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SUSTAINING GROWTH

Soil fertility management in tropical smallholdings

Karl M. Müller-Sämann and Johannes Kotschi

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Headquarters: "De Rietkampen", Galvanistraat 9, Ede, Netherlands
Postal address: Postbus 380, 6700 AJ Wageningen, Netherlands
Telefon: (31) (0) (8380)–60400
Telex: (44) 30196 CTA NL
Telefax: (31) (0) (8380)–31052

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Dag-Hammarskjöld-Weg 1+2, 65760 Eschborn, Germany
Telefon (0 61 96) 79-0
Telex 4 07 501-0 gtz d

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Margraf Verlag

CIP-Titelaufnahme der Deutschen Bibliothek

Müller-Sämann, Karl M.:
Sustaining growth : soil fertility management in tropical smallholdings / Karl M. Müller-Sämann ; Johannes Kotschi. [CTA ; GTZ. Transl.: Christine Ernsting and Simon Chater]. – Weikersheim : Margraf , 1994

ISBN 3-8236-1226-3

NE: Kotschi, Johannes;

Title of the German edition:
Bodenfruchtbarkeit und standortgerechte Landwirtschaft

Translation:
Christine Ernsting and Simon Chater

Typesetting and layout:
Johannes Kotschi

Cover photo:
Johannes Kotschi

Printing and binding:
Böhler Verlag, Würzburg
Germany

Publisher and distributor:
Margraf Verlag
Hohenloher Str. 2
97990 Weikersheim
Germany

ISBN 3-8236-1226-3

Acknowledgements

This book is the result of many years of work. Numerous people have contributed towards its publication.

We are grateful to staff members of the Farm Systems Section of GTZ at Eschborn, especially Reinhard Adelhelm and Ulrich Hoesle, for their constant willingness to engage in discussion and their stimulating ideas.

Many colleagues from development projects, universities and research stations have read drafts and contributed valuable criticism, ideas and suggestions for improvement. They include Ulf Baum, Wolfgang Bayer, Jörg Haas, Atef Moawad, Wolfgang Moll, Bernd Neugebauer, Kurt Raquet, Reinhard von Schaafhausen, Karl Schleich, Hans Schön, Berthold Schrimpf, Ewald Sieverding and Ann Waters-Bayer.

Our special thanks go to Chris Ernsting, Simon Chater and Shirley Fawcett for their help in translating and editing, and to Ortrud Behre for typing the manuscript.

Last but not least, our thanks go to GTZ and CTA for their financial support.

Foreword

It is characteristic of our times that we are inundated with facts and figures describing the ecological destruction of the earth. We know more and more about the problems, yet seem to have fewer and fewer answers to them.

Of course the damage to our environment must be analyzed in detail, but it is not enough to do this. To be able to act, we must concentrate all our energy on finding solutions to environmental problems and on overcoming the widespread paralysis that seems to infect our institutions, as well as ourselves as individuals. The aim of this book is to make a modest contribution towards this end.

For the past 15 years German overseas aid has been oriented towards promoting sustainable agriculture in some of the world´s most challenging environments, the sensitive tropical ecosystems of developing countries. It is as a result of these efforts that this book has come into existence. It is a compilation of recent research results and practical experience as well as a re-examination of older knowledge that has fallen out of circulation. Agroforestry, green manuring, the use of manure, mulch, compost, and natural symbionts - all are ancient methods about which too little is yet known by modern science. They represent a vast untapped potential, especially for small-scale farmers with little or no access to external inputs.

The first edition of this book appeared in German in 1986. It met with such a favourable response that we decided to have it translated into English. At the same time the work has been updated and extended to include recent findings in the fields of agroforestry and green manuring.

With this new edition we hope to reach beyond the German-speaking world, making our contribution to the global debate on soil fertility and how to maintain and increase it in the tropics and subtropics. Our aim is also to help widen the circle of scientists and development workers willing to actually do something to promote soil fertility instead of merely wringing their hands and beating their breasts.

