92 - 12/73
1247

Soil fertility
Asia, India, field trial, legumes, arid areas, phosphate application, soil nitrogen, pearl millet

KATHJU, S. et al.

**EVALUATION OF DIVERSE EFFECTS OF PHOSPHATE APPLICATION ON LEGUMES OF ARID AREAS.**

Trop. Agric. (Trinidad), 64, 2, 1987, 91-96

Low organic matter and low N in most soils of arid and semi-arid parts of Rajasthan present the opportunity for the adoption of a low-input approach towards improvement of fertility through the cultivation of legumes. It is also felt that soil N, thus augmented, might contribute much towards the yield improvements of subsequent cereal crops, particularly of pearl millet, grown extensively in these parts. In this regard, the importance of phosphate fertilization to legumes for the improvement of their performance and $N_2$ fixation has been documented in a number of reports. Although mungbean, moth bean and clusterbean are widely cultivated in these parts, there seems to be little knowledge regarding the effects of phosphate fertilization on these legumes and succeeding cereal crops. Such an assessment, moreover, is particularly needed because of the uncertainty of monsoonal rains and the drought-prone nature of the region; the effects of P on the growth, yield and water-use of legumes in different rainfall situations assume importance. Again, the implication of P application on soil N enrichment and the consequent yield improvement of the succeeding cereal crop warrant special consideration in view of the reports of beneficial effects of P on soil N status, even in situations where the performance of the legumes was not influenced. This paper relates some findings in these areas.
Mungbean (*Vigna radiata*), moth bean (*Phaseolus acontifolius*) and clusterbean (*Cyamopsis tetragonoloba*), grown over three successive years under low and variable rainfall on loamy sand soils of arid western Rajasthan, did not reveal any marked effect of phosphate application (0, 20, 40, 60 and 80 kg $P_2O_5 ha^{-1}$) on the consumptive use of moisture. The effects on dry matter production and seed yield were marginal, but not significant. Uniform distribution of precipitation during the growing period, rather than its quantum, had the more favourable influence on plants. P application induced a small increase in the available P status of the soil and also in N and P uptake. But the weight of nodules per plant and root CEC progressively increased with increasing level of P up to 40-60 kg $P_2O_5 ha^{-1}$. Phosphate application also led to an increase in soil N, particularly of the hydrolyzable organic-N fraction. Effects on mineralized N were marginal. The amount of $N_2$ fixed was greater in mungbean and moth bean than in clusterbean but the mineralized and hydrolyzable organic-N fractions increased more under clusterbean. While the phosphate levels did not have any effect on the



succeeding pearl millet (*Pennisetum typhoides*) crop, the legumes significantly promoted its yield equivalent to > 80 kg N $ha^{-1}$, despite the prevalence of acute drought conditions. The beneficial effect of clusterbean was found to be greatest, followed by moth bean and mungbean. It seems that the beneficial effect of legume cultivation arose not only from the total $N_2$ fixed but also from the level of mineralized and hydrolyzable organic N contributed by plant residues left in the soil.

1248 92 - 12/74

Soil fertility
Asia, India, dryland agriculture, field trial, clay loam soil, cropping systems, fertilizer, pigeonpea, sorghum, sole cropping, intercropping

PANDEY, R.C. et al.

**EFFECT OF N AND P FERTILIZERS ON SUSTAINABILITY OF PIGEONPEA AND SORGHUM SYSTEMS IN SOLE AND INTERCROPPING.**

IPN, 15, 1992, pp. 12-15

This paper attempts to identify nutrient management in sole and intercropping systems which improves the soil environment and maximizes productivity on a sustained basis.
Three cropping systems, sole pigeonpea, sole sorghum, and pigeonpea intercropped with sorghum (1:2) were tested under two sets of fertilizer regions.
The sustainable yield index (SYI) and the sustainable value index (SVI) were computed to analyze the comparative performance of sole and intercropping systems with respect to fertilizer use.
The data indicate among others that sole pigeonpea gave maximum pigeonpea seed equivalent yield followed by pigeonpea + sorghum intercropping at all levels of N under study. Enhancing the application of nitrogen from 15 to 60 kg $ha^{-1}$ increased the yield by 40% for sole pigeonpea and sole sorghum, and by 54% for pigeonpea + sorghum intercropping system in terms of pigeonpea seed equivalent over the lowest dose. This showed that an intercrop of pigeonpea + sorghum was beneficial and efficient compared to sole cropping in respect of nitrogen uptake. The maximum LER (1.24) was obtained in pigeonpea + sorghum intercropping system at 60 kg N $ha^{-1}$.
The superiority of intercropping over sole cropping in terms of insurance from risk, better resource use, and higher return has been highlighted by many workers. But sustainable fertilizer management in an intercropping system is not yet well understood. Under dryland situations, land, water, and crop management systems which guarantee sustained production and productivity over a wide range of environments or over many years in the same location would qualify to be called sustainable agricultural systems.



