

## Stabilität von Agroforstsystemen in Zentral-Amazonien – produktionsökologische und physiologische Studien an der Nutzpflanze *Theobroma grandiflorum* (WILLD. ex SPRENG.) SCHUM.

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### Abstract

Small farmers are responsible for 30% to 60% of the annual deforestation in the Brazilian Amazon. The prevalent slash-and-burn practices result in a rapid degradation of cultivated areas. The loss of productivity of these areas is compensated by clearing of additional forest. In the SHIFT project "Recultivation of degraded mono culture areas in the Central Amazon" the question was tackled whether it is possible to alleviate resource losses and soil degradation by production systems designed for ecological self-stabilisation. Rapidly emerging mechanisms of nutrient cycling and soil protection are basic prerequisites for ecological stability under the pedoclimatic conditions in the Central Amazon. In this context a high efficiency of resource capture is synonymous with avoidance of resource loss. Thus, in this study it was examined, a) to which extent mixtures of different crop plants are capable to increase the efficiency of resource capture and b) which key factors are decisive for the success of particular cultivation systems.

Different agroforestry systems were installed on a 19 ha abandoned rubber plantation near Manaus, Brazil. The efficiency of resource capture was monitored by means of the development and production of 750 indicator plants, *Theobroma grandiflorum*, the cupuaçu tree. Beside the effect of the cultivation systems, the relevance of different site factors has been analysed by multivariate statistical approaches: fertiliser treatments, inoculation of seedlings with VA-mycorrhiza, relief of the terrain, distance to the adjacent forest, and degree of soil degradation.

From all factors the system effect was most evident. The best performing system was characterised by intensive inter-row cropping with *Carica papaya*. In the more open systems the plant development was significantly retarded. In relation to this system effect all other site factors were less evident. Besides, suboptimal site factors arising from soil degradation, from reduced fertilisation, and from strong incline were compensated in the successful system, while they became apparent in the open systems. The system effect obviously relied on micro-climatic and hydrological factors, since it disappeared in the microclimatic sphere of the adjacent forest. Therefore it was examined to what extent water is a limiting factor - despite the perhumid climate characteristic - and how micro-climatic functions of agroforestry systems can counteract water deficits.

The spatial pattern of water uptake and diurnal courses of the leaf conductance of 5 years old *T. grandiflorum* trees were studied. The effect of different microclimates on transpiration was estimated by calculating the daily water losses on the basis of diurnal patterns of leaf conductance under varying leaf to air vapour pressure differences. In addition, stomatal limitations of assimilation were computed by use of models of stomata reaction on climate variables.

Reduced vapour pressure deficits, as measured within a margin of 30 m from the edge of the adjacent forest, could reduce the transpiration losses of *T. grandiflorum* substantially. As a result the soil water was depleted at lower rates and the cupuaçu plant could face longer drought periods without stress symptoms. Consequently, in the course of the 5 years of climate observation in the field, the incidence of drought stress in the microclimatic sphere of the adjacent forest could be reduced to approximately 50%. When, however, in the course of extended drought periods the soil water was depleted, the reduced vapour pressure deficits near the forest permitted higher leaf conductivity which was capable to improve the potential CO<sub>2</sub> assimilation by 9% to 15%.

The improved water use efficiency - as consequence of both lower transpiration rates and less stomatal limitation of CO<sub>2</sub> influx - is caused by an increase of the absolute humidity around 4 - 5 g m<sup>-3</sup>. This means that comparatively small microclimatic modifications can vitally affect the primary production and, thus, the effectiveness by which minerals are incorporated into biomass.

Considering the stand structures of the different culture systems it became clear that in the "successful" agroforestry systems a rapid biomass accumulation was closely related to microclimatic and hydrological site conditions. In particular the functional traits of three plant species were associated with the amelioration of respective site factors: *Carica papaya*, *Pueraria phaseoloides* and *Bactris gasipaes*.

Apart from the direct effects on primary production a more humid microclimate might also indirectly affect the nutrient mobility and the soil flora and fauna. These factors are also of crucial importance for the stability of agroforestry systems in the Central Amazon.

From these findings the following conclusion can be drawn:

1. Water is a substantial limiting factor in the Central Amazon - despite its classification as perhumid region.
2. The efficiency of nutrient capture of agroforestry systems and, thus, their ecological stability depends considerably on hydrological and microclimatic factors.
3. Respective system properties can be brought forward by designing agroforestry systems on the basis of ecological key functions of plant species.