Hans Wilhelm von Haugwitz
Deputy Director Planning and Development Division, GTZ

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1. Introduction

For several decades efforts have been made to intensify agriculture in the tropics using "modern" methods of agricultural production. Innovations that led to large production increases in the industrial countries were expected to have similar results in the developing world. It was hoped that, by breeding and disseminating high-yielding crop varieties and applying mineral fertilizers and chemical plant protection, the rapid gains in yields needed to keep pace with population increases could be achieved. The "Green Revolution" was declared.

This process was successful for larger farmers in the high-potential irrigated areas of Asia and Latin America. In some areas the gains were spectacular, as in the case of wheat cultivation in northern India. But the majority of subsistence-oriented small-holdings, especially those in marginal areas, remained unaffected.This was especially the case in Africa, where difficult environmental conditions and the inability of farmers to invest in inputs made the new technology quite unsuitable. Moreover, even in areas where the Green Revolution was successful, it gave rise to serious problems, notably increased susceptibility to pests and diseases and a reduction in local bio-diversity as well as the pollution of soils and water supplies and - most important - greater vulnerability to soil erosion and the loss of soil fertility. In short, the assumption that agricultural practices from industrial countries could be transferred to developing countries proved flawed. The underlying conditions for agriculture are too different.

According to BRINKMANN (1914), farming systems arise out of the tension between opposing groups of forces: those which impel towards specialization and those which impel towards diversification. In the industrialized countries, the trend towards specialization has steadily gained in strength since the beginning of this century, since when the factors favoring diversification have fallen into decline. Public-sector efforts to promote agricultural development in the tropics began only in the second half of the century. By this time, the concept of specialization had become so widespread that it became the dominant model for planners and policy makers in the developing

countries. As a result little attention was paid to the interactions between different enterprises on the farm (crops, livestock and trees) and to local environmental conditions and socio-economic factors. It was assumed that the same set of forces operating in industrial countries prevailed in developing countries.

Several basic differences between the developed and the developing countries are important for agricultural planning purposes. In developed countries, with their low population growth rates, the number of people employed in agriculture has declined - and is still doing so - in both absolute and relative terms, as a result of the rapid growth of non-agricultural sectors (v. URFF 1982). For the individual farm, this implies increased labor productivity (largely through mechanization), greater specialization, growing involvement in the market, and the reduction of subsistence farming. These trends have been fostered by the apparently unlimited availability of external inputs and, as most industrialized countries lie in temperate areas, by the relatively low risk of crop failure caused by adverse climatic conditions and the lower dangers to the soil incurred through mechanization.

In general, the conditions found on most tropical smallholdings are the opposite to those prevailing on farms in the industrialized countries (Table 1.1). Tropical smallholdings are characterized by high production risks, and limited purchasing power to obtain external inputs. These conditions favor diversification and the integration of different enterprises.

Parallel to the mainstream concept of agricultural development, numerous attempts have been made over the past 20 years to develop alternatives more suited to the needs of tropical smallholders. Thus German aid has developed the concept of "site-appropriate" agriculture, building on a long tradition of micro-economics and farm management theory. Similar approaches are being promoted by other countries in many different parts of the world. Terms such as "ecologically sound agriculture", "biodynamic farming", "organic farming", "conservation agriculture", "ecofarming", and - universally - "sustainable agriculture" are gaining increasing currency.

Table 1.1. Conditions for agricultural development in industrialized and developing countries

Criteria	Industrialized countries	Tropical smallholdings
Climate-related production risk	Low	High
Potential negative impact of mechanization on environment	Low	High
Population growth	Low	High
Proportion of population employed in agricultural sector	Decreasing	Constant
Transport and market structure	Good	Poor
Degree of market involvement	High	Low
Purchasing power and availability of inputs	High	Low
Specialization and labor productivity	High	Low

Source: Adapted from KOTSCHI et al. (1989)