1249 92 - 12/75

Soil fertility
Review, book, humid tropics, acid upland soils, Oxisols, Ultisols, plant nutrients, organic matter, soil management systems, fertilizer, crop production, FAO

VON UEXKULL, H.R.

**EFFICIENT FERTILIZER USE IN ACID UPLAND SOILS OF THE HUMID TROPICS.**

FAO Fertilizer and Plant Nutrition Bulletin, 10, ISBN 92-5-102387-5, 1986, 51 pp. + references

The largest reserves of potential arable land still available in the world are located in the humid tropics.
Significant advances have been made in the characterisation and management of acid soils in the uplands of the humid tropics. The aim of this bulletin is to review the experience already acquired and to summarise the research findings which have recently become available.
On the uplands, acid soils predominate and agriculture at a low level of inputs is only possible through shifting cultivation, in which the land is cropped for a few years in alternation with long periods of fallow.
In most cases crop growth in acid soils can be directly correlated with Al saturation or Al concentration in the soil solution. High H+ concentrations in the soil solution, however, favour weathering of soil minerals, resulting in the release of $Al^{3+}$ and the leaching of ions such as $K^{+}$, $Mg^{2+}$, $Ca^{2+}$ and $Mn^{2+}$.
Poor crop growth on acid soils is usually caused by aluminium and/or manganese toxicity and/or by deficiencies of phosphorus, calcium and magnesium.
Most of these soils are at present under virgin rain forest, with smaller areas under savanna, tree crops and shifting cultivation.
The main reason for lack of development of these soils is that a high standard of management and costly inputs are needed to bring them into permanent arable cropping.
Most of the acid upland soils of the humid tropics are classified as Oxisols (Ferrasols) and Ultisols (Acrisols). Both groups are very acid with low base status, their mineral horizons containing small amounts of most nutrients.
When cropped without proper management, most acid soils of the humid tropics deteriorate, chemically and physically, so quickly after clearing that after a few years no crop can be grown on them. With adequate inputs and proper care, the annual productivity of these soils can far exceed the productivity of most fertile soils in temperate regions.
Where population pressure is low, shifting cultivation is often still the most appropriate land use system.
Better techniques of forest clearing are being developed. Zero-burn techniques in which the felled forest biomass is broken down

under a short term leguminous cover crop followed by moderate applications of lime and P fertilizer show considerable promise.
Three levels of intensity can be distinguished and are discussed in this book:
- shifting cultivation with no lime or fertilizer inputs, relying on long fallow periods for regeneration;
- continuous cultivation with moderate applications of lime and P fertilizer, using leguminous cover crops or alley crops to provide biologically fixed nitrogen and organic matter;
- intensive continous cropping with large and continued inputs of NPK fertilizer, lime and other nutrients, a system that is capable of reaching and maintaining very high levels of productivity.

With good management once infertile acid tropical soils can produce annually the equivalent of 15 to 20 t/ha of grain. The availability of high yielding and disease resistant cultivars means that maize yields in excess of 10 t/ha per crop are now obtainable, while acid tolerant and disease resistant soybean cultivars can yield 2.5 to 3 t/ha per crop. It will usually take several years of good management to achieve these yield levels.
High rates of fertilizer are recommended by the author to maintain production when three crops are taken.
The rates are very similar to the rates used by many temperate region farmers aiming for comparable yields.
When high inputs are used the risks involved must be minimised. For acid upland soils this can only be done by conserving organic matter.
Organic matter, lime, and P are the three main factors on which a successful soil management and crop productivity programme for acid tropical soils can be built.
The agronomic practices adopted must supply a correct balance of organic manure and additional mineral fertilizer.



1250

Soil fertility

92 - 12/76

Review, book, Latin America, Colombia, CIAT, mycorrhiza management, agronomic importance, cropping systems, practical technologies

SIEVERDING, E.

