998 91 - 12/51

Soil fertility
Pacific, review, proceedings, workshop, soil management, steeplands, smallholder, sustainable land-use, agroforestry, adaptive research, cropping systems, land evaluation, land-use planning, fertilizer use, nutrient cycling, soil parameters, sociology, traditional knowledge, ODA, ORSTOM, USAID, SMSS, AIDAB, IBSRAM, CTA

PUSHPARAJAH, E. and C.R. ELLIOT

Soil management and smallholder development in the Pacific Islands.

IBSRAM Proceedings, No. 8, ISBN 974-7613-20-4, 1989, 282 p. + Appendix

This paper deals with the proceedings of an international workshop.
The workshop on Soil Management and Smallholder Development in the Pacific Islands was held in Honiara, Solomon Islands, from 16-22 September 1988. It was in response to the need for sustained food production in the high islands of the Pacific, where a very fragile environment on sloping lands, generally of volcanic origin, is regularly cleared by small farmers.
The workshop comprised five main features: presentation of technical papers, presentation of country reports followed by tentative national proposals, group discussions, field visits, and a final closing session (Appendix III).
Five of the seven days were taken up with presentations and discussions. Fifteen papers reviewing current knowledge were presented over four sessions. Additionally, six papers on case studies and developments in the region were presented and discussed during two sessions.
One day was devoted to the presentation of reports by four working groups on: (i) site selection and characterization, (ii) experimental design, (iii) monitoring of soil and plant parameters, and (iv) socioeconomic characterization and evaluation (Appendix I).
The contents of the workshop and this book are as follows:
- Current status and future perspectives
- Fertilizer, organic matter, and nutrients
- Biological and soil parameters
- Sociology and traditional knowledge
- Local experience
- Appendixes

In order to allow the participants to see the agriculture and soils in the Solomon Islands, two days of field visits - interspersed with the technical discussions - were organized. The visits enabled the participants to see the current traditional farming systems and the severe soil degradation.

999 91 - 12/52

Soil fertility
Study, soil type, pesticide residues, groundwater, soil parameters

LOCH, J.P.G.

Effects of soil type on pesticide threat to the soil/groundwater environment.

In: Chemistry, Agriculture and the Environment; Ed. M.L. Richardson, The Royal Society of Chemistry, UK, 1990, pp. 291-307

In recent times, residues in groundwater have been observed for pesticides of which laboratory sorption and degradation studies indicated no groundwater threat. A major cause of this discrepancy is that in extrapolating laboratory studies to the field, too little attention has been given to soils vulnerable to pesticide leaching. These are the permeable soils with low content of organic matter and clay.
The environment threats considered are accumulation of pesticide residues in the top soil and their leaching to the groundwater. These should be considered as simultaneous processes. Metabolites are part of the total residue involved and need to be included in the risk assessment.
The comments in this paper will be limited to soils of moderate climates, overlying unconfined groundwater.
Concluding, it can be said that the risk of contamination of groundwater and soil by respectively leaching and accumulation of pesticide residues is not only determined by the properties of the residue compounds involved but also by the type of soil where the pesticides are applied.
Highly critical is the metabolic activity of the soil. It determines the degree of removal from the total soil/groundwater environment. Generally, there are no clear rules to distinguish soils in this respect, although a high nutrient level and supply of fresh organic matter will favour biological activity. When assessing transformation of pesticides in the soil, it is important to have knowledge of intermediates and the rate of complete mineralization.
As most pesticides are of low volatile, non-ionic nature, the organic matter content of the soil and the thickness of the humic soil horizons are the next major soil properties to determine the residence time of compounds in the soil and, therefore, the degree of transformation at a given persistence. For weakly acid compounds the pH has also a strong influence, with higher mobility at high pH.
A number of soil types are recognized, where the underlying phreatic groundwater is undoubtedly vulnerable to contamination by pesticide residues in moderate climates. These are the sandy soils of low organic matter belonging to the soil groups (FAO classification) of arenosols, gleysols and podzols. Soils of high organic matter content like the histosols, fimic anthrosols,

chernozems and other soils with a thick mollic surface horizon tend to accumulate persistent residues.
Field monitoring shows that several other soils, including some of relatively high organic matter content, fail to protect groundwater against pesticide contamination. This can be due to dispersion, influence of pH, and redox condition. In groundwater risk assessment it is essential that these processes are taken into account.
Although soil type and compound give an indication of the vulnerability of the soil/groundwater environment, the best way to estimate risks is by field monitoring and field experiments on the soil involved. After pesticide use, monitoring for the presence of its residues, including intermediates, in soil and groundwater should be continued.

1000

91 - 12/53

Soil fertility
Review, humid tropics, tropical rain-forests, deforestation, ecology, land clearing methods, microclimate, soil restoration, IITA, IBSRAM, GTZ, USAID

LAL, R.

Need for, approaches to, and consequences of land clearing and development in the tropics.

In: Proceedings of an IBSRAM Inaugural Workshop, Bangkok, Thailand; 1987, pp. 15-27

This paper is a state-of-the-art report on tropical rainforests, their geographical distribution, and the rate, causes, and ecological consequences of deforestation.
Deforestation in the tropics is an important ecological factor that has strong environmental consequences. The most notable regional and local effects of deforestation include changes in soil properties, primarily soil bulk density and penetrometer resistance and water retention and transmission properties, soil organic-matter content, and population and activity of soil fauna. In addition to local effects, deforestation has regional and global effects.
Removal of the protective forest vegetation exposes structurally unstable soil to the driving force of rains, resulting in accelerated soil erosion from arable lands of even gentle slopes. The magnitude of soil erosion also depends on deforestation methods, soil and crop management, and land-use.
Soils supporting tropical rainforests are usually old, highly weathered, and excessively leached.
The most common soils in tropical rainforests are Oxisols, Ultisols, and Alfisols containing predominantly low-activity clays. Whereas Oxisols and Ultisols occur in the humid tropics, Alfisols are predominant in the seasonally dry tropics. In general, Alfisols have higher chemical fertility than Ultisols and Oxisols.
The most common minerals, except quartz, are weathered to kaolinite and to iron and aluminium oxides and hydroxides. The most soluble elements e.g., sodium, potassium, calcium, and magnesium have been leached and replaced by aluminium in highly weathered Oxisols and to some extent in Ultisols.
The predominance of kaolinite in the clay fraction has important implications for land clearing and development. Kaolinite has low swell-shrink capacity and forms stable microaggregates. In Oxisols, these stable microaggregates usually persist throughout the soil depth; some Alfisols and Ultisols also exhibit stable aggregation. All other groups of Alfisols and Ultisols have less stable structure. Kaolinite has low cation-exchange capacity, particularly at low pH. Most of the nutrient-retention capacity, therefore, is attributed to the humus content, which is often low and declines rapidly with cultivation.

Methods of land clearing for arable land use are reviewed in terms of their effects on soil, microclimate and crop yield. Appropriate post-clearing soil-management techniques are discussed in this paper.
Research conducted to date indicates that most tropical soils can be intensively cultivated and produce high and sustained yields when an ecological approach to agriculture is adopted. Land clearing techniques play an important role in this.
The author concludes that it is important that priorities are defined and research goals are sharply focused. A coordinated effort is needed to achieve these objectives.

1001

91 - 12/54

Soil fertility
USA, study, laboratory analysis, field analysis, organic farming, conventional farming, soil fertility parameter, farming systems, erosion control, tillage operations, cropping systems

REGANOLD, J.P.

Long-term effects of organic and conventional farming on soil productivity.

In: Proc. of the Seventh IFOAM Scientific Conference, Ouagadougou, 1989, pp. 232-243

This paper summarizes soil biological, chemical, and physical data from studies, which were conducted on farms in the Palouse Region of Washington State, USA. The objective of each of these four studies was to determine the long-term effect of organic and conventional farming on selected soil properties of Naff silt loam.
The U.S. Department of Agriculture defines organic farming to be a system that avoids or excludes the use of synthetic fertilizers and pesticides and relies upon practices such as crop rotations, use of animal and green manures, and aspects of biological pest control. Conventional farming is a system that is heavily dependent on the use of synthetic fertilizers and pesticides.
Surface soil organic matter was almost 60 percent higher on the organically-farmed soil than on the conventionally-farmed soil. Soil from the organically-farmed field had significantly higher polysaccharide content than soil from the conventionally-farmed field. Polysaccharides, some of which are produced by soil microorganisms, serve as active binding agents in soil aggregate formation, and are one of several factors involved in aggregate stability.
The higher polysaccharide content in the organically-farmed soil may suggest it has greater aggregate stability.
The organically-farmed soil had a significantly higher CEC, presumably because of the higher organic matter content. The lower pH in the conventionally-farmed soil probably resulted from ammonium fertilizer applications and from a lower buffering capacity because of less organic matter. Total N in the surface soil was significantly higher for the organically-farmed soil, whereas mineral nitrogen was significantly higher in the conventionally-farmed soil because of the addition of chemical nitrogen fertilizer. Total and extractable P were not significantly different between farms. Extractable K was significantly higher in the organically-farmed soil, but extractable Ca and Mg concentrations were not significantly different.
The surface layer of the organically-farmed soil was darker than of the conventionally-farmed soil due to the significantly higher organic matter levels in the organically-farmed soil.

