BANANAS IN COFFEE AGROFORESTRY IN LATIN AMERICA: ASSESSING ECOLOGICAL AND SOCIO-ECONOMIC BENEFITS

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SUMMARY
Bananas are commonly grown by small coffee growers in shaded coffee fields throughout Latin America. Coffee technicians advise small coffee growers against planting bananas in their coffee fields. We analyzed the results from a study in seven sites in Central and South America to assess the costs and benefits of bananas in shaded coffee. Does the presence of banana reduce the availability of light, nutrients and water for coffee below crop requirements? Does banana increase soil pest problems for coffee? Do bananas increase labor costs for coffee production? Does labor invested in banana provide better returns than if the same labor were invested in coffee? Results showed that banana with coffee is useful for reducing coffee production costs through weed suppression, low cost, easy shade management with quick shade recovery and improved soil health and conservation. The income generated by banana covers household expenses and routine coffee management practices after coffee income has been spent. The major drawback from banana production in coffee is the increased potassium use. The analysis points to the need for additional studies on the marginal returns to alternative investments in coffee or tree management, external inputs and diversification.

INTRODUCTION
Bananas are commonly grown by small coffee growers in shaded coffee fields throughout Latin America, occupying over a half million hectares in Mesoamerica, the Caribbean and South America [1]. Coffee technicians, focusing on coffee modernization, advice small coffee growers to eliminate bananas from their coffee fields, proposing that bananas generate excess shade, compete for nutrients and water, increase nematode problems for coffee, and cause damage to coffee bushes during banana harvest. Given that the practice is widespread, further analysis is merited to orient programs with smallholders. Does the presence of banana reduce the availability of light, nutrients and water for coffee below crop requirements? Does banana increase soil pest problems for coffee? Do bananas increase labor costs for coffee production? Does labor invested in banana provide better returns than if the same labor were invested in coffee? Mixed cocoa agroforestry, for example, had greater productivity through economies of scope, since associated crops shared production costs and provided additional income [2].

MATERIALS AND METHODS
We analyzed the results from our grant focused on small farmer strategies to improve the productivity and value of banana in shaded coffee to assess the agroecological and socioeconomic costs and benefits of bananas in this system. In six sites in Honduras, Nicaragua, Costa Rica and Peru we surveyed 30 shaded coffee plots with banana in each country to characterize coffee, banana and tree density and estimate light partitioning. In meetings with farmer experimentation groups during 2010-2012, we collected and analyzed data on labor and input costs and income with farmers. Studies were also conducted on the effects of the presence of banana on nematodes in different combinations of coffee and trees.

RESULTS

Do bananas reduce the availability of light, water and nutrients?

Coffee density was quite uniform across sites from 3500-5000 plants/ha, while banana ranged from 288 to more than 500 mats/ha and trees from 161 to more than 500/ha. Light reaching coffee in these multi-strata systems was generally below 50%, averaging between 29 and 49% in the different zones (Table 1). Visual estimates suggested that banana intercepted between 11 and 32% of total light for 5 zones with one zone at 50% interception. Light interception by the tree strata was more variable between 16 and 53% [3]. In most plots sampled, coffee received less than adequate light for good production, but tree shade was often much higher than banana shade. In addition, tree pruning was infrequent and minimal in four of the sites.

Table 1: Light availability to crops in substrata (% open sun) and % substrata crops shaded by upper strata

	Costa Rica	Honduras		Nicaragua		Peru
	Turrialba	Laureles	Tutule	Yasica	Monterrey	Selva Central
% light to coffee	46 ±3	36 ±4	34 ±3	49 ±6	41 ±5	39 ±2
% light to banana	68 ±2	68 ±3	84 ±2	79 ±4	52 ±7	50 ±2
% coffee plants with banana leaves above	61 ±5	47 ±5	64 ±8	61 ±6	60 ±3	56 ±4
% banana mats with trees above	38 ±5	66 ±4	54 ±8	38 ±6	55 ±4	73 ±7

Calculations of nutrient export in banana and coffee indicated that farmers had a positive balance for nitrogen, but were negative for potassium (Table 2). The production of 300 20 kg bunches/year/ha, the potential yield from bananas at a density representing about 15-20% light interception, increases potassium export by 30 kg/ha/year, equal to potassium in 11 hundredweights of green coffee.

Table 2: Nutrient balance for 5 growers – Nutrients (N, K) in coffee, banana and firewood taken off field were subtracted from nutrients added through organic and chemical fertilizer to yield balance for N and K

Grower	Coffee sacks/ha	bunches banana/ha	Wood kg/ha	Nutrients export kg/ha				Nutrients applied kg/ha		Nutrient balance kg/ha	
				coffee		Banana					
				N	K	N	K	N	K	N	K
R T	30	160	0	87	87	5	17	120	30	28	(-74)
J S	12	0	500	35	35	0	0	32	9	(-4)	(-26)
W T	6	200	500	17	17	6	21	52	0	27	(-39)
M A	26	90	800	75	75	3	10	102	18	22	(-67)
I R	23	120	350	67	67	4	13	77	23	6	(-57)

Studies on water use were not conducted, but data on stomatal conductance showed higher rates for banana than coffee or legume trees (*Erythrina, Inga*) at field capacity. Banana is a water conserving crop under water stress conditions. Stomata close when soil water drops to -0.10 to -0.20MPa, well above levels for coffee at -.50 to -1.0MPa [4].

