Measurement of Disease Severity of Rice Crop Using Machine Learning and Computational Intelligence

Prabira Kumar Sethy, Baishalee Negi, Nalini Kanta Barpanda, Santi Kumari Behera and Amiya Kumar Rath

Abstract This study was conducted to develop a prototype which computes the severity of diseases appears in the rice crop using machine learning and computational intelligence. The symptoms of rice crop diseases imply the seriousness of the disease and suggest choosing the best approach to dealing with the disease. Most of the diseases in rice crop appear as a spot on the leaves. It is also needful to diagnose the disease properly and on-time to avoid the great harm of the rice crop. The treatment of rice crop diseases by applying disproportionate pesticides increases the cost and environmental pollution. So the use of pesticides must be minimized. This can be actualizing by targeting the diseased area, with the appropriate quantity and concentration of pesticide by estimating disease severity. This paper introduces Fuzzy Logic with K-Means segmentation technique to compute the degree of disease severity of leaves in rice crop. The proposed method estimated to give up to about 86.35% of accuracy.

Keywords Disease grading · K-means clustering · Fuzzy logic
Percentage of infection · SVM

1 Introduction

Agriculture has become a main source of life to feed ever growing population. So, plants are playing a key role in our society and a fundamental piece of the puzzle to solve each and every issue. There are many diseases that hamper the growth and productivity plants which lead to great ecological and economical losses. For this reason, it is better to diagnose diseases accurately and measure the severity of the disease to avoid such losses timely. The detection of plant disease can be done in many ways including manual and computer based systems. Manual measurements are visually made by plant pathologists. So, they must be used their experience to carefully manner. Such kind of process can be costly, lengthy and tiresome and can also leads to errors due to fatigue. So, new techniques are like image processing, computer visions are used to get more accurate with consuming less time and at an

S. Gurumoorthy et al., *Cognitive Science and Artificial Intelligence*,
SpringerBriefs in Forensic and Medical Bioinformatics,
https://doi.org/10.1007/978-981-10-6698-6_1

affordable cost [1]. In this paper, introduce an approach to measure the severity of disease by the automatically grading system. For automatic grading purpose, Fuzzy Logic is implemented [2]. In the field of disease management, grade of the disease is determined to provide a precision and accurate treatment advisory. The results are getting from the automatically grading system using Fuzzy Logic which proved to be accurate and satisfactory in contrast with manual grading. K-means based color image segmentation technique is used for segmentation and from that segmented image features will be extracted as well as infected area and disease grade will be evaluated. SVM is used as a classifier in this paper to identify the risk of that disease.

2 Literature Review

The disease appear on leaves can be measured by use of several quantification methods.

i. Sannakki et al. [2] proposed a technique to measure disease based on Fuzzy logic. They demonstrate by use of pomegranate leaves. At first they convert the samples image to L*a*b* color space. Then by application of K-Means clustering pixel are grouped in certain classes. They also suggest a disease grading system based on Fuzzy Logic.
ii. Rahul S. Phadatare and Sanjay S. Pawar [3] proposed a technique to determine as well as quantifying the leaf disease based on image processing, ANN and Fuzzy logic. Here ANN and Fuzzy logic are used for classification and Grading purposes respectively.
iii. Huang et al. [4], apply Canopy Spectral Data Analysis for measuring disease severity. They use ASD field spec pro spectrometer fitted with 25° field for spectral measurement. The disease index is calculated using Eq. (1) given below,

$$DI(\%) = \frac{\sum(x * f)}{n * \sum f} * 100 \tag{1}$$

where ‘f’ is the total number of leaves of each degree of disease severity, ‘x’ is incidence level and ‘n’ is the light incidence level.

iv. Rashedul Islam and Md. Rafiqul Islam [5], they proposed a method to measure the severity of disease found on paddy leaf. First, the input leaf image is segmented using K-Means segmentation, then the cluster contains healthy and diseased portion will be converted to a binary image. From that binary image, white pixel contains by the both cluster has been calculated because that white

pixel will help to calculate a number of pixels affected by the leaf disease. The percentage of the infected pixel can be calculated by Eq. (2).

$$P_A(\%) = \frac{wp_a}{P_l} * 100 \tag{2}$$

$$\text{where } P_l = wp_a + wp_u$$

v. Powbunthorn et al. [6] experimented on brown spot leaf disease in cassava crop. As per their method the RGB of sample image is transformed to HIS color space, then the infected pixels are extracted by differentiating the Hue. The disease severity is calculate using Eq. (3).