Summer water contents were significantly higher in the organically farmed soil, which may also be attributed to its having higher organic matter levels.
The surface soil structure for the two soils were distinctly different, with that of the organically-farmed soil being granular and that of the conventionally-farmed soil being subangular blocky parting to granular. A well-granulated soil has the best structure for most ordinary crop plants, allowing free percolation of excess moisture and at the same time enabling roots to grow freely in the pore space between the soil aggregates.
The moist consistence of the organically-farmed soil was friable, whereas that of the conventionally-farmed soil was firm.
Since soil consistence is a measure of the ease with which a soil can be reshaped or ruptured and is relevant to tillage by farm machinery, mechanical tillage should be easier on the organically-farmed soil because it is less hard (when dry) and more friable (when moist). The organically farmed soil had a significantly lower modulus of rupture, an index related to the hardness of surface crusting. In general, the lower the modulus of rupture, the easier it is for seedlings to emerge. Because of its more granular structure, more friable and less hard consistence, lower modulus of rupture, and higher organic matter content, the organically-farmed soil had better soil tilth than did the conventionally-farmed soil.
The data indicate that, in the long-term, the organic farming system was more effective than the conventional farming system in maintaining the productivity and tilth of the Naff soil and reducing its erosion rates. The difference in erosion was indicated by the difference in the thickness of productive topsoil on the two farms, the organically-farmed topsoil depth being about 16 cm greater than the conventionally-farmed topsoil depth.
This dramatic difference in topsoil loss was most likely due to a difference in crop rotations between the two farms; i.e., only the organic farm used a green manure legume crop in its rotation, and it had different tillage operations. However, the benefits from green-manuring with a legume crop, along with the use of the chisel plow, could be included in the conventional farming system, which would result in higher organic matter levels, less soil erosion, and a reduction in fertilizer and pesticide requirements.

1002

91 - 12/55

Soil fertility
Review, cassava, soil productivity, nutrient absorption, restoration of soil fertility, soil erosion, CIAT

HOWELER, R.H.

Long-term effect of cassava cultivation on soil productivity.

Field Crops Research, 26, 1991, pp.1-18

The objective of this paper is to review the literature and examine whether cassava is highly exhaustive of soil nutrients, and degrades soils by causing excessive erosion, to compare cassava in this respect with other crops, and to discuss possible solutions.
Cassava (*Manihot esculenta* Crantz) in the tropics is grown on the poorest soils, such as on eroded slopes or extremely sandy soils, where it produces something whereas other crops would not.
Cassava production may cause erosion and drastically reduce soil productivity. In many cases, however, cassava is planted on already eroded slopes, where no other crop can produce on the highly acid and infertile exposed subsoil.
This paper reviews the literature to show that cassava does extract large amounts of nutrients from the soil. However, when nutrient extraction is calculated on the basis of per unit quantity dry-matter produced, cassava extracts much less N and P than, and similar amounts of K to, most other crops. Long-term fertility trials indicate that, without adequate K fertilization, cassava yields eventually decline due to K depletion, except in those soils containing large amounts of K-bearing minerals.
When expressed in terms of kg of nutrients removed per ton of DM produced, cassava removes much less N and P than, and similar amounts of K to, many other crops.
Long-term fertility trials in several countries have shown that cassava may respond more significantly to applications of N and P in the first year, but that invariably K becomes the most limiting nutrient after several years of continuous cassava production. Thus, medium-to-high levels of K should be applied annually to cassava in all soils except those that have an exceptionally high K-supplying power, in order to prevent soil nutrient exhaustion and maintain high yields.
The effect of these practices on erosion and cassava yield should be determined locally to identify those practices that are most effective. While some cassava varieties may still be quite productive when grown on eroded soils, in most cases yields are drastically reduced by a severe degree of erosion.
Soil productivity and high yields of cassava can be maintained as long as the nutrients removed by the crop harvest are replaced and the crop is adequately managed to prevent excessive levels of erosion.

1003 91 - 12/56

Soil fertility
Asia, India, study, mixed farming, integrated systems, coconut, monocropping, rhizosphere, soil biomass, soil enzymes, soil fertility

BOPAIAH,B.M. and H.S. SHETTY

Microbiology and fertility in coconut-based mixed farming and coconut monocropping systems.

Trop. Agric. (Trinidad), 68, 2, 1991, pp. 135-138

In this study, in addition to soil microflora, soil enzyme activity profiles, microbial biomass and fertility of the soils in the root zone (three depths) and the rhizosphere of coconut mixed farming and coconut monocropping systems are studied.
In pure stands of plantation coconuts under normal spacing of 7.5 x 7.5m, about 75% of the total areas is not being effectively utilized. There is scope for growing several inter- or mixed crops in coconut gardens.
The mixed farming system aims at increasing the productivity of coconut plantings and to integrate livestock production.
The mixed farming experiment was started in 1972 with Napier grass Var.NB-21 (*Pennisetum purpureum* Schum.) in a 60-year-old coconut garden.
The mean annual rainfall of the area is 3700 mm.
The spacing adopted for planting of coconut was 7.5 x 7.5 (175 palms ha^{-1}). The basin region of the coconut palms was left without grass. Black pepper (*Piper nigrum* L.) was trailed on the trunks of the coconut palms, which were fertilized with 500-320:1200 g NPK $palm^{-1}$ $year^{-1}$.
The grass received 20 kg N, 8 kg P_2O_5 and 60 kg K_2O ha^{-1} after every cutting, in the form of urea, superphosphate and muriate of potash, respectively.
The grass was cut at 30-40-day intervals to feed the dairy animals. The cowdung was placed in a biogas plant and the slurry was recycled into the coconut/grass mixed stand. During the dry period, sprinkler irrigation (2 cm weekly) was provided to ensure the steady growth of the grass.
Rizosphere soils were collected from the coconut/grass intercrops and from coconut monocrops plots.
Bacterial counts were higher in the rhizosphere of coconut and Napier grass of mixed farming than in coconut monocropping. The microflora and enzyme activities were greater in the rhizosphere soil than in the root zone soil.
The greater microbial biomass is due to the increased microbial load in the mixed farming system. The organic carbon and total N contents of the soil were higher in the mixed farming system than in the coconut monocropping system. The addition of slurry from the biogas plant added considerable organic matter into the system, thereby increasing the various microbial and biochemical

properties of the soil. The total available P was sligthly higher in the mixed farming system.
The enhanced microbiological and biochemical properties in the mixed farming system may be one of the factors contributing to increased productivity. The recycling of cowdung from the biogas plant in the mixed farming system helps to maintain soil fertility at levels higher than in the coconut monocropping system. The greater root volume of crops per unit volume of soil adds more organic matter by way of dead roots.
The build-up in soil organic carbon, N and P indicates the improvement in the soil fertility.

1004 91 - 12/57

Soil fertility
Humid tropics, study, nutrients, cropping systems, leaching loss, simulation model

SEYFRIED, M.S. and P.S.C. RAO

Nutrient leaching loss from two contrasting cropping systems in the humid tropics.

Trop. Agric. (Trinidad), 68, 1, 1991, pp. 9-18

In this study, nutrient leaching losses from two contrasting cropping systems, monocropped annual (MA) and multiple cropped perennial (MP), were compared to determine if water and nutrient use is more efficient in the latter. Water movement through the soil profile was estimated with a mathematical model. The data were combined with measured soil solution nutrient concentrations to estimate nutrient leaching loss. A method of characterizing cropping systems in terms of sensitivy to nutrient leaching loss is discussed.
Measurements of nutrient leaching loss from agricultural fields in the tropics are rare. Existing published results indicate a wide range in such losses, but there is strong evidence that leaching loss can be very significant.
The major objectives of this study were to compare nutrient leaching losses from two contrasting cropping systems.
A capacity-parameter based model of water and solute movement was modified to include the effects of a fluctuating water table. Profile soil-water content, calculated using the model, closely approximated measured values over a 98-day period. Nutrient leaching losses were estimated from model-calculated deep percolation values and measured soil solution nutrient concentrations. Soil solution concentrations of NO_3^-, K^+, Ca^{2+} and Mg^{2+} at a depth of 90 cm were approximately constant over the 242-day measurement period. Losses of the latter three elements were significantly greater, by 2-15 times, in the MA system. Estimated loss of NO_3^--N from the MA plot was 56 kg ha^{-1} and approximately 1 kg ha^{-1} from the MP system. Model simulations indicated that little residual fertilizer NO_3^- would be available to a subsequent crop in the MA system. These calculations were extended to develop another parameter, the solute residence time within the crop root zone. The slightly greater solute residence time of the MP system was not sufficient to explain the much larger leaching losses from the MA system; this was attributed to more efficient nutrient retention and uptake capabilities of the MP system. The solute residence time may prove most useful for comparison of similar cropping systems under different soil and climatic conditions.

