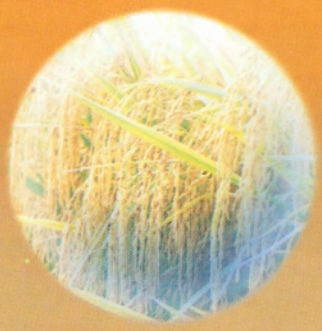
SOILS 2003

Towards Maximum Land Use and Productivity



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MODELLING THE DYNAMICS OF DRY MATTER AND FRUIT YIELD OF BANANA AND PINEAPPLE INTERCROPPED WITH IMMATURE-RUBBER

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ABSTRACT

The results from a computer model that simulates dry matter and fruit yield of banana and pineapple intercropped with immature-rubber, were sufficiently accurate when compared to observed data. Monocrop and intercrop scenario analysis showed that the intercropping system has a productivity advantage of 90% more than monocrops of the component crops. The model can be useful for predicting potential yield of the afore-mentioned intercropping system under varying temperature and radiation environment scenarios as well as acting as a guide for plant density experimentation.

INTRODUCTION

There is an established knowledge, although not in all cases, that intercrops usually do better that monocrops in terms of crop productivity (Willey, 1979). This paper presents the case of banana and pineapple intercropped with immature-rubber to quantify their dry matter and fruit yield in intercropped and monocrop scenarios using a simulation model. Simulation modelling has been shown to be a powerful complimentary tool to conventional field experimentation for predicting and extrapolating crop yield for different environmental and crop management scenarios. This possibility was explored and made use of to obtain the results presented here.

METHODOLOGY

A computer model that simulates the daily light interception and utilization by immature-rubber, banana and pineapple intercropping system was used to simulate intercrop and monocrop scenarios to estimate dry matter yield (DMY) for all crops as well as fruit yields for banana and pineapple. 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. Only temperature, radiation, crop morph-physiology and plant population density (PPD) are considered as influencing factors in the cropping system

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. Fruit yield was quantified based on the fraction of remaining assimilates partitioned to the fruits after respiratory losses have been subtracted. This fraction was determined by an empirical routine in the model, which is a function of the phenological stage of the crop.

The DMY results of the model were compared with results of a field experiment conducted at field 10 in UPM using the Mean Prediction Error (MPE) and Mean Deviation (MD) analysis (Malezieux *et al.*, 1994; Wilson *et al.*, 1995).

Intercropping advantage was determined using the land equivalent ratio (LER) analysis (Vandermeer, 1989) for known PPD's of the intercropping system and compared to known optimum PPD's of monocrop scenarios.

SUMMARY OF FINDINGS

In general the model predicted DMY of the banana parent-crop accurately compared to field measurements with a MD of 1.3 and MPE of 1.6 as shown in Figure 1. However, the model overestimated DMY after 150 DAP. In the case of pineapple, the model generally predicted DMY accurately with a MD of 46.8 and MPE of 54.4 with overestimations 150 DAP (figure 2). The large values of MD and MPE can mislead one to conclude that the deviation and error are quite high, but this is not the case as the units are in g plant^{-1}, which inherently gives high absolute values. Rebolledo-Martinez et al., (1993) reported between 350 – 400 g plant^{-1} at 300 DAP for Smooth cayenne in Mexico under different fertilizer regimes. The results do not differ much for the observed and simulated values shown in Figure 2, which is about 300 and 375 g plant^{-1} respectively. The results are also very similar to those measured and simulated using ALOHA by Zhang (1992) and Zhang and Bartholomew (1993) under Hawaiian conditions.