Do bananas increase soil pest problems for coffee?

Banana and coffee suffer from several plant parasitic nematodes – *Meloidogyne*, *Pratylenchus* and *Heticotylenchus*. A study comparing different combinations of banana, coffee and trees showed that the presence of banana is not associated with higher plant parasitic nematodes in coffee [5]. *Meloidogyne* nematodes in coffee roots, the most common genus found in the study, were lower in the presence of banana (Table 3). Nematode levels of these three genera

in coffee and banana were linked significantly to different soil physical and chemical parameters, suggesting that different nematode species or subpopulations may be involved. This response may have been mediated through the presence of free living nematodes stimulated by greater organic matter inputs in the presence of bananas which in turn contributed to altered predator – prey ratios [4]. Banana and tree plots had greater amounts of ground cover litter followed by coffee with bananas or trees and coffee alone (Table 3).

Table 3: Leaf litter and nematodes in different combinations of coffee, banana and trees in Monterrey, Nicaragua

	Coffee – banana - legume	Coffee – banana	Coffee – legume	Coffee
Shade %	78 ± 2 b	64 ± 4 a	71 ± 3 b	0
Total leaf litter g/40 cm^2	125 ± 10 d	72 ± 7 b	83 ± 8 c	35 ± 5 a
Leaf litter banana g/40 cm^2	37 ± 4 a	45 ± 22 a	-	-
Leaf litter coffee g/40 cm^2	35 ± 5 a	28 ± 4 a	34 ± 4 a	33 ± 5 a
Leaf litter trees g/40 cm^2	53 ± 5 a	-	48 ± 4 a	-
Meloidogyne nematodes /100 gs coffee roots	2843 a	2586 a	3429 b	2914 b
Metabolic footprint ratio predators/objective prey	44 ± 8.6 a	18 ±8.4 b	29 ±8.2 ab	40 ± 8.2 a

Do bananas increase labor costs for coffee production?

While coffee technicians sometimes suggest that smallholders do not manage their banana, from zone to zone and farm to farm the average number of tall banana stems for fields in the different zones varies from 1.2 to 3/mat and total stems from 2.2 to 4.3/mat. Within zone variability is much higher with some growers as high as 6-7 total stems/mat, a level suggesting little mat management. The banana component absorbs between 15-40 work days/hectare which is approximately 12% of total production costs/ha. Deleafing and desuckering represent between 52-66% of the labor costs for banana, without including harvest costs. Other routine practices include cutting down and chopping up harvested stems and planting and replanting new plants to fill gaps or replace unproductive mats. Some growers debud and dehand the bunch to increase finger size, but these practices are not widely adopted. Practices such as deleafing and desuckering are often done during weeding which increases the total weeding cost. However, other farmers weed and then separately carry out banana mat management. Farmers agreed that the presence of banana reduces the cost of weeding compared to coffee without banana for numerous reasons (Table 4). Bananas provide additional crop residues which protect the soil and reduce weed growth. Bananas provide shade which is rapid to establish, rapid to recover after leaf pruning and stem cutting and easy to manage from the ground. Weeding makes up nearly 50% of labor used in coffee production, increasing the value of bananas in cost reduction.

Does labor invested in banana or coffee provide better returns?

The available data do not permit an analysis of marginal returns for redistributing labor among banana or coffee either at the field or the household level. Gross income from bananas ranged from $USD200-450 or the value of 1-3 hundredweights of green coffee, with minimal purchased input cost, about $10-12 gross return per day of labor. A day of labor in coffee generated 0.3 – 1.1 qq coffee depending on the zone with an additional investment of 0.2 – 0.6 qq fertilizer/qq coffee. Given the flexible labor scheduling of banana management throughout the year, the shifting labor from banana to coffee may not compensate the loss of banana income with increased coffee yields. In addition, the income from banana is monthly, taking on a greater importance, according to farmers, when coffee income has run out, 3-4 months after the harvest. Data on monthly banana sales indicated that sales were higher during the period once coffee income was no longer available.

Table 4: banana production practices - Labor use and possible effects on coffee

Banana production practices	Average person days/ha	Possible effects on coffee labor costs	Possible effects on coffee productivity
Planting/replanting	3	Reduce weeding costs	Banana spacing linked to shade % / distribution
Chopping down / cutting up harvested/fallen stems	4	Reduce weeding costs	Banana crop residues protect soil /improve structure
Desuckering	2	Ensure adequate banana spacing	Number stems/mat linked to shade %/distribution
Deleafing	8	Reduce weeding costs	Banana leaf number linked to shade %
Deflowering	3	None	None
Banana harvest	12	None	None
Total days/ha	32	Higher banana costs reduce coffee costs	Higher banana costs ensure coffee productivity

Conclusions

Banana intercropped with shaded coffee, as currently practiced by millions of smallholder coffee growers in Latin America, plays a useful role in reducing the costs of coffee production through weed suppression and providing a shade management practice which is low cost, easy and with a quick response time. The income generated by banana covers household expenses and routine coffee management practices after coffee income has been spent. Adequate tree pruning and appropriate banana spacing with timely desuckering and replanting of bananas should ensure adequate sunlight for coffee production. The major drawback from banana production in coffee fields is the increased demand for potassium, also an important element in coffee production. This analysis of bananas in coffee agroforestry points to the need for additional studies on the marginal returns to alternative investments in coffee or tree management, external inputs or diversification to guide farmer decision-making for greater returns, lower risks and improved household resilience.

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