in semimechanized systems, small-scale water conservation, and sorghum and millet breeding.

XII SOIL FERTILITY

216 88 - 12/1

Soil fertility
Review, proceedings, developing countries, tropics, soils, soil fertility, ecosystems
GARVER, C.L.
Management of acid tropical soils for sustainable agriculture.
IBSRAM Proceedings No. 2, 1987, 299 pp., ISBN 974-7614-39-1

Acid tropical soils - Oxisols and Ultisols - support an increasingly large proportion of the developing world's population, but technologies for their sustained production are at early stages of development. Recognizing the urgency of this situation, IBSRAM organized the inaugural workshop on management of acid tropical soils for sustained production. The importance of this meeting is quite evident from the following facts:
- Acid tropical soils account for about 1 billion ha of land around the world.
- Of this area, acid humid tropical ecosystems comprise about 700 million ha, while acid savannas occur on about 300 million ha. Both ecosystems are located primarily in the developing world.

Brazil and Peru, the host countries of the inaugural workshop of the Acid Tropical Soils Management Network, contain highly representative areas of both the humid tropics (Yurimaguas) and the acid savannas (Brasilia). Traditional farming systems on the acid soils of the tropics are mainly based on the slash-and-burn method of shifting cultivation. After a few years of cropping, this land is reverted to bush fallow and, over many years, returns to forest. Population pressure, however, has forced many farmers to intensify cropping on these areas, which exposes many of the soils to chemical and physical degradation.
The most common constraints to agriculture on Oxisols and Utisols are high soil acidity, associated secondary and micronutrient disorders, and low available phosphorus. In addition, nitrogen and sulfur deficiences and a high susceptibility to compaction and erosion may occur to varying degrees.
The conquest of the agricultural frontier has to be made at a very low cost on a per-hectare basis. To achieve this goal, research, knowledge generation and management will play a fundamental role in removing constraints to agricultural production in the humid tropics, especially in areas such as:
- soil fertility evaluation,
- availability of germplasm tolerant to soil stresses,
- management of soil acidity,
- nitrogen fertilizer efficiency,
- phosphorus fertilizer management,
- biological nitrogen fixation,
- land-clearing methods, and
- improved farming systems, including:
  . sustained production in Oxisols and Utisols,

. continuous and or/multiple cropping systems,
. agroforestry, and
. low-input systems.

Probably even more important is the area of technology transfer through:
- validation and adaption of research results,
- developing fertilizer recommendations, and
- training in information services.

Through the above-mentioned areas of research, knowledge generation and management conducted on a network basis throughout the developing world, it is sure that economically feasible forms of agriculture in the tropics can be attained, while preventing deterioration of the ecosystem.
To achieve this, however, cooperation is the fundamental word. Cooperation is the reason and the main objective of the network. The International Board for Soil Research and Management (IBSRAM) is a nonprofit international research support agency with the primary objective of assisting national agricultural research programs in overcoming soil constraints to increase food production on a sustained basis. This is primarily accomplished through a coordinated, multicountry network for research and training. IBSRAM supplies backstopping support through assistance in experimental design, soil and statistical analyses, data processing and information exchange.

217 88 - 12/2

Soil fertility
Review, soils, developing countries, developed countries, food supplies, population expansion, natural resources, crop yields, cropping systems, fertilizer, water management
BRADY, N.C.
Soils and world food supplies.
In: Proc. of the 13th International Soil Science Society (ISSS) Congress, Hamburg, FRG, 1986, pp. 61-79.

The significance of soils and their management to world food supplies has never been greater than it is today. The world has witnessed an unprecedented growth in human population. This, in turn, has forced equally unprecedented attention to meeting the food needs, without permitting the deterioration of soils and other natural resources.
The magnitude of the food production problems is seen in population growth statistics. Each year worldwide, there are about 89 million more mouths to feed. Furthermore, six out of seven of these are in the developing countries, most of which are already pressed to produce enough food to meet today's needs. Projections for the future are of even more concern. The developing countries, whose combined population was about 3.6 billion in 1980, are expected to have nearly 5 billion by the year 2000. This will likely rise to 7-8.5 billion by 2050, when 85% of the world's population will be living in what are now considered developing countries.