1005 91 - 12/58

Soil fertility
USA, study, maize, clover, soybean, nitrogen fertilizer, conservation tillage, cropping systems

OYER, L.J. and J.T. TOUCHTON

Utilizing legume cropping systems to reduce nitrogen fertilizer requirements for conservation-tilled corn.

Agron. J., 82, 1990, pp. 1123-1127

The objective of this study is to determine the effects of a winter legume (crimson clover) reseeding system in combination with a soybean-corn rotation, on N fertilizer requirements of corn grown in a conservation-tillage system.
This study was conducted during 5 years on sandy loam and fine-sandy loam soils in the Appalachian Plateau and Coastal Plains of Alabama, respectively.
Alternate and renewable sources of energy are needed in agriculture because of rising costs and potential shortage of fossil fuel. Nitrogen fertilizer represents the largest single input of the total energy required to produce a hectare of corn (*Zea mays* L.) in the USA.
The need to reduce costs has promoted a renewed interest in using legumes as a source of N for non-leguminous summer crops. Development of legume cropping systems which will permit reseeding of winter cover-crop legumes is a promising approach to reducing legume establishment costs. Field studies were conducted in Alabama for 4 yr on Wynnville sandy loam and Dothan fine-sandy loam soils (fine-loamy, siliceous, thermic, Glossic Fragiudults and Plinthic Paleudults, respectively) to determine the effects of both cash crop and winter cover-crop legumes in cropping systems on N fertilizer requirements of corn (*Zea mays* L.) grown in a conservation-tillage system. On the Wynnville soil, soybean (*Glycine max.* L. Merr.) was more effective in providing early season N, and clover (*Trifolium incarnatum* L.) in providing late-season N. The system with soybean and clover resulted in an even more effective contribution of N to corn grain yield, and a higher yield level than that of continuous corn regardless of N fertilizer rate. On the Dothan soil, the benefits of cropping systems were not as pronounced, and the responses were eliminated by N fertilization, suggesting increased yields were due to N and not to a rotation effect.
These data indicate that growing reseeding crimson clover in combination with a soybean-corn rotation appears to be an agronomically viable system for conservation-tillage corn production. The soybean-clover-corn system consistently produced the highest yields among the systems studied, in both adequate and inadequate rainfall years, and provided a 68 to 159 kg N ha^{-1} fertilizer equivalent for corn.

91 - 12/59

1006

Soil fertility
Asia, India, sandy loam soil, field trials, split plot design, *Azolla pinnata*, planting direction, nitrogen fixation, spacing, rice

SINGH, A.L. and P.K. SINGH

Intercropping of *Azolla* biofertilizer with rice at different crop geometry.

Trop. Agric. (Trinidad), <u>67</u>, 4, 1990, pp. 350-354

The objective was to study the effects of wide-row spacing and row orientation on the growth and N_2-fixation of *Azolla* and their effects on rice growth and yields.
Field experiments were conducted during the dry and wet seasons of 1983 and 1984 at the Central Rice Research Institute, Cuttack, India.
The increasing cost of chemical N fertilizer and the widening gap between its supply and demand have generated great interest in the use of *Azollas* as alternate source of N for rice in many countries.
Azolla is used as a green manure crop before transplanting and also as a dual (inter-crop) crop with rice after transplanting. Shading under the rice canopy increases gradually with the rice growth; by widening the gap between rice rows, *Azolla* has been grown continuously under rice canopies.
Intercropping of *Azolla* with rice transplanted in rectangular (10 x 40 cm) spacing produced greater biomass and accumulated more nitrogen in the *Azolla* than its intercropping in square (20 x 20 cm) spacing. The differences in biomass and N accumulations were greater in the second crop of *Azolla* at 50 days after transplanting (DAT) of the rice crop than in the first crop of *Azolla* at 30 DAT. The E-W direction of rice rows in the rectangular spacing produced greater biomass and fixed more nitrogen in the *Azolla* than with rice rows in the N-S direction. Growing and incorporating *Azolla* once before transplanting and twice after transplanting produced the highest grain and straw yields, greater number and weight of panicles, and N uptake by rice.
The organic C, total N and available P contents of the soil after the rice harvest were significantly greater with *Azolla*, but spacing did not alter these. Their contents were significantly greater in *Azolla* basal + *Azolla* dual twice incorporated treatment than in others, in agreement with earlier studies.
The application of *Azolla* also significantly improved the soil fertility by increasing total N, organic C and available P of the soil.

1007

91 - 12/60

Soil fertility
Asia, Philippines, studies, soil biology, organic fertilization, wetlandrice, Frankia, biofertilizer,in vitro culture, nitrogen fixation

ASPIRAS, R.B. et al.

Frankia as biofertilizer for wetland rice.

In: Proc. of the Seventh Scientific IFOAM Conference, Ouagadougou, 1989, pp. 269-281

The objective of this study is to determine the distribution of Frankia in wetland rice soils, the nitrogenase activity in vitro and in the presence of rice roots, and study the possible application as biofertilizer for rice.
Members of the genus Frankia are able to fix atmospheric nitrogen in the root nodules of woody plants.
Interest was boosted by the results showing that the amount of nitrogen fixed compares favorably with the rhizobium-legume system, and the energy requirement for nitrogen fixation in plants.
Frankia grows in vitro predominantly in the form of *septate hyphae*, and under suitable conditions will form vesicle, the structures considered as seat of nitrogen activity. Nitrogenase activity was observed only in cultures with vesicles and was correlated with the number of vesicles.
Frankia has not been enumerated in soil. Results of other studies indicate the wide distribution of this actinomycete in the Philippines considering the observation of well nodulated *Casuarina equisetifolia* and *Elaeagnus philippensis* throughout and also of *Alnus maritima*, *Mirica javanica* and *Coriaca intermedia* in high altitude areas.
From the studies presented in this paper it can be summarized that
- Frankia is widespread in wetland rice soils,
- Frankia supports substantial nitrogen fixation in the rice roots, and,
- Frankia treatment on rice seedlings can result in increased grain yield.

The results support the use of Frankia as a bio-fertilizer. This technology can be adapted quite easily at the farm level considering that it grows very easily using soil extract amended with table sugar as medium.
Frankia isolated grow fast forming colonies in two to three days while those isolated in temperate countries would form visible colonies in three weeks of incubation.
The Frankia technology can be easily adopted be used to great advantage in lessening dependence of farmers on expensive sources of commercial nitrogen.

91 - 12/61

1008

Soil fertility
Review, manual, tropics, compost, organic wastes, humus production techniques, farming systems, agricultural output, manual labour, mechanization, economic aspects

DALZELL, H.W. et al.

Composting in tropical agriculture.

Publ. of Int. Institute of Biological Husbandry, Station Approach, Needham Market, Ipswich IP6 8AT, UK, 1981, 30 p. + Appendices; Review Paper Series No. 2

The present manual describes the process, proposes a simple approach to compost heap construction and examines the economics of compost production and use.
Composting is the breakdown of organic wastes by enormous numbers of micro-organisms and soil fauna, such as worms, in a moist, warm, aerated environment to give a humus end product.
The microorganisms take in moisture, oxygen from the air and food from the organic wastes. They give off carbon dioxide, moisture and energy; they reproduce themselves and eventually die. Some of the energy is used for growth and movement; the rest is given off as heat which one tries to conserve in a compost heap. As a result the heap passes through warming-up, peak temperature, cooling down and maturing stages. The final compost product, humus, consists of the resistant parts of the organic wastes, some breakdown products, plus dead and living micro-organisms.
For the process to give a satisfactory compost product the organisms must be given optimum conditions of food, air, moisture and warmth.
Composting can be of value to the general economic life of rural areas by recycling wastes which are currently discarded or burnt, by providing opportunities for work, and by reducing heavy dependence on imported inorganic fertilisers. If compost is made properly, in a heap that heats up adequately, then weeds, pests and diseases in the raw materials are controlled and the product can be used safely in agriculture.
Composting can compete economically with inorganic fertilisers in many areas on a nutrient basis when fertiliser costs are high, labour costs are low, organic raw materials are readily available and where cash for fertiliser purchase is borrowed at high interest rates.
Composting can be carried out at any time and hence can be fitted into any slack period in the farming year. Compost can be used in conjunction with inorganic fertilisers; an improved response is normally obtained.
To prepare good compost attention must be paid to the choice of raw materials and to the moisture, temperature and aeration of the heap. In making compost the following points must be remembered:
- Use organic materials only (except for approved additives).

