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ORIGINAL ARTICLE

Potential Disease Severity Assessment Approach for Potato Late Blight with Smartphone-Based Image Capturing

W. M. A. M. Ranasinghe[1*], A. S. A. Salgadoe[1] and C. Ranasinghe[2]

[1]*Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka*

[2]*Agriculture Research Station, Seetha Eliya, Sri Lanka*

Correspondence:

[*]*ranasingheasitha7@gmail.com*

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Abstract

Accurate and timely evaluation of the severity of Potato Late Blight (PLB) is vital in disease control and being confident that fungicides are utilized efficiently. PLB is caused by *Phytophthora infestans* and is one of the most destructive diseases affecting potatoes. Knowledge gap in determining the severity of the PLB using the Late Blight Key (LBK) results in erroneous disease evaluation, unregulated chemical use, and exorbitant management expenses for PLB. The purpose of this research was to build a novel technique based on smartphones to measure the PLB severity in relation to the LBK. Using a smartphone camera, digital images of sick PLB leaves were taken at a consistent height, and simultaneously the related visual disease severity rating score was recorded using the LBK. The MATLAB (R2019b) image processing toolbox was used to process the photos, which included cropping, manually defining the areas of the leaf and lesion, and determining the pixel ratio (the ratio of PLB lesion to leaf pixels). When data from all the images were merged at the conclusion, regression analysis revealed a virtually perfect linear association (R^2=86.6%) between the image-derived pixel ratio and the visual ranking scores of the PLB sickness severity. According to these results, image processing analysis that has been built may precisely identify the leaf areas that are infected with PLB and assess the disease's severity level.

Keywords: *pixel ratio, Phytophthora infestans, potato late blight, RGB image processing, smartphone-based imagery*

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1. Introduction

Potato Late Blight (PLB) caused by *Phytophthora infestans* is a soil-born pathogen that invades the potato plant through roots when soil is moistened and spread to vegetative plant parts via the development of mycelium (Fry et al. 1993; Fry et al. 2008). Once the mycelia infects the leaf tissues, it develops water-soaked gray lesions on the leaf surface and white molds on the underside of the leaves (Zegeye et al. 2011). PLB management requires accurate diagnosis and correct assessment of the disease severity (Kelaniyangoda et al. 2013). This needs special skills such as identification of the symptoms and assessing the severity based on the standard ranking scale, such as late blight key (LBK) which was introduced by the Agricultural Research Station, Seethaeliya. The LBK assesses the PLB severity by visually assessing the lesion size and counting the number of instances in the sampling area ($1m^2$). Farmers possess a lack of knowledge to conduct a severity assessment using the LBK, even though trained, the majority's judgment is highly subjective. Instead of visual judgments, computer-based vision technology through digital images provides a novel quantitative and objective way of assessing severity. According to Mahlein (2016), advanced digital image-based technology may offer greater abilities for disease detection and quantification effectively. Digital images are possible to acquire through Red, Green, and Blue (RGB) sensors, thermal sensors, imaging spectral sensors, and fluorescence imaging sensors which are adapted to record the light reflected from leaves in a grid of pixels producible in digital photograph formats such as JPEG (Petrellis, 2017; Mahlein, 2016). Therefore, the objective of this study was to develop a non-destructive image analysis technique by using a smartphone connected to a cloud platform to precisely measure the disease severity level.

2. Materials and Methods

This study was carried out in the open fields of Agricultural Research Station Seethaeliya ($6^0$55'26.2" N, $80^0$46'18.0" E) during the "*Maha* season" from September to December 2020 for the potato variety of "Granola". Digital red, green, and blue (R, G, B) color images of infected leaves were acquired using a smartphone (OPPO A5s with the model of CPH1909, and 13 Megapixels+ 2 Megapixels Rear camera) pointing parallel 1m above the crop canopy. PLB disease severity was assessed visually according to the LBK (Table 1).

Image Processing and Analysis

Images were normalized to overcome the environmental variations and manually segmented the captured potato leaf area and the lesion area by using an automated computational script as developed by MATLAB (R2019b) toolbox (Plate 1). The mean values of plant pixels associated with the colour images of the targeted leaf and the lesion were obtained by separating the red-green-blue (RGB) channels. The relationship of these images derived measurement with the visually assessed LBD severity was analyzed using regression analysis in MATLAB with the 0.05 threshold significance level.

Table 1: Late Blight Key for plot-level disease severity estimation

Blight (%)	Nature of infection
0.0	No disease was observed.
0.1	A few scattered plants blighted; >1 / 2 spots in a 10m radius.
1.0	Up to 10 spots per plant; or general light infection.
5.0	About 50 spots per plant; up to 1 or 10 leaflets infected.
25	Nearly every leaflet was infected, but the plant retained its normal form.
50	Every plant is affected and about 50% of the leaf area is destroyed.
75	About 75% of the leaf area is destroyed.
95	Only a few leaves on plants, but the stems are green.
100	All leaves dead; stems dead or dying.

