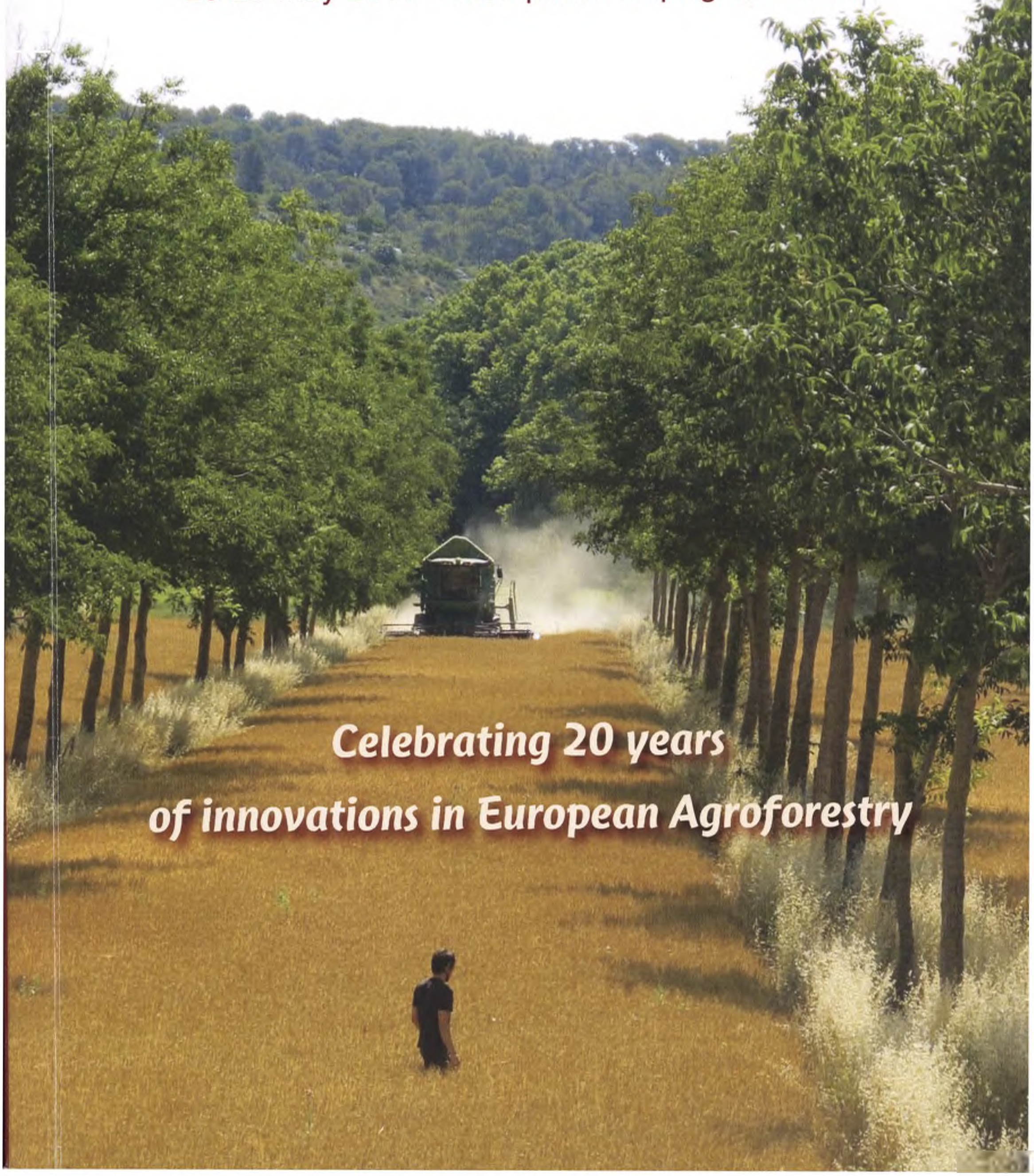
Book of Abstracts

3rd European AGROFORESTRY Conference 2016

23-25 May 2016 – Montpellier SupAgro, France



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EUROPEAN AGROFORESTRY FEDERATION

3rd European Agroforestry Conference

Celebrating 20 years of Agroforestry research in Europe

Montpellier, France, 23-25 May 2016

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EFFECT OF PLANT DIVERSITY ON THE GLOBAL PRODUCTIVITY OF AGROFORESTRY SYSTEMS IN TALAMANCA COSTA RICA