- Mix ingredients thoroughly.
- Water carefully to the damp sponge condition.
- Turn the heap thoroughly at the right times.
- Cover the heap when necessary.

The importance of recycling organic wastes is being increasingly recognised. At present many of the wastes available in tropical situations are poorly used. Composting is an excellent method of converting them to a form which provides significant agricultural benefits.
During his 10 years experience of agricultural development in India, the author has carried out the practice of composting, with support from the University team in England. This manual is the result of the joint experiences.
The booklet is easily read and can be recommended to all those interested in the sustainability of tropical soils and agricultural production.

1009 91 - 12/62

Soil fertility
Review, manual, tropics, green manure, soil improvement, fertilization, soil conservation, legumes, nitrogen fixation, organic wastes, animal manure, crop residues, mulching, water conservation, agroforestry, trees and shrubs, intercropping, strip cropping, biofertilizer, rhizobium inoculation, AGROMISA, CTA, POOL

BRANDJES, P. et al.

Green manuring and other forms of soil improvement in the tropics.

Agrodok 28; AGROMISA, P.O.B.41,6700 AA Wageningen, The Netherlands, ISBN 90-72746-16-3, 1989, 35 p. + Literature + Appendices

AGRODOKS are a series of low-priced, simple manuals on agricultural practices in the tropics.
This Agrodok discusses green manuring and several other forms of soil improvement in the tropics. In particular, attention is paid to plants that can fix atmospheric nitrogen.
There are many areas in the tropics where a lack of nitrogen limits the yield of a crop. Chemical manure is not yet easily available in all places, or often too expensive for farmers. In such cases one can grow these nitrogen fixing plants and/or use them as a fertilizer for other crops that require but cannot fix it themselves.
Plants that are able to fix atmospheric nitrogen are called green manures because when they are ploughed into the soil they are a form of organic manure. These plants are often also used as so-called cover crops to prevent erosion by wind and water.
The contents of the booklet are:
- Soil
- Soil conservation
- Fertilization
- Fertilization and water conservation possibilities in the semi-arid tropics
- Fertilization and soil conservation possibilities in the sub-humid tropics
- Green manuring possibilities in the humid tropics

Literature
Appendix 1 - Deficiency symptoms
Appendix 2 - Addresses for rhizobium inoculant
Appendix 3 - Rhizobium-inoculation of seeds
Appendix 4 - List of green manures
Appendix 5 - List of seed suppliers

This Agrodok has been written for field workers in developing countries and anyone else who is interested in practical information about the above subjects. Although the relevant scientific publications have been consulted, there are only those data included that have practical relevance.

The authors of this Agrodok have assumed that not all readers have an agricultural background and training. This is why they have included a short introduction about the soil, soil conservation and fertilization. These are followed by discussions of practical possibilities for green manuring in the semi-arid, subhumid and humid tropics. The appendices contain background information about green manuring and addresses of green manure seed and inoculant suppliers.
This Agrodok and other publication in this series are well written, easily read and therefore particulary important for field workers, undergraduates and practitioners. These booklets are highly recommended.

XIII EROSION AND DESERTIFICATION CONTROL

91 - 13/37

1010

Erosion and desertification control
Africa, soil erosion, farmer perspectives, government involvement, donors, soil productivity, soil degradation, macroeconomics, microeconomics, off-site effects, indigenous conservation techniques, IIED, SIDA

FONES-SUNDELL, M.

Perspectives on soil erosion in Africa: whose problem?

Gatekeeper Series No SA 14, 1989, 14 p., Publication of Int. Institute for Environment and Development (IIED), 3 Endsleigh Street, London, WC1H ODD, UK

The aim of this paper is to examine soil erosion in Africa as it fits into the problem hierarchy of the farmer, the government and the donor and to try and understand why these different actors place different priorities on land husbandry activities, including sustainable agriculture programmes.
Peasant farmers are not irrational, they place more emphasis on short-term planning than do governments and donors. From the point of view of the farmer, the strategy is one of minimising risk, guaranteeing subsistence and generating cash income simultaneously. This can be summarized as "reliable multi-purpose production".
This means that farmers are motivated to participate in soil conservation work when they perceive erosion to be an immediate threat to their livelihood. Investments in land husbandry measures, including the labour input, must be profitable in the short run and not represent a total break with traditional farming practices. This reduces risk for the farmers and enables them to satisfy immediate subsistence needs.
But it is important to keep in mind that farmers, governments and donors might have different reasons for engaging in land husbandry.
Governments are interested in the health of the national economy and staying in power, often by creating patronage bonds with powerful groups. They also must be very aware of the short-term considerations. Aid donors do not suffer the same serious economic or political consequences as farmers and governments in the event of failure. They are able to be more concerned with the long-term planning horizon than the other two, and have not been overly cost conscious in conservation efforts thus far.
In the past too little thought has been given to legitimate short-term needs of farmers and governments by donors designing sustainable agriculture and other environmental protection programmes.
Farmers usually do not perceive soil erosion to be their major problem and they are seldom in a position to directly benefit from investments in sustainable agriculture programmes. The government rightly sees more efficient ways to achieve the quick increases in agricultural production necessary in the current climate of political and economic crisis.

In the light of all this the following considerations should be taken into account:
- Less emphasis on top down approaches
- Planning and implementation should be based on better information
  . soil loss/soil productivity relationship
  . macroeconomics of erosion/degradation
  . microeconomics of erosion/degradation
  . off-site effects
  . indigenous conservation techniques

There should be clear division of conservation responsibility between the state and the individual. This is because soil erosion is a process with long term costs to society whose eradication is a cost all too often borne by individuals in the short term.
Where soil conservation measures are not profitable in the short term and/or farmers are not interested, then the state will have to assume financial and maintenance responsibility.

91 - 13/38

1011

Soil erosion and desertification control

Review, semi-arid region, drought, agriculture, soil erosion, political implications, social change, climate, soil, farmer, physical potential, technology transfer, integrated programs, biological soil conservation, water conservation, water harvesting, trees, shrubs, grazing land

HUDSON, N.W. et al.

Soil and water conservation in semi-arid areas.

FAO Soils Bulletin 57, 1987, 169 pp. FAO Publications Division, Via Delle Terme di Caracalla, 00100 Rome, Italy

This Bulletin deals with the problems of soil and water conservation in semi-arid regions.
The Bulletin reviews methods and techniques which have been tested and found useful somewhere, and which might be suitable for use in other conditions.
The first three chapters are introductory, and outline the scale and importance of the problem, the difficulties and the possibilities for improvement. The Bulletin argues strongly, and presents evidence, that drought is part of the natural order in semi-arid areas, and that the recent disasters of degradation and famine in Africa result from misuse and mis-management of the natural resources which reduced the region's ability to cope with the additional stress of drought.
Chapter 2 starts with a review of the extent of the erosion problem and the pressures on semi-arid ecosystems resulting from increasing human and livestock populations.
Looking at the possibilities for improving agriculture in Chapter 3, a case is made for wider adoption in semi-arid regions of the existing techniques of resource inventory which would allow developing countries to make long-term plans for the optimum development of their resources, maximizing development of better land and minimizing stress on the marginal areas.
The first of the four technical chapters deals with soil conservation under the headings Principles, Biological Soil Conservation, and Mechanical Conservation Works. It is argued that in semi-arid regions, with inevitable low production, much of the conventional approach is inappropriate because it has been developed in very different conditions.
Chapter 5, called Water Harvesting, deals with methods to increase the amount of moisture stored in the soil profile or where there is some small movement as surplus run-off. The choice of methods of water conservation is difficult because the desired objective may change from one season to another.
Under the section "Water Spreading" there is a discussion of various forms of localized use of surface run-off, either occurring naturally from hill areas or after it has been diverted and collected in channels. Several ancient examples of this type of run-off farming are described from the American Indians, Tunisia, and Israel. There are also more recent examples from Kenya, Pakistan, and the Yemen Arab Republic. Inundation methods are where floodwaters are impounded and retained long enough to saturate the soil so that a crop can be grown on the stored moisture. These range from small-scale examples from the Sudan to Brazil to the much larger schemes in semi-arid areas of India, some of which have been used for hundreds of years. The diversion and spreading of floods and spate flows without storage are discussed with examples from Pakistan, Yemen Arab Republic, and several countries in Africa. Sub-surface drainage is felt to have limited application in semi-arid regions, but several examples of simple surface drainage systems are described.
Methods where surface run-off is collected and stored in dams, tanks, or cisterns for later use are described in Chapter 6 on "Water Harvesting and Use." The amount of run-off is critical to such schemes, so there is a discussion of ways of treating the catchment to improve run-off. Practical guidance is given on the design and construction of small earth dams and weirs. Sand dams are discussed, where water is stored in the pore spaces of sand retained by a weir, a method which may be particularly useful in hot climates because surface evaporation losses are reduced. Off-stream storage is described, including the traditional 'hafirs' of Arabic-speaking northern Africa, the tanks of India, and the small reservoirs used in Western Australia for stock watering. There is a discussion of methods for reducing seepage losses through the floor of storage basins, and evaporation losses from the surface, although the available solutions to both these problems are frequently too expensive for general use. This chapter ends with a discussion on groundwater, covering methods of recharge and extraction from wells, boreholes, and horizontal wells, including the ancient qanats of north Africa and western Asia, and modern drilled horizontal wells in the western USA.
Chapter 7 discusses applications of water conservation to grazing land and to trees and shrubs. Examples are shown from Niger and from Namibia in this chapter. There is no doubt that national herds of livestock are increasing and numerical examples are quoted from Swaziland, and from the Mambilla Plateau on the border of Nigeria with Cameroon. The decreasing mobility of nomadic or semi-nomadic pastoralists is discussed, quoting the example of Botswana where the two main causes are settlement, and the provision of permanent water supplies at the cattle posts by replacing the previous natural water supply with boreholes. Two examples of successful group livestock management schemes are mentioned, from Niger and from Eastern Senegal. Examples of good management are taken from the western USA and compared to the traditional management of the grazing by linking it to water supplies in the Butana region of the Sudan.
Ethiopia is the model for a study of the progressive phases of degradation starting with depletion of the tree growth, and ending in a massive exodus. The methods suggested are variations of the rainfall multiplier approach discussed earlier for cropland. They range from a small basin in which a tree seedling is planted, perhaps with small channels to lead extra water to the basin, up to the 250 m^2 microcatchments developed in the Negev desert in

