Tropentag 2008
University of Hohenheim, October 7-9, 2008
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Musa in Shaded Perennial Crops - Response to Light Interception

Dold, Christian[a], Staver, Charles[b], Pocasangre, Luis[b], Heller, Joachim[d]

a University of Bonn, Agricultural Science and Resource Management in the Tropics and Subtropics, Nussallee 1, Germany. Email neophyta960@gmail.com
b International Network fort the Improvement of Banana and Plantain (INIBAP), Costa Rica
c University of Applied Science, Wiesbaden, Faculty of Geisenheim, Von-Lade-Straße 1, 65366 Geisenheim, Germany

Introduction

Throughout the tropics banana and plantain (*Musa spp.*) is a common crop in agroforestry systems, characteristically cultivated by small scale farmers. Millions of small farm households produce this crop associated with perennial crops and trees for consumption and market, but encounter few technologies targeted to their production constraints. In Central America, typically, it is associated with perennial crops like coffee (*Coffea sp.*) and cacao (*Theobroma sp.*) and an upper storey of timber trees. Thus, banana is cultivated in highly shaded conditions, and light interception is one significant limiting factor (Stover and Simmonds 1987, Eckstein and Robinson 1999).
While research is mainly focused on all other production units, the improvement of shaded banana and plantain yield is widely neglected. Occasional research on the effect of shade on banana productivity has shown that shade reduction up to 20% can have few negative impacts (Israeli *et al.* 1995, Israeli *et al.* 2002). Shade may reduce wind damage and leaf disease pressure, offset water and nutrient stress and contribute to a more diverse soil food web. Greater light reduction extends the crop cycle and may reduce bunch size, especially under increased plant densities.
Our objectives were (1) to measure effect of shade on plant growth and disease pressure on banana, and (2) to understand how radiation in agroforestry systems can be improved in relation to banana production.

Material and Methods

A project at CATIE, Costa Rica, supported by Bioversity International and GTZ-BEAF, studied the improvement of banana production in agroforestry systems. In two sites we measured light response.
From March 2007 to September 2007, we observed plant growth and leaf characteristics, including disease level of *Musa* ‘Gros Michel‘, 10 plants in sun and 10 plants in shade. The plants were randomized with no replications. Shaded banana was associated with cacao under a tree canopy of *Schizolobium parahybum.* We utilized hemispherical photography above banana canopy to estimate light availability. There were two-week measurements of height and circumference. Height was the total length from the ground to the upper edge of the pseudostem. We measured circumference of the pseudostem in one meter height above the ground. Leaf number, leaf area, and leaf emission rate of functional leafs (minimum width of 10 cm) were measured weekly. We used destructive and non-destructive measurements of leaf area, according to Turner (2003) and Murray (1960). For leaf emission rate, we used Brun’s scale.

Leaf folding as an indicator for water stress was observed once by estimating leaf blade angles. Additionally, we counted the strips of torn leaves twice to evaluate the windbreak effect of the upper storey. Furthermore, one-time measurement of leaf angle should indicate, if the plant responds to light availability.
We also observed impact of Black Sigatoka (*Mycosphaerella fijiensis)* weekly. We included disease severity by Gaul's scoring system, as well as Disease Development Time and Youngest Leaf Spotted (Carlier *et al.* 2002).

In June 2007, we measured radiation in six different coffee agroforestry systems with plot size of 288 m², to determine light availability for a possible banana intercrop. The plots included an upper storey of *Erythrina poeppiggiana* (Poró), *Terminalia amazonia* (Roble Coral), and *Abarema idiopoda* (Cashá) in single stands and mixed stands. The three species have different tree habitus. In case of Poró the tree were recently pruned before data taking with two to three major branches. Planting distance was 6m x 4m, with exception of the Poró single stand (12m x 8m).
We used hemispherical photography above coffee plants. Photos were taken every 2m x 2m. There were no replications.
For both sites we calculated percentage of total transmitted light via software Gap Light Analyzer.

Results and Discussion

In full sun (70% light), banana grew faster and taller, had higher leaf area, developed more leaves, and showed faster leaf emergence (see also Table 1). In contrary, in high shading (30% light) leaf folding is less, indicating that water stress is reduced. However, there was no significant difference of leaf tearing; either due to less impact of wind at this site, or there was no beneficial effect on wind of the upper storey. Furthermore, leaf angle was not significantly different. Thus, there was either no response with plane leaf angles on reduced light availability, or leaf angle measurements as an indicator fail.

