row ($X_i \in S^p$) of X.
2. For each column Z, find the pair of neighbouring points with the largest angular distance between them and rotate Z such that these neighbours have the largest linear distance between them.
3. One dimensional matrix for k-means is initialized with greatest value integer obtained from (K (p -2)$^{1/(p-2)}$ equi-spaced quantities.

4.2.1. Applying masking to K-means algorithm.

For a given k and initial cluster centres { k; k=1…k}, the general strategy is to position the datasets into k clusters, then to iterate the cluster mean directions until convergence [20]. The exact algorithm can be explainedas follows.

1. Given "k" initialising cluster mean directions 1, 2, … k, find the two closest mean directions for every Observation Xi; i= 1, 2…n.
2. Classify the groups by C1i and C2i respectively. Assign the update equation

$$V\,k- = (nk-1)^2 - nk^2\,\|Xk\|^2\text{-1 and} \quad \text{-------------------------} \quad (1)$$

$$V\,k+ = (nk+1)^2 - nk^2\,\|Xk\|^2\text{-1 (2)} \quad \text{-------------------------} \quad (2)$$

All clusters are in the live image set at this stage.

3. The live set is updated to find optimum convergence
4. Optimum transfer stage: For each Xi, i= 1,2…n, we calculate the maximum reduction in the objective function. By replacing the live function !i with another class, maximum reduction can be obtained as

$$W_i = (n_{ki}+1)\left(V_k^{+} - 2n_{ki}X_k^{-1}X_i\right) - (n_{\varsigma i}-1)\left(V_{\varsigma i}^{-} + 2n_{\varsigma i}X_{\varsigma i}^{-1}X_i\right) \qquad (3)$$

If Wi > 0, then the only quantity to be updated is C2i = Ki .

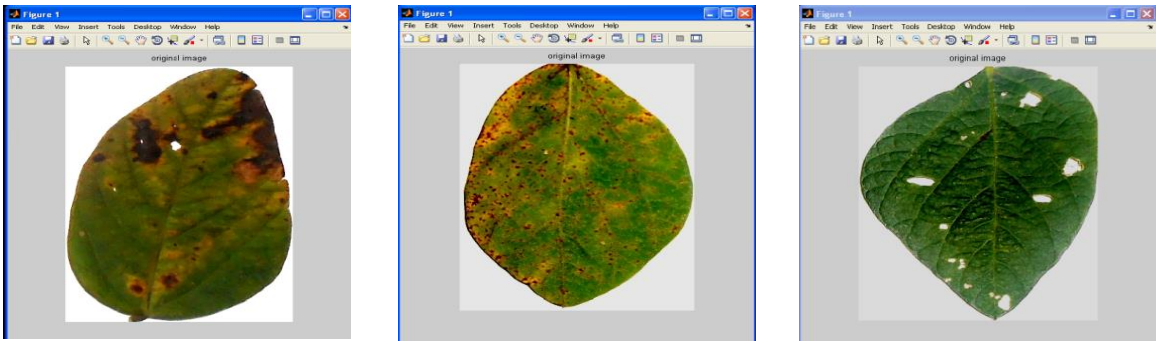
5. Quick transfer stage includes swapping and the objective function and the change in the objective function can be calculated as

$$Obj_k = \sum_{k=1}^{k} n_k \left(1 - \|X_k\|\right) \qquad (4)$$

It is providing a quick way of obtaining final value.

The exact extraction of the lession areas of the soybean leaf can be detected by masking the clustered sample containing the plant region and then subtracting it from the acquired image. The modified algorithm developed using k-means clustering can be discussed with the experimental results obtained from a, Bacterial Blight, Septoria Brown Spot, and Bean pod Mottle infected diseased leaf resepectively.

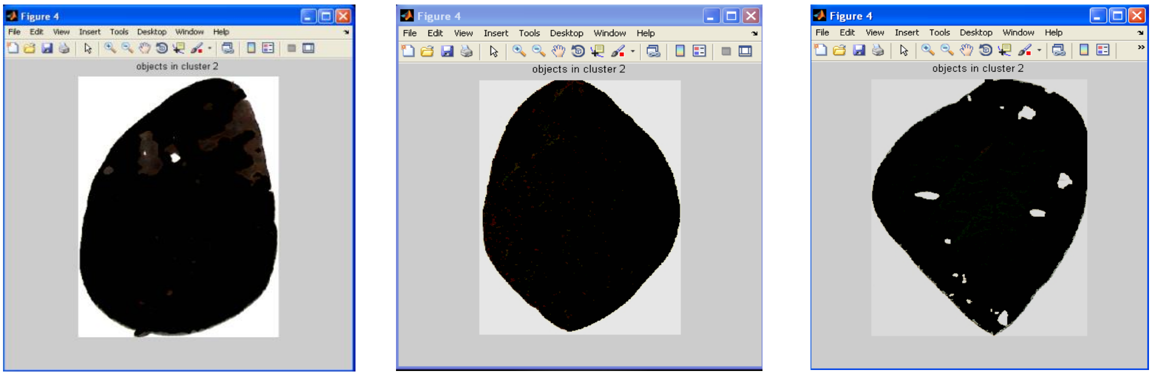
5. EXPERIMENTAL PROCEDURE
5.1. Image Acquisition
This study takes Bacterial Leaf Blight, Septoria Brown spot, Bean Pod Mottle Virus infected soybean leaf images of soybean as example for illustrating the plant disease extentgrading method [14]. Infected leaves are placed flat on a white background. The optical axis of digital camera is perpendicular to the leaf plane to shoot images, which are deposited in the computer for future use. Figure 2(a-c) shows acquired image of soybean leaf diseses.



