Linking physiological response to shade with growth and yield in different coffee agroforestry systems in Ecuadorian Amazonia

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Robusta coffee is mainly grown in full-sun monocultures. In contrast, coffee agroforestry systems might be more sustainable

We tested effects of 5 shade types (full sun, trees of *Myroxylon balsamum*, *Inga edulis*, *Erythrina* spp. & *Myroxylon balsamum* + *Erythrina* spp. combined), 4 shade amounts (0%, 5%, 30% & 45%) & 4 farming practices: intensive conventional, moderate conventional, intensive organic & low organic on: leaf chlorophyll concentration, height & cherry yield

Methods

Study area: La Joya de los Sachas, province of Orellana, Ecuador. 250 m a.s.l., Andic Dystrudept soils, humid moist forest with annual rainfall of 3217 mm, mean temperature 24° C, relative humidity 91.5%

Leaf chlorophyll

monthly, Mar- Jun 2020, chlorophyll meter (Apogee MC-100), 2 measurements per leaf at middle and 1 cm from main vein (Plate 1)

Plant organs evaluated: 4 leaves per coffee plant situated at the middle of a middle branch

Plate 1. Chlorophyll concentration meter

Height

(Apr 2020): Rope & flexometer, measure from soil to tip of coffee plant (Plate 2)

Cherry yield

Mar-Jun 2020: Stems ready for harvest identified using BBCH-scale (85-88, Plate 3)

Harvested cherries soaked & drained before measuring weight, mean surface water weight per cherry estimated & deducted from measured weight

Plate 2. Height measurement

Shade evaluation

May-Jun 2020, homogeneous distance zones (18) for shade trees defined for each shading method

Solar radiation measured once in 5 different spots on each coffee plant (4 per zone) at 2.5 m height, with a pyranometer (Apogee MP-200, Plate 4): on apex, east, west, north & south of plant

Mean % shade per zone determined & grouped into 4 shade categories

Plate 3. Cherries at stages 88 (left) and 85 (right) on the BBCH-scale

Statistics

descriptive statistics & regression

Plate 4. Pyranometer for total solar radiation measurement

Results

- Coffee plants intercropped either with *Inga edulis* or *Erythrina* spp. were taller (>12.7%, Fig. 2A), & had higher chlorophyll concentrations (>30%, Fig. 1A) than those under other shade types
- Full sun and *I. edulis* shade types had higher cherry yield per stem than *E.* spp., *M. balsamum* (>7.1%) or *M. balsamum* + *E.* spp. combined (>20.2%) (Fig. 3A)
- 45% shade increased height by 12.3% (Fig. 2B) & chlorophyll concentration by 29.3% (Fig. 1B). 30% shade increased chlorophyll concentration by 17.8% (Fig. 2B).
- With conventional practices, coffee was taller (>7.6%, Fig. 2A), with higher chlorophyll concentrations (>10.5%, Fig. 1A) & higher cherry yield per stem (>33.5%, Fig. 3A) than with organic practices

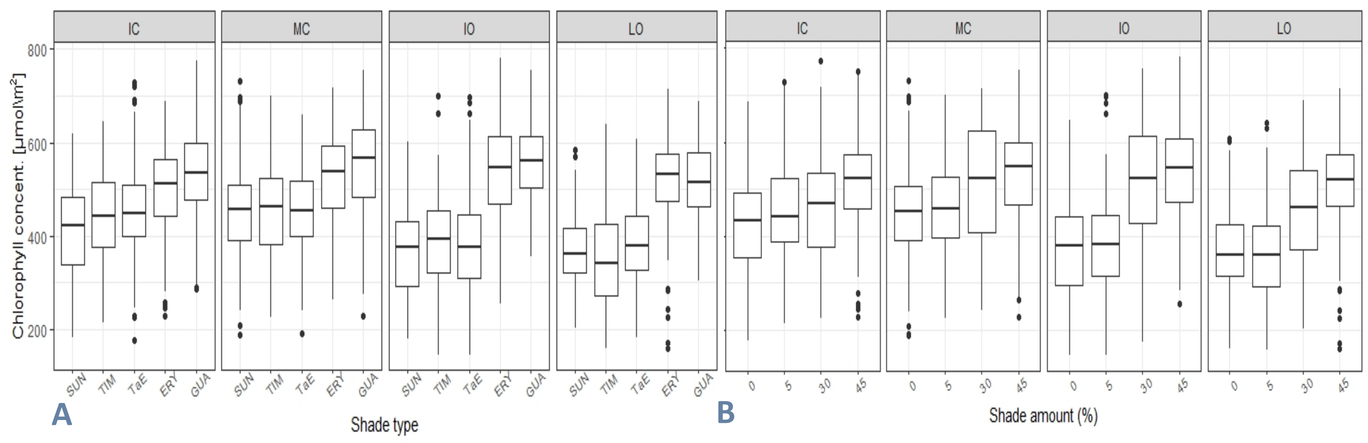

Fig 1 Boxplots of chlorophyll by farming practice & A) shade type or B) shade amount