Israel. Other variations of this principle are quoted from several countries in Africa.
This Bulletin does not offer easy solutions to all the problems of soil and water conservation in semi-arid regions. The conditions vary too much - the climate, the soil and the social and economic factors. The book can be recommended to all who are interested in Africa's development and environment protection of the resource base
Authors' summary, shortened

1012

91 - 13/39

Soil erosion and desertification control
Review, tropics, arable land, soil surface management, development priorities, cover crops, residue mulching, no-tillage practices, conservation techniques, steep land management, mixed cropping

LAL, R.

Soil erosion from tropical arable lands and its control.

Advances in Agronomy, 37, 1984, pp. 183-248

With its far over 300 references this is a review on tropical soil erosion, especially on basic research information of the last 15 years and its consequences. Its most striking opening statement is that the ability to prevent soil erosion on tropical lands is hardly better than that of the stone-technology slash-and-burn agriculture of the Mayan civilisation. The paper becomes most interesting in the last three chapters, where soil surface management for erosion control, run-off management and research and development priorities are treated. Soil surface management techniques that have an important influence on soil erosion include seedbed preparation, crop residue use, weed control and some husbandry measures. In this chapter residue mulching gets dealt with intensively, together with cover crops, in situ mulch and no-till for soil erosion reduction. Examples are geographically well distributed and good quantitative examples are given, such as regression equations relating soil erosion with slope for different mulch rates, effects of mulch rate on soil physical properties and the effect of different tillage practices on run-off and soil erosion. A list of some 20 cover crops (grasses and legumes) used for soil and water conservation in the tropics is also tabled. On run-off management, the paper discusses terraces, diversion banks and contour ridges and quantifies with examples, among others reduction of soil erosion losses from various conservation techniques and effects of mulch, tillage and strip cropping on run-off and soil erosion. The paper concludes that the topics of priority research must bear on practical problems. Basic data collection must have first priority. Suggested priority research subjects are in the field of erosion rates, erosivity, erodability, steep land management, soil erosion/productivity relationships, soil degradation, methodology and conservation-effective farming systems. On this last subject it is concluded that ground cover by mulch, cover crops, no-till, vegetative cover and mixed cropping have shown to be important in erosion control on tropical arable land.
Abstract by L.J. Stigter

1013 91 - 13/40

Soil erosion and desertification control
Review, tropics, weather, soil loss, runoff, appropriate research methods, field plots, rainfall measurement, monitoring

EL-SWAIFY, S.A.

Monitoring of weather, runoff, and soil loss.

In: IBSRAM Proceedings No. 8 - Soil Management and Smallholder Development in the Pacific Islands; ISBN 974-7613-20-4; 1989, pp. 163-178

The objective of this paper is to discuss data requirements, and simple methods for monitoring rainfall erosion and runoff rates from farmlands. Special emphasis is placed on tropical agroenvironments.
The erosion hazard in tropical agroenvironments is so high that, if manifested, it detrimentally affects the productivity and stability of valuable resources. Assuring the success and sustainability of agricultural enterprises requires not only sound conceptualization, effective technical design and deliberate, socioeconomically feasible implementation, but also the regular monitoring and assessment of a farming system's conservation-effectiveness.
It is particularly useful to distinguish two classes of erosion - geological and accelerated - although other classifications have been proposed and may be useful in particular situations.
Accelerated erosion is usually a more rapid process that is largely induced by such human practices as forest clearing, raising crops and domesticated animals, mining, and construction. It is this form of erosion by water, which is more detrimental - but also amenable to limitation and control - that is the focus of this report.
While this view of erosion emphasizes the role of overland flow, it must also be realized that the energy associated with raindrop impact is an important factor; the raindrop is the initiator of the erosion process. Classic and recent studies have quantified the role of three major subprocesses which control the dynamics of the overall erosion process, namely detachment by rainfall or runoff (entrainment), transport, and deposition. Transportation of soil particles generally occurs with overland flow, but may also be accomplished by raindrop splash.
Essential erosion-monitoring parameters are best introduced in relation to the overall factors which enhance erosion by water. These factors may be summarized as:
- high quantity, intensity, and long duration of rainfall,
- high volume, and velocity of overland flow,
- poorly structured, slowly permeable, and easily detachable soils,
- steep topography and long slopes,

- sparse vegetative cover, lacking ground cover protection, and/or insufficient organic residue, and tillage practices and land surface configurations that are conducive to a high volume and increased velocity of runoff.

These factors interact to determine runoff and erosion magnitudes, and the extent to which land productivity and downstream environments may be detrimentally affected.
Concluding, the paper reviews various forms of soil erosion by water, discusses approaches, and methods for studying erosion, and indicates the appropriate scale required in making this study. It discusses the need to consider both existing and potential erosion by the use of field plots, in which attention must be given to proper plot placement, rainfall measurement, and systems for the collection and sampling of sediments. Complementary monitoring of biological and socioeconomic parameters is also needed.
Finally the paper considers the level of acceptable soil loss, and suggests that a level lower than that considered as acceptable in the USA may be more appropriate for the tropics.

1014 91 - 13/41

Soil erosion and desertification control
Latin America, Peru, Asia, Indonesia, West Sumatra, humid tropics, case studies, soil degradation, land reclamation, crop production, compacted soil, soil chemicals

ALEGRE, J.C. et al.

Strategies for reclamation of degraded lands.

In: IBSRAM Proceedings No. 8 - soil Management and Smallholder Development in the Pacific Islands; ISBN 974-71613-20-4; 1989, pp. 77-91

In this paper an approach on degraded land caused by damaged soil chemical and physical properties resulting from mechanical land clearing is discussed.
Various mechanical land-clearing methods have been and are being used in many locations in the humid tropics to replace the manual slash-and-burn method. The heavy machinery, however, compacts the soil, reduces root penetrability and soil aeration, and decreases the infiltration rate and hydraulic conductivity. The net result is that crop yields are decreased.
Soil chemical properties can also be damaged by mechanical clearing. Bulldozers, especially those equipped with straight blades, can drastically reduce fertility levels because they may remove too much topsoil, either due to careless bulldozer operators or when trees with extensive root systems are dug out or piled in windrows. Regardless of the cause, topsoil removal decreases the A-horizo thickness and removes a high percentage of the native soil organic matter and soil fertility.
The approach used in this paper is to reclaim degraded land for continuous crop production. The steps include: first, gain knowledge about crop production in the area surrounding the degraded land. After this reconnaissance survey, characterize the physical and chemical properties of the degraded land by measuring soil properties using a well-designed sampling plan. Carefully analyze this soil information to identify the soil property that is limiting crop production. Then formulate and impose one or mor land reclamation treatment(s).
The results of the two case studies indicate that degraded land can be successfully reclaimed. The overall strategy entails a reconnaissance survey of crop response and soil properties of soils in the area similar to the land to be reclaimed; quantification of soil physical and chemical properties of the degraded land; evaluation of soil property data to determine the most likely cause of land degradation; formulation of one or more techniques to reclaim the land; and, finally, implementation of land reclamation treatment(s).
The practical implementation of measures and techniques has not been dealt within this paper.

1015 91 - 13/42

Soil erosion and desertification control
Africa, Zambia, sub-humid zone, highlands, soil conservation, agroforestry, case study, project experience, diagnostic survey, women, appropriate package, NGO, PANOS, Earthscan

KERKHOF, P.

Soil conservation and agroforestry project, Zambia.