While the absolute increases are largest in Asia, the rates of increase are highest in Africa.
These statistics are indeed sobering. They represent a challenge to all who are concerned with the world's capacity to feed itself. They also tell that one must conserve and wisely manage soils and other natural resources on which the world's food-producing capacity is largely dependent.
Most of the world's future food production will come from increased yields on land now being cultivated. Furthermore, the increases will come primarily from the tropics and subtropics, where most of the increases in population will occur. Unfortunately, too little is known about soils of these areas and how they might best be managed. Soil scientists have the obligation to obtain that information, and to work with scientists from other disciplines in developing sustainable food production system.
Four major areas of current and future contributions of soil scientists are emphasized, particularly as they relate to the tropics: 1) enhanced characterization and classification of soils of the tropics, 2) improved means of removing nutrient deficiencies and chemical toxicities, 3) improved and sustainable soil and water management systems, and 4) improved farming systems which provide stable crop yields and minimize environmental deterioration.

218 88 - 12/3

Soil fertility
Review, tropics, soil fertility, sustainable agriculture, land clearing
LAL, R. et al.
Tropical land clearing for sustainable agriculture.
IBSRAM Proceedings No.3, 1987, 153 pp., ISBN 974-7614-40-5, Thailand

Clearing of new agricultural lands for fuelwood or for grazing areas is reducing the size of the tropical forest at an accelerated pace, thereby creating a worldwide environmental concern. The population rise does not allow to envisage a decrease in the demand for food and other agroforestry products in the near future. There may not be sufficient agricultural lands in some areas, however, so that more of the remaining forests may still have to be cleared.
Appropriate technologies exist to reclaim degraded lands, to clear the forest using methods that scarcely damage the environment, and to use the cleared lands most effectively. Yet, their use by farmers or governments is still limited, probably because of a lack of dissemination of available information and because reclaiming and post-clearing soil management technologies and further adaptive research need to be implemented.
Recognizing the urgency of this problem, IBSRAM organized the inaugural workshop on "Land Clearing and Development for Sustainable Agricultural Production" to define avenues to address these problems. The meeting was held in Jakarta and Bukkitingi, Indonesia,

from 27 August to 3 September 1985, and was attended by 75 participants representing 20 countries.
The themes of the workshop were:
Part I: Basic Concepts
Need for, approaches to, and consequences of land clearing and development in the tropics; agroforestry in the context of land clearing and development in the tropics; strategies for socio-economic aspects of land clearing and development; institutional and economic issues in developemnt of humid tropical lands; strategies for reclamation of degraded lands; research methodology for minimizing water runoff and soil erosion;
Part II: Case Studies
Potentials of constraints to and development strategies for agricultural land development in Indonesia; current program problems; strategies for land clearing and development in Malaysia; land clearing and development in Papua New Guinea.
The results of this conference, together with these proceedings, form the scientific background for the IBSRAM network on "Tropical Land Clearing for Sustainable Agriculture", which was formed during this workshop.

219 88 - 12/4

Soil fertility
Review, manual, soil fertility, soil science, nutrients, pot technique, soil sampling, soil testing
AGROMISA
Soil science: some examples of soil fertility testing.
Agrodok 1, 22 pp., Agromisa, P.O.B. 41, 6700 AA Wageningen, Netherlands

In determining soil fertility, the following methods can be used:
- field trials (quantitative and qualitative),
- pot experiment, and
- chemical analysis of soil and crop.
For the latter method, an experienced researcher and a well-equipped laboratory are necessary. Therfore, only the first two simpler methods are dealt with in this booklet. First, field trials are discussed in which, among other things, the effect of the use of manure of the yield is investigated. Then, a particular method for a pot experiment discussed, namely the double pot technique. Field trials require relatively much time and a large trial area; the pot experiments described here are more difficult than field trials.
The contents of the booklet are:
Chapter I: Function of the soil
Vegetative habitat of the plant
Storage and supply of water
Storage and supply of nutrients
Chapter II: Fertilizer treatment
Nutrients
A few fertilizers
Fertilization tests

Investigation into the type of fertilization
Investigation into the quantities of fertilizers
Chapter III: The double pot technique
Preface
Technical execution
The preparation of nutrient solutions
Measuring the growth
The relative rate of growth
Chapter IV: Agriculture experimental stations which test and assess soil samples
Chapter V: Reading list

Agromisa is a volunteer organization of students and graduates of the Agricultural University Wageningen in The Netherlands. The organization, established in 1934, aims at improving the position of socially and economically underprivileged groups in developing countries by transferring agricultural knowledge to organizations and persons who are working for the benefit of these groups. Another activity is to increase the awareness among the Dutch people of the situation in the developing countries.

