Evaluation of agroforestry systems in Robusta coffee plantations in the Amazonian Ecuadorian Region with respect to pests and diseases

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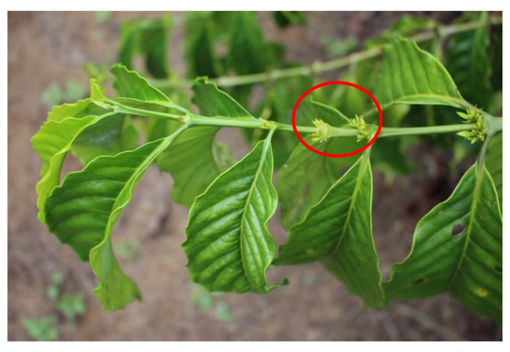
Robusta coffee is mainly grown in full-sun monocultures. In contrast, coffee agroforestry systems might reconcile production, social and environmental goals.

We tested effects of 5 shading methods (full sun, trees of *Myroxylon balsamum*, *Inga edulis*, *Erythrina* spp. and *Myroxylon balsamum* + *Erythrina* spp. combined) & 4 farming practices: intensive conventional, moderate conventional, intensive organic & low organic on: infestation rates of pests *Hypothenemus hampei*, *Xylosandrus morigerus* & *Leucoptera coffeella;* incidence rates of diseases *Colletotrichum* spp., *Phoma* spp., *Cercospora coffeicola*, *Pellicularia koleroga;* & presence of entomopathogen *Beauveria bassiana* on berries damaged by *H. hampei*. *C.* spp. severity & the shade % of each shading method were determined.

Picture 1. Leaf lesions caused by *Colletotrichum spp.*



Picture 2. Short internode on the branch of a coffee tree.

Picture 3. Spots of *Cercospora coffeicola.*

Picture 4. Holes of *Xylosandrus morigerus.*

Picture 5. Berries perforated by *Hypothenemus hampei.*

Picture 6. Necrotic spots caused by *Phoma* spp.

Picture 7. Dead brown leaves infected by *Pellicularia koleroga.*

Picture 8. Necrosis due to feeding activity of *Leucoptera coffeella* larvae inside leaf.

Materials and 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%

Infestation and incidence evaluations:
Frequency: monthly from July - September 2018
Method: visual evaluation of symptoms in the field
Plant organs evaluated:

- *L. coffeella* (Pict. 8), *C.* spp. (Pict. 1), *P.* spp. (Pict. 6), *C. coffeicola* (Pict. 3) and *P. koleroga* (Pict. 7): leaves of 3 branches after the short internode (Pict. 2);
- *X. morigerus* (Pict. 4): all the branches of a stem;
- *H. hampei* (Pict. 5) and *B. bassiana*: cherries of 3 entire branches.

To calculate rates of infestation, incidence and presence: number of plant organs with symptoms / total number of plant organs evaluated.

***C.* spp. severity evaluation:** in July 2018.
Treatments: same as for infestation & incidence:

1. Picking 6 leaves per coffee plant, situated directly after the short internode
2. Scanning the picked leaves
3. Determining the total leaf area damaged by *C.* spp. with the ImageJ programme

Shade % determination: conducted from July to September 2018
Treatments: 5 shading methods.
Method:

1. Homogeneous distance zones for shade trees were defined for each shading method;
2. Solar radiation was measured once in 5 different spots on each coffee plant at a height of 2 m, with a pyranometer (Apogee MP-200): on the apex, the east, the west, the north and the south of the plant;
3. Shade % for each shading method was calculated by comparing the solar radiation measured above the coffee plant to the one obtained in full sun exposition. The extension of each zone was considered to determine shade % of net area.

Statistics: linear mixed models after Tukey's test

Results

- **Robusta coffee plants intercropped with *Inga edulis* trees had lower *Xylosandrus morigerus* infestation (<9%) compared with those in full sun (Fig. 1A)**
- **Organic farming practices had lower *X. morigerus and H. hampei* infestations (<12%) than conventional ones (Fig. 1B, 2A)**
- **Organic farming practices had lower % of berries damaged by *H. hampei* with *B. bassiana* presence (<17%) than conventional ones (Fig. 2B)**
- **In organic farming practices, *Colletotrichum* spp. severity is up to 3% higher than in conventional farming practices (Fig. 3A).**