In: Agroforestry in Africa: a survey of project experience; Publ. by Panos Publications Ltd., Angel House, 9 White Lion Street, London N1PD, UK; ISBN 1-870670-16-7, 1990, pp. 143-148

Declining agricultural yields and recurrent drought are among the major problems faced by the Tonga people in southern Zambia. Widespread crop failures have brought famine to some areas in recent years.
The Tonga are a farming people with a substantial number of livestock. Maize is the main subsistence food crop while sweet potatoes, cow-peas, sorghum and several vegetables are also cultivated. Maize and the recently introduced cotton are the major cash crops. *Acacia albida* is a traditional part of the farming landscape and these vast trees are widely dispersed in the croplands. Miombo woodland covers much of the area not under cultivation.
Project implementation was carried out by Lusume Services. Lusume Services is an NGO which is active in several rural development activities and receives general assistance from the United Church of Canada.
The initial programme in 1984 relied purely on mechanical soil conservation measures. It concentrated on activities such as building dams, promoting contour ploughing and the construction of contour bunds. This was highly unpopular among farmers since it involved them in a great deal of work, especially at the ploughing and harvest seasons when the demands on their time are already at a maximum. It also reminded them of the forced labour that was imposed during colonial times.
The emphasis was therefore switched to soil conservation through improved agricultural practices, particularly the use of permanent ground cover. Ideas about ecological farming were gained from an international course held in The Netherlands. These included the use of cover crops, nitrogen fixing crops, crop rotation and natural pesticides. But it soon became clear that the complexity of the systems involved would not be acceptable to local farmers. The dense spacing of leguminous trees, for example, would prevent oxen-weeding. The majority of the experiments were therefore abandoned.
The present programme began 1986, when a decision was made to promote intercropping with *Acacia albida* as a means of increasing the ground cover and improving the fertility of the soil. Other project objectives included the promotion of tree planting in windbreaks and on field boundaries; the use of live fences;

planting trees and shrubs on contours; raising awareness about impending fuelwood shortages; encouraging the planting of fruit trees; and growing trees for fodder.
It is now clear that planting *Acacia albida* in croplands is not particularly popular among farmers. This is mainly because of the labour involved and the fact that the planted seedlings require a considerable amount of protection against fire and livestock. Neither are farmers prepared to plant trees for fuelwood or fodder on their croplands, although they might be more willing to try it on grazing lands.
The project can nevertheless show a number of useful gains. Because of the publicity, farmers increasingly recognise *Acacia albida* as a valuable tree and instead of weeding them out are leaving seddlings growing,and a programme to promote this has been incorporated in the project. There has also been a certain amount of success in encouraging the planting of windbreaks and live fences, and some farmers appear to be starting their own small nurseries.
It is obviously difficult for a small NGO to change long-entrenched official attitudes such as those in the Department of Agriculture and the Forestry Department. Nevertheless the project has already shown that something can be done to change farmers' attitudes to *Acacia albida*. It has demonstrated that farmers are responsive to tree planting if appropriate species are available. It has shown that women can be reached in agricultural extension, if given due attention.
If such lessons were to be taken up by the Department of Agriculture with its large and permanent extension service, it could have a significant effect on agricultural development in Zambia.

1016

91 - 13/43

Soil erosion and desertification control
Review, book, land degradation, desert

GRAINGER, A.

The threatening desert: controlling desertification.

Publ. by Earthscan, UK, ISBN 1-85383-0410, 1990, 368 pp.; price £ 9.95

The "Threatening Desert" looks at the nature, causes and extent of desertification; describes ways by which it can be brought under control and gives examples of projects which have aimed to do this. It then evaluates progress made so far. As many examples in the book demonstrate, when projects do not take into account the needs and wishes of local people, they are likely to fail. The social and policy components of projects are not optional extras or even supplementary to the basic techniques of resource management, they are absolutely essential. Arousing awareness and enthusiasm is difficult but therein lies the challenge for controlling desertification.
The book has been written both for the general reader, who is looking for a concise overview of the subject, and for those who are more concerned with the design and implementation of projects to bring desertification under control. The author points out that if forecasts of climatic change are correct, farmers all over the world will have to learn to adapt their agricultural practices. In those areas where climatic shifts make crop production a marginal activity there is a danger that over-cultivation will degrade the land. The parallels and possible linkage between desertification and the greenhouse effect suggest that we should do well to place far more emphasis on desertification control activities now in order to have a sound basis for wider action in the future.
Abstract from SPORE

1017 91 - 13/44

Soil erosion and desertification control
Developing countries, review, soil conservation, water conservation, participation, technology, water harvesting, productivity

CRITCHLEY, W.

New approaches to soil and water conservation.

ILEIA Newsletter 1 + 2, 1991, pp. 51-52

The "new approach" to soil and water conservation has come about more by necessity than by design. The conventional type of project - with its emphasis on building structures and reducing soil erosion - has failed so often that there has been no option but to change strategy. With the new thinking, kilometres of expensive terracing and rigid targets are out - and people's participation, flexible workplans and conservation for production take centre stage.
An increasing number of documents have appeared over the last few years articulating the change in attitude. One of the first contributions to the debate criticized aid agencies and soil conservation departments for persistent failures in projects, and simultaneously stressed the importance of basing technology on farmers' traditional systems. Several more recent publications have brought the new approach into the mainstream of thinking, and have highlighted, particularly, the potential of biological methods and the need to move away from a purely engineering approach. A recently developed video has distilled the lessons into a training module for local development workers in dryland Africa. Perhaps most significantly, the language and content of project proposals has subtly begun to change as well. The first step from thinking to doing is underway.
The new attitude acknowledges that it is useless to coerce people into accepting systems of conservation that they don't appreciate. This seems self-evident, but it's not so simple. Conventionally, technicians design the structures, and the implementors ensure the "cooperation" of local farmers with incentives such as food-for-work or even payment. The farmers often don't understand the purpose of the terraces and bunds, and because they expect incentives to continue for maintenance, the structures are commonly left to deteriorate in the post-project phase. The result can be breached bunds and increased environmental damage.
Participation has become the "buzzword" of the moment, but it is not just a passing development fashion, it is essential for lasting impact - for sustainability. Participation means the involvement of the land users in all phases of project planning and implementation. It is now realized that the target group has a wealth of knowledge and experience, and is receptive to training - women as well as men. Developing skills in land use planning and surveying, for example, demystifies technology and instills a

sense of achievement. Training helps to mobilize the wealth of popular enthusiasm that exists untapped in so many areas.
If participation is the key to the management aspect of the new approach, then it is the key which opens the door to new technology also. The two most interesting developments are the emphasis on biological methods of conservation in the more humid regions, and water harvesting in the drier areas. No longer are engineering structures seen as the essential backbone of conservation programmes, but merely as "support practices". Where structures are required, for example on higher slopes, semipermeable vegetative barriers are given priority over solid earth bunds. These barriers filter out sediment while allowing excess runoff to pass through at non-erosive velocities. Establishing vegetative barriers almost always involves less labour than constructing earth bunds - though they often take two seasons or more to become really effective.
The new approach to soil and water conservation implies changes in both techniques and managerial aspects of projects. Greater sensitivity is required of project designers and soil conservation specialists alike. Soil conservation is less often quoted as an objective in itself. Conservation through productivity has become the target. It is now, rightly, an unwritten rule that gender aspects are given attention.
But the truth is that project documents do not always determine precisely what happens in the field. There is still a considerable gap between rhetoric and reality. The challenge now is for the new approach to soil and water conservation to be increasingly translated from the pages of the project documents to the fields of the farmers.
Authors' Abstract, shortened.

1018 91 - 13/45

Soil erosion and desertification control
Asia, Philippines, sloping lands, agroforestry models, NGO's

TACIO, H.D.

The SALT system - Agroforestry for sloping lands.

Agroforestry Today Vol. 3, No. 1, 1991, pp. 12-13

In the Philippines, government agencies are implementing a number of agroforestry-based rural development projects in different parts of the country. Non-governmental organizations (NGO's) also undertake their own agroforestry projects.

The focus is on sloping land, where many small-scale farmers face serious problems of soil erosion. Called Sloping Agricultural Land Technology (SALT), the objectives are to:

- Control soil erosion
- Help restore soil structure and fertility
- Produce food efficiently.

To encourage acceptance by local farmers, the system is designed to require a minimum of labour and resources, without relying on outside loans. It is meant to be economically feasible, environmentally sound, and fully functional in as short a time as possible. It is also designed to be culturally acceptable to Filipino farmers.

In 1980, the first experimental plot was established to test and develop the SALT system. This first SALT model, now known as SALT 1, was designed for a 1-hectare farm on land with a 25% slope. It was followed in 1984 by Test SALT and Contour Hedgerow Test SALT, and in 1987 SALT 2 (Simple Agro-Livestock Technology) and SALT 3 (Sustainable Agroforest Land Technology) were developed. Replicated trials have shown that these models, based on agroforestry technologies, can be more productive than traditional cropping systems while dramatically reducing soil loss.