220 88 - 12/5

Soil fertility
Review, bulletin, production systems, shifting cultivation, soil resources, soil fertility, soil conservation, soil managment
FAO
Improved production systems as an alternative to shifting cultivation.
FAO Soils Bulletin, No. 53, 1984, 201 pp., ISBN 92-5-102121-X

Shifting cultivation, under its diverse forms of slash-and-burn systems, is a traditional method of cultivating tropical upland soils, mostly for subsistence purposes.
The subsistence farmers in the tropics - some 200-300 million people worldwide that live from this system of cultivation - are increasingly faced with falling yields, more poverty and even less opportunity to subsist, left alone improve their living standards. Apart from these problems of human misery, shifting cultivation, as currently practised in many areas, is wasteful of scarce land resources and frequently leads to intolerable erosion, particularly of hillsides and sloping lands.
It is for these reasons that FAO is studying and researching, in collaboration with national and international institutions, ways and means to improve this traditional farming system of the tropics. The ultimate objective is to provide feasible alternatives for improving these practices or replacing them with systems of permanent cropping.
The present set of papers is the result of an expert consultation on the subject. The object of the consultion was to provide guidelines for future activities and policy decisions in this subject area.

The bulletin consists of three parts. The first one is entitled "Improved permanent production systems as an alternative to shifting intermittent cultivation". Historical, environmental and socioeconomic setting for shifting cultivation are described. Justification for a Farming Systems Research orientation is given and characteristics as well as changes of shifting cultivation areas are outlined. Technical aspects of land management and the development of alternatives are discussed.
The second part of the bulletin presents papers from an informal meeting on improvements in shifting cultivation.
The last part proposes a cooperative program for improving shifting cultivation.

221 88 - 12/6

Soil fertility
Netherlands, pot experiment, cereals, rock phosphates, alkaline uptake pattern, phosphate-mobilizing capacity
FLACH, E.N. et. al.
A comparison of the rock phosphate-mobilizing capacities of various crop species.
Trop. Agric. (Trinidad), 64 (4), 1987, pp. 347-352

During recent years an impressive number of phosphate rock discoveries has been registered. In 1975, the known quantity of phosphate rock reserves was 82 x 10^9 t. With each new discovery, the question can be raised whether the phosphate as such or after beneficiation can be put to use in the agriculture of the country of origin. When, for technical or economic reasons, benefication is not feasible, it is especially important to examine whether ground rock phosphate can contribute to the P nutrition of crops. Too little attention seems to be paid to the evidence that, in acid and neutral soils, the long-term effect to alkaline rock phosphate can be comparable with that of superphosphate. However, it is understandable that a farmer investing money in fertilizer also expects a short-term effect in the form of a yield increase in the first crop grown after fertilizer application. Relevant questions in such a situation are: 1) which crops distinguish themselves favorably from others in their response to newly applied alkaline rock phosphates, and 2) which factors, soil-borne or plant-borne, are responsible for the favorable response?
The rock phosphate-mobilizing capacity of three cereals was tested in a pot experiment. It was shown that the capacity increased in the order maize < pearl millet < finger millet. This was also the order of increasing quantities of calcium absorbed by the three species. It is reasoned that the shift in mass-action equilibrium of alkaline rock phosphates, brought about by high Ca absorption, favors their solubilization. In a second pot experiment, it was shown that the alkaline uptake pattern underlying the ability of legumes to mobilize alkaline rock phosphates was not present in finger millet and therefore could not account for its rock-phosphate mobilizing capacity. The result obtained with the millet species in this experiment do not support the general view that

millet belongs to the category of plants incapable to utilizing rock phosphate-P.
In conclusion, it can be stated that: 1) both finger millet and cowpea are capable of mobilizing P from alkaline rock phosphates; 2) the mechanisms by which the rock phosphates are mobilized are different for these two crops species; 3) the higher P-mobilizing capacity and the lower P requirement of finger millet account for the finding that several rock phosphate materials could sustain proper growth of this crop whereas none was adequate for cowpea; and (4) there is little or no justification for classifying millet species as `poor phosphate feeders'.