(a) (b) ©

Figure 2. Acquired Image of soybean (a) Bacterial Leaf Blight. (b) Septoria Brown spot. (c) Bean pod mottle.

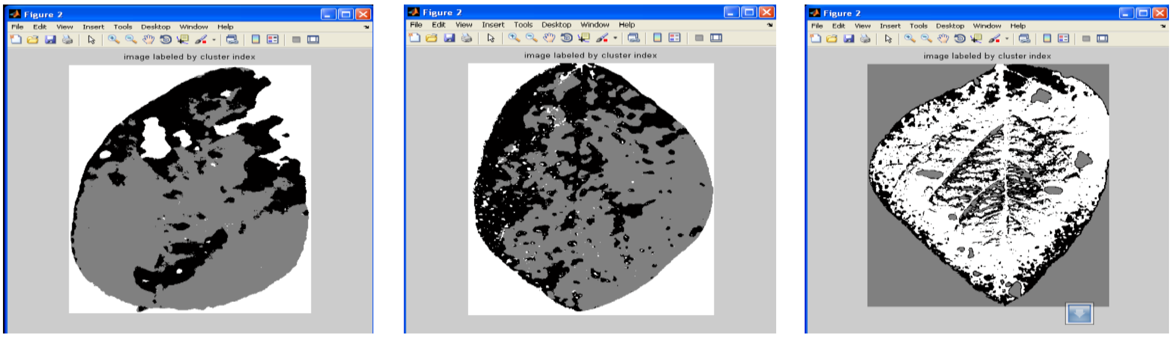
5.2. Segmentation To Extract Diseased Objects In The Cluster
After acquiring the image, clustering is done to separate the background and the foreground image.This is done by updating the live set with cluster groups of lower intensities as a group. In this step it is checked whether the Cni group satisfies Wi > n. The foreground image is thus mapped with a zero level intensity to perform further logical operations on the cluster group. Figure 3(d-f) shows Segmentation to extract the region of interest (ROI).



(d) (e) (f)

Figure 3. Segmentation to extract the region of interest (ROI) for Bacterial Leaf Blight (d), Septoria Brown spot (e), and Bean leaf pod mottle (f).

5.3. Clustering Based On Intensity Mapping
The acquired image is then separated to cluster groups based on k-means clustering. Then gray level mapping is performed to separate the image to intensity fields which helps in separation of the leaf image from the obtained image. The leaf image area to be highlighted is labelled in with the cluster index as shown in figure 4(g-i) for Bacterial Leaf Blight. (g) Septoria Brown spot. (h) and Bean pod mottle (i).

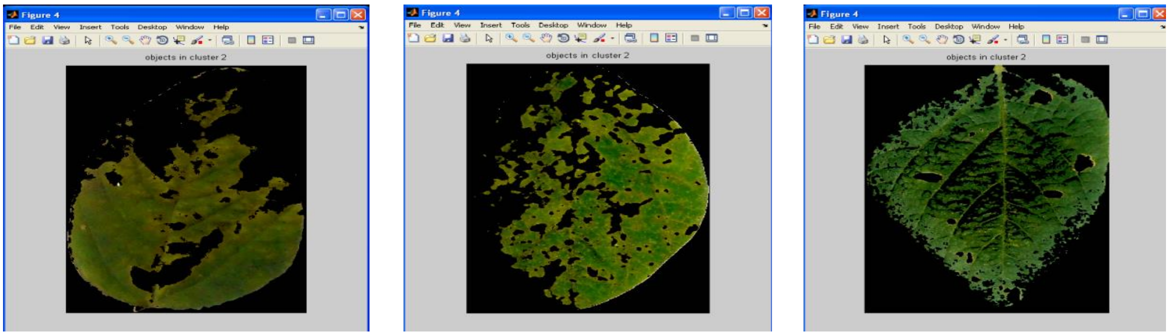


(g) (h) (i)

Figure 4. Separation of image into gray level clusters to obtain useful leaf area for Bacterial Leaf Blight. (g) Septoria Brown spot. (h) and Bean pod mottle (i).

