

Comparing productivity and profitability of agroforests and monocultures in Bolivia

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Abstract

The global demand for cacao has increased. To meet this demand, the cultivated area has been expanded in tropical forest areas and production has intensified by replacing traditional agroforestry systems with monocultures. This has led to a loss of biodiversity in cacao growing areas. The implementation of more sustainable agricultural practices for cacao production such as organic farming and agroforestry systems depends on the profitability of such practices for the farmers.

In this study, the productivity and profitability of agroforestry and full-sun monocultures (with 2 years of temporary shade with plantains) under organic and conventional farming are compared for the first five years of a newly established long-term trial in Alto Beni, Bolivia. Cacao and by-crops (plantain/banana) yields, costs, revenues, and labour demand were registered, and the return on labour, i.e. the return per working day, were estimated for each system.

The results showed that yields of cacao were about 40% higher in the monocultures compared to the agroforestry systems. But the revenues derived from the sales of banana and plantains economically overcompensate for this difference. So, the return on labour across the years was roughly twice as high in the agroforestry systems compared to the monocultures, even though agroforestry systems were more work demanding than monocultures, mainly because the time needed to manage the shade trees. Efforts for developing and making markets accessible for the farmers to sale by-crops such as bananas or plantains is then capital to ensure the profitability of the agroforestry systems.

Comparing organic and conventional management, cacao yields and return on labour were similar under both managements in the agroforestry systems. But in the monocultures, cacao yields were nearly 50% lower under organic farming. However, the return on labour was similar. This was mainly due to the lower cost of the organic management. These might have a strong implication for smallholder farmers, who usually hold limited savings and lack of access to credit. In addition, organic management was not more work demanding than conventional management.

Introduction

Over the last decades the global demand for cacao (*Theobroma cacao* L.) has drastically increased (Vast and Somarriba 2014). The cultivated area has been expanded in tropical forest areas and production has been intensified by replacing traditional agroforestry systems with full-sun monocultures at high-input levels. To guarantee a further extension of more sustainable agricultural practices such as agroforestry systems and organic management, such systems need to be profitable for the farmers.

In this study we compare the agronomic and economic performance of four different cacao production systems, i.e. agroforestry and full-sun monocultures under organic and conventional management during the first five years of a newly established field trial. Cacao and by-crops (plantain/banana) yields, costs, revenues, and labour demand were registered, and the return on labour, i.e. the return per working day, were estimated for each system.

Material and methods

The experimental trial was located in Sara Ana (390 m a.s.l.), Alto Beni, in the department of La Paz, Bolivia. The climate is tropical humid with dry winters; the average annual precipitation and temperature are approximately 1'540 mm and 26.6 °C, respectively. The soils are Luvisol and Lixisols. The natural vegetation is composed of nearly evergreen humid forests.

The establishment of the plantation finished at the beginning of 2009. From 2010 to 2014 the productivity and profitability of the 4 different production systems were assessed. Cacao tree spacing was 4 m × 4 m. In the agroforestry systems, cacao trees were complemented by timber, palm and leguminous trees. Plantain was planted in both monocultures and agroforestry systems as temporary shade for the cacao trees, but they were removed at the end of 2011 in the monocultures and replaced by banana trees in the agroforestry systems, according to local practices (Schneider et al. 2016).

The organically managed systems followed the EU regulations. A perennial legume cover crop was sown. Compost was used as fertilizer and weeding was done manually and with brushcutters. In the conventional managed systems, mineral fertilizer was applied and weeding was done by means of both herbicides and manual weeding and brushcutters. Due to the low pressure of pests and diseases, no chemical pesticides were used. Manual control was done when necessary.

The annual yield of cacao and banana and plantain was calculated as the sum of all of the single harvests. Revenues derived from cacao were calculated for each year using annual average sales prices of each category of beans: first-quality conventional beans (average price across years \pm SE: 20.95 ± 2.75 Bs Kg⁻¹), second-quality conventional beans (11.93 ± 0.93 Bs Kg⁻¹), and organic beans (23.99 ± 2.25 Bs Kg⁻¹). Bananas and plantains were sold as conventional produces due to the lack of access to organic market. The exchange rate of one US dollar and Euro to Bs is about 6.8 and 7.5, respectively.

The cost calculation included the costs of tools and materials for pruning, weeding, fertilizing and in the organically managed systems, the cost of certification. The transport costs for purchasing the materials were also considered.

The working time devoted to each single agronomic activity in the field was registered. Additionally, the working time of the activities performed outside the plots was also considered, such as the compost preparation, herbicide applications preparation, cacao and banana post-harvest process and purchasing tools and materials. The return on labour, i.e., the benefit per 8 hours' labour, was calculated by dividing the annual gross margin (revenues minus costs) by the total annual working days.

Results

The cumulative cacao yields were higher in the monocultures compared with the agroforestry systems (Figure 1). No differences were found between organic and conventional management in the agroforestry systems, but higher yields were obtained under conventional management in the monocultures. As expected, the agroforestry systems achieved higher plantain/banana yields across the years, since plantains were replaced by banana trees only in the agroforestry systems.

The sales of banana of the agroforestry systems economically compensated for the difference in cacao yield between agroforestry and monoculture systems, which highlights the role of by-crops to the contribution to farmer's income during the establishment phase of the cacao plantation (Figure 1). The costs were lower in the agroforestry systems and also under organic management.

