Phosphate Solubilizing Bacteria from the Rhizosphere of *Theobroma grandiflorum* (Willd. ex Spreng.) Schum. and *Bactris gasipaes* H.B.K.: Potential for Plant Growth Promotion

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Despite high total phosphorus (P) concentrations in many tropical soils P deficiency may limit plant growth. P availability is low due to formation of insoluble P salts and/or sorption of P to Fe/Al oxides and hydroxides as well as to the organic matter. Productivity of crop plants may be increased by inoculation with mycorrhiza or P solubilizing microorganisms. While the use of mycorrhizal fungi is widespread inoculation P solubilising microorganisms is still uncommon. However these microorganisms may have a potential to increase plant growth particularly in combination with mycorrhizal fungi. Plant growth promotion is often increased not only by P solubilization but also N2 fixation and production of phytohormones.

We have isolated bacteria from the rhizosphere of two perennial crop plants (*Bactris gasipaes* and *Theobroma grandiflorum*) growing on the SHIFT experimental site near Manaus. More than 70% of the isolates were capable to grow in the presence of Fe and Al phosphate as a sole P source. The two bacteria chosen for further studies were identified as Bacillus sp. and Gordonia sp. An in vitro study showed that the P solubilisation by the organisms is probably due to the excretion of organic acids. Organic acids increase P solubilization by chelation of Fe and Al and by displacement of P from the binding sites. However most of the P solubilized was taken up by the cells and the P concentration in the medium remained low.

Results of green house experiments with tomato were ambiguous. In one experiment both organisms increased plant growth on Fe/Al phosphates compared to the not inoculated control while this was not the case in the second experiment. Possible explanations for these conflicting results are differences in inoculum survival and light intensity. It is planned to repeat the experiments and to include mycorrhizal fungi.

Characteristics of Sustainable Polyculture Production Systems on Terra Firme

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Stable systems in tropical rain forest areas must possess regulatory factors similar to those of the primary forest: closed mineral recycling systems and efficient mechanisms for water and energy distribution. These features can not be achieved by a single species, but depend on a combination of species with various suitable, synergistic properties in root and canopy formation as well as in biochemical and biophysical factors adapted to the site.

The combination of soil science, forestry, agronomy and biology allowed an analytical comparison of various experimental mixed culture systems. From these studies, a descriptor system was developed which allows to understand the contribution of each plant species to nutrient cycling, water distribution, litter formation, overall biomass production and crop production. This knowledge allows to combine plants so that their properties interact to form a system, which minimizes mineral losses and which regulates air humidity and water distribution and thus leads to stable crop production.

The artificial planting systems are designed as production systems for small holders. They must deliver food crops as early as possible to maintain survival on a subsistence basis and they must rapidly produce cash crops in order to provide family income and to pay for various management steps. All systems undergo changes in time and space and consist of an installation phase, where only some annual production of maize, cassava, beans are available, followed by a transition phase with production of papaya, maracuja,

palmito and a production phase with an increasing variability in market-relevant products.

The general conclusion which can be drawn after eight years of polyculture study is

a) Stable production systems for smallholder families have been developed; they consist of a combination of plants for production and helper plants necessary for system stabilization.
b) The systems are variable. They can be adapted to the respective site conditions.
c) The management of these plantations requires a deeper understanding of the cultivation systems and an intensive dissemination of knowledge and a well developed on-farm training system for farmers.