Table 1. Leaf area (m²), weekly leaf number and total leaf number of *Musa* in 70% („sun“) and 30% light („shade“)

	Leaf Area (m²)	# Weekly Leaf	# Total Leaf
70 % Light	29.6 ± 7	7.0 ± 0.6	16 ± 1
30 % Light	24.2 ± 6	8.0 ± 0.6	14 ± 1
p	No sign.	0.00	0.03

In high shading (30% light), Black Sigatoka infestation is delayed (see also Table 2). The total number of necrotic leafs is less, and Disease Development Time was reduced by 4 days. However, the Youngest Leaf Spotted was equal in both light conditions, indicating that Black Sigatoka starts to develop at the same time. Thus, shading prolongs the development of the disease which leads to less dead leafs.
However, less impact of Black Sigatoka, and reduced water stress could not overcome the faster leaf development which assumes that light availability was the main limiting factor.

Table 2. Impact of Black Sigatoka on *Musa* 'Gros Michel' in 70% Light („sun“) and 30% Light („shade“):number of necrotic leafs, Disease Development Time, and Youngest Leaf Spotted

Impacts of Sigatoka	70 % Light	30% Light	p
# Necrotic Leaf	8 ± 2	3 ± 2	0.0
Disease Development	50 days ± 11	54 days ± 11	0.0
Youngest Leaf Spotted	3 ± 1	3 ± 1	No sign.

According to our findings, some shading of an upper storey can be beneficial, when other factors than light are more limiting. Israeli *et al*. (2002) found that reduced light (80% of total PAR) in subtropical Jordan Valley is beneficial for cropping, since water stress was higher than limited light. This corresponds to our findings, where leaf folding was stronger in 70% light.
Second, delay of Black Sigatoka might be beneficial where disease pressure is severe, or the use of fungicides is not affordable and economically or ecologically not useful. This is especially important for the main producer of banana and plantain – the small scale farmers – who have seldom the capital or knowledge of secure and effective fungicide spraying. Vicente-Chandler *et al.*(1966) found that plantain yield was twice as high in 50% available light in an agroforestry system due to the severe impact of Yellow Sigatoka (*Mycosphaerella musicola, syn.: Cercospora musae*) in full sun. The plot was in the mountainous region of Puerto Rico, where spraying was not practical to this date.

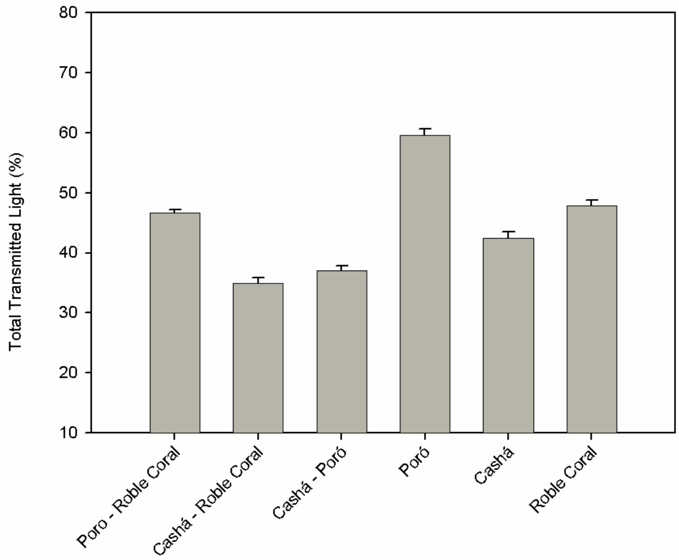

Figure 1. Percentage of total transmitted light in six coffee agroforestry systems (12m x 8m)

As expected light was highest in the Poró – coffee agroforestry system (see also Figure 1) since tree density was less and Poró was pruned before data taking. With growing Poró the light availability for understorey plants will get lower. Considering that only slight shading is possible for improved banana production, just the pruned Poró – coffee agroforestry system (12m x 8m) showed possible intercropping with banana. Thus, a tree density less than 100 trees/ha can be recommended for intercropping. Thereby, possible planting places for banana could be located with the help of light dispersal maps (see Figure 2). In addition, Espinoza (1985) recommends an upper storey density of maximum 300 – 340 plants/ha, where bananas should not exceed the amount of 120 plants/ha (because of negative impact on coffee production).