**VESICULAR-ARBUSCULAR MYCORRHIZA MANAGEMENT.**

Publ. of GTZ, 6236 Eschborn, Postf. 5180, Germany, ISBN 3-88085-462-9, 1991, 371 pp., pbk

Increasing crop production and land productivity in the tropics is essential if the food demand of the growing population in these areas is to be met. Of all the soil-related constraints on crop production, low soil fertility is the most severe on more than half of the arable land in the tropics. Infertile soils are acidic and may be deficient in phosphorus, nitrogen and potassium. On these soils crop production can only be improved when fertilizers, in either organic or inorganic form, are applied, and when soil amendments are combined with improved crop production technologies. This is explained by Ewald Sieverding in his book Vesicular-Arbuscular Mycorrhiza Management, in which he describes the role these fungi can play in improving soil fertility.
The author explains that until about 20 years ago, vesicular-arbuscular mycorrhizal (VAM) fungi were virtually ignored by most soil and plant scientists. However, under controlled greenhouse conditions it has been demonstrated that VAM fungi increase phosphorus uptake. They also play a role in the uptake of other plant nutrients as well as in the biological nitrogen fixation of *Rhizobium*, the biological control of root pathogens, and the drought resistance of plants.
In 1980 a Mycorrhiza Special Project was initiated at the Centro Internacional de Agricultura Tropical (CIAT), in Cali, Colombia. The general objectives of this project were to test the agronomic importance of VAM in tropical crop production systems and to develop practical technologies to utilize VAM fungi as a biological resource to enhance phosphorus uptake and utilization.
Although the content of this book relates directly to South America, with particular reference to cassava, the principles of the VAM technology presented can be transferred to other crops and to conditions in tropical Africa and Asia, provided that the technology is adapted to the prevailing ecological and socio-economic conditions.

1251 92 - 12/77

Soil fertility
Germany, study, greenhouse conditions, mycorrhiza, pigeonpea, phosphorus fertilizer, plant growth

DIEDERICHS, C.

**IMPACT OF TROPICAL VA MYCORRHIZAE ON GROWTH PROMOTION OF *CAJANUS CAJAN* AS INFLUENCED BY P SOURCES AND P LEVELS.**

Publ. of the Institute of Agronomy in the Tropics, Univ. Göttingen, Germany. Presented at the Int. Symposium on Management of Mycorrhiza in Agric., Hortic. and Forestry, Perth, Australia, 1992

The aim of the present paper revolves around the following questions: Are there differences between various VA mycorrhizal fungi in improving P uptake from different P sources with varying solubility? Do different P fertilizers exert an effect on the interaction of VA mycorrhiza and rhizobium? Does pigeon pea take advantage of a dual symbiosis?
The contribution of legumes in tropical cropping systems to maintain/restore soil fertility is gaining increasing importance. The most important aspect of tropical legumes is their ability to fix P in association with rhizobium atmospheric dinitrogen which becomes available to subsequent crops in rotational cropping systems. This is true for pigeon pea (*Cajanus cajan*) which fits into many agronomic management systems because of its multipurpose use. However, unfavorable soil conditions in the tropics often impede development of pigeon pea and phosphorous is considered to be the most limiting factor. Studies indicate the need for application of between 20-100 kg/ha of phosphorus. This, however, is a luxury most farmers in the tropics with very limited financial resources can ill-afford. Consequently, seeking other possibilities to overcome this problem deserves special attention. In this context, the management of effective VA mycorrhizal fungi could become a promising tool to increase the efficiency of applied P fertilizers and thus reducing financial expenses.
The present research work was conducted under greenhouse conditions using a non-sterilized P fixing soil. Three P sources were applied at the following rates (kg P/ha): single superphosphate 10, 30, 60; and two rock phosphated from Brazil; Patos de Minas (total P, 10.7%): 50, 150, 300; and Araxá (total P, 12.1%): 50, 150, 300. The soil contained 2 native species of Glomales: *Glomus albidum* and *Glomus intraradix*. The mycorrhizal inoculum consisted of an air-dried mixture of soil/roots/spores and was applied at the rate of 2g/pot. Four VAM species originating from the Cerrado Ecosystem of Brazil were tested: *Glomus clarum*, *Glomus pallidum*, *Entrophospora colombiana*, *Acaulospora rehmii* and *Glomus manihotis* from CIAT/Colombia (C-1-1). *Cajanus cajan* plants were not fertilized with N but inoculated with a peat-based inoculum of effective strains of rhizobium also from the Cerrado region.



The present results clearly indicate a strong dependency of pigeonpea on VAM fungi under P stress and *Glomus clarum* proved to be the most effective fungus irrespective of the P source and P level. In general, mycorrhizal infection rate was not influenced by the P source. However, with the exception of *Glomus clarum*, infection rate tended to decrease with increasing P levels. P uptake of inoculated plants corresponded well with the plant development and a similar tendency was observed with N uptake. With inoculated plants a significant relationship between P uptake/nodule formation and nodule formation/shoot dry weight was found, in particular with rock phosphate (Araxás). This relationship decreased with increasing solubility of the P source. The present results bear evidence that the fertilizer efficiency of low grade rock phosphates is dependent on an effective VA mycorrhiza. With *Çajanus cajan* an additive interaction of effective VA mycorrhiza and rhizobium was observed resulting in: improved P and N uptake, increased nodule formation and, enhanced plant growth.