The SALT 3 model has been designed for a farm of 2 hectares. The aims are to produce food, fruit, animal feed, fertilizer, fuelwood, and timber. Based on the original SALT 1 system, development begins with the location of contour lines on a 1 hectare plot in the lower part of the farm, using an A-frame. The contour lines are spaced 4 to 6 metres apart.

The farmer then plants woody perennials to form hedgerows along these lines, using primarily nitrogen-fixing trees or shrubs. Previously, Filipino farmers generally preferred *Leucaena leucocephala*. However, this species now suffers widely from psyllid infestation in the Philippines, so attention has turned to alternative species.

To date, the centre has screened about 35 local and exotic hedgerow species. The criteria for screening include survival, biomass production, nitrogen-fixing capacity, rate of litter decomposition, fodder and fuelwood production, seed production, drought tolerance, and resistance to pests and diseases. Based on

these criteria, five hedgerow species have been identified as good alternatives to *L. leucocephala*. These are *Flemingia congesta*, *Desmodium rensonii*, *Gliricidia sepium*, *Leucaena diversifolia*, and *Calliandra calothyrsus*.

Farmers are encouraged to plant a variety of species. One approach is to plant *Flemingia congesta* and *Gliricidia sepium* or another nitrogen-fixing species in alternate hedgerows. Planting every other row with different species discourages pest attacks.

Between the hedgerows, the recommendation is to plant a combination of permanent, semi-permanent, and annual crops. Crop combinations are balanced to enhance soil fertility, maximize yields, and allow the farmer to organize an efficient work schedule.

Every first and second alley between the hedgerows is planted in annual crops. These include maize, upland rice, beans, ginger, and pineapple. Crop rotation in these alleys helps maintain soil fertility and good soil formation. Normal recommendations for crop management, such as weeding and pest control, should also be practised on a regular basis.

In every third alley, farmers plant fruit trees and other permanent cash crops, such as coffee, cocoa, banana, citrus species, guava, rambutan (*Nephelium lappaceum*) durian (*Durio zibethinus*) and lanzones (*Lansium domesticum*). In these alleys, weeding should be confined to spot weeding around plants until the hedgerows are large enough to hold the soil in place. During the initial development phase, short-term cash crops - such as cowpea, groundnut, mungbean, eggplant, and tomato - may also be planted.

Hedgerows should be cut when they grow to a height of 2 metres. At this point, they should be cut back to a height of 50 centimetres to encourage coppice regrowth. Cut foliage is spread in the alleys to provide organic fertilizer.

The one-hectare portion of the farm upslope from the agroforestry plot is used for tree production. Again, farmers are encouraged to plant a variety of species. The selection should include trees that are harvested at different times: from 1 to 5 years, 6 to 10 years, 11 to 15 years, and 16 to 20 years.

Short-term tree species are used mainly for fuelwood, poles, charcoal, construction material, and furniture. Medium-term trees provide material for furniture, construction, charcoal, and leaf meal. The long-term species provide saw-logs, lumber, charcoal, and fuelwood.

In the Philippines, recommended species are *Samanea saman*, *Acacia auriculiformis*, *A. mangium*, *Pterocarpus indicus*, *Swietenia macrophylla*, *Calliandra calothyrsus*, *Sesbania sesban*, *S. formosa*, and *Leucaena diversifolia*. Each species is planted in pure stand in a strip along the contour. The space between the upper and lower hectares of the farm may be planted with Bamboo (*Bambusa* spp.).

Development of the two-hectare SALT 3 farm during the first 21 months costs P6500 (US$3.25) as long as seedlings are free and all labour is provided by the farm family. At this point in the production cycle, the family can begin to earn a net income of P1,200 (US$60) per month. Total family income rises as soon as the perennial crops and fruit trees reach a marketable age.
Authors' Abstract

1019 91 - 13/46

Soil erosion and desertification control
Review, books, conservation farming, steep lands, soil and water conservation, land husbandry

HOLDENHAUER, W.C. and N.W. HUDSON

Conservation farming on steep lands.

Publ. by Soil and Water Conservation Society, Ankeny, Iowa, USA, ISBN 0-935734-19-8, price USD 25.00

For the past seven years or so, a new wave of thought has been flowing across soil conservation, carrying two basic ideas: first, that conservation can only be successful if done with the active cooperation of the farmer; and, second, that there are alternative technical methods to earth structures, based on biological means and the use of soil cover.
Land husbandry presents a clear outline of these ideas and their implications. It is written in a style suitable for non-specialists, but at the same time it has enough technical detail to gain the respect of soil conservationists.
The final part of the last chapter lapses somewhat into an account of conventional earth structures. The potential of contour aligned hedgerows is scarcely mentioned. This is surprising because they exemplify both the use of biological methods and features of acceptability to farmers. Unfortunately, the photograph on the front cover and several of those within portray the kind of labour-intensive, hard-to-maintain, earth-moving conservation methods to which the text seeks to offer alternatives.
These criticisms do not greatly detract from an excellent and accessible acount, which should be read by everyone concerned with soil management on sloping lands. Agroforestry specialists will enjoy thinking about how the ideas this book presents can be applied by means of trees and shrubs - as barriers, as soil cover, and for production.
Conservation Farming on Steep Lands is basically a set of symposium proceedings containing 32 papers, well edited and presented. It is primarily for libraries and specialists, but can be consulted with profit by others.
All the authors of Land Husbandry are represented, some with such intriguing titles as 'Tilting at windmills or fighting real battles?' and 'Conserving soil by stealth'. Another of the new-wave proponents, M.G. Douglas, gives an acount of integrating conservation with farming systems in Malawi. Many of the papers are case studies of conservation projects, including socio-economic aspects.
Both books may be ordered from the Soil and Water Conservation Society, 7515 Northeast Ankeny Road, Ankeny, Iowa 50021-9764, USA.
Abstract by A.T. Young.

1020 91 - 13/47

Soil erosion and desertification control
USA, review, crop residues, tillage practices, stubble mulching, ecofallow, direct drill, wind erosion, water erosion, soil temperature

UNGER, P.W. and T.M. McCALLA

Conservation tillage systems.

Advances in Agronomy, 33, 1981, pp. 1-58

Conservation tillage systems are systems of managing crop residue on the soil surface with minimum or no tillage. Other names are stubble mulching, ecofallow, limited/reduced/minimum tillage, no-tillage and direct drill. Leaving crop residues serves water and wind erosion control, conservation of soil and water and reduction of energy use. The review is limited to the salient points that have been researched over the last twenty years and is limited to the United States. General remarks in the sections on seed bed preparation and crop seedling, control of wind erosion, control of water erosion, weed control with tillage and the three sections on soil temperature and the same number on soil structure and other physical properties are of most importance. On wind erosion, after a general introduction, the wind erosion equation is dealth with. Tillage has a direct bearing on the factors I, soil erodibility; K, soil surface roughness and V, equivalent quantity of vegetative cover. Surface residue influences V, tillage proper influences mainly I and K. Partial (de) coverage of a field would influence L, equivalent with of field (maximum unsheltered distance across the field along the prevailing wind erosion direction). Kind, amount, texture, height and orientation of surface residue all influence wind erosion. Tillage operations that minimize soil pulverization and smoothing are effective for maintaining K and keeping clodiness for maintaining I. Examples are given from the USA. A comparable approach is followed in the chapter on water erosion, using the influence of residue and tillage effects on the Universal Soil Loss Equation. The section on soil temperature deals with the effects of surface residue: changing the radiation balance accompanied with an insulation effect, and with residue factors involved in these effects: residue age (decoloration; decomposition), color, geometry, distribution and amount. Again some examples. Finally its biological effects on crops are dealt with. After dealing with soil aggregation, porosity and density as affected by tillage, other soil physical factors dealt with as influenced by tillage operations are soil texture, crusting, hydraulic conductivity and water storage capacity. Tillage reduction in the USA can't be considered without the rapid technological advances in the use of herbicides. It is estimated to serve from 5 to 15 cm of additional water to rain-fed agriculture. Only more interdisciplinary knowledge will advance this field of soil science.

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Soil erosion and desertification control
Africa, Nigeria, Cameroon, humid tropics, erosion risk assessment, farming systems, cost effective measures, soil loss measurements, GTZ, IITA

BERNARD, M. et al.