222 88 - 12/7

Soil fertility
Review, booklet, USA, Canada, soil fertility, soil management, ecology, soil ecosystem, soil evaluation, fertilizer
GERSHUNY, G. and SMILE, J.
The soul of soil: a guide to ecological soil management.
2nd ed., GAIA Services, 1986, 108 pp., ISBN 0-9616496-0-7; available from: GAIA Services, Box 84, RFD 3, St. Johnsbury, VT 05819, USA or R.R. 3, Weedon, Erle, Quebec JOB 3JO, Canada

Soil management is a central focus of ecological agriculture, as the basis of farm productivity. Skill and planning are required to eliminate the need for fast-acting remedies relied on in conventional systems. There is continuing controversy about what methods are acceptable in ecological systems and whether certain practices can be permitted in the production of organic food.
This book provides an introductory guide to ecological soil management. The authors describe the practical farm implementation of ecological theory.
The book consists of the following chapters:
- Introduction
- Understanding the soil ecosystem
- Observing and evaluating your soil
- Soil management practices
- The marketplace and organic certification
- Appendices

The book was written from a northeastern US-bioregional perspective, but the principles for ecological soil management are the same for farmers in other regions.

223 88 - 12/8

Soil fertility
Review, book, tropics, subtropics, soils
BURINGH, P.
Introduction to the study of soils in tropical and subtropical regions.
Centre for Agric. Publ. and Documentation (CTA), Wageningen, Netherlands, 1979, 120 pp., ISBN 90-220-0691-3

This book is written for soil scientists and specialists in related subjects who are interested in soils of the tropics and subtropics, and in their evaluation for agricultural use. It is an introduction, dealing with general aspects of major soils. The reader is supposed to have a basic knowledge of soil science.
The book contains the following chapters:
- Land use
- Soil science
- The major soils of the world
- Soil formation
- Soil conditions
- The US-Soil Taxonomy
- Agricultural productivity of soils
- Soil erosion: destruction of land
- Soil improvement
- Soil investigations in the tropics
- Glossary of older soil names
- Short description of the soil profiles
- Selected literature
- Index

This introduction is a compilation of knowledge and experience of some generations of soil scientists throughout the world. Reference is made to bibliographies and to generally available books and reports that are interesting for those who want to learn more about soils.

224 88 - 12/9

Soil fertility
Review, book, tropics, subtropics, soil tillage
KRAUSE, R. et al.
Bodenbearbeitung in den Tropen und Subtropen (Tillage in the tropics and subtropics).
GTZ, Eschborn, 1980, 244 pp., ISBN 3-88085-79-8; distributor: TZ-Verlag, Roßdorf, FRG

Soil tillage for plant production is an art which is nearly 10 000 years old. To increase and stabilize the yields, use of machinery and energy has been increasing tremendously in the last decades. In many cases, the total energy input exceeds the plant energy regained, soil tillage being one of the major consumers. It is hardly possible today to keep abreast of the wide variety of equipment for cultivation available on the market. Excessive and often irreparable damage to the soil (erosion, salination) is often due to the misuse of machinery. The selection and use of appropriate implements well adapted to the overall farming system, proper timing and precision of operation can contribute to the productivity of the soil and yield stabilization.
This book is written for experts in the field of tropical and subtropical agriculture, extension workers, farmers, teachers and students. It begins with a brief summary of the targets of soil

tillage and of the interaction between climate, farming system and methods of cultivation.
The main part of the book presents the most important tillage implements for primary and secondary cultivation in rainfed and irrigated cropping and dry farming, and also covers some new implements and shows the trends in development. The fields of application for each implement are defined, the pros and cons discussed, and details given of operation, technical design, energy requirements, handling and some technical specifications.