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Introduction

The relative effect of plants diversity on the performance of the agroforestry systems was studied under a range of farms in Talamanca, Costa Rica. The evaluation of multi-species cropping systems is a major issue to understand complex agroforestry systems. The evaluation of the systems will help to understand the advantages of use of resources in spatial and temporal scale.
In the region of Talamanca in Costa Rica, cropping systems are highly diversified and most are multi-strata with trees. These systems are an inherent part of the life of the indigenous Bribris and Cabecar, and tend to mimic the forest both in structure and in usage of species. The association of species follows ancestral rules linked to their functional role (Borge 2011). Most common associations consist in cocoa (*Theobroma cacao L.*) combined with shade trees, such as laurel (*Cordia alliodora* Ruiz & Pav.) or cedar (*Cedrela odorata* L.) from remnants of forest, selected from natural regeneration or planted. Organic banana (*Musa* spp. AAA) is an important crop for farmers, sharing the canopy with fruit species such as citrus (*Citrus* spp.), avocado (*Persea americana* Mill.) and peach palm (*Bactris gasipaes* Kunth), and farmers claim that fruit trees are well grow within the cacao and banana plantation to establish home orchards. Some other species such as jicaro (*Crescentia cujete* L.) and senko (*Carludovica palmata* Ruiz & Pav.) are used for craft while guava (Inga sp) and turkey tail (*Cupania cinerea* Poepp.) are used for firewood and other environment services that the system gives as a whole.
The evaluation of the global productivity is challenging because of the diversity of the products the system provides. In this study, we propose to standardize the measurement of the productivity of each type of plant and to measure it dynamically. We aim at testing the effect of plant diversity and of spatial structure of agroforestry systems on their agronomic performances.

Materials and methods

Experimental site
We studied a network of 20 plots (30m x 30m) that cover a wide range of diversity and spatial organization of agroforestry systems in Talamanca region. All sampled farms had organic management and our measures did not cause any change in farm practices. We measured the growth and the biomass of each plant during two years. Species were identified for each plant and coordinates were registered, leading to a dataset including 2287 plants. All the plants present in the plots were tagged with a unique code, allowing multiple measures over time.

Measures of production
Plant composition was classified in five functional groups according to the farmer's management, taxonomic criteria, and functions in the system. These groups were banana, cacao, fruits, timber, and firewood. Measured productivity methods change according to the group.

For bananas, we measured pseudostem circumference of the mother plant (one meter above of the ground level) and heights of the sucker plants. Using allometric relationships, we estimated the potential of vegetative and fruit production of each banana plant (Fernandez, E & Garcia, V 1972). In addition, we measured the weight of bunches and counted numbers of fruits.
For cacao, before harvest, healthy and damaged pods were recorded and fresh beans from healthy pods were weighted. We applied a 56% discount to the average weight of fresh beans per pod to obtain the dry cocoa commercial yield according to Braudeau cited by Deheuvels et al. (2012).
For every timber plant, total height, commercial height and DBH (diameter at breast height) was measured, using a hypsometer and diametric tape. Cubic meters of wood was calculated based on empirical relations, reported by Almendarez, Orozco, & Lopez (2013) and with a form factor of 0.7 for timber species and 0.5 for firewood species.
Fruit production was calculated for each plant using theoretical values reported in the literature; notably from studies carried out in the same region (Burgos, Armero & Somarriba, 2008).

Statistical analyses
Generalized linear mixed-effects models (GLMM, Bolker et al., 2009) were used to examine the relationship between plant diversity, spatial structure indices, and production of agroforestry systems. We considered the community' in which plot were located as a random effect. All statistical analyses were performed with R 2.15.0 (R Development Core Team 2012) and with an alpha level of 0.05.

Results and discussion

Productivity
For statistical analysis, the AFS production was grouped into five crop categories with different species richness: cacao, banana, fruits, timber and firewood. The timber group had the highest biomass, while banana had the lowest (**Figure 1A**), while the same trend can also be applied to the representation of the canopy multi strata.Total biomass and plant densities were calculated, but the results for productivity (**Figure 1B**) were estimated according to each group production considerations (Kg, m^3, units ha^{-1}).

Five of the sample plots exceeded 167 $m^3 ha^{-1}$ of wood. In three plots, density of bananas was up to 1733 plants per hectare, a density similar to intensive banana production farms. Plots with higher density of cocoa were not necessarily those who obtained higher productivity. For example, a plot with 37% less cocoa trees had 10% more of production. Fruit species had an important participation, although in two plots was no presence of any fruit species.