Key: SUN = full sun, TIM = *M. balsamum*, TaE = *M. balsamum* x *E.* spp., ERY = *E.* spp. and GUA = *I. edulis*
IC = intensive conventional, MC = moderate conventional, IO = intensive organic, LO = low organic

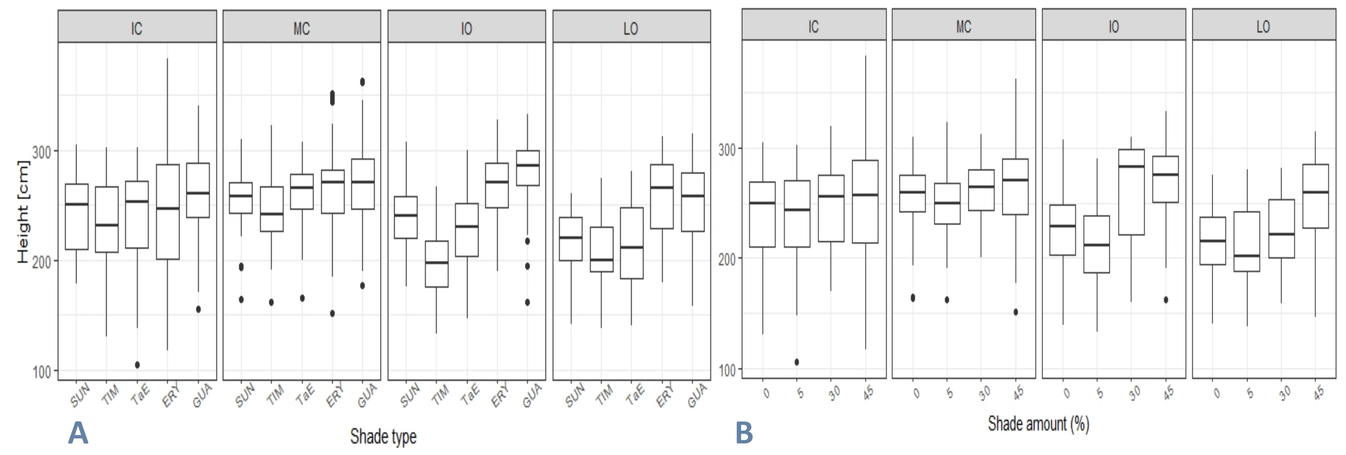

Fig 2 Boxplots of height by farming practice & A) shade type or B) shade amount

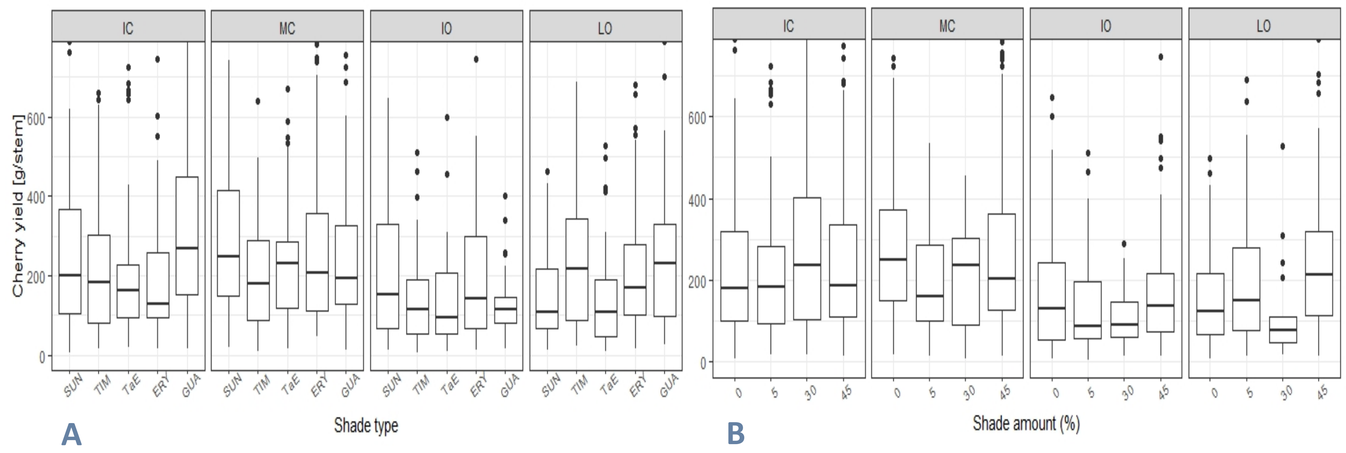

Fig 3 Boxplots of cherry yield by farming practice & A) shade type or B) shade amount

Conclusions

- Shade and farming practices acted interactively on coffee growth, physiology & yield
- Heavy shade (45%) can maintain growth, leaf chlorophyll concentrations & high cherry productivity

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