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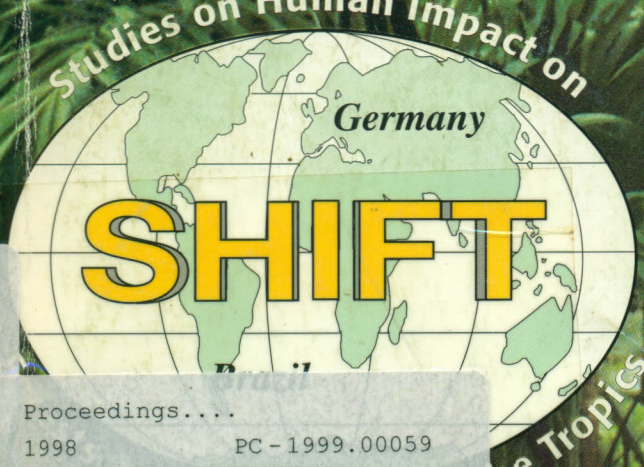

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Agroecological profile of plants used as production factors and as management components in tropical polyculture systems

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ABSTRACT

Polyculture plantings enriched by controlled growth of secondary vegetation after slash and burn treatment are suitable systems for recuperation of degraded areas in Central Amazonia. In order to adapt polycultures to their individual sites, predominantly indigenous useful plants have to be combined. These plants act as production factors and as site management components. There is an urgent need to study the inherent ecological adaptability and phenotype flexibility of these plants, their specific nutrient needs, their reaction to environmental factors and their impact on their specific sites in order to work out rational combinations of plants for resistant and resilient polyculture systems. The development of a descriptor system for polyculture system plants is on its way. The results of the SHIFT projects ENV 23, 23/2, 42, 45 and 52 contribute to this descriptor system.

RESUMO

Sistemas de cultivos misto combinado com plantas da vegetacao secundaria sao usados para a recuperacao das areas degradadas e abandonadas na Amazonia Central.

Quatro projetos do programa SHIFT (ENV 23, 42, 45, e 52) objetivam analisar as interações planta-ambiente em um senso amplo. O sítio experimental e as combinações das plantas foram selecionadas pelo ENV 23, onde estudam-se o desenvolvimento das plantas, os aspectos fitopatológicos, a produção e as interações das plantas com a vegetação secundária. Os impactos químicos e físicos das plantas sobre o sítio de crescimento, fluxo de água e nutriente no solo são estudados no projeto ENV 45. A produção primária e a formação da madeira nas árvores, suas limitações pelos fatores nutricionais são analisados no ENV 42. Os mecanismos de armazenamento de nutrientes e a ciclagem interna dentro da planta assim como o quociente de minerais para a biomassa orgânica são quantificadas e têm sido identificadas como importantes características de sistemas de plantio estáveis.

O fator principal da estabilidade das plantas de cobertura é o forte sistema de reciclagem de minerais que impede qualauer perda de nutrientes essenciais e gerante a redistribuição dos elementos minerais. Os sistemas radiculares, sua distribuição sobre e sob o solo (ENV 23, 45), a interação das raízes de diferentes plantas e a capacidade metabólica das raízes são considerados como ponto central.

Além das relações planta/elemento mineral, a interação biótica direta planta-planta, planta-microorganismos (ENV 23), planta-animal assim como as relações indiretas destes compartimentos bióticos estão sob estudos (ENV 52).

O desenvolvimento de um sistema descitor para diferentes plantas, permite, sob uma experiência racional, combinar plantas para formar sistemas de policultivo estáveis ecologicamente, de boa produção, adaptados ao sítio, com baixa necessidade de input e, assim, planejado com um enfoque multidisciplinar.

ZUSAMMENFASSUNG

Zur Rekultivierung degradierter, brachliegender ehemaliger Brandrodungsflächen in Zentralamazonien werden Polykultursysteme eingesetzt, in die die spontane Sekundärvegetation partiell integriert wird. Um möglichst standortangepaßte Polykulturen zu erhalten, bestehen die Pflanzenkombinationen überwiegend aus solchen Pflanzen, die primär dem Amazonasbecken entstammen. Diese Pflanzen werden sowohl als Produktionsfaktoren als auch als Managementkomponenten für die Flächen eingesetzt. Um die Pflanzen gezielt einsetzen zu können, ist erforderlich, die ökologische Anpassungsfähigkeit, die Phänotypflexibilität, den Einfluß der Pflanzen auf den jeweiligen Standort, die Nährstoffbedürfnisse und die Reaktion auf Umweltfaktoren zu kennen. Zu diesem Zweck wird ein Deskriptorensystem für Polykulturpflanzen entwickelt. Die Ergebnisse der SHIFT-Projekte ENV 23, 23/2, 42, 45 und 52 tragen zu dem Deskriptorensystem bei.