For the sake of brevity, the term sustainable agriculture will be used as a catch-all for these various approaches, which differ little in their basic premises. The aim of sustainable agriculture is to find ways of using agricultural land that achieve high and lasting productivity while maintaining or enhancing the natural resource base (KOTSCHI and ADELHELM 1984). According to TAC/CGIAR (1988) it represents "...successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources." Other definitions embrace a wider context. WEINSCHENCK and WERNER (cited in KOTSCHI et al. 1991) consider agriculture to be "site-appropriate" if it preserves all the functions of the landscape in which it is integrated. GIBS (1986, cited in REINTJES et al. 1992) maintains that sustainable agriculture is not only ecologically sound but also economically viable, socially just, humane and adaptable. By humane he means "...that all forms of life (plant, animal, human) are respected. The fundamental dignity of all human beings is recognized, and rela-

tionships and institutions incorporate such basic human values as trust, honesty, self-respect, cooperation and compassion. The cultural and spiritual integrity of the society is preserved and nurtured". By adaptable he means "...that rural communities are capable of adjusting to the constantly changing conditions for farming: population growth, policies, market demand, etc. This involves not only the development of new appropriate technologies but also innovations in social and cultural terms".

Despite the range of ideas covered by these definitions, they all have one objective in common, namely to combine gains in productivity with stability over time. The demand for increased productivity is one that every generation makes. The goal of stability over time arises from our obligation to pass on to future generations an environment able to meet the same basic human needs as today. Productivity and stability are often seen as irreconcilable goals involving a conflict between short- and long-term interests. Sustainable agriculture demands that consideration be given to achieving both goals simultaneously, especially in the context of the smallholding.

This book presents a range of practices conducive to sustainable agriculture and of particular importance for the development of smallholdings in the tropics. These include agroforestry, intensive fallowing and green manuring, the use of mulch, compost, stable manure and, not least, the deliberate use of natural symbionts. The aim of all these practices is the maintenance of soil fertility using a minimum of external inputs. Much ancient knowledge related to these practices has been forgotten over the years. It is re-examined here, in the light of recent research findings.

Soil fertility lies at the heart of sustainable agriculture. But solving the technical problems associated with maintaining soil fertility goes only part of the way towards creating sustainable agriculture. The problems of poverty and other causes of environmental degradation in rural areas must also be addressed. Below we outline some of the principles essential to observe in attacking this broader range of problems.

Dealing with agro-ecological systems as whole. Natural resources such as soil, water, flora and fauna are components of whole systems, in which they function in complex interactions. As users of natural resources, human beings make an impact on ecological systems as a whole and not just on individual components. This means that

agricultural development always takes place in the context of entire ecological systems. The role of man is not that of "outside observer" but of an active system component.

Ecological systems are capable of self-regulation and behave like organisms or living beings. Although they possess a degree of autonomy they are not closed off from their environment, but link together with other ecosystems of similar organization and size to form higher-level ecosystems. The principle of ecosystem aggregation "from the bottom upwards" is universal, from single-cell organisms to the planet earth. For example, individual fields and woods have hills and valleys in common, which are aggregated into the regional water catchment area. Each level of aggregation can be referred to as an ecosystem.

Basic laws of ecosystems should be respected. Ecosystems research suggests that high productivity and stability of ecological systems are associated with high degrees of cohesiveness (STEINER 1925, HARTMANN 1973), functional diversity and complexity (EGGER 1979). Ecofarming involves finding the optimum (rather than the maximum) cohesiveness and functional diversity for each specific location (KOTSCHI 1981). Modern agriculture has developed in a direction entirely contrary to cohesiveness and functional diversity:

* Rather than being cyclical, modern agricultural production tends towards an open flow of materials. The growing use of external inputs (mineral fertilizers, plant protection agents, machinery etc) means that formerly closed systems are being increasingly opened up and are thus losing their cohesiveness.

* As we have seen, modern farming systems tend towards specialization. Production is increasingly confined to a few crop varieties with an ever more restricted genetic base, grown as monocrops rather than in mixed or rotational systems. Crop and livestock enterprises are increasingly divorced from one another.