1252 92 - 12/78

Soil fertility
USA, study, greenhouse experiment, sorghum, genotypes, mycorrhiza, phosphorus efficiency, cost/benefit analysis

RAJU, P.S. et al.

**BENEFIT AND COST ANALYSIS AND PHOSPHORUS EFFICIENCY OF VA MYCORRHIZAL FUNGI COLONIZATIONS WITH SORGHUM (*SORGHUM BICOLOR*) GENOTYPES GROWN AT VARIED PHOSPHORUS LEVELS.**

Plant and Soil, 124, 1990, pp. 199-204

This study was conducted to determine benefit and cost analysis and P efficiency (dry matter produced/unit P absorbed) of *Glomus fasciculatum* colonization with sorghum roots when genotypes were grown at different soil P levels.
Sorghum [*Sorghum bicolor* (L.) Moench] was grown in a greenhouse in a low P (3.6 $mgkg^{-1}$) soil inoculated with the vesicular-arbuscular mycorrhizal fungi (VMAF) *Glomus fasciculatum* and P added at 0, 12.5, 25.0, and 37.5 $mgkg^{-1}$ soil to determine the effects of VAMF-root associations on plant growth, and P efficiency (dry matter produced/unit P absorbed).
Root associations with vesicular-arbuscular mycorrhizal fungi (VAMF) normally benefit plant growth, particularly through enhanced P uptake. Host plants must provide carbohydrates to VAMF for development and growth.
In this study root colonization with VAMF and shoot growth enhancements decreased with increased soil P applications. Mycorrhizal plants were less P efficient than nonmycorrhizal plants. Shoot dry matter differences between mycorrhizal and nonmycorrhizal plants were considered the benefit derived by plants from VAMF-root associations. Shoot dry matter differences between mycorrhizal and nonmycorrhizal plants with similar P concentrations were considered the costs paid by plants for VAMF-root associations. Values of benefit and cost analysis for VAMF-root associations were highest when soil P was lowest and decreased with increasing P applications. Genotypic differences for calculated costs were pronounced, but not benefits. Benefit and cost analysis may be helpful to evaluate host plant genotypes and VAMF species to optimize efficiencies of VAMF symbiosis in different soil environments.
VAMF associations with plant roots not only benefit growth and mineral element uptake, but VAMF infected plants can give greater tolerance to root pathogens, drought, low soil temperatures, adverse soil pH, and transplant shock. VAMF-root associations have great potential in land reclamation and agriculture practices on arid and acid lands, where drought, low soil fertility (especially P deficiency), and high soil salinity and/or toxicity elements can be major constraints to crop production.



## XIII EROSION AND DESERTIFICATION CONTROL

1253

92 - 13/51

Erosion and desertification control
Review, Africa, indigenous methods, soil and water conservation, ethno-engineering, maintenance, project interventions, research needs, policy requirements, IIED

REIJ, C.

**INDIGENOUS SOIL AND WATER CONSERVATION IN AFRICA.**

Gatekeeper Series Nr. 27; Int. Inst. for Environment and Development (IIED), London, 1991, 32 pp.; price £2.50 inc. p and p

The objective of this paper is to assess the current knowledge of indigenous Soil and Water Conservation (SWC) in Africa and to identify research needs and policy requirements in the field of African indigenous SWC.
Many parts of Africa are experiencing annual population growth rates between 2 and 4%, degradation of the natural resource base, recurrent droughts and a growing dependence on food aid as well as the import of cereals to cover food deficits. During the last two decades increasing financial outlays for agricultural research in Africa have neither produced significant breakthroughs nor led to agricultural growth.
Numerous reports have warned against the disastrous effects of increasing erosion, land degradation, desertification, mismanagement of natural resources due to increasing demographic pressure, and as a result, soil conservation emerged as a central concern in East Africa.
In many African countries considerable efforts have been made during and since colonial times to conserve soil and water resources. Yet most soil and water conservation projects in sub-Saharan Africa have failed. A major argument is that what has been constructed - often at great expense - has seldom been maintained by the "benficiaries".
The most important reasons for these failures in African soil and water conservation (SWC) include a dominant top-down approach, the use of techniques which are complicated to design and expensive to maintain both in terms of labour and capital, and therefore are not replicable by farmers, a neglect of farmer training, a heavy reliance on machinery for the construction of conservation works and an indiscriminate use of food-for-work.
Partly as a reaction to the disappointing results of integrated rural development programmes (IRDP's) with their strong emphasis on "transfer of technology", the 1980's have seen a growing awareness of the importance of indigenous environmental knowledge. As part of this trend, the awareness of the importance of indigenous SWC techniques has also increased.
Three major issues are explored in this paper:

- The first demonstrates that despite a growing awareness of its importance, African indigenous SWC continues to be neglected.
- The second analyses present trends in indigenous SWC. Are indigenous techniques increasingly abandoned and if so, why?
- The third briefly examines the effect of project interventions. Some examples will be given of project interventions damaging indigenous SWC and of others improving the efficiency of indigenous SWC techniques.