INTRODUCTION

The tropical rain forest is characterized by an enormous species richness of plants, animals and microbes. Among the organisms a high complexity of interactions and of functional organization has been developed. The stability and resilience of these tropical ecosystem and their ability to accumulate and maintain a high biomass is based on efficient and multifactorial control of energy scavenging and recycling of nutrients and water (Bruehnig, 1991).

The use of these ecosystems by man causes changes in species diversity and, consequently, in regulation of the functional interaction of organisms. The utilization of tropical forests implies the modification of biotic balances. Extraction of non-timber products like nuts, fruits, resin and hunting, etc. causes only minor losses in biodiversity and biomass (Homma, 1996). Changes in carbon emission, nutrient, water and soil losses caused by extractors are very low. Modern gatherers, excessive tapping of rubber, high scale timber extraction and slash and burn treatment are unsustainable use forms and produce a destabilized residual forest, which lost its regulatory compounds for watershed, nutrient recycling, and, above all, of regular regeneration of key species and populations.

Socioeconomic needs are the driving forces for considerable environmental activities and losses of integrity of nature. Small holders, large scale plantation farmers and ranchers apply slash and burn treatment of forests to prepare a basis for so-called traditional forms of agriculture, plantations and ranching, which not at all are sustainable. In many studies the high carbon emission, nutrient losses, erosion, impairment of water sheds, enhancement of fire susceptibility, extinction of functional biodiversity and reduction of biomass accumulation have been analyzed and quantified (e.g. Serrão and Nepstad 1996).

Actual approaches to minimize forest destruction and environmental disasters are based on concepts new forms of land use of the humid tropics. Selective logging systems are developed in which the regenerative potential of forest plots is analyzed, agroforestry systems are tested

worldwide (Nair, 1991) and adapted polyculture systems are formed in which different useful plants are combined in consortia.

Polyculture systems are regarded to fulfil an important task. They produce enough of crops and agricultural products to guarantee life of small holder families and they build up ecological land covers which minimize destructive effects like enhanced erosion, fire susceptibility, impairment of water mobility and loss of nutrients.

PLANT RESOURCES AND MANAGEMENT FACTORS

The plant resources for polyculture systems are so far only poorly defined, though the primary forests reveal an enormous species diversity. In a 1 ha plot of primary forest on the Terra Firme near Manaus, Brazil, Preisinger et al. (1994) identified 465 plant species, in another plot near Manaus, Klinge (1971) found 502 higher plant species. Often not more than two or three individuals per species have been detected per ha. In principle, the potential for making use of these plants is very high. Prance (1996) listed more than 60 Amazonian species which were marketed and which do have a potential for further domestication.

In addition to these plants which may serve as production factors in polyculture systems, also 'helper plants' are needed, which fulfil management services like soil protection against erosion, fixation of nitrogen, production of shade, stabilization of heterogeneous microbe populations, etc. Polyculture systems in the Amazon are highly diversified production systems which are to take over ecological functions of the primary forest while additionally producing a diversity of crops and agricultural products. Within these systems the plant components must develop the main mechanisms for stabilization like the plants of the primary forest. Very important plant features for the resilience mechanisms are

- a direct and fast mineral recycling (e.g. Went and Stark 1968) in order to store most of the minerals in the living biomass
- the formation of root mats covering the mineral soil and growing in the top soil layer
- maintenance of microbial systems which are able to fix nitrogen, to solubilize phosphate and which enhance the biologically active surfaces for mineral take up
- formation to take up systems and distribution systems for water in soil, plant cover and atmosphere

Besides these factor, a host of other properties is needed to fulfil the complex interactions found in rain forests. Very essential are the interactive relations between plants, fauna and plants and microbes and plants. A first step to facilitate the development of polyculture systems is to evaluate plants according to the above-mentioned main features for resilience besides their productive value. Thus a specific task for research and development on applied tropical ecology and for tropical agriculture and agroforestry is to develop descriptors for the plants with potential use in polycultures under the aspects of plants as production factors and under the aspects of plants as management factors.