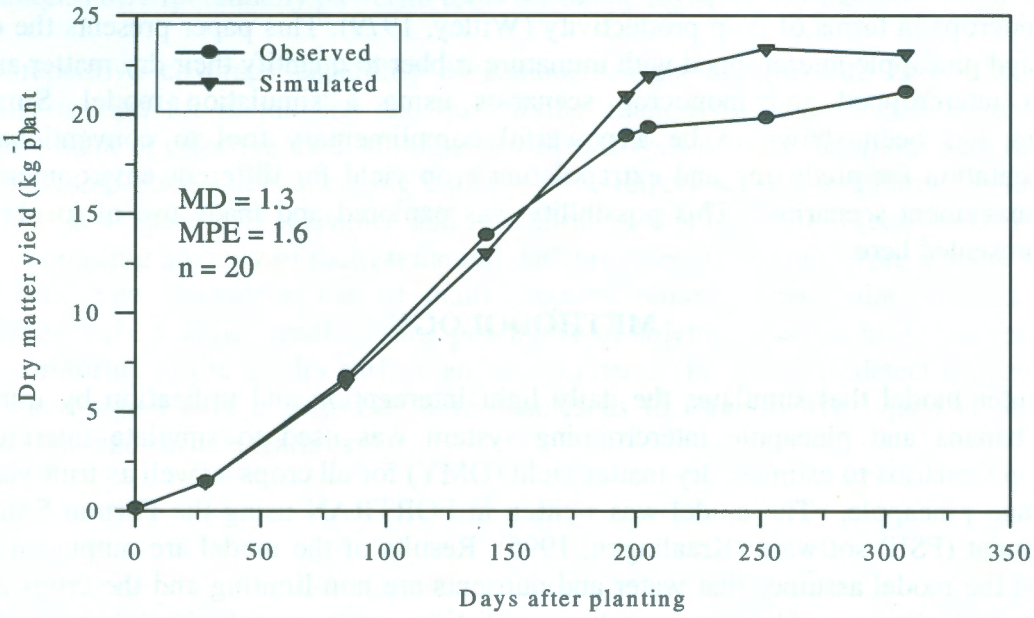

Figure 1: The observed and simulated dry matter yield of banana parent plants for the UPM field plot

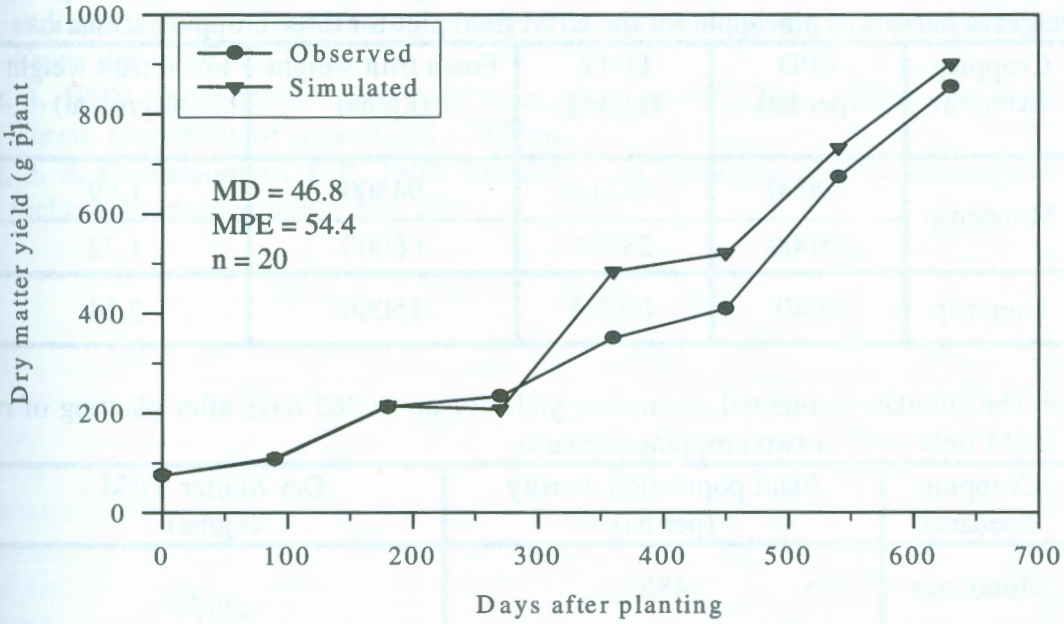

Figure 2: The observed and simulated dry matter yield of pineapple plants for the UPM field plot