$$PI = \frac{A_d}{A_t} * 100 \tag{3}$$

where A_d = Area affected by disease, A_d = Total Area

vi. Bharambe et al. [7], proposed a method to measure the severity of leaf disease of ground nut. Here they apply Geometric moment to calculate degree og disease severity.

vii. C. H. Bock, G. H. Poole [8], use imaging spectroscopy to determine the disease severity. A large amount of data order of hundreds Mb per image is pre-processed and data is proceeded to take many forms as per its similarity. The popular classification technique is supervised classification which is based on statistical similarity.

viii. Sanjay B. Patil et al. [9], used Triangle method of the thresholding to measure the severity of brown spot leaf disease found in sugar cane crop. The severity of the diseased plant leaves is measured by the leaf area and lesion area ratio. The disease severity can be expressed in below Eq. (4).

$$S = \frac{A_d}{A_l} \tag{4}$$

where A_d = Diseased Leaf Area, A_l = Total Leaf Area

ix. Jayme Garcia Arnal Barbedo [10], presented a method to detect and measure the severity of leaf disease using digital image processing. The proposed image analysis method is based on widely used morphological mathematical operations. Also by the use of the 'a' channel of the L*a*b* color representation, which made it possible to derive general rules that hold true even when the leaves and symptoms have different shade and hue characteristics. They suggest that their method is simple to implement and is not computationally complex.

x. P. Saranya et al. [11], presented a method to measure the severity of fungi caused disease in leaf using image processing technique. Triangle thresholding and Simple threshold methods are used to segment the leaf area and disease region area correspondingly. They suggest that image processing tools to measure plant disease severity are suitable and correct because this eliminates the subjectivity of usual methods and person induced errors. The disease severity extent can be expressed in Eq. (5).

$$\mathrm{DSE} = \mathrm{LA}/\mathrm{AL} \tag{5}$$

where DSE = Disease Severity Extent, LA = Lesion Area, AL = Total Leaf Area

3 Proposed Methodology

This paper presents an efficient approach of fuzzy logic and SVM to quantify the disease severity accurately. The flow graph of this system is represented in Fig. 1.

The step below explained the proposed disease grading and risk recognition system:

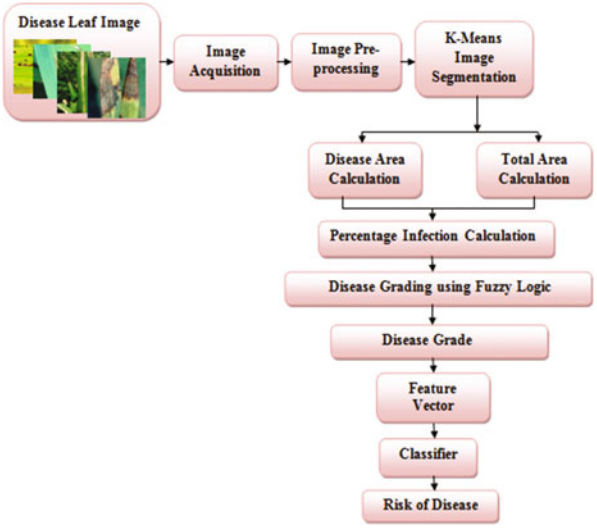

Fig. 1 Proposed disease grading and risk recognition system

(1) Image Acquisition considers as the first step for the proposed methodology. First, take the input leaf image of the rice crop has captured by the camera. The input image is in RGB (Red, Green, and Blue) form. Then, the RGB leaf image is converted into suitable color space as per the requirements.
(2) In Preprocessing phase, the query image converted to suitable color space i.e. L*a*b color space on which the algorithm can be worked. The required information from the image extracted more efficiently by image resizing and contrast enhancement.
(3) This step includes the segmentation of an image using K-Means algorithm. It is quite a helpful method for detection of the object which is based on a set of features into K number of classes [12]. By minimizing the sum of the squares of the distance between the corresponding cluster and the object it can able to detect the interesting part of the input image. In K-Means clustering techniques, the clusters are determined by the grouping of pixels having the same value present in an image. Practically, the computational speed of this new image processing technique is very fast as well as gives more accurate output. The input dataset is partitioned into K number of clusters and each cluster is considered by a cluster center which is adaptive by nature. Initially considered values are known as seed-points and inputs are also known as data points. Estimation of the distances between the centers, inputs, and allocate inputs to the nearest center is only possible by using K-Means clustering technique.
(4) After the successful execution of K-Means algorithm, we can calculate the total leaf area (A_t) as well as diseased area (A_d) of the leaf; the percentage of infection (P) is calculated by the following equation.

