Comparison of Color Image Analysis to Visual Assessment in Bean Rust Severity Measurement

Belayneh Admassu [1] ***and B. Hau***[2]
[1] *EARO, Plant Protection Research Center, P O Box 37, Ambo, Ethiopia*
[2] *Institute of Plant Diseases and Protection*
Hannover University, Herrenhauser Str 2, 30419 Hannover, Germany

SHORT COMMUNICATION

Abstract

A study conducted to compare image analysis using a LemnaTec computer program with visual assessment in bean rust severity measurement showed a significant quadratic relationship between the two methods. However, the image analysis had its own shortcoming that it was unable to distinguish between light green and light yellow colors.

Introduction

Counting and visual assessment are the two common methods of disease quantification. Both have their own merits and drawbacks. Although counting is close to accuracy, it is labor and time consuming. Visual assessment, on the other hand, lacks accuracy and reproducibility (Hau et al. 1989). Color image analysis is becoming an option to overcome these shortcomings as it combines the speed of visual assessment with the accuracy, objectivity and reproducibility compared to counting and visual method of disease measurement (Kampmann & Hansen 1994). Therefore, an experiment was conducted to determine the accuracy of visual rust severity assessment using the descriptive key of Godoy et al. (1997) compared to an image analysis using the LemnaTec computer program.

Materials and Methods

Trifoliate leaves of bean (*Phaseolus vulgaris*) cultivar Dufrix plants were inoculated with different concentrations ($4x10^2$, $4x10^3$ and $4x10^4$ spores/ml) of *Uromyces appendiculatus* (UA) urediospores in a greenhouse and adjusted to 22 ± 2^0C in order to create a range of rust severities. Seventeen days after inoculation, the severity of individual leaves was visually assessed using the descriptive key. Immediately after the visual assessment, each leaf was placed under a LemnaTec camera attached to a computer with the adaxial side upwards. The pictures were taken and stored as digital images in the computer installed with LemnaTec color image analysis program. This program was used to differentiate and calculate the area covered by each color on the leaves. Bean leaves infected with rust had three color categories, and for the sake of analysis rusted leaf part was defined as brown (B), the hallo area surrounding each pustule as yellow (Y) and the healthy leaf part as green (G). The background colors (K) are in the memory of the computer, and do not need to be defined during the analysis.

Analysis of the stored images gave the total area (T) under the range of the camera lens including the background area, and the percentage of each defined color out of the total area. The actual disease severity was calculated using the following formula:

Total leaf area (TLA) = T – K
Diseased leaf area (DLA) = B + Y
Healthy leaf area (HLA) = G
Disease severity = (DLA/TLA) * 100

Simple linear regression analysis was used to compare the results of the two disease assessment methods.

Results

Figure 1 shows the scatter plot and regression of rust severities visually assessed and determined by image analysis with LemnaTec. It was apparent that the points were more or less arranged quadratically, and a quadratic regression model relating the two assessment methods assuming visual assessment as an independent variable explained 99.1% of the variation in the image analysis.

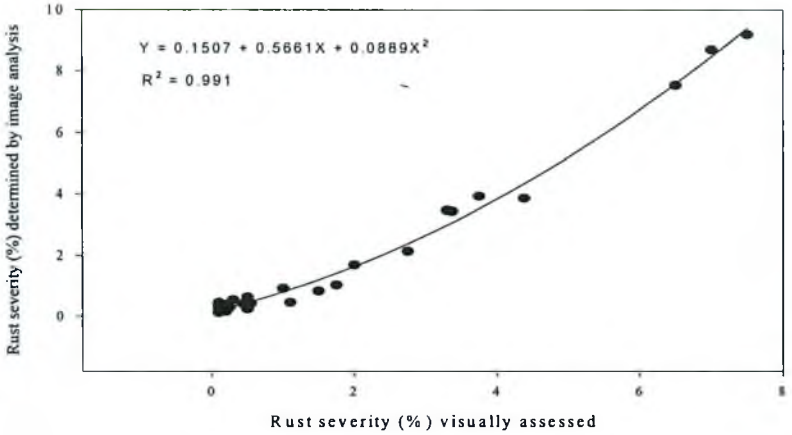

Fig. 1. The relationship between visual and LemnaTec methods in bean rust severity measurement. The values of the partial regression are significant at a probability of 0.05

Discussion

Image analysis using the LemnaTec programme was able to estimate rust severity precisely and comparably to the visual assessment method. A significant linear relationship was also established between visual and planimeter assessment of coffee rust severity (Price et al. 1993). Similarly, images of oat leaves affected by crown rust were analysed using computer software, and the results obtained by image analysis showed significant correlation with those obtained by the visual assessment method (Thome-Gladis et al. 1997). Evaluation of rust severity using image analysis on field grown pinto beans showed that the number of uredia determined from digitised images compared favourably with manual counts when uredia were large (Venette and Venette 1991). On the other hand, Price et al. (1993) reported that color image analysis, using a Matrox digitizer, was more accurate than visual estimates or black and white imaging systems in discriminating between rusted and healthy leaf tissues in color transparency photographs of rusted coffee leaves.

It was also observed that the LemnaTec image analysis programme had its own shortcomings that it was too sensitive for a very small colour change, so that it was unable to distinguish between light yellow (areas on the periphery of a hallo)

and that of green colour. To avoid such confusions another colour group was defined for such cases, which later on was added to the yellow group. In addition, the visual assessment method had a tendency of over estimating and under estimating at lower and higher severity levels, respectively.

References

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