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Proceedings
of the

20th Nitrogen WORKSHOP

"Coupling C - N - P - S cycles"

June 25-27, 2018

Rennes, France
Couvent des Jacobins
Conference Centre

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SHADE TREE SPECIES IMPACTS ON SOIL FAUNA AND C, N, P CYCLES IN COSTA RICAN ORGANIC AND CONVENTIONAL COFFEE AGROFORESTRY SYSTEMS

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INTRODUCTION

Coffee is a major export product for developing countries that provides the livelihoods of tens millions of people (Pendergrast, 2009). Coffee is traditionally grown under shade trees to decrease physiological stress and provide additional services to the farmers as food or material supply (fruit trees, timber trees) (Tscharntke et al., 2011). However, agricultural intensification in Central America led to conversion of shaded to unshaded coffee systems to increase short-term income, but may have direct consequences on soil biological fertility (Perfecto et al., 2007). An important stake nowadays is to find the right compromise between decent yields and synthetic inputs reduction through promotion of soil biological activity.

Our objective was thus to determine how two common shade trees in coffee agrosystems, *Terminalia amazonia* and *Erythrina poeppigiana*, would impact on soil C, N, P cycling in association with soil fauna.

MATERIAL AND METHODS

We worked in an experimental site from Turrialba (Costa Rica), where various management levels and shade tree associations in coffee plantation were continuously compared since 2000 (Haggar et al., 2011). We compared in August 2017 soil fertility from two management levels (organic and conventional, Table 1), both management being declined in three shade trees association: unshaded, shaded by *Terminalia amazonia* (timber tree), shaded by *Erythrina poepiggiana* (N_2-fixing service tree).

Table 1: Organic and conventional system annual management.

	Organic	Conventional
Fertilization	5 t ha^{-1} coffee pulp: 66 kg N ha^{-1}, 2 kg P ha^{-1}, 44 kg K ha^{-1}	Mineral fertilizers: 150 kg N ha^{-1}, 10 kg P ha^{-1}, 75 kg K ha^{-1}
Phytosanitary Control	Regular mowing	5 Herbicides applications 1-4 fungicides/insecticides as required

Total C, total N, inorganic N and Olsen P contents, along with pH (H_2O) were analyzed on the top soil layer (0-10 cm) in August 2017. A bioassay (biomass production of maize in pots for 45 days) was done from each combination of management and shade trees associations. Soil nematodes and microarthropods communities were extracted, counted, identified and separated into functional groups.

RESULTS AND DISCUSSION

Shade tree impacts on soil fertility depended on tree- species. The association with *Erythrina* increased soil inorganic N content and bioassay (Fig. 1a), but not Olsen P. *Terminalia* impacts depended more on the system management. Moreover, association with shade trees had higher impacts on soil fauna than on soil fertility, with a large increase of its density and diversity compared to the unshaded systems excepted under *Terminalia* in organic system (Fig. 1b). *Erythrina* had higher positive effects on soil fauna (both for density and diversity) than *Terminalia.* Specific relationships between soil community structure and soil fertility were studied in this work and

showed positive correlation of nematodes functional groups with soil inorganic N content, while soil Olsen P was more linked to detritivores diversity.

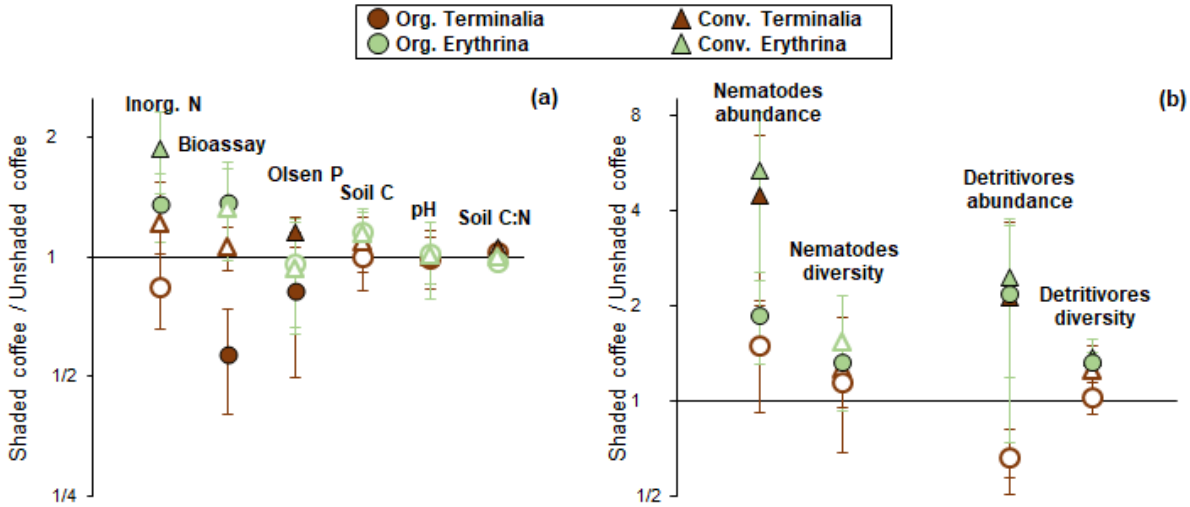

Figure 1. Shade tree impacts on soil fertility (a) and fauna (b). Non-significant data (P-Value > 0.05) were tested by ANOVAs and are represented with hollow symbols. Fauna diversity was represented with Shannon index calculated at respectively the genera (nematodes) and morphotype (detritivores) levels. Ratios between shaded and unshaded coffee are represented in the Y-axis with a log-2 scale. Detritivores: collembola and oribatid mites.

CONCLUSION

Our results underscore the importance of associated shade trees in soil biological properties and in fertility of coffee systems. Part of the shade tree impacts on soil fertility were balanced by fertilizers addition in the conventional system, yet soil fauna mirrored well soil biogeochemical changes in both systems, underlining the potential of using fauna functional groups as indicators of soil biological fertility.

Acknowledgements: The present work was funded by Agropolis foundation with STRADIV project (n° 1504-003). The authors thank Victor Hugo Mendez Sanabria, Patricia Leandro, Nancy Rakotondrazafy, Najat Talha, Jean Larvy-Delarivière and Jean-Marc Souquet for their help with soil sampling and analyses.

REFERENCES

Haggar, J., Barrios, M., Bolaños, M., Merlo, M., Moraga, P., Munguia, R., Ponce, A., Romero, S., Soto, G., Staver, C., Virginio, E. de M.F., 2011. Coffee agroecosystem performance under full sun, shade, conventional and organic management regimes in Central America. Agroforestry Systems 82, 285–301.

Pendergrast, M., 2009. Coffee second only to oil? Is coffee really the second largest commodity? Tea & Coffee Trade Journal.

Perfecto, I., Armbrecht, I., Philpott, S.M., Soto-Pinto, L., Dietsch, T.V., 2007. Shaded coffee and the stability of rainforest margins in northern Latin America. In: Stability of Tropical Rainforest Margins, Environmental Science and Engineering. Springer, Berlin, Heidelberg, pp. 225–261.

Tscharntke, T., Clough, Y., Bhagwat, S.A., Buchori, D., Faust, H., Hertel, D., Hölscher, D., Juhrbandt, J., Kessler, M., Perfecto, I., Scherber, C., Schroth, G., Veldkamp, E., Wanger, T.C., 2011. Multifunctional shade-tree management in tropical agroforestry landscapes – a review. Journal of Applied Ecology 48, 619–629.