Outlook and Conclusion

Shading is one possibility to delay Black Sigatoka, and to reduce water stress. This might be interesting for small-scale farmers, since agroforestry systems are common practice, and pesticides or irrigation are not available. However, leaf emission is delayed, leading to a longer crop cycle. Tree density should not exceed 100 trees/ha.
Shade which lengthens the time to bunch harvest without reducing bunch weight or number of fingers may be a useful criteria to determine maximum shade levels. Further research should focus on possible shade tolerant varieties, farmer's knowledge of tree effects on banana and canopy arrangements to maximize light availability to banana.

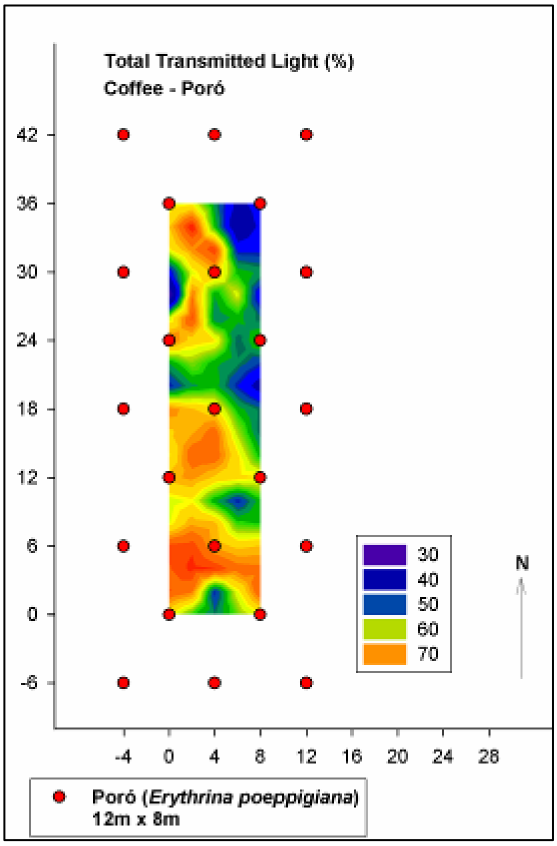

Figure 2. Light dispersal map; (%) total transmitted light; Poró – coffee agroforestry (12m x 8m)

References

CARLIER J., D. DE WAELE AND J.V. ESCALANT (2002): INIBAP Technical Guidelines 6, Montpellier, France, INIBAP ISBN: 2-910810-52-6

ECKSTEIN, K. and ROBINSON, J.C. (1999): The influence of the mother plant on sucker growth, development and photosynthesis in banana; Journal of Horticultural Science & Biotechnology (1999) 74 (3), pp. 347 – 350

ESPINOZA, L. (1985): Untersuchungen über die Bedeutung der Baumkomponente bei agroforstlichen Kaffeeanbau an Beispielen aus Costa Rica. Göttinger Beiträge, Heft 10, p. 164

ISRAELI, Y., PLAUT, Z., SCHWARTZ, A. (1995): Effect of shade on banana morphology, growth and production, Scientia Horticulturae 62 (1995) 45-46, pp.45 – 56

ISRAELI, Y., ZOHAR, C., ARZI, A., NAMERI, N., SHAPIRA, O., LEVI, Y. (2002): Growing banana Ander shade screens as a mean of saving irrigation water: preliminary results, Acorbat Memorias XV. 2002. Medellín (COL): pp. 384 -389

MURRAY, D.B. (1960): The Effect of Deficiencies of the Major Nutrients on Growth and Leaf Analysis of the Banana, Tropical Agriculture (Trinidad), Vol. 37, No. 2, pp. 98 – 107

STOVER, R. H. AND SIMMONDS, N. W. (1987): Bananas, 3rd edition, ISBN 0 582 46357 2

TURNER, D.W. (2003): An integral method for estimating total leaf area in bananas,InfoMusa, The International Journal on Banana and Plantain, Vol. 12, No. 2

VICENTE-CHANDLER, J. ABRUNA, F. SERVANDO, S. (1966): Effect of Trees on Yields of Five Crops in the Humid Mountain Region of Puerto Rico; Journal of Agriculture of University of Puerto Rico, pp. 218-225