Concluding, the author states amongst other that slowly but surely, a certain consensus is emerging that indigenous SWC techniques could be used and have a role to play. This trend reflects a feeling of disappointment with or even despair about the failure to narrow the gap between food needs and food production in Africa and the inability to create conditions for sustainable rural development.
A marriage between indigenous and modern techniques may be required to increase the technical efficiency (coping with degradation) as well as the returns to labour (higher incomes).
Indigenous SWC techniques are not well known and require some research. Experiments should be designed to improve their technical efficiency, and several techniques should be tested at village level and evaluated by technicians and villagers. It may take 3-5 years before the best and most acceptable technical package is identified, hence tangible results can rarely be obtained before 5-10 years have elapsed. It is essential that donor agencies and governments accept these time frames for projects.



1254

92 - 13/52

Erosion and desertification control
Latin America, Ecuador, proceedings, workshop, DESFIL, USAID, sustainability, slopes, agriculture, methods, strategic planning institutions, incentives, DESFIL, USAID

HANRAHAN, M.S.

**SUSTAINABLE USES FOR STEEP SLOPES.**

Workshop Proceedings "Sustainable Uses for Steep Slopes", Vol. II; DESFIL in coop. with USAID, USA; 1987, 47 pp. + annex

During the Inca period, the Andean highlands were home to 20 million persons, and sustained an efficient agriculture, evidently sufficient to support this population, indeed with excess production to trade with lower areas. The historical record left by these peoples attests that it is possible to practice efficient and sustainable agriculture in the region.
Therefore, a workshop for applied development practitioners, was held 1987. The workshop had two general purposes:
- To report experience in implementation and applied research on the development and the intensified but sustainable uses of fragile, steeply sloped areas; and
- To draw conclusions and lessons learned from past experience for the design and management of future development on fragile, steeply sloped areas.

Presentations were made by persons and institutions that had attempted project implementation or had concluded applied research projects based on steep slopes, could document what happened, and could draw lessons learned, implications for policy, and recommendations for the design and management of future projects from these experiences.
The working groups emphasized sociocultural themes and community participation. Those present, most of whom were not social scientists, were overwhelmingly of the opinion that effective technical measures for degradation control - such as terraces, windbreaks, living barriers, diversion or infiltration ditches, mulching techniques, crop rotation, cross-slope farming, and so on - proved under on-farm conditions, existed.
Farmers, however, and many personnel in public sector institutions and donor agencies were unaware that degradation was a problem, did not immediately perceive or pay for its effects, and were thus reluctant to apply or continue to apply the efficacious, available control measures.
The sociocultural deficiencies that the working groups identified in development projects and programs in fragile areas are, in general, that local participation was not included in development efforts and that the talent, leadership, and traditions of the native communities and of the national-regional technicians community were not called upon. In addition, projects are usually designed to cover relatively short time spans, and so do not

provide for postproject continuity of degradation-control programs.
In the design and management of natural resources projects, the working groups signaled a need for an interdisciplinary focus on the multiple phases and effects of the degradation problem.
Workshop participants noted the existence of certain problem-prone areas, such as páramos, dormant volcano craters, and very high cloud forests, which nevertheless offer development potential. The key to the development of these areas is multiple, non-intensive, non-agriculturally based uses (such as a combination of forestry, tourism, and public education programs, or the non-intensive exploitation of indigenous species). Basic data on the identification and sustainable uses of such zones are lacking.



1255 92 - 13/53

Erosion and desertification control
Africa, review, land restoration, revegetation, agro-silvicultural methods, shelterbelts, plantations, rangeland, forests, woodlands, case studies strategies, constraints, control measures, intervention methods, knowledge gaps

ELHOURI AHMED, A.

**LAND RESTORATION AND REVEGETATION.**

In: FAO Conservation Guide No. 21, "Role of Forestry in Combating Desertification"; FAO, Rome, 1989, pp. 253-265

This paper deals with the objectives of land restoration and revegetation, the strategies and practices carried out to realize the objectives within the context of the constraints, and arrives at recommendations of lines of action to deal with the problem.
The broad objectives of land restoration and revegetation are:

- to restore the land and vegetation for increased food production.
- to enhance food production and also to generate income and to improve the quality of life through resource conservation and development.