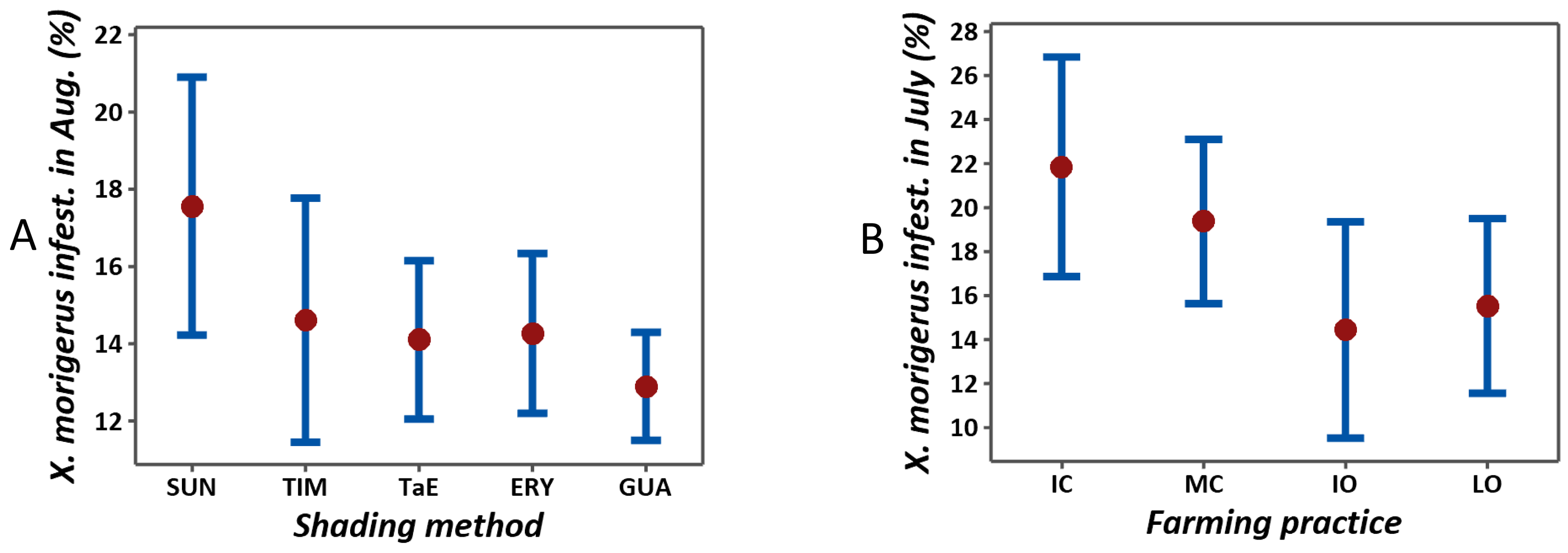


Figure 1. (A) 95% confidence intervals of mean *X. morigerus*, by shade treatment (SUN = full sun, TIM = *M. balsamum*, TaE = *M. balsamum* x *E.* spp., ERY = *E.* spp. and GUA = *I. edulis*), (B) mean *X. morigerus* infestation (July) by farming practice (IC = intensive conventional, MC = moderate conventional, IO = intensive organic, LO = low organic)