Tables 1 to 3 show the results of DM yield for different cropping scenarios. From the calculations below, based on the results shown in the tables, the total hectarage of rubber, banana and pineapple monocultures needed to produce the equivalent of a single hectare of rubber-banana-pineapple intercrop is 1.9, which is the LER. This means the intercropping advantage in terms of land area used is 90 %.

$$LER = \left(\frac{25942}{25974} + \frac{20292}{27922} + \frac{4063.4}{23218} \right) ha$$

$$= 0.99 + 0.73 + 0.18$$

$$= 1.9 ha$$

Tables 1 and 2 also show that variations in PPD have a relationship with DMY and fruit yield. The higher the PPD, the greater the DMY but the fruit weight per plant is reduced. Measured average fresh fruit bunch weight for banana was 18 kg per plant and the average fresh fruit weight per plant for pineapple was 2.1 kg.

Table 1: The simulated potential dry matter yield for up to 265 days after planting and fresh fruit weight at harvest of banana for the UPM field plot for three cropping scenarios

Cropping Scenario	PPD (per ha)	DMY (kg/ha)	Fresh fruit weight (kg/ha)	Fresh fruit weight (kg/plant)
Monocrop	1680	27922	29232	17.40
	1800	28031	27684	15.38
Intercrop	880	20292	16984	19.30

Table 2: The simulated potential dry matter yield for up to 265 days after planting and fresh fruit weight at harvest of pineapple for the UPM field plot for three cropping scenarios

Cropping Scenario	PPD (per ha)	DMY (kg/ha)	Fresh fruit weight (kg/ha)	Fresh fruit weight (kg/plant)
Monocrop	50000	23218	94500	1.89
	55000	23738	66000	1.72
Intercrop	7040	4063.4	15066	2.14

Table 3: The simulated potential dry matter yield for up to 265 days after planting of rubber for the UPM field plot for two cropping scenarios

Cropping Scenario	Plant population density (per ha)	Dry Matter Yield (kg/ha)
Monocrop	485	25974
Intercrop	485	25942

CONCLUSIONS

The model predicts DM and fruit yield with sufficient accuracy but there is still room for improvement where over-estimation occurs as well for expansion of the model to include water and nutrient balances for a more holistic system analysis.

Intercropping of banana and pineapple with immature-rubber is more productive than the component crops grown as monocrops in their respective optimum PPD per hectare.

The results indicate that the model can act as a guide to experiment on plant population density effects on yield for optimum combinations selection.

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ERRATA

MODELLING THE DYNAMICS OF DRY MATTER AND FRUIT YIELD OF BANANA AND PINEAPPLE INTERCROPPED WITH IMMATURE-RUBBER

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1. Intercropping advantage value, 90% is incorrect. — It should be **80%**
2. The LER value, 1.9 is incorrect. — It should be **1.8**
3. The Intercrop DMY value in Table 2, 4063.4 is incorrect. — It should be **2048.1**
4. Subsequently, the calculation below is incorrect

$$LER = \left(\frac{25942}{25974} + \frac{20292}{27922} + \frac{4063.4}{23218}\right) ha$$

$$= 0.99 + 0.73 + 0.18$$

$$= 1.9 ha$$

It should be as follows, (corrected values in bold italic)

$$LER = \left(\frac{25942}{25974} + \frac{20292}{27922} + \frac{\boldsymbol{2048.1}}{23218}\right) ha$$

$$= 0.99 + 0.73 + \boldsymbol{0.09}$$

$$= \boldsymbol{1.8} ha$$

5. The value 150 DAP in line 4 of Summary of Findings is incorrect. — It should be **280** DAP