225 88 - 12/10

Soil fertility
America, tropics, soil fertility, oxisols, ultisols, low-input technology
SANCHEZ, P.A. and SALINAS, J.G.
Low-input technology for managing oxisols and ultisols in tropical America.
Advances in Agronomy, 34, 1981, pp. 279-406

Low-input technology includes: 1) adaptation of plants to soil constraints rather than elimination of all constraints to meet the plants requirements; 2) maximization of output per unit of added chemical input; 3) advantageous use of favorable attributes of acid infertile soils. It is emphazised that elimination of fertilization is not contemplated. Main components of the technology are: selection of most appropriate land where low-input technology has the comparative advantage over high-input technology; use of plant species and varieties that are more tolerant to the major acid soil constraints as well as being adapted to climate, insect and disease stress; use of low-cost and efficient land clearing, plant establishment, cropping systems and other practices to develop and maintain a plant canopy over the soil; managing soil acidity with minimum inputs, with emphasis on promoting deep root development into the subsoil; managing P-fertilizers at the lowest possible cost with emphasis on increasing the efficiency of cheaper sources of phosphorus and prolonging the residual effects of application; maximizing the use of biological nitrogen fixation with emphasis on acid-tolerant Rhizobium strains; identifying and correcting deficiencies of other essential plant nutrients.
The low-input technology for acid soils targets at obtaining about 80% of the maximum yields of acid-tolerant germplasm with the most efficient use of soils, fertilizers and lime.

226 88 - 12/11

Soil fertility
Africa, Sub-Sahara, nitrogen fixation, soil fertility, forage legumes, potentials
HAGUE, I. and JUTZL, S.
La fixation symbiotique de l'azote par les legumineuses fourragers en Afrique Subsaharienne: potentialités.(Symbiotic nitrogen-fixation by forage legumes in sub-Saharan Africa: potentials).
Bulletin CIPEA, 20, 1984, pp. 2-14, Addis Ababa, Ethiopia

This very exhaustive article underlines the importance of the role of tropical legumes in N-fixation. After describing the potentials (some legumes like Centrosema pubescens, Leucaena spp., Stylosanthes guianensis, Trifolium repens, fix more than 250 kg/ha) and constraints (nature of rhizobium, water content in the soil, phosphorus content), some techniques of improvement and forms of introduction into agricultural systems are presented and discussed:
- seed coating (calcium, phosphorus, microelements)
- introduction of short-term legume crops in cereal rotations
- green manuring crops
The other roles of legumes (organic matter supply, enrichment of soil structure) are only superficially mentioned, which is most regrettable.
Abstract from Agriculture actualité (GEYSER)

227 88 - 12 /12

Soil fertility
Organic matter, soil fertility, guide, organic improvements
ANRED
Amendements organiques; guide de l'utilisateur (Organic improvements: a user's guide).
ANRED, 1987, 11 papers, 30 pp., available from: ANRED, 2 square Lafayette, F-49004 Angers Cedex, France

The problems of improvements and of organic substrates are usually considered under the industrial aspect of their production; rarely are they approached under the utilization aspect.
This document is addressed primarily to the farmer and his advisor but also to everybody working in this field. Four papers deal with organic matter in general, its integration into soil, the costs, the regulations and analyses. The other seven papers give instructions for the different crops, concerning the use, dosage and application techniques.
Abstract from Agriculture actualité (GEYSER)

228 88 - 12/13

Soil fertility
Review, book, soil fertility, sustainable agriculture, micro-organisms
LOPEZ-REAL, J.M. and HODGES, R.D.
The role of microorganisms in a sustainable agriculture.
AB Academic Publishers, Berkhamsted, 1987, 246 pp., ISBN 0-907360-10-6, £ 29.50; available from: AB Academic Publishers, P.O.B. 97, Berkhamsted, Herts. HP 42 PX, England

Microorganisms in their capacities as decomposers, nutrient recyclers, symbionts or pathogens play a crucial role in all agricultural systems. They are, however, of special relevance to the biological/organic approach, where the natural processes are not short-circuited by the use of agrochemical inputs. A conference to examine the roles of microorganisms in such agricultural systems was attended by more than 100 delegates from 30 countries.
The aims of the conference were twofold: 1) to enable practitioners of biological farming to hear and read about the important role that microorganisms play in agroecosystems, and 2) to consider microbial activity not just in the context of agriculture but in terms of sustainable agriculture - a system of food production which aspires to resource efficiency and enhanced environmental quality. Eight keynote speakers presented papers covering a diverse range of topics - from soil structure and organic waste recycling to nitrogen inputs and biological control - a clear enough indication to the general reader of the crucial role that microorganisms play in such an approach to agriculture.
Abstract from ISRIC, amended