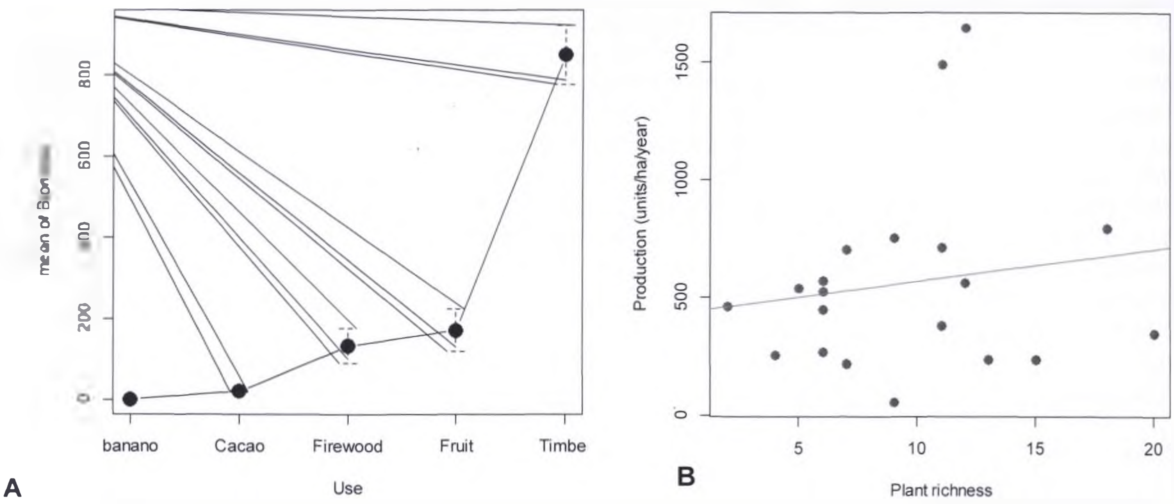

Figure 1. A) Total biomass (t/ha) of each crop group and **B)** effect of plant richness and productivity (units $ha^{-1}year^{-1}$)in in the 20 agroforestry systems sampled plots (Talamanca, Costa Rica).

Plant diversity

Every crop group represented a wide variety of plant species. Timber had 11 different species recorded, being laurel the most representative with 83% for all timber species in the sampled plots. In the firewood group, we found 18 different species. For fruit species we recorded 27 different fruit trees. Cacao and bananas also had a variety of genotypes. In cacao trees, we found Creole and Trinitarian subspecies while in bananas, we recorded five different varieties of *Musa* spp. AAA.The plot with more diversity had 18 species represented on the five groups and the plot with less diversity had two species corresponding to the group of bananas and timber wood.

Banana is the crop with more individual plants per unit while firewood group has fewer plants per unit (Figure 2). In this range of plant diversity and estimated production, the results suggestthe positive effect of plant richness in theyield of these agroforestry system(Figure 1B).

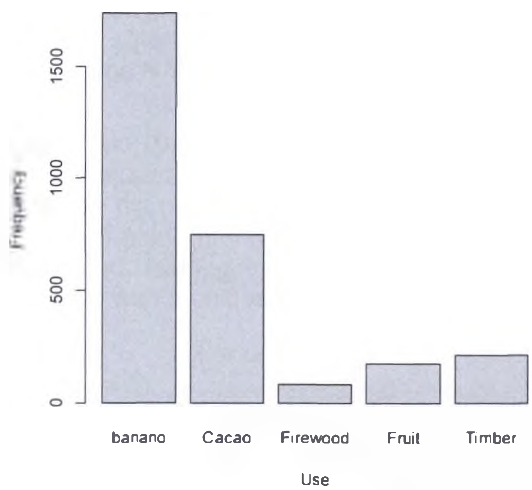

Figure 2. Plant density (individuals/ $90m^2$) of each crop group in the 20 agroforestry systems sampled plots (Talamanca, Costa Rica).

There is not a common pattern among Talamanca agroforestry systems. Sampled plots represented different scenarios in productivity and diversity between crops. Densities in banana and cacao plants show a clear interest in the production of these crops while timber and fruits were considered complementary production species. Consistently with reported by (Borge, 2011; Deheuvels et al. 2012; Guiracocha, 2000 and Kapp, 1989).

This study strongly supports the positive effect between plant diversity and global productivity in Talamanca agroforestry systems. The approach taken helped usto understand trends of optimal cropping organization. While predicting the production performance to discuss their relevance according to farming constraints.

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