Shade canopy diversity in coffee plantations at Turrialba, Costa Rica

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Introduction

There is a great diversity in the botanical composition and the vertical, horizontal, and temporal structure of shade canopies in coffee plantations. Coffee systems have been studied in Costa Rica (Espinoza, 1983), Mexico (Jiménez, 1979), Venezuela (Escalante et al., 1987) and other countries. Some environmental and socio-economic conditions determine the structure and diversity of the coffee plantations. In this study a methodology to typify coffee farms was developed, identifying the socio-economic and biophysical factors that determine the diversity of shade canopy in the coffee plantations of Turrialba, Costa Rica. This methodology will be used to analyse coffee plantations in Central America.

Materials and Methods

The study was carried out in 29 farms. The following five types of shade were identified based on the observed composition of the shade canopy (*a priori classification)*: only shade components, shade-timber components, shade-*Musa* spp., plantation fruit trees, and mixed shade. At least four farms for each type of shade were selected for study. Socio-economic and biophysical information was gathered by interviews and mensuration of temporary plots (50 x 20 m) in selected locations of the coffee plantations. The information was analysed by means of three different procedures (Table 1). Multivariate techniques included discriminant analysis and canonical discriminant analysis.

Table 1. Procedures of information analysis

Procedure No.	Method of variable selection	Method of classification
1	None	*a priori*
2	None	Cluster analysis
3	Principal component analysis	Cluster analysis

Results

Methodology in order to determine typologies

The best procedure in order to determine the typology of the farms was the third one (Table 2).

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Table 2. Canonical discriminant analysis [canonical variables (CAN)]

Procedure	CEE (%)	CAN	Canonical correlation	Eigenvalue	Cumulative proportion
		1	0.997$^{n.s.}$	186.81	0.70
1	79	2	0.992$^{n.s}$	65.14	0.94
		3	0.961$^{n.s}$	12.12	0.98
		4	0.899$^{n.s}$	4.22	1.00
		1	0.998*	305.89	0.89
2	66	2	0.981$^{n.s}$	26.51	0.96
		3	0.962$^{n.s}$	12.56	1.00
		1	0.929***	6.33	0.47
3	19	2	0.902**	4.37	0.80
		3	0.856*	2.73	1.00

CEE: Count error estimate
$^{n.s.}$ non significant
* significant ($P < 0.05$)
** significant ($P < 0.01$)
*** significant ($P < 0.0001$)

The best explanatory variables are related to shade canopy diversity (richness and abundance of shade components) and coffee management intensity (total cost per hectare, coffee yield, and cost and quantity of fertiliser).

Typology of farms
Four coffee farm types were identified: 1) low diversity and intensively managed coffee plantations, 2) highly diversified and intensively managed coffee plantations, 3) highly diversified coffee plantations with medium management intensity, and 4) poorly managed coffee plantations (Table 3).

Table 3. Means of selected variables per farm type

Group	Abundance (shade plants ha^{-1})	Richness (Number of shade components)	Cost (US$ ha^{-1} year^{-1}†)	Income (US$ ha^{-1} year^{-1}†)	Yield (fanegas‡ ha^{-1} year^{-1})	Fertilisers (kg ha^{-1} year^{-1})
1	350	1.5	1815	2073	41	1099
2	680	3.3	1446	969	25	1423
3	510	5.0	1073	1465	26	318
4	280	2.0	765	588	14	390

† 1 US$ = 260 colones
‡ 1 fanega = 400 lt of coffee cherry = 258 kg of coffee cherry = 46 kg of green coffee

Discussion

Shade canopy diversity in the study area is more related to socioeconomic factors than to biophysical ones. Low management intensity is associated to high diversity and viceversa, in agreement with studies in other regions (Espinoza 1983, 1986; Lagemann and Heuveldop 1983; Villatoro 1986; Escalante *et al.* 1987). Small farms diversify at the level of the coffee plantation (diverse composition in shade canopy) whereas big ones diversify at the farm level (different

activities in separate areas). Unlike coffee plantations in Mexico where several species of *Inga* are used for shade (Jiménez, 1979; Gallina *et al.*, 1996) only one shade species (*Erythrina poeppigiana)* is used in Turrialba. Numerous timber shade species are used as shade in Ecuador (Peck and Bishop, 1992) whereas only *Cordia alliodora* is used in the study region, most times as a second storey over *E. poeppigiana*. (Somarriba 1990; Beer 1995).

Conclusions

Farm socio-economic conditions affect the composition of the shade canopy in the studied coffee plantations. Diversity decreased as coffee management intensity and farm size increased. Small farms diversify at the level of shade canopy and big ones at the farm level (different crops in different areas).

Principal component analysis to select the most explanatory variables followed by cluster analysis and canonical discriminant analysis is recommended for the study of farm typologies in the study area. Four farm types were identified, based on the diversity of the shade canopy and the level of coffee management intensity.

References

Beer, J. 1995. Efectos de los árboles de sombra sobre la sostenibilidad de un cafetal. Boletín PROMECAFE 68: 13-18.

Escalante F., E.E., Aguilar R., A. and Lugo P., R. 1987. Identificación, evaluación y distribución espacial de especies utilizadas como sombra en sistemas tradicionales de café (*Coffea arabica*) en dos zonas del estado Trujillo, Venezuela. *Venezuela Forestal* 3(11): 50-62.

Espinoza P., L. 1983. Estructura general de cafetales de pequeños agricultores. *In*: Heuveldop, J. y Espinoza, L. (eds.). El componente arbóreo en Acosta-Puriscal, Costa Rica. CATIE, Turrialba, Costa Rica. pp. 72-84.

Espinoza P., L. 1986. El componente arbóreo en el sistema agroforestal "cafetal arbolado" en Costa Rica. *El Chasqui* No. 12: 17-22.

Gallina, S.; Mandujano, S. and González-Romero, A. 1996. Conservation of mammalian biodiversity in coffee plantations of Central Veracruz, Mexico. *Agroforestry Systems* 33: 13-27.

Jiménez, E. 1979. Estudios ecológicos del agroecosistema cafetalero. I. Estructura de los cafetales de una finca cafetalera en Coatepec, Ver., México. *Biotica* 4(1): 1-12.

Lagemann, J. and Heuveldop, J. 1983. Characterization and evaluation of agroforestry systems: the case of Acosta-Puriscal, Costa Rica. *Agroforestry Systems* 1: 101-115.

Peck, R.B. and Bishop, J.P. 1992. Management of secondary tree species in agroforestry systems to improve production sustainability in Amazonian Ecuador. *Agroforestry Systems* 17: 53-63.

Somarriba, E. 1990. Sustainable timber production from uneven-aged shade stands of *Cordia alliodora* in small coffee farms. *Agroforestry Systems* 10: 253-263.

Villatoro P., R.M. 1986. Caracterización del sistema agroforestal café-especies arbóreas en la cuenca del Río Achiguate, Guatemala. Tesis Profesional. Facultad de Agronomía, Universidad de San Carlos de Guatemala. Guatemala. 153 p.