SUSTAINABLE COFFEE AGROFORESTRY IN ADVERSE CLIMATIC CONDITION IN NICARAGUA

Padovan, M.P.*; Brook, R.M.; Barrios, M.; Cruz-Castillo, J.B.; Galeano, E.A.V.; Rapidel, B.

*padovan@incaper.es.gov.br

INTRODUCTION

Coffee agroforestry has been considered as a strategic land use to cope with the effects of global climate changes. However, potential competition for water between coffee and shade trees (Padovan et al 2018) and lower coffee yields under shade (Vaast et al 2006) are among the main constraints of agroforestry. Beyond the ecosystems services provided, the shade tree component may be a harvestable crop in its own right (Bertrand et al 2011), but little is published on ecological and economic aspects combined in agroforestry systems.

OBJECTIVE

This investigation analyzed and compared ecological and economic performance of unshaded arabica coffee (NS) and shaded (AFS) by a mixture of evergreen *Simarouba glauca* DC. and deciduous *Tabebuia rosea* Bertol. in adverse climatic conditions.

Fig 1. The Study site.

MATERIAL AND METHODS

The study was carried out during 2012 and 2013, in a 12-year old agroforestry experiment (Fig 1), in sub-optimal coffee growing conditions in Masatepe, southern Nicaragua, Central America (map).

- 27^{0}C mean annual temperature.
- 455 m altitude.
- 1470 mm annual rainfall.
- Six months dry season.

Soil evaporation was measured by using weighing lysimeters (Fig 2) while coffee and tree transpiration by using the Stem Heat Balance – SHB (Fig 3) and the Granier heat dissipation (Fig 4) sap flow methods, respectively. Timber production from 4 shade trees of each species was directly measured (Fig 5). Results were extrapolated by using tree density.

Fig 2. 8 and 7 weighing lysimeters were installed in AFS and NS, respectively.

Fig 3. Sap flow of 4 coffee trees in AFS and NS was measured by using SHB.

Fig 4. Sap flow of 4 trees of each species was measured by using Granier heat dissipation method.

Fig 5. Timber production was measured by using a sample of 4 trees of each species in the plot.

RESULTS

The AFS system was a more efficient water user than NS system. Shade trees had an effect of reducing water loss from soil evaporation by 12% compared to NS which represented more water available for coffee. Transpiration was greater in AFS plots; however, most of the water was transpired by coffee rather than by shade trees or evaporated from the soil (Fig 6).

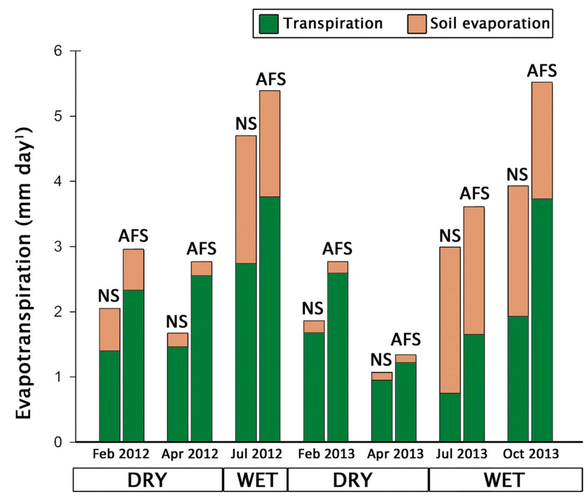

Fig 6. Evapotranspiration (mm day^{-1}) in NS and AFS in the dry and wet seasons from February 2012 to October 2013.

Despite 29% lower coffee production in AFS compared to NS, 13-year old shade trees produced 33.7 m^3 ha^{-1} of timber (US$173 m^{-3} local price) that minimized lower net revenues in AFS (Fig 7). Financial analysis revealed that both systems were financially viable. Agroforestry reached net present value of US$ 5941 by the end of the experiment, cost benefit ratio of 1.7 and internal rate of return of 38% (Table 1).

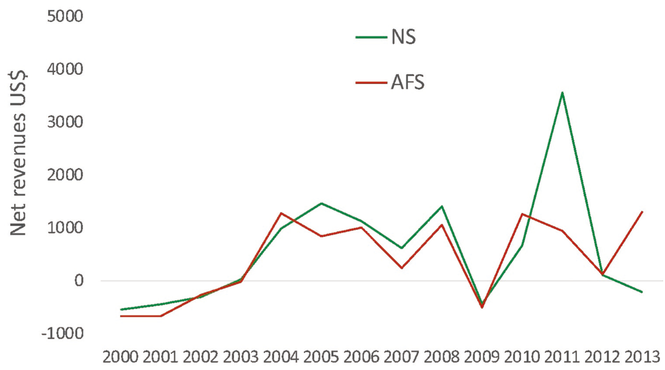

Fig 7. Net revenues in the NS system (coffee) and in the AFS (coffee and timber) in the period of 2000- 2013.

Table 1. Financial analysis in AFS and NS systems over the period of 2000-2013.

	NS	AFS
Incomes	17060	14614
Costs	9034	8673
Net revenue	8026	5941
Discount rate	8.3%	8.3%
Net present value	8026	5941
Cost/benefit ratio	1.9	1.7
Internal rate of return	49%	38%

CONCLUSIONS

- Agroforestry presented better environmental performance saving more water from soil evaporation with more biomass production compared to NS system.

- The lower coffee yield in AFS was minimized by timber production by the end of the experiment.

- Ecological advantages and economic viability found in the shade may encourage coffee farmers for agroforestry adoption in such sub optimal coffee growing condition.

REFERENCES

- Bertrand,B.; Alpizar,E.; Lara,L.; SantaCreo,R.; Hidalgo,M.; Quijano,J.M.; Montagnon,C.; Georget,F.; Etienne,H. 2011. Performance of Coffea arabica F1 hybrids in agroforestry and full-sun cropping systems in comparison with American pure line cultivars. Euphytica, 181:147-158.
- Padovan,M.P.; Brook,R.M.; Barrios,M.; Cruz-Catillo,J.B.; Vilchez,S.J.; Costa,A.N.; Rapidel,B. 2018. Water loss by transpiration and soil evaporation in coffee shaded by *Tabebuia rosea* Bertol. and *Simarouba glauca* dc. compared to unshaded coffee in sub-optimal environmental conditions. Agric. and For. Met. 248: 1-14.
- Vaast,P.; Bertrand,B.; Perriot,J.J.; Guyot,B.; Genard,M. 2006. Fruit thinning and shade improve bean characteristics and beverage quality of coffee (*Coffea arabica* L.) under optimal conditions. J Sci Food Agric 86:197-204.

ACKNOWLEDGEMENTS: We are grateful to FONTAGRO Caf'Adapt project, CIRAD and INCAPER who funded this research.