Analysis of the structure of decision-making. At every level of aggregation of ecosystems there are decision-makers who may seek to influence the use of resources.

The interests of different groups may conflict. Crop farmers and livestock owners, city and rural people may argue over the equitable use of a particular area. Two villages on a watercourse may feud over water rights. Government or social objectives, such as the preservation of forests, may conflict with the need of the local population to obtain firewood, and so on. Decisions are usually a compromise between these conflicting interests, and solutions are "negotiated" by decision makers.

In analyzing the structure of decision-making in these situations it is important to understand the balance of power. Where agriculture is practised, the primary decision-maker is the farmer (male or female), though other members of the family may bear responsibility for certain parts of the farm. Higher decision making levels may influence the farmer in important ways, for example through laws passed by government or through the prices paid for agricultural products, but the farmer is still the key decision-maker (BLAIKIE and BROOKFIELD 1987). In analyzing the structure of decision-making it is therefore advisable to begin with those responsible at individual farm level and then to inquire into framework conditions - a sequence which is unfortunately not often followed.

Agricultural technology is site-specific. Agricultural development requires an intimate knowledge of local conditions. Farming in Africa, Asia and South America is practised under a wide range of natural, economic and political conditions and by a great diversity of cultures. In view of the site-specific nature of many agricultural problems, widely applicable solutions are rare. Technologies and practices must be adapted to meet the needs of specific locations. For example, "blanket" recommendations for the use of chemical fertilizers for an entire country or region should not be made. Different soil types, rainfall patterns and cropping systems on individual fields must be considered.

Site-specific solutions can be found only if development planners, researchers and extension workers strive to collaborate with farmers and assist them in their efforts to develop the most appropriate technologies and practices for their particular conditions, rather than trying to implement pre-conceived ideas and methods that may have been successful in another context but are ill adapted to local circumstances.

Interdisciplinary understanding of agro-ecosystems. Ecology as a science deals with the relationships between organisms and their environment. However, the environment is not confined to natural conditions alone; it encompasses the entire complex of physical, economic, social and cultural conditions, and all their relations and interactions. Social and economic studies must therefore take their place alongside the biological sciences in all attempts to understand and influence the evolution of ecosystems. It should be emphasized that an interdisciplinary understanding of ecosystems is easiest at the lowest level and should, accordingly, begin there. Small units such as single farms are easier to understand than whole societies or regions.

Mobilization of indigenous knowledge. For many farming systems, practical ecological knowledge has been accumulated by generations of farmers, who often undertook "deliberate efforts to improve and/or protect the value of life-supporting resources and to insure some reasonably secure long-term viability" (BEYER 1980). Seen in this way, millions of small farmers throughout the tropics are in fact professionals and should be treated as such (CHAMBERS 1980). Scientists, planners and agricultural advisers must learn from local farmers because their expertise "represents the single largest knowledge resource not yet mobilized in the development enterprise" (HATCH 1976). This learning process involves recognizing and understanding indigenous ecofarming systems and technologies so that these can be promoted, developed and extended to other farmers operating under similar conditions. It also involves placing farmers and their families at the center of the technology design process, as well as obtaining their inputs to problem diagnosis and technology testing and evaluation. Recent forms of on-farm research, notably participatory technology development, have begun to do this.

These principles indicate that the term "ecological" cannot be applied in any absolute sense, nor can it be expressed in quantitative terms. It relates rather to a developmental process, in which changes in the ecosystem must be continuously assessed to determine whether or not the practices giving rise to them are of value. This means that farming techniques are not good or bad per se; their value depends on their applicability within a particular system. For example, minimum tillage may be appropriate in one case, while plowing may be necessary in another.

It would be naive and presumptuous to expect to meet the needs of small farmers in the tropics with a mere concept of sustainable agriculture and a corresponding collection of technologies. The problems are too great and too complex. On the other hand, it would be irresponsible not to make available the knowledge which has been gained. With this book we hope to fill a gap by presenting this knowledge clearly and succinctly.

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