Soil erosion studies in the humid tropics of Nigeria and Cameroon.

entwicklung + ländlicher raum, 24, 5, 1990, pp. 23-25

In order to control soil erosion it is necessary to develop methods to assess the erosion risk particularly under local conditions and to predict the effect of different farming systems on soil erosion. Only by knowing these factors it is possible to identify cost effective measures to reduce the degradation of soil resources.
Many erosion studies show that existing models are of limited use in the tropics, mainly because they are based on data collected in temperate zones only and that they do not adequately consider factors like the high intensity of tropical rains and the special erodibility of tropical soils.
Hence, the study of tropical soil erodibility is one of the main objectives of a research program launched by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in 1983. The project is carried out by the Institute of Soil Science of the Technical University of Munich in co-operation with the International Institute of Tropical Agriculture (IITA) Ibadan and the National Center for Soils (CNS) of Cameroon, which joined the project in 1986.
At the present research is proceeding at five different sites in Nigeria and Cameroon. To determine soil erodibility at each site soil loss was measured after each storm on a 500 square meters bare fallow plot. Additional erodibility measurements on a broader range of soils were done with the help of a field rainfall simulator, and various soil physical tests were carried out in the laboratory.
Existing models for soil erodibility assessment cannot be applied to tropical soils without modification. In order to develop an alternative method for erodibility assessment of tropical soil it is planned to increase the number of tested soils. Soil loss measurements will now be done with a new rainfall simulator on 12 plots. The objective of this study will be to develop a model that includes those soil parameters that are most important for erodibility of tropical soils.
Bearing in mind the positive results obtained with simple dispersibility tests, further work on selecting simple tests which best reflect erodibility of tropical soils is planned. The latter could serve as a useful tool for erodibility assessment where basic soil analytical data, a necessary input into models, is lacking.

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Soil erosion and desertification control
Africa, Tanzania, highlands, sustainable agriculture, macro-contourlines, environmental effects

PFEIFFER, R.

Sustainable agriculture in practice - the production potential and the environmental effects of macro-contourlines in the West Usambara Mountains of Tanzania.

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This study should be looked upon as a contribution to further development of sustainable agricultural strategies, which have recently been implemented in the West Usambara Highlands. The centerpoint of the technical package is the 'Macro-Contourline', which is under discussion throughout this thesis for technical improvement and practical acceptability.
The macro-contourline (MCL) is primarily meant as a productive, multifunctional and physical barrier against soil erosion,which integrates measures from the livestock, plant production and forestry sectors in a way that each measure not only stops further environmental deterioration but also supports the measures of the other sectors. As a classified agroforestry approach the MCL-system comprises the simultaneous agricultural production of any chosen crops and intercroppings in between the permanent MCLs. According to the slope gradient the MCL is advised to be established within horizontal intervals of 5-20 m. The MCL shows a width of approximately 2.0 m including tufted foddergrasses, creeping legumes and fodderbushes, which form a closed line to be supported by agroforestry (AF) trees adjacent beneath the line. Depending on its composition and frequences the MCL requires 10-30% of the arable land.
In order to achieve the objectives of the study production trials, environmental surveys and interface trials were carried out on 4 on-station research fields in the three major agro-climate zones of the West Usambara Mountains of Tanzania during the period of November 1984 - April 1989.
The results are summarized as follows:

- The bulk dry matter biomass production of the MCLs started with the 2nd year of production and summed up to
  . 1.3 - 2.1 t/1000 m/year at the dry/cold zone
  . 3.3 - 6.3 t/1000 m/year in the humid/warm zone
  . 4.9 - 7.4 t/1000 m/year at the dry/warm zone

  The biomass production of associated creeping legumes was almost nil. Bana (*Pennisetum purpureum x P. americanum*) and Napier grass (*Pennisetum purpureum*) produced most, but their dry matter production was characterized by low dry season production. The seasonality of biomass production was less pronounced with Guatemala grass (*Tripsacum laxum*). Reduced growth of the grasses during the dry seasons could be partly compensated by ongoing growth of the fodderbush components during dry seasons.
- As a function of kind of forages used as feed and agro-climatic conditions on average 6.4 kg consumable milk per day (range 3.1 - 17.8 kg) can be theoretically produced by an average farm in the West Usambara Mountains, when establishing 2500 m MCLs (demanding 20% of arable land of medium sized farm at medium sized gradient).
  Average fuelwood yields of fodderbush coppices amounted to 1.44 m^3/1000 m/year and covered approximately 50% of the fuelwood requirements of an average family in the West Usambara Mountains. Additionally via regular thinning the most important AF-tree species, *Grevillea robusta*, annual wood yields of 4.5 m^3/ha AF field could be achieved.
- Topsoil was accumulated adjacently above the lower MCLs and led to higher organic matter contents, cation exchange capacities and higher water infiltration rates at these alley positions. Higher base saturations and aggregate stabilities could be observed at the upper alley positions as Ap- and transitional AB-horizons were moved away by erosion processes, and an argillic B-horizon became the top horizon of the soil profile. Reduced radiation, which was primarily caused by the different habitus of the AF-tree species and less by differing heights of MCL plants, could be observed adjacent to the MCLs. Accordingly, air and soil temperatures were lower adjacent to the MCLs. Daily temperature fluctuations were most pronounced in the proximity of the AF-trees and less, adjacently above the lower MCLs, in the proximity of fodderbushes.
  Relative humidities were higher adjacent to the MCLs- compared to the middle part of the alley. Potential evaporation rates decreased in the vicinity of the MCLs.
- As a function of applied cropping techniques and planted crops in between the MCLs - the calculated yield reductions (reduction compared to the middle section of the alley) of the MCLs covered a wide range of 3.3 - 60%.
  The method of cropping exerted a greater impact than the kind of crop, which was planted in the alleys. The negative influence was substantial, especially during dry cropping seasons, and, when closed spacings and intensive intercropping were applied on the alleys.
  The average yield reductions of sunflowers (8.6%) and Irish potatoes (8%) were lowest. Bean yield reductions ranged from 3.3 - 60% (average 28.8%) and were directly related to the availability of water. On average climbing beans were less affected than bush beans. Overall calculated yield reductions of maize amounted to 24% (range 16 - 41%).
- It was observed that tufted grasses, as they show fast and vigorous initial growth, exert not only more yield reduction on adjacent crops, but also considerable negative effects on associated fodderbushes, creeping legumes and AF-trees, especially during the early growing stages.
  Thus a modified MCL design, which partly cancels the negative effects of the grasses on interplanted crops, and takes into account the slower initial growth of the AF-trees and

fodderbushes, was proposed. It was suggested planting alternating fodderbush rows, or double rows of fodderbushes with an intra-row spacing which would allow the planting of grasses in between the fodderbush lines,once the fodderbushes and AF-tree, which were proposed as being planted in front of the fodderbush line, are established.
It can be stated, that the MCL is a promising way to prevent soil erosion on the one hand and to produce biomass concurrently. It is characterized by a high degree of complementarity of functions and perfectly integrates livestock, plant and forestry productions.
Authors' summary, shortened

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Soil erosion and desertification control
Africa, Ruanda, erosion control, terracing, extension, economic of terracing, DSE, IFOAM, GTZ

PREISSLER, R.

Erosion control by terracing in Ruanda - Technique, extension method and socio-economic aspects.

In: Proceed. of 8th IFOAM Conference, Budapest, 1990, pp. 125-127

Agriculture is characterized by intensive land use due to high population density (300 inhabitant per km^2) and a land concentration process (land is occupied by functionaries and rich merchants to cultivate cash-crops). So land scarcity, erosion and decreasing soil fertility are the main problems of agricultural development.
Characteristics of the Giciye region: altitude 1700-2400 m, precipitation 1300 mm, mean annual temperature 15°C, mean farm size 0,75 ha (upper quartile 1,38 ha, lower quartile 0,29 ha), land man ratio 5,5 labour forces per ha, rainfed agriculture, no mechanization, most agricultural work is done be women.
Ruandan farms are forced to intensify their agricultural methods. Terracing can be the first step and the base for further intensification. Well-applied terracing can totally stop erosion. By fixing the slope of the terrace with grass (*Setaria sphacelata*, *Pennisetum clandestinum*) fodder is produced (or mulching and compost material). Fodder production leads to stabling and manure production. Compost, mulch and manure provide organic material to the cultivated land, here the only source to fix nutrients in the soil. So terracing is the base for optimising all farm-internal inputs like manure, compost, labour force and also all external inputs like seeds, rock phosphate. Furthermore, it facilitates field work and leads to a better farm organization (crop-rotation etc.) Agroforestry is also applied.
Top-layer and underground are separated, the underground is terraced and then the topsoil is used for the recovering of the underground. The slope of the terrace is fixed by planting grass. The terrace itself has a small inclination towards the slope of the upper terrace to avoid that water will run downwards. Before cultivating the new terrace manure and rock-phosphate are applied.
The aim of our extension work is that a great number of farms in our region should terrace a small piece of land to gain their own experience with the new erosion control system (no model-farmers). After 3 years 10% of the 50.000 farms have some terraces now (average 4 ares per farm) and the number of interested farms is always increasing. Special terracing extension workers show interested families how to make a terrace, they work together with the family for 2 days and then the people continue their work alone.
The project is now intensifying a group approach: interested women and men are trained for 1 week; afterwards, they start terracing