The specific goals are:
- Protection of the soil from wind and water erosion and maintenance of its fertility.
- Protection of catchment areas and perennial and seasonal water courses to assure regulated flow of water both in quantity and quality. Also efficient and wise use of the scarce resource of water.
- Enhancement of the productive role of the vegetation to realize maximum production of fodder, wood, fibers, medicinal products, tannins, perfumes, gums and other products.

Land restoration and revegetation is carried out through execution of corrective measures on land where the degradation has occured. The current measures usually executed are summarized in this paper such as:
- On cultivated land:
  . Agro-silvicultural methods
  . Shelterbelts
  . Plantations on seriously degraded irrigated or rainfed crop land
- On rangeland
- On forests and woodlands
- On bare land: sand and sand-dune fixation

The case studies discussed illustrate what happens when vegetation is destroyed by imbalanced use of land.
The following conclusions and recommendations are drawn:

Land and vegetation degradation is essentially a land use problem and the key to success for restoration and revegetation centres on:
- Integration of land use within ecological context.
- Active peoples' participation, through various means, as no government can cope with these problems,
- Building and strengthening the staff base at all levels to execute these programmes, and filling the present gaps in knowledge.
- Integration of all available knowledge into working practical models that can solve the problems.

No effort on land restoration and revegetation can achieve its objectives without the active participation of the people. This cannot be done without motivation. That coercion through laws alone has largely failed needs no illustration. There is a need for studies to evolve methods of motivation, coercion and others that can lead to sound practices of efficient utilization and conservation.



1256

92 - 13/54

Erosion and desertification control
Africa, Nigeria, study, IITA, land-use, shifting cultivation, soil erosion, alley cropping, bush fallow system, no-tillage system, economic analysis

EHUI, S.K. et al.

**ECONOMIC ANALYSIS OF SOIL EROSION EFFECTS IN ALLEY CROPPING, NO-TILL, AND BUSH FALLOW SYSTEMS IN SOUTHWESTERN NIGERIA.**

IITA Research No. 3, 1991, pp. 1-5

Based on a simulation model, this paper uses a capital budgeting approach to determine how land-management technologies are compared with each other and with traditional bush fallow systems in southwestern Nigeria, taking into account both the short-term and long-run impact of soil erosion on agricultural productivity and profitability.
The analysis is also conducted under two population density scenarios (high and low), which permits to verify the hypothesis that there exists a positive correlation between population density and agricultural intensification. This study thus differs from previous economic analyses in that the productivity effects of soil erosion and population growth rate are assessed.
Five land-management technologies in maize production are evaluated in the study.
They are continuous alley cropping systems with leucaena (Leucaena leucocephala) hedgerows planted at 2-m and 4-m intervals, continuous no-till system, and two traditional bush fallow systems with 25% an 50% farming intensities.
Shifting cultivation is typical of traditional agricultural systems in tropical Africa.
The International Institute of Tropical Agricultural (IITA) has concentrated its research efforts over the past two decades on developing sustainable soil management technologies, which enhance food production and preserve the natural resource base.
Although some economic analyses are available on the viability of improved land-use systems in sub-Saharan Africa, none of them accounts for the erosion process with its resultant long-term impact on costs and returns.
These results confirm the hypothesis that there exists a positive correlation between intensity of land use and population density. The argument is that for given agroclimatic conditions, increases in population density will gradually move the agricultural system from forest fallow to annual cultivation. Thus intensive cultivation of permanent fields in the frontier, using labour-demanding technologies (such as the 4-m alley cropping) or external input demanding technologies (such as the no-till system), becomes the norm only when arable land is exhausted. It can, therefore, be concluded that where land value rises due to land shortages, farmers with lower discount rates are likely candidates for the adoption of the 4-m alley cropping system

compared to the no-till. For those farmers exhibiting high discount rates under high population density conditions, research should focus on reducing the establishment cost of the 4-m alley cropping system to make it competitive with the no-till system.
To test if the technologies fit into the farmers' production plan, economic analysis based on a whole-farm modeling approach is necessary. Whole-farm models reflect the basic production processes involved in agricultural (e.g., nitrogen-fixing capabilities of leguminous trees) as well as many of the resource characteristics and constraints with which farmers must work (e.g., labour, land, and credit, to name a few). This further research should now be a priority.