5.4. Highlighting The Leaf Area

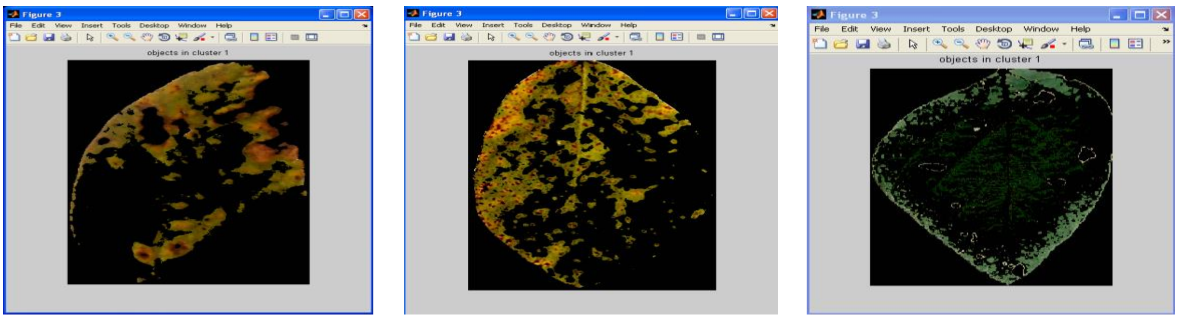
The pixel groups belonging to the intensity marked area alone are extracted and is shown in the image below to obtain the highlighted leaf area alone from the acquired image. The extracted leaf image is further corrected by masking with an image matrix of similar intensity pixels. It provides a better clarity for the obtained image and aids the separation of image using distinguishable features of the leaf image. An example of the output of K Means clustering for a leaf infected with Bacterial Leaf Blight (k), Septoria Brown spot (l), and Bean leaf pod mottle(m) disease is shown in figure 5(k-m).



(k) (l) (m)

Figure 5. Extracting the leaf area for Bacterial Leaf Blight (k), Septoria Brown spot (l), and Bean leaf pod mottle (m) (reference image**)**

5.5. Subtracting The Clustered Leaf Image From The Base Image.



(n) (o) (p)

Figure 6. The Final Clustered Area Containing The Infected Area For Bacterial Leaf Blight (d), Septoria Brown Spot (e),and Bean Leaf Pod Mottle.

The final clustering is done by subtracting the reference image from the base image formed from convoluting the cluster obtained from fig 4 with the acquired image. The advantage of this algorithm is that it gives high precision with low operating time. The final clustered image showing the Bacterial Leaf Blight (n), Septoria Brown spot (o), and Bean leaf pod mottle (p) in figure 6(n-p).

The overall flow of the program can be summarized with the following steps.
Step1: Acquiring the image.
Step2: Storing the ROI as the base image to be clustered for further operations.
Step3: Cluster to extract useful leaf area from the ROI
Step 4: Storing the leaf image obtained after applying the cluster field and using it as reference image.
Step 5: Subtracting the reference image from the base image.

6. RESULT and CONCLUSION

A suitable gray level clusters used to obtain useful leaf area. From the figure it can be seen that the leaf region can be well detected and after subtracting the clustered leaf image from the base image disease region can be well detected. It can be seen from the figure that although some veins can be detected, they can be dealt as noise since they are scattered and their unit area is small compared to the lesion case. To select the appropriate circular structure elements to unseal to obtain the final clustered area containing the infected area image of lesion. After final clusturing the number of pixels $\underset{(x,y)\epsilon R_d}{P\sum 1}$ in the desease region is **33430** and the number of pixels $\underset{(x,y)\epsilon R_l}{P\sum 1}$ in the leaf region is **144704** for (Bacterial Leaf Blight). Thus it can be calculated that the ratio **DS** of the diseased and leaf area is **0.231** and its severity is **23.10%**. and **disease scale rating is 5** According to the grade table, as the following table 1, of the soybean leaf disease provided by the literature [4][5][6], the disesed severity is lies between **10.1 – 25% and hence disease scale rating (Grade) is 5** after programming to check up the table.

Subsequently, ten images–of area diagram key for assessment of bacterial leaf blight, Septoria brown leaf spot and Baean lef pod mottle mosaic virus were tested and calculated **DS** value by image analysis. Analysis of the area diagram key was analyzed by images processing number of pixel lies in disesed area and leaf region area but percentage of infect considerably approxiamte especially levels of 1–7 (Table 1). The image analyses were used further classification of the severity levels.