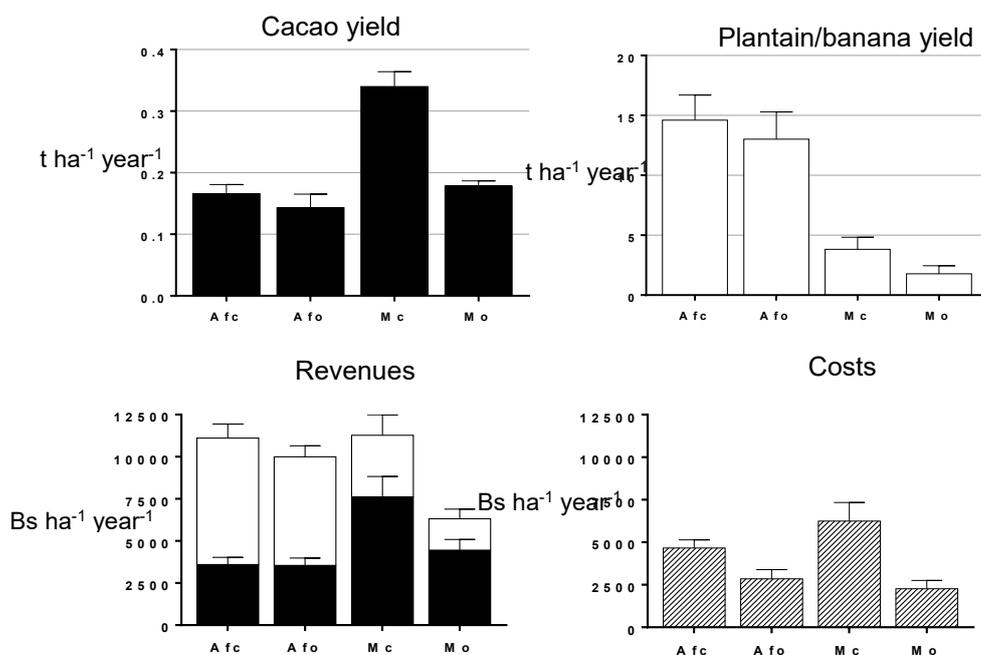


Figure 1. Mean (\pm SE) cacao and plantain/banana yields, revenues from cacao (in black) and plantain/banana (in white) sales and total costs per ha and year for the different production systems: Afc: agroforestry conventional, Afo: agroforestry organic, Mc: monoculture conventional and Mo: monoculture organic.

Agroforestry systems were more work demanding than the monocultures (Figure 2). However, no differences in the total working time between organic and conventional management were detected in the monocultures. This result contrasts those of previous studies claiming that organic farming is more laborious than conventional farming (Jansen 2000). In the case of the agroforestry, conventional management was less work demanding, but only because of the lower time spent for applying synthetic fertilizer compared with the compost under organic farming.

Overall, the return on labour was almost the double in the agroforestry systems (Figure 2). This is explained by the fact that the working time was an average of 16 % higher in the agroforestry systems; on the other hand, the gross margin was, on average, 51 % higher compared with the monocultures.

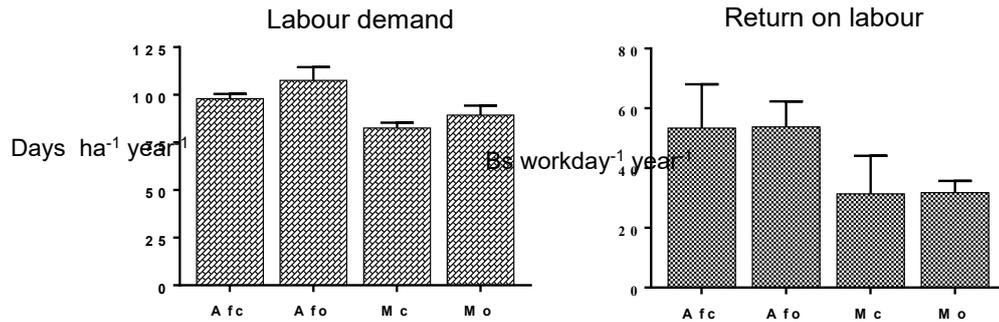


Figure 2. Mean (\pm SE) working days per ha and year and return on labour for the different production systems: Afc: agroforestry conventional, Afo: agroforestry organic, Mc: monoculture conventional and Mo: monoculture organic.

Discussion

Premium prices for organic cacao did not compensate for the yield gap between the organically managed monocultures compared with the conventionally managed. The premium prices obtained on organic cacao were lower than the often reported premium gain (Crowder and Reganold 2015). Even though both the yields and the revenues of cacao were higher in the monocultures, the revenues obtained from the sales of plantain/banana in the agroforestry systems overcompensated for the lower cacao revenues. Indeed, plantains and bananas were not sold as organic products because of the lack of access to the organic market. The lower costs in the agroforestry systems were due to the lower cost of the fertilizer and weeding, related to the lower presence of weeds in the agroforestry systems. When comparing organic and conventionally managed systems, the costs were higher under conventional management because of the higher cost of synthetic fertilizers. The lower costs in the agroforestry and organic systems may have a strong implication for smallholder farmers, as they usually hold limited savings and access to credits.

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