1257

92 - 13/55

Erosion and desertification control
Review, book, developing countries, soil conservation, conservation practices, watershed management, grassland management, research, organisation, education, extension, environment

FAO

**SOIL CONSERVATION AND MANAGEMENT IN DEVELOPING COUNTRIES.**

FAO Soils Bulletin No. 33, ISBN 92-5-100430-7, 1985, pp. 208 + appendices

The purpose of this book was to re-examine the question of soil conservation and management in the developing countries, bearing in mind socio-economic aspects, administrative structures, technology and financial resources.
The discussions concluded that there are problems in the organization of soil conservation and management and possible solutions were suggested.
Soil conservation in the past was commonly equated with the mere prevention of erosion or with the restoration of areas in which accelerated erosion has already taken place. The modern thinking however, assigns to soil conservation a more comprehensive and more positive role, in that sustained improvement complemented by the preservation of available resources should form the central concept. Soil conservation is not merely a technical problem.
The basic concept of a multi-disciplinary approach to the solution of the problems has unfortunately been overlooked in most cases.
The following general recommendations were made amongst others:
- Soil erosion, and consequently the need for conservation, is not confined to land under arable use; it frequently affects grazing lands, and can be associated with mining, road construction, forestry and other kinds of land use.
- Soil conservation refers not only to mechanical protection measures but includes all aspects of land use planning, development and management which contribute to the maintenance and improvement of soil resources.
- Soil conservation is an interdisciplinary subject, which involves agronomy, soil science, range management, forestry, ecology, hydrology, engineering, geography, economics, sociology and other disciplines.
- The damage caused by severe soil erosion is frequently irreversible. It is consequently desirable to take conservation measures to prevent onset of erosion rather than acting after it has commenced.
- Detailed knowledge of the nature and distribution of land in an area are the basic pre-requisites of any conservation programme.
- Soil is a basic resource, for the present and the future. As such, the value of its conservation extends beyond that which can be expressed in monetary terms.

Conservation education and extension are areas where particular attention must be directed in the developing countries. Many countries transfer without due consideration to socio-economic factors, conservation education methods from other environments with the pious hope of solving their own problems.
The organizational set-up is often uncoordinated with the general machinery of other Government Departments. This has in many cases resulted in ineffective, disorganized programmes which failed or even, in some cases, perpetuated the problem. There are examples in many countries of expensive soil conservation structures which are not properly maintained and which result in a worsening of the situation. In many of these countries, techniques need not always be complex. Such simple practices as contouring and terracing, constructed with the farmers' own tools, may in the aggregate, contribute as much as the more spectacular large scale development.
Specific guidelines are made for:
- research
- education
- extension and
- practical and technical aspects.

As a general principle, it is suggested that the contribution of FAO should be directed towards the coordination and dissemination of results and assistance to individual countries; and that individual countries and institutions should concentrate on work related to their local or regional circumstances.



1258

92 - 13/56

Erosion and desertification control
Review, book, land evaluation, rainfed agriculture, soil resources management, land utilization types, land-use, land-use requirements, crop requirements, land qualities, agroclimatic zones

FAO

**GUIDELINES: LAND EVALUATION FOR RAINFED AGRICULTURE.**

FAO Soils Bulletin No. 52, FAO, Rome; ISBN 92-5-101455-8, 1984, 191 p. + appendices

The principal objective of land evaluation is to select the optimum land use for each defined land unit, taking into account both physical and socio-economic considerations and the conservation of environmental resources for future use.
The need for optimum use of land has never been greater than at present, when rapid population growth and urban expansion are making land available for agriculture a relatively scarce commodity. The increasing demand for intensification of existing cultivation and opening up of new areas of land can only be satisfied without damage to the environment if land is classified according to its suitability for different kinds of use.
These "Guidelines" are intended to assist field staff in carrying out land evaluation for rainfed agriculture according to the principles of the FAO Framework for land evaluation. The present publication is an expansion of the basic concepts of the framework giving procedures and methods necessary in evaluation for rainfed agriculture. It provides practical guidelines on the planning and execution of the various steps in land evaluation, from interpretation of basic data to the final recommendations which form a basis for land use planning and project implementation.
The "Guidelines" refer only to crop production. Both annual crops (arable farming) and perennial crops (tree and shrub crops) are included.
The procedures are applicable at all levels of scale, ranging from continental or national, through regional and district scales, down to detailed or intensive surveys for local projects, village-level schemes and farm planning.
These "Guidelines" occupy a position intermediate between the "Framework for Land Evaluation" and detailed local manuals on evaluation. The "Framework" gives the principles and basic concepts on which land suitability evaluation is based, and indicates overall strategies for their application. The "Guidelines" provide a detailed methodology for carrying out the strategies.
In attempting to be fairly comprehensive, the Guidelines present the maximum range of procedures or aspects to be covered. Some procedures are covered only briefly. Similarly, the checklists are intentionally long to ensure that no relevant aspect is overlooked.

