

Should agroforestry coffee have an O layer?

Contributions of the agroforest floor to productivity and resilience

Staver, C., Bioversity International, Montpellier, Francia; Barrios, M., Navarrete, E., Navarrete, L., Sepulveda, N., CATIE, Managua, Nicaragua



O layer, agroforest floor, leaf litter or ground cover?

Water retention, nutrient cycling and soil carbon sequestration are enhanced by trees in coffee. The ground cover layer interfaces between above- and below-ground ecosystem processes. Depending on type and extent of tree cover and weed control practices, the composition of the ground cover layer in agroforestry coffee may vary. However, system management focuses primarily on trees and coffee with little regard for the status of leaf litter accumulation or ground cover composition.

Crop management – nutrient and ground cover management treatments

	Intensive conventional (IC)	Intensive organic (IO)	Moderate conventional (MC)	Moderate organic (MO)
NPK source/amount	Chemical – 144, 41, 85 kg/ha NPK	9 t/ha coffee pulp, 7 t/ha chicken manure	Chemical – 72, 20, 43 kg/ha NPK	9t/ha Coffee Pulp
Ground cover management	Bare soil with herbicides	Manual selection to conserve low ground cover between row and clean within row	Manual and herbicide selection of low ground cover between row and clean within row area	2-4 routine machete weeding per year

What were effects of 5 agroforestry treatments x 4 input mgmts?

A long-term experiment in Masatepe, Nicaragua, with a 5-month dry season at an altitude of 450 meters compared 4 tree species in 2-species combinations with full sun coffee under two conventional and organic nutrient and ground cover managements (see tables below). Three replicates were planted in 2000-2001 and managed through the harvest of 2014. Data on the coffee, tree and ground cover components serve to clarify the status of the O layer and key ground cover dynamics influenced by tree species and weed management.

Tree species characteristics

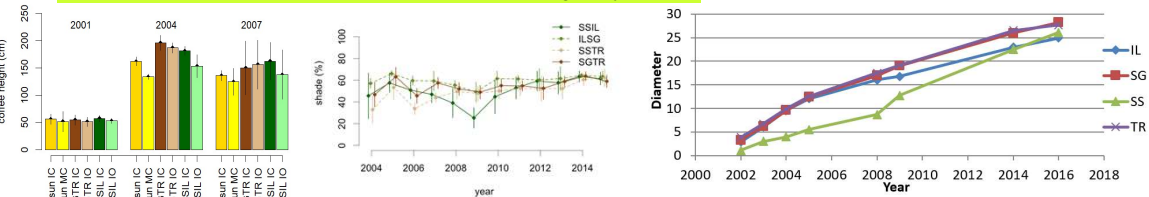
Tree species	Leaf phenology	N-Fixer	Canopy shape	Use
<i>Inga laurina</i> (IL)	Evergreen	Yes	Low spreading	Service
<i>Samanea saman</i> (SS)	Evergreen	Yes	High spreading	Timber
<i>Simarouba glauca</i> (SG)	Evergreen	No	High narrow	Timber
<i>Tabebuia rosea</i> (TR)	Deciduous	No	High narrow	Timber

Tree x management plots

Main plots	Subplots
Full sun	IC, MC
SSIL	IC, MC, IO, MO
ILSG	MC, IO
SSTR	MC, IO
SGTR	IC, MC, IO, MO

Coffee and tree growth. The experimental area of 3 hectares had mixed use with open areas, coffee, abandoned avocado and brush with unevenly scattered trees. After manual clearing, coffee, trees and temporary shade (*Cajanus* and *Ricinus*) were planted. By year 3 to 4, coffee had reached its maximum height and tree shade was already near or above 40%. Selective pruning was practiced in coffee with increasingly variable plant height across each plot with time. Tree shade was managed around 40-60% through thinning and pruning. Tree diameter continued to increase.

How did coffee-tree combinations evolve during 15 years?

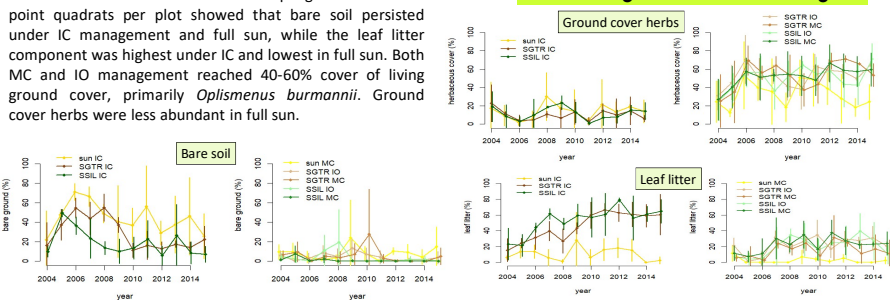


After 2011, coffee production collapsed due to loss of plants, low plant vigor and coffee rust. All tree species reached a diameter of 25cm by 2016. The fotos illustrate the contrasting changes between open sun and trees for leaf litter and ground cover vegetation.