Source: Potato Late Blight Key introduced by the "Agriculture Research Station Seethaeliya, Sri Lanka"

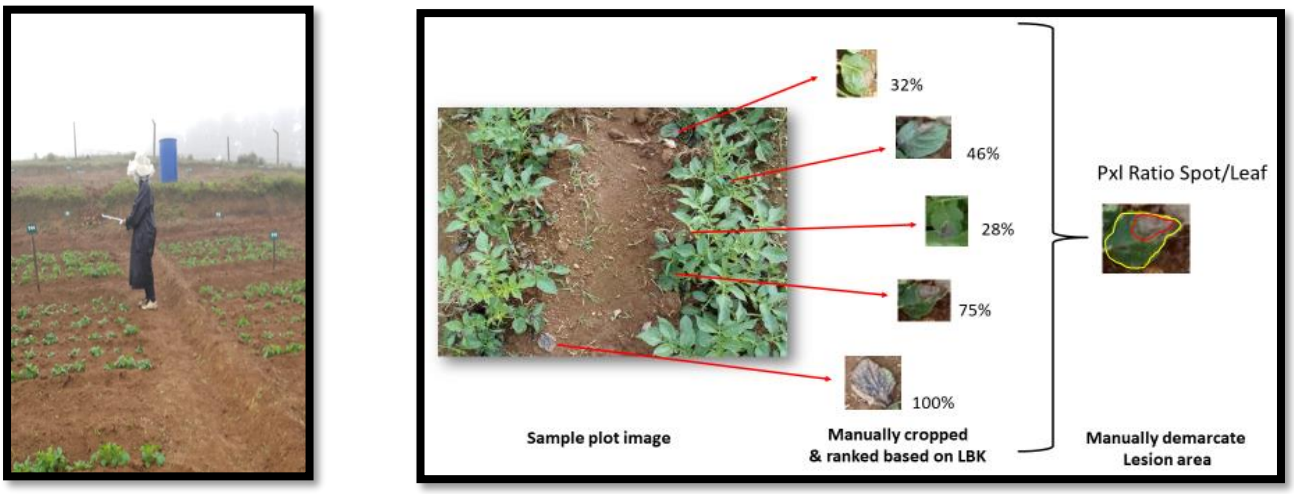

Plate 1: Steps in Smartphone image analysis

3. Results and Discussion

Digital Image Acquisition for Disease Severity Assessment

The data from all the segmented images were pooled, a near-perfect linear regression relation of R^2= 86.6% between the image-derived pixel ratio and visual ranking scores of the PLB disease severity was obtained. (Fig. 2). When the pixel ratio increased an increasing LB severity was recorded with the saturation above the regression ratio of 80%.

It can be interpreted by pixels where through image processing the area of the lesion was possible to measure in correspond to the leaf area by counting the number of pixels was proved to be strongly correlating. Duarte-Carvajalino et al. (2018) proved, the colour-reflects of the lesion area against the healthy leaves captured by digital cameras, can be measured for accurate disease severity assessment. Thus, it is highly beneficial to develop a quantitative objective method for assessing disease severity using a smartphone and also can aid in maximizing yield, minimizing

resource wastage and applying fungicides timely in commercial potato production.

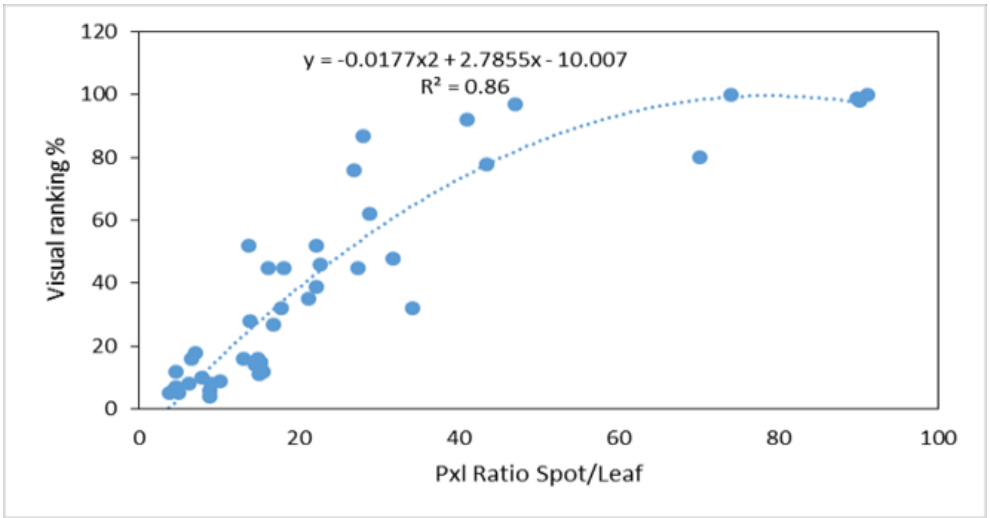

Fig. 2: Pixel Ratio Spot/Leaf Vs Visual Ranking Percentage of Late blight lesion

(Pixel Ratio/ Leaf = No of Pixels of spot lesions × 100%)
Total pixels in lesions

Further studies are recommended to be carried out in developing an image processing algorithm. Finally, it can be expanded to a web-based smartphone app which is beneficial to identify disease severity easily and accurately.

4. Conclusions

Based on the analytical results, a strong linear regression relation of R^2= 86.6% confirmed that the image processing analysis can accurately detect the PLB-infected leaf area and precisely assess the disease severity level. Furthermore, this study proposed a cloud platform that combined a web-based interface and a simple smartphone app to effectuate the task of PLB detection application in real-time.

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Conflicts of Interest: The authors declared that there is no conflict of interest.

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