$$P = \frac{A_d}{A_t} * 100 \tag{6}$$

(5) Fuzzy logic builds on and start with set of user supplied human language rules. Later the user supplied rules are converted into mathematical equivalents. So as a user input, percentage of infection has given to the design Fuzzy system. Again the Fuzzy system consists of three parts i.e. Fuzzier, Inference System and Defuzzifier. In Fuzzifier the user input or percentage of infection is converted to a set of fuzzy input values which consist of some membership function and this fuzzy input values are provided to Inference System. In Inference System, rules are designed according to the user need and also decision has been taken here. Then finally the decision is provided to Defuzzifier, where Defuzzifier is converted the set of fuzzy output values into a single user output value i.e. disease grade.

Fuzzy system is used here because of its flexible nature and conceptually easy to understand.

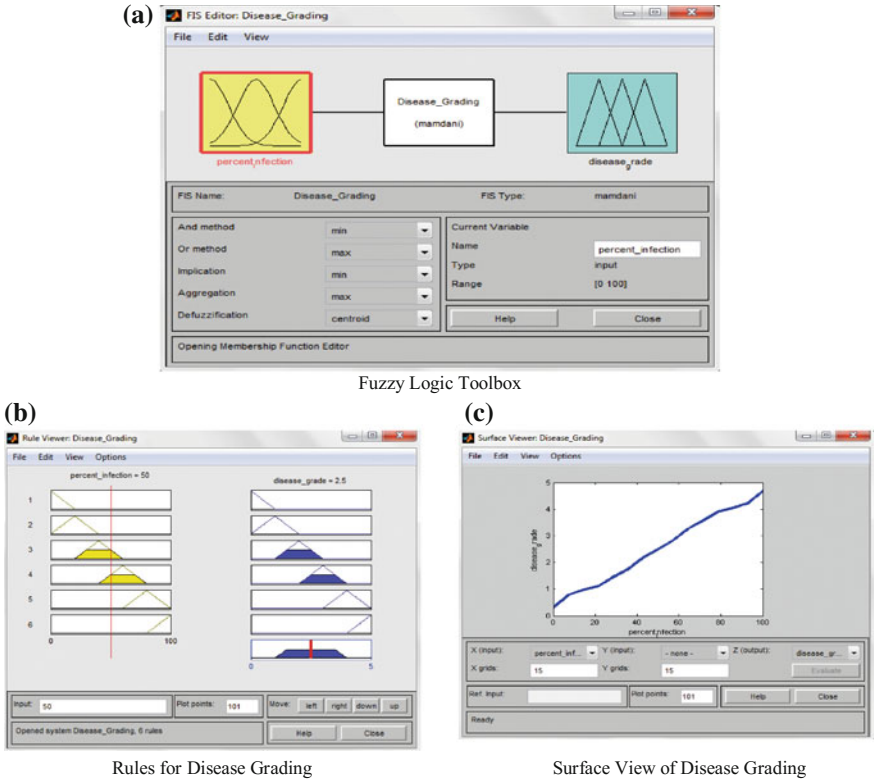

Fig. 2 Fuzzy logic toolbox for disease grading

From the research paper [13], it conclude that in precision agriculture, the fuzzy logic permeate in several application of agriculture sector such as texture analyser, grading system and herbicide sprayer. Here we use fuzzy logic for grading of leaf disease in rice crop which shown in Fig. 2.

(6) Feature extraction plays a vital role in image classification. It allows representing the content of the image as perfect as possible. In feature extraction phase, GLCM (Gray Level Co-occurrences Matrix) is used to extract features from the segmented image [14].

(7) Support Vector Machine is used in this paper to identify the risk of disease. SVM is a machine learning technique which is basically used for classification. It is a kernel based classifier; initially, it was developed for linear separation which has able to classify data into two classes only, now it can be used as multi-class SVM. SVM has been used for different realistic problems [15]. The extracted features, the percentage of infection and disease grade is given as input to the SVM. On the basis of comparison between the training data and testing data, the result of risk will declare.