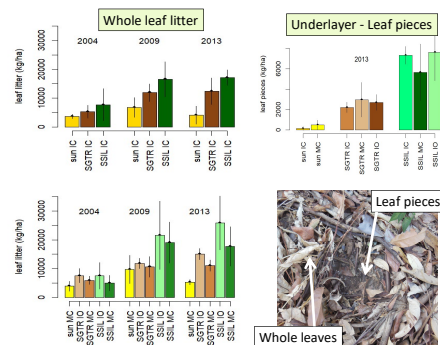
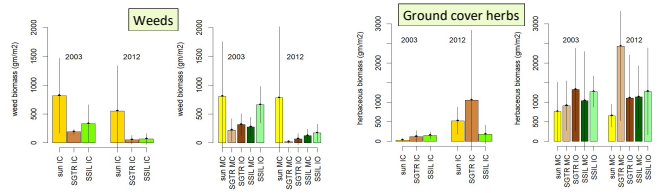


Visual cover estimate. Annual sampling based on 100 point quadrats per plot showed that bare soil persisted under IC management and full sun, while the leaf litter component was highest under IC and lowest in full sun. Both MC and IO management reached 40-60% cover of living ground cover, primarily *Opilismenus burmannii*. Ground cover herbs were less abundant in full sun.

How did ground cover change?



"Weed" biomass. Mid-rainy season sampling just prior to weed management practices in quadrants in and between coffee rows showed that in full sun plots weeds targeted for control were more abundant. These include grasses and broadleaves, both annual and perennial. Trees reduced weed growth compared to full sun. Selective management to favor low-growing, shallow rooted herbs was facilitated by tree presence. Within two years by 2003, biomass of *Opilismenus burmannii* was greater the weed biomass.



How did the O layer develop in 15 years?

Dry season leaf litter. Mid-dry season sampling of the litter layer in and between coffee rows with 4-5 year intervals showed that slight differences began by year 4, but became more marked by year 8. By year 12 treatments with trees had double the layer of full sun treatments. Plots with IL had almost double the whole leaf layer of other tree plots. Broken and partially decomposed leaves were only found with tree plots with IL plots. Plots with IL had more than double the amount of non-IL plots. The accumulated leaf litter contained from less than 100 kg N/ha for full sun and up to 500 kg N/ha for IL plots.

Treatment	% N (0-10cm)	% N (10-20cm)	% OM (0-10)	% OM (10-20)	N content kg/ha	yield/year t/ha coffee	herbicide use l/ha
Sun IC	0.65	0.52	12	10.9	85	7.7	56.2
Sun MC	0.6	0.48	10	9	117	6.1	43.5
SGTR IC	0.66	0.55	11.8	10.6	225	6.4	30.8
SGTR MC	0.71	0.58	12.9	12.2	232	5.7	20.6
SGTR IO	0.65	0.63	13.3	10.6	297	6	0
SSIL IC	0.67	0.56	12.2	10.1	373	5.8	26.3
SSIL MC	0.66	0.49	11.1	10.6	377	5.2	18.8
SSIL IO	0.67	0.6	13	9.7	514	6.3	0

Other ground cover dimensions



Soil OM & N. % N was higher, but more variable, in 2002 than 2010. %OM and N in 2010 was slightly higher in tree plots than full sun plots in 2010.

Coffee yields. Full sun plots had higher average yield over 8 years, in spite of increased leaf litter and %OM/N.

Weed control costs. Herbicide use was >50% higher in full sun compared plots with trees. Selective management for ground cover herbs used 20-30% less herbicide than bare soil mgmt.

Opilismenus burmannii. This low-growing annual grass which prospers in shade also becomes part of the O layer when it flowers and dies off each year in the early dry season. The dry biomass covers the soil and holds leaf litter in place during dry season winds.

Conclusions – should O layer development be a goal?

- Weed management, ground cover and leaf litter are a dynamic component of coffee production systems with implications for costs, biodiversity and soil health.
- Contrasting conditions for the ground cover layer did not generate large differences in crop performance or soil parameters.
- Selective ground cover management and O layer development through leaf litter accumulation provide a low cost pathway to maintain soil-based ecosystem services. *Opilismenus burmannii* was easy to promote as ground cover with useful growth and life cycle traits, although plant species diversity in the ground cover was lost.
- Ideal conditions for ground cover are pictured in the foto with little weedy growth and complete soil cover even during coffee renovation pruning.



Recommendations – methods to study ground cover

Research methods and budget could be improved and enriched in the following areas:

- overall research in ground cover and soil surface dynamics in agroforestry perennial crops;
- quantification of tree and coffee leaf fall and pruning and seasonal decomposition dynamics and nutrient release and interaction with coffee pests and diseases;
- role of quality of tree and ground cover herb leafy material, twigs and small branches in soil health and biology;
- water use and retention for different tree species, pruning regimes and ground cover managements.