Especially related to the ecological management function of plants it must be realized that these systems underlay strong changes in time and in space.

A phase related development means to install plant combinations which are changing over time by enrichment or by changing components. Polycultures can roughly be divided in an installation phase which is followed by a transition phase which ends in a production phase.

The plants used in these phases can be different and must be chosen with special regard to functional aspects.

For most of these plants from the primary forest none of the essential information on production and development are available in contrast to this, crop plants of highly developed agricultural monocultures are generally precisely defined by genotype, variability, quality determining factors, production potential.

Under conditions of temperate climate agriculture developed in a way to reach highest production by application of best technical means and by high input of materials and energy. In most cases this high input management results in short lasting land up to 20 or 30 years and in impoverishment of nature and man. The general strategy was to overcome restrictions given by nature in order to achieve high production.

In highly complex and sensitively balanced systems like the tropical forests all inputs immediately lead to severe disturbances. Thus the adapted strategy of agriculture and agroforestry is to copy nature as perfect as possible in order to develop sustainable systems. This strategy of assuring lowest emission and of reducing disturbances of environment by minimal input can only be carried out using well defined and locally adapted plant material and must be based on intimate knowledge of site factors.

The four SHIFT-projects ENV 23/2, 42, 45, 52 carried out in collaboration with EMBRAPA, Amazônia Ocidental, Manaus are focussed on the development of sustainable land use systems. Ecological resilience factors are analyzed by qualitative descriptions and quantitative evaluations of system inherent factors.

The experimental site has been precisely defined and described (e.g. Feldmann et al. 1995): a secondary forest-fallow of the EMBRAPA research center, Amazônia Ocidental, Manaus was cut down and burned in 1992 and was transferred into experimental plots in order to study nutrient and water flow (ENV 45), plant development (ENV 42), soil fauna (ENV 52) and interaction of organisms, production and management parameters in polycultures (ENV 23 and 23/2).

The development of polycultures planted on the experimental site was followed since six years now. In Table 1 the general list of ecologically relevant properties in given. The comprehensive data collection is going to be prepared for the final report in 1999/2000. Preliminary parts of the results are already published in this proceedings volume.

Table 1: Examples for ecologically relevant properties of polyculture plants.

Plants predominantly studied are *Theobroma gradiflorum*, *Bactris gasipaes*, *Hevea brasiliensis*, *Bixa orellana*, *Bertholletia excelsa*, *Swietenia macrophylla*, *Vismia guianensis*, *Pueraria phaseoloides*.

Examples for ecologically relevant properties of polyculture plants	**Data collected by ENV**
I. Plant characteristics (autecological features)	
life cycle (annual, perennial)	23
development (slow, fast, rhythmic)	23
growth form types	23
light/shade distribution	
water distribution, canopy, stem flow, root system	45
water recycling, microclimate	23, 42, 45
nutrition storage, retention, external/internal recycling	23, 42, 45
litter production, regular, irregular leaf shedding, quality of litter	42, 45, 52
II. production factors	
nutrition needs	23, 42
protection against pest/diseases	23
products, quantity and quality, quality determining factors	23
variability	23
classical descriptor items for production	23
III. plant-animal interaction	
pollinators	-
fruit/seed dispersal	52
plant specifically associated animals (e.g. ants, nematodes, meso-, microfauna)	52
specialized pests	23
attractant/repellent producer	-
IV. plant-plant interaction	
competition (water, nutrients, space, microbes)	23
inhibition by allelochemicals	(23)
V. plant-microbe interaction in (rhizo-, phyllo-, spermosphere)	
symbiosis (mycorrhiza, symbiontic bacteria, N_2-fixation,)	23
association with phosphate solubilizing bacteria,	23
protective growth promoting microbes	--
minor pathogens	--
litter decay promoting microbes	(52)
growth hormone producers	-
endophytic microbes	--
saprobes, pathogens	
VI. plant-soil interaction	
pore formation	45, 52
attraction of litter decaying organisms	52
formation of humus	45, 52
enrichment of soil organic matter	45
effective adsorption and absorption of mineral elements	23, 42, 45
limitation of soil losses by erosion	--
regulation of soil climate	--

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