4 Experimental Results

For experimental purpose different disease infected leaf samples has been taken. After the successful computation of the algorithm in MATLAB software, the percent of affected area and disease grade will be observed by using Fuzzy Logic Toolbox which is illustrated in Table 1.

Grade stage of the disease is decided by using Table 2 [16]. According to their percentage of infection, the risk will be decided.

After the measurement of the percentage of infection and grading of disease using the fuzzy system, stage of grade or risk can be predicted by using SVM. SVM gives the percentage of infection and disease grade, by the features extracted from segmented image as input. The result will be decided on the basis of comparison between the test samples with respect to the train data. The result of input pre-processed image, segmented image and classifier for risk management will present in Figs. 3 and 4.

The accuracy of the proposed methodology for severity measurement of individual disease will be illustrated in Table 3. In our demonstration we have taken 4 number of sample image of four different type of disease that is in a whole 16 number of samples are taken. And the accuracy for brown spots is 85.71%, Bacterial Blight is 86.02%, Leaf Scald is 86.56%, Leaf Blast is 87.12% and the average accuracy is 86.35% (Fig. 5).

Table 1 Percentage of infection and grade of disease result per disease for proposed method

Sl no.	Dimension of sample image	Type of disease	Percent of affected area (%)	Disease grade
1	363 × 319 × 3	Brown spots	15.017	0.964
	354 × 360 × 3		15.0015	0.94
	494 × 563 × 3		16.0016	0.976
	300 × 349 × 3		19.1881	0.998
2	498 × 387 × 3	Bacterial blight	15.0016	0.964
	355 × 256 × 3		21.001	1.07
	640 × 428 × 3		10.9182	0.891
	640 × 428 × 3		16.1408	0.977
3	310 × 199 × 3	Leaf scald	15.001	0.964
	509 × 541 × 3		31.0021	1.54
	937 × 640 × 3		12.0278	0.915
	296 × 239 × 3		18.003	0.993
4	1595 × 1344 × 3	Leaf blast	21.4305	1.1
	491 × 462 × 3		15.7133	0.973
	300 × 324 × 3		7.1156	0.778
	395 × 432 × 3		5.004	0.688

Table 2 Disease scoring scale for leaves

Class	Risk	Percentage of infection (%)
1	Very low risk	Between 1–10
2	Low risk	Between 10–20
3	Medium risk	Between 20–30
4	High risk	Between 30–50
5	Very high risk	Between 50–100