Table 1. Soybean Leaf Disease Severity Scale Rating [4]

Disease Scale Rating	Disease Severity	Description
0	--	No lesions/spots
1	1%	leaf area covered with lesions/spots
3	1.1 - 10%	leaf area covered with lesions/spots, no spots on stem
5	10.1 – 25%	leaf area covered with lesions/spots, no defoliation; little damage
7	25.1 – 50%	leaf area covered with lesions/spots; some leaves drop; death of few plants; damage conspicuous
9	50% of Above	More than 50% area covered, lesions/spots very common on all parts, defoliation common; death of plants common; damage more than 50%.

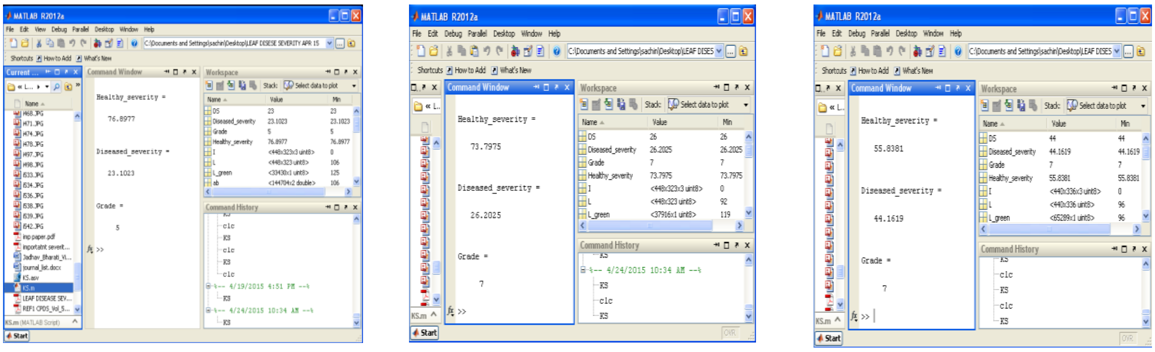
6.1. Severity Estimation

Disease severity is the lesion area of the leaves showing symptoms of spot disease and it is most often expressed as a percentage [6]. The disease severity of the soybean leaves is measured by comparing the number of infected pixel lesion area with the total pixels of leaf area from the segmented image [7][12][13]. The lesion percentage of leaf is computed using equation (5).

$$DS = \frac{A_d}{A_l} = \frac{\underset{(x,y)\epsilon R_d}{P\sum 1}}{\underset{(x,y)\epsilon R_l}{P\sum 1}} = \frac{\underset{(x,y)\epsilon R_d}{\sum 1}}{\underset{(x,y)\epsilon R_l}{\sum 1}} \quad \text{----------------} \ (5)$$

Hence; $DS = \frac{A_d}{A_l} \times 100$

Where, *DS* is lesion of disease severity A_d is total pixel in diseased area of segmented lesion, and A_l is total pixel of leaf area. Figure 7 (q-s) shows estimated soyben disease severities with its scale rating for Bacterial Leaf Blight **(DS=23.10% & Grade= 5).** (g) Septoria Brown spot **(DS=26.20% & Grade= 7)**. (h) and Bean leaf pod mottle **(DS=44.16% & Grade= 7)** (i).



(q) (r) (s)

Figure7. Estiamted diseased severity and its scale rating for: Bacterial Leaf Blight (q), Septoria Brown Spot (r) and Bean leaf pod mottle(s).

CONCLUSION

A digital image analysis technique proposed in this work is developed to measure percentage of severity for, bacterial leaf blight Septeroial brown leaf spot, and bean leaf pod mottle, soybean diseases resepectively. In the severity estimation, wider lesion results in higher severity estimation. The new technique has resulted high accuracy in identifying soybean leaf disease scoring grade with severity estimations for bacterial leaf blight **(DS=23.10% & Grade= 5),** Septeroial brown leaf spot **(DS=26.20% & Grade= 7)** and bean leaf pod mottle **(DS=44.16% & Grade= 7)** .Manual technique reffered to measure the percentage of disease severity of area diagram key found that values approxiamate corresponds to estimated classified criteria value. Comparative assessment results showed a good agreement between the numbers of percentage scale grading obtained by manual scoring and by image analysis .Compared to thresholding technique clustering k means proves simple and effective in determining the infected area with reduced requirement of manual cluster selection.The usage of proposed image processing technique for plant disease degree grading will help to eliminates the subjectivity of traditional classification methods and human-induced errors. Hence this approach will be efficient for estimation of disease severity and cause to provide accurate data for disease pesticide control application. An algorithm for updating the clusters through iteration could further improve the obtained results.

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