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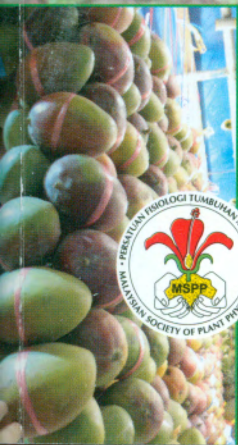

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Hawa ZE Jaafar (Editor-in-Chief)
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SIMULATED LEAF AREA GROWTH IN AN INTERCROP OF IMMATURE-RUBBER WITH BANANA AND PINEAPPLE USING THE *SURHIS* MODEL

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INTRODUCTION

*The leaf is very useful in plants as it is the organ where photosynthesis happens. Therefore, quantifying leaf area growth in crops is important to plant and crop physiologists. Accurate non-destructive field measurements of leaf area growth of crops is time consuming and sometimes problematic or impossible. Simulation modelling has been shown to be a powerful complimentary tool to conventional field measurements for predicting and extrapolating crop variables such as the leaf area growth for different environmental and crop management scenarios. This paper presents the simulated leaf area growths of an intercropping system of immature-rubber with banana and pineapple, using a model named SURHIS (**S**haring and **U**tilisation of Solar **R**adiation intercepted in a **H**edgerow-**I**ntercropping **S**ystem).*

METHODOLOGY

A computer model (SURHIS), based on the generic model SUCROS1 (Goudriaan and van Laar, 1994), that simulates the daily solar radiation or light interception and utilization by immature-rubber, banana and pineapple intercropping system was used to simulate the leaf area growth for the component crops and expressed as leaf area index (LAI). The model was written in FORTRAN using the Fortran Simulation Environment (FSE) software (Kraalingen 1995). Results of the model are output on a daily basis and the model assumes that water and nutrients are non-limiting and the crops are free of pests and diseases. Temperature, radiation, crop morpho-physiology and plant population density (PPD) were considered as influencing factors in the cropping system.

Light interception by leaves was quantified using a modified beer's law (Monsi & Saeki 1953; Kustas & Norman 1999). Dry matter was quantified in the model based on the difference between carbon assimilation from photosynthesis and respiratory losses due to metabolic and growth processes. Part of the dry matter is differentially partitioned to leaf growth during a crop's life cycle. Leaf area increment was quantified based on the fraction of assimilates partitioned to the leaves. This fraction was determined by an empirical routine in the model, which is a function of the phenological stage of the crop. Equations 1 and 2 show the simplified formulae used for calculating the leaf area increment and death.

$$GLAI = SLA \cdot G_{lv} \quad [1]$$

$$DLAI = LAI \cdot R_s \quad [2]$$

where,

GLAI	= Growth in LAI	
SLA	= Specific leaf area	(ha kg^{-1})
G_{lv}	= Daily leaf weight increase	(kg ha^{-1} d^{-1})
DLAI	= Leaf death rate	(m^2 m^{-2} $(^0C\ d)^{-1}$)
R_s	= Relative death rate of leaves	($(^0C\ d)^{-1}$)

The LAI results of the model were compared with results of a field experiment conducted at field 10 in Universiti Putra Malaysia (UPM) using the Mean Absolute Error (MAE) analysis (Wilson *et al.*, 1995) shown as equation 3.

$$MAE = \frac{\sum_{i=1}^{n} |Y_i - X_i|}{n} \quad [3]$$

where,

n = sample size

$|Y_i - X_i|$ = ***the absolute error term, wherein Y_i and X_i are the ith predicted and observed values respectively***

SUMMARY OF FINDINGS

Figures 1 shows that simulated LAI for rubber corresponded well with the observed data for the UPM plot with MAE of 7.7%. Similarly, banana LAI for parent and the first ratoon crops were simulated fairly accurately in comparison to the observed values (Figures 2 and 3) although the model overestimated the parent-crop LAI from 200 DAP and from 150 days after emergence (DAE) for the first ratoon LAI till harvest, with MAE of 15.2% and 27.0% respectively.

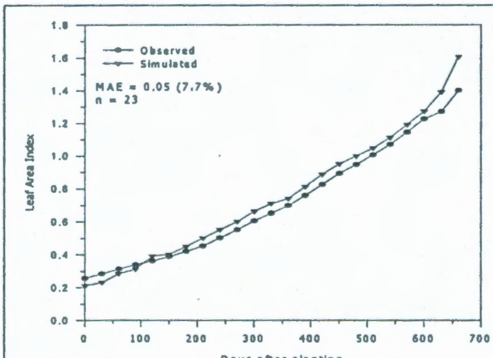

Figure 1: The observed and simulated LAI of rubber plants

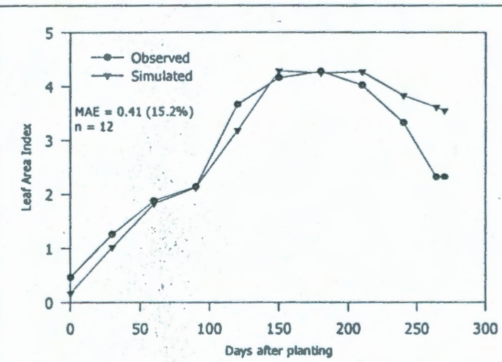

Figure 2: The observed and simulated LAI of banana parent-plants

Pineapple LAI was simulated with little error compared to the observed values (Figure 4) although the model little overestimated LAI from about 400 DAP till harvest with MAE of 6.4%. At 600 days after planting (DAP), the simulated leaf index (LAI) of rubber and pineapple was on average 1.4 and 4.5 respectively. The simulated LAI for the parent crop of banana was about 4.3 at peak growth (150 DAP), and at the same time the simulated LAI of the first ratoon crop was about 2.7.

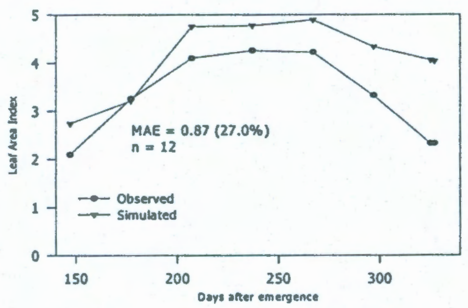

Figure 3: The observed and simulated LAI of banana ratoon-1 plants

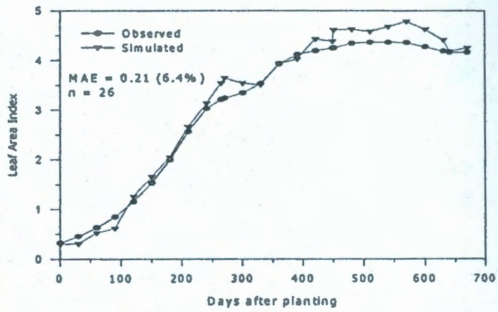

Figure 4: The observed and simulated LAI of pineapple plants

There have been no studies in the past for this particular intercropping system which makes comparison with existing literature impossible. However, the results from the field experiment are in themselves good enough to compare the simulations. The model overestimated LAI for a greater part of the simulation, which can be explained by the fact that the model simulation assumes potential production conditions, which is not quite the case in actual field conditions.

CONCLUSION

The model predicts LAI with sufficient accuracy but there is still room for improvement where over-estimation occurs, and expansion of the model to include water and nutrient balances for a more holistic system analysis. The model has a potential to act as a tool for predicting the LAI of the above intercropping system for different cropping densities, sunlight and temperature conditions.

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