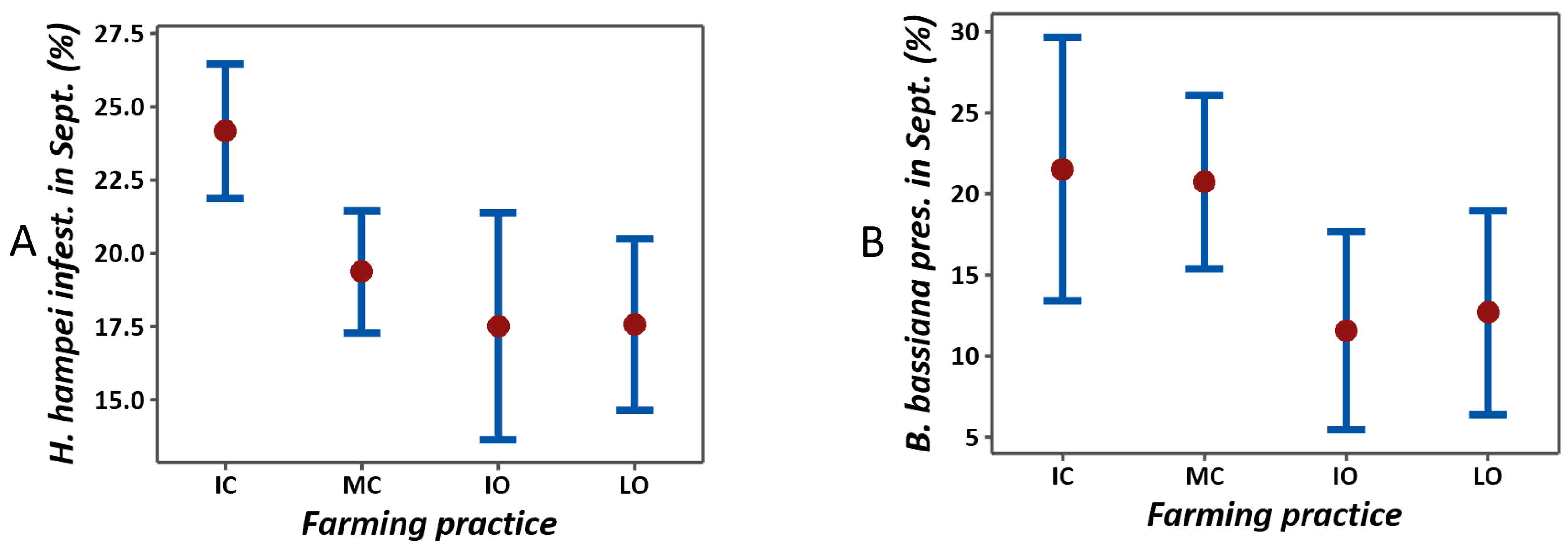


Figure 2. (A) 95% confidence intervals in September of the *H. hampei* infestation according to the farming practice, (B) in September of *B. bassiana* presence according to the farming practice

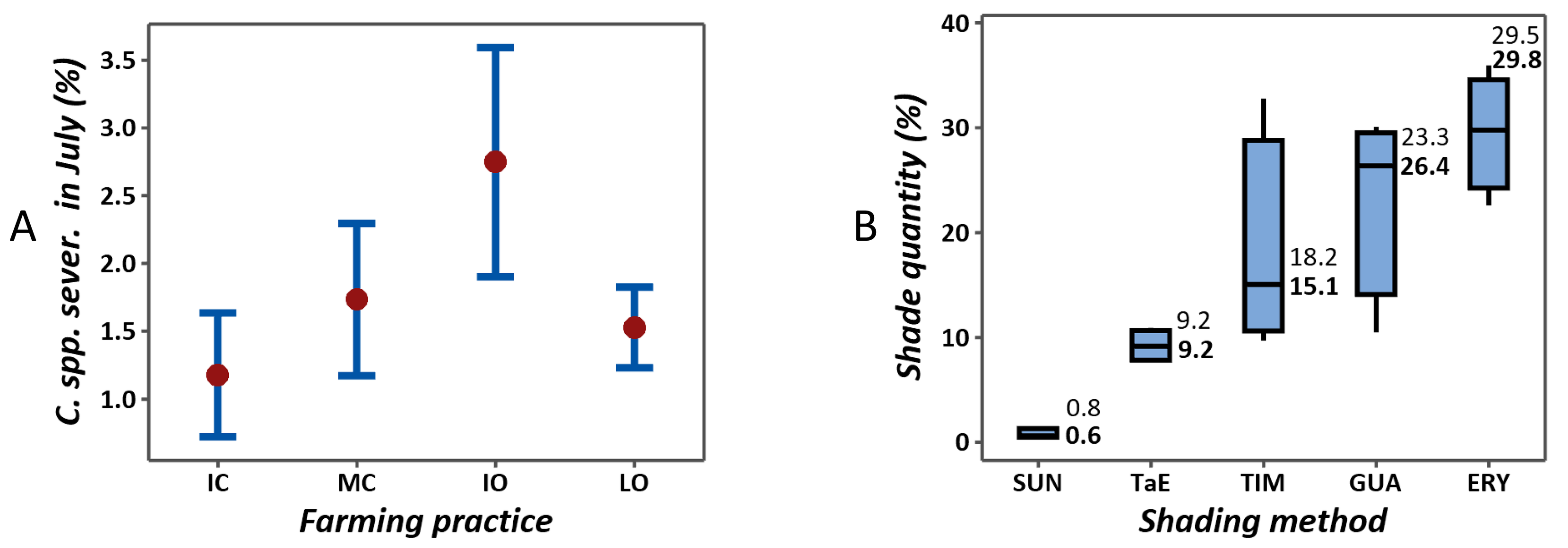


Figure 3. (A) 95% confidence intervals of *C.* spp. severity (July), according to the farming practice, (B) box and whisker plots of the 2018 mean shade quantity of different shade treatments (**bold numbers** are medians, non-bold numbers are means)

Conclusions

I. *I. edulis* trees reduced *X. morigerus* infestation in coffee, probably because they attract the pest

II. Organic farming practices reduced infestation rates, possibly due to maintaining natural enemies

III. Further research is needed with more developed trees or higher density per hectare, to draw firm conclusions

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