229 88 - 12/14

Soil fertility
Soil management, soil fertility, tillage systems
ICARDA
Tillage and stubble management.
ICARDA Annual Report 1987, pp. 19-20, Aleppo, Syria

Soil is a basic resource and, for all practical purposes, non-renewable. Within the ICARDA region, tractors have become widely employed, and the tractor-pulled plows and harrows originally imported from Europe and North America are now manufactured locally. With increasing population, mechanical cultivation is spreading to marginal lands, often to fields that slope more steeply. There is abundant evidence of soil loss through water erosion, especially that caused by thunderstorms at the onset of the rainy season after a hot, dry summer.
Research at ICARDA has shown that, except at times of intensive rainfall, most of the rain does penetrate the soil. The type of tillage seems to have little effect on this, except on steep slopes where the direction of plowing is usually dictated by the

configuration of small landholdings and, unfortunately, is often up and down the slope.

Typically, farmers begin with a deep primary tillage (20-30 cm). Later, they use a harrow or tyned implement for seedbed preparation. Often, seed is broadcast and the seedbed is then ridged so that the cropping pattern is in broad longitudinal bands.

With this practice, the controversial step is the deep primary tillage which, of course, is costly in terms of fuel and time. Some believe it permits quick, deep penetration of rain and, thus, the retention of moisture that plants may need to resist droughts late in the growing season. Others point to the evaporation losses that occur, especially when soil is inverted and exposed to sun and wind. There is much evidence that deep tillage, by burying weed seeds, serves to prevent their germination. But shallower tillage, which is less costly, may be just as effective both for weed control and for ensuring moisture penetration.

Weeds are indeed a major problem, especially in North Africa where farmers value weedy fallow for grazing, and their management practices tend to maintain a supply of weed seeds. Repeatedly, herbicides (or, alternatively, handweeding in the case of legumes) have been shown to provide a positive economic return but, in terms of weed control, ICARDA has not so far been able to see any marked benefit of one tillage practice over another.

Many of the soils are self-mulching clays which are plastic when wet and which crack extensively when they dry out. Such a surface, untilled and unprotected, loses water to evaporation, both from the cracks and through micropores: presumably, this is the reason why the owners of olive orchards keep the soil constantly tilled even when they grow nothing between the trees. The cereal/fallow rotations on the central Anatolian plateau employ deep tillage in the spring of a fallow year, partly to bury grass seeds but also to break up the surface and leave it rough. Then, at the end of the rainy season, farmers make a shallow till to leave a fine surface which reduces evaporation during the long, dry summer. Such techniques are widely employed, but they probably do little to prevent wind erosion during the summer or water erosion at the onset of the next season's rains. If stubble or other crop residues were left on the land after the harvest, would these reduce the erosion? To obtain protection throughout the period when the land is most vulnerable to erosion, the stubble would need to remain until the next year's crop is established; this implies zero tillage and the sowing of the next crop through the remaining stubble before or soon after the first rains.

Indeed, after the cereal crop, stubble is usually left and is then used for grazing during the summer but, since the practice of burning stubble is becoming more prevalent, perhaps more is being produced than can usefully be employed by livestock. Where tillage is not needed for weed control, and if stubble is as effective as tilling for hindering evaporation, than the farmer's balance sheet, as well as soil conservation, might be better served by his adopting techniques of stubble retention and zero tillage.

Evidence is accumulating that, when land is continuously cropped to cereals, there is a progressive decline in yield that cannot be offset by applying more fertilizer. From the point of view of sustainability, the cereal/legume rotations are much more effective. So the studies of stubble retention and zero tillage must be set within the context of an overall farming system, which includes livestock, and must take account of effects, not only for the present year, but also for those that will follow. Clearly, the goal is to develop technologies that are environmentally conservative and that farmers will be willing to adopt. Much of the needed research will be carried out in association with farmers on their own fields. For a given year, however, it is likely that a conservative technology will be less rewarding than an exploitive technology and, since many farmers and their families are living in poverty, this year's income matters more to them than an unquantifiable future benefit.