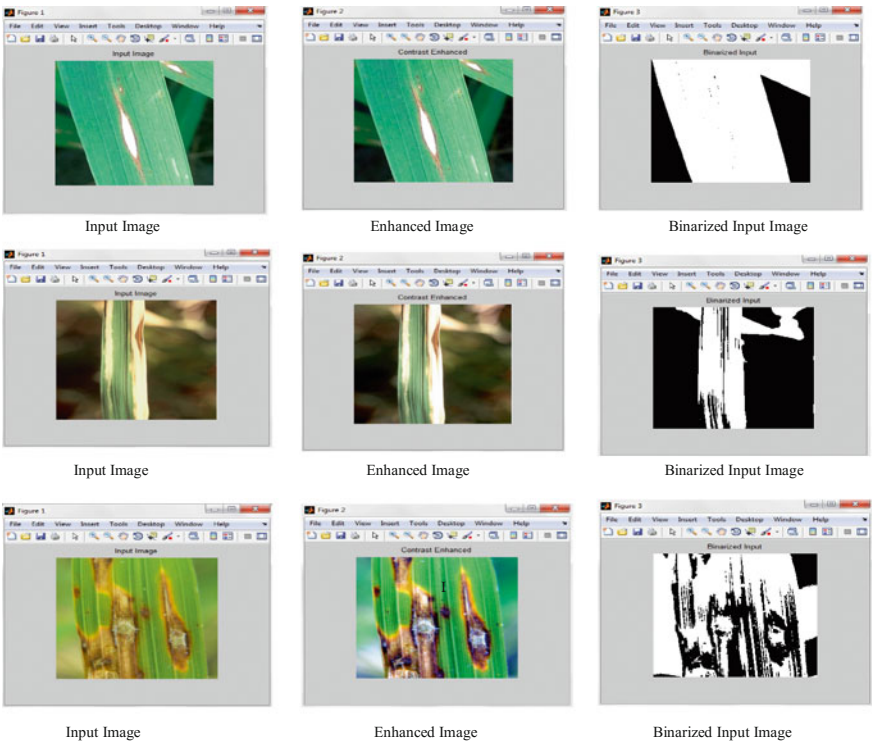

Fig. 3 Disease input and pre-processed images

5 Conclusion and Future Scope

This paper represents a prototype for leaf disease severity measurement and grades the leaf disease using Fuzzy Logic. The proposed grading system comprises of fuzzy logic and machine vision tool for estimating the severity of leaf disease in rice crop and implies 86.35% accuracy. The method is not computationally complex as

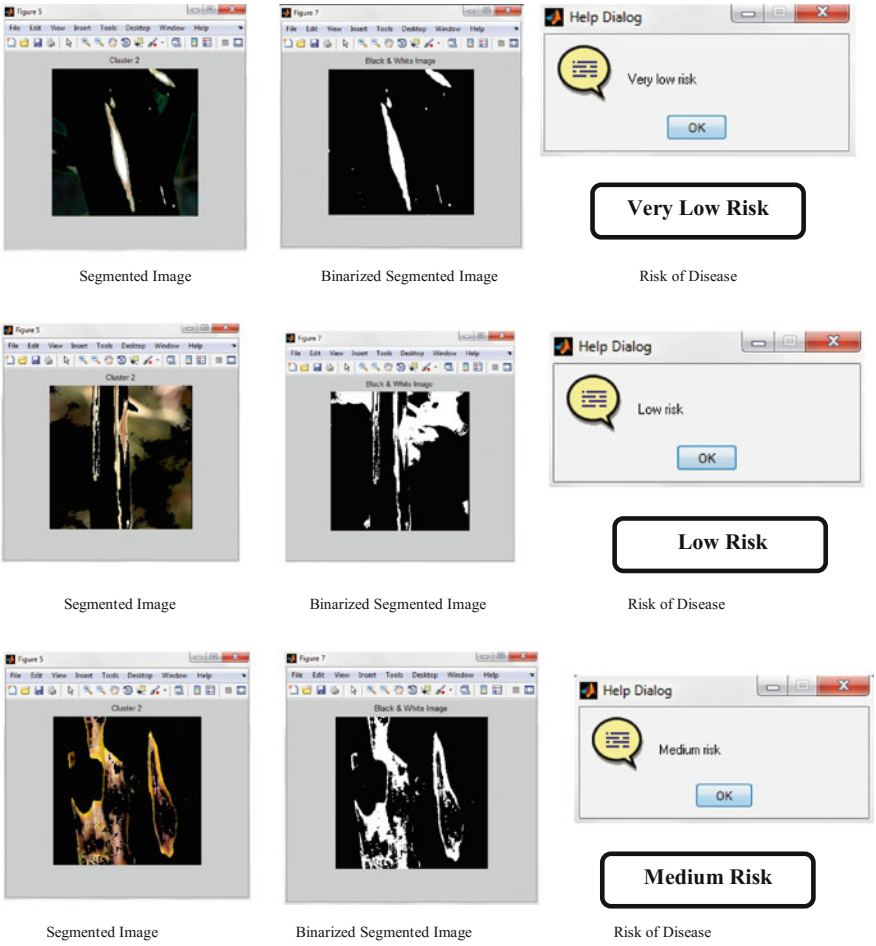

Fig. 4 Segmented and classified image as per disease severity/risk

Table 3 Accuracy result per disease for proposed algorithm

Sl no.	Name of disease	Percentage of accuracy
1	Brown spots	85.71
2	Bacterial blight	86.02
3	Leaf scald	86.56
4	Leaf blast	87.12
Average accuracy		86.35

well as is easy to implement. Also, this system gives a fast and accurate grading of disease severity and predicts the risk of disease into different stage as compared to manual method. The study may be extended by considering more types of disease and with large data set.

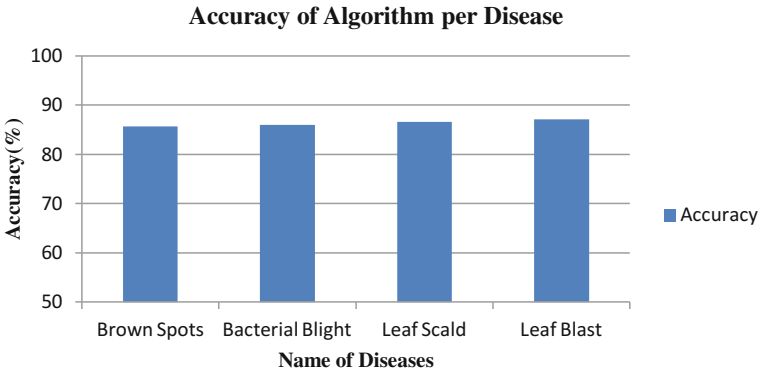

Fig. 5 Accuracy result per disease for proposed algorithm

References

1. Barbedo, Jayme Garcia Arnal (2013). Digital Image Processing Techniques for Detecting, Quantifying and Classifying Plant Diseases, SpringerPlus.
2. Sannakki, Sanjeev S. et al. (2011). Leaf Disease by Machine Vision and Fuzzy Logic. *International Journal of Computer Applications* 2 no. 5: 1709–1716, ISSN: 2229-6093.
3. Phadatare, Rahul S., and Sanjay S. Pawar. (2016). Leaf Disease Detection and Grading using Image Processing. *International Journal for scientific research & Development* 4 no. 9, ISSN: 2321-0613.
4. Huang, Wenjiang, Qingsong, Guan et al. (2014). New Optimized Spectral Indices for Identifying and Monitoring Winter Wheat Diseases. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 7 no. 6.
5. Islam, Rashedul, and Md. Rafiqul, Islam. 2015. An Image Processing Technique to Calculate Percentage of Disease Affected Pixels of Paddy Leaf. *International Journal of Computer Applications* (0975–8887) 123, no. 12.
6. Powbunthorn, Kittipong, Wanrat, Abudullakasim, and Jintana Unartngam. (2012). Assessment of the Severity of Brown Leaf Spot Disease in Cassava using Image Analysis. *The International conference of the Thai Society of Agricultural Engineering*.
7. Bharambe, Chandan J., Vidya N. More, Sumeet S. Nisale. (2011). Detection and Analysis of Deficiencies in Groundnut Plant using Geometric Moments. *World Academy of Science, Engineering and Technology International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering* 5, no. 10.
8. Bock, C.H., and G.H. Poole. (2010). Plant Disease Severity Estimated Visually, by Digital Photography and Image Analysis. *Reviews in Plant Sciences* 29, no. 2: 59–107. https://doi.org/10.1080/07352681003617285.
9. Patil, Sanjay B. et al. 2012. Leaf Disease Severity Measurement using Image Processing. *International Journal of Engineering and Technology* 3 no. 5: 297–301.
10. Barbedo, Jayme Garcia Arnal. 2014. An Automatic Method to Detect and Measure Leaf Disease Symptoms using Digital Image Processing. *APS Journal* 98, no. 12. http://dx.doi.org/10.1094/PDIS-03-14-0290-RE.
11. Saranya, P., S. Karthick, and C. Thulasiyammal. 2014. Image Processing Method to Measure the Severity of Fungi Caused Disease in Leaf. *International Journal of Advance Research* 2, no. 2: 95–100.

12. Sethy, Prabira, Baishalee Negi, and Nilamani Bhoi. 2017. Detection of Healthy & Defected Diseased Leaf of Rice Crop using K-Means Clustering Technique. *International Journal of Computer Applications* 157, no. 1: 0975–8887.
13. Kavdir, Ismail, and Daniel E. Guyer. (2003). Apple Grading Using Fuzzy Logic. *Turkish Journal of Agriculture and Forestry,* 375–382 © T. BÜTAK.
14. Gebejes, A., and R. Huertas. 2013. Texture Characterization based on Grey-Level Co-occurrence Matrix, ICTIC.
15. Byun, Hyeran, and Seong-Whan Lee. 2002. Applications of Support Vector Machines for Pattern Recognition—A Survey. Springer, SVM 2002, LNCS 2388, pp. 213–236.
16. Standard Evaluation System for Rice. 2015. *International Rice Research Institute (IRRI)*, 5th ed.