1259 92 - 13/57

Erosion and desertification control
USA, study, wind erosion, mixed vegetation, control and prediction

SKIDMORE, E.L. and R.G. NELSON

**SMALL-GRAIN EQUIVALENT OF MIXED VEGETATION FOR WIND EROSION CONTROL AND PREDICTION.**

Agron. J., 84, 1992, pp. 98-101

The purpose of this analysis was to examine this discrepancy and derive an improved expression to determine the small-grain equivalent of mixed vegetation.
Control and prediction of wind erosion requires knowledge of the effectiveness of surface vegetative cover. Scientists realized early the value of crop residue for controlling wind erosion and reported quantitative relationships.
Amounts of wheat (*Triticum aestivum* L.) straw needed to protect most erodible dune sands and less erodible soils against strong winds were determined. Standing stubble was much more effective than flattened stubble. Standing sorghum (*Sorghum bicolor* (L.) Moench) stubble controlled wind erosion more effectively with rows perpendicular to wind direction than with rows parallel to wind direction.
Siddoway et al. (1965) quantified the specific properties of vegetative covers influencing soil erodibility and developed regression equations relating soil loss by wind to selected amounts, kinds, and orientation of vegetative covers; wind velocity; and soil cloddiness. They found a complex relationship among the different kinds and orientations of residue in terms of relative effectiveness.
The relative value of kinds and orientations of residue in controlling erosion must be quantified by soil, wind velocity, and variable characteristics of the residues.
Therefore, control and prediction of wind erosion require knowledge of the effectiveness of surface vegetative cover. The effectiveness is usually referenced to as small-grain equivalent. The procedure used to convert mixed vegetation to small-grain equivalent was found faulty. Improper weighting of regression coefficients caused the conversion procedure to predict that adding crop residue decreased small-grain equivalent. Therefore, the purpose of this analysis was to improve the conversion of mixed vegetation to a small-grain equivalent. The new expression derived for this purpose gave a logical conversion where the previous procedure failed. It did not predict a decreasing small-grain equivalent with increased soybean (*Glycine max* (L.) Merr.) residue in the 0 to 300 kg/ha range as did the former method. Applied to the same data that were used for testing the previous procedure, the new procedure reduced the error by almost 50%. The new procedure improves the conversion of mixed vegetation to small-grain equivalent.



1260 92 - 13/58

Erosion and desertification control
Asia, Philippines, survey, technology transfer, farmer-participatory research

FUJISAKA, S.

**A METHOD FOR FARMER-PARTICIPATORY RESEARCH AND TECHNOLOGY TRANSFER: UPLAND SOIL CONSERVATION IN THE PHILIPPINES.**

Expl. Agric., 25, 1989, pp. 423-433

This paper discusses farmer-to-farmer technology transfer and the participation of resource-poor farmers in the adaptation of agroforestry technologies, as well as a range of interlinked, mostly agronomic and biophysical, research issues.
The research was done on volcanic plateau and alluvial plain sites with moderately well drained acidic clay soils of pH 3.9-5.2.
Although rice, maize, cassava and perennials are grown throughout the area, there are three distinct zones which correspond roughly to increasing altitude and rainfall. Upland rice-fallow rotations and cassava are the main cropping patterns in the lowest altitude area (400-500 m). Maize-maize and maize-fallow rotations predominate in the middle area (500-650 m). Maize, vegetables (especially tomato) and perennials dominate the upper area (650-950 m).
The interdisciplinary research involved scientists from IRRI and the DA. Efforts to incorporate a farmer perspective used methods from agricultural anthropology to understand farmers' practices, perceptions and technical knowledge, to link this to appropriate research into technology development and to incorporate both into farmer technology adaptation and dissemination.
Initially, 55 farmers were selected at random and informally interviewed using open-ended, interactive and structured guide questions which had been selected after a period of exploratory research had determined some of the key issues facing farmers.
Concluding, the author states, that in terms of farming systems methodologies, the experience shows that a simple alternative method for on-farm research and technology transfer might consist of first understanding farmer practice, perception and technical knowledge; using this and farmer experiments to help identify technical possibilities and research issues; back-up research on a combination of alternatives that integrates farmer and researcher concerns and contributions; and transfer of technology from adaptor-adopters to farmers who want solutions to problems addressed by the technologies.
This work supports the idea that participation is a two-way process and that a participation 'paradigm' should progress from the obsolete view that 'the experts know best' to the increasingly fashionable concept that 'the local people know best' and on to the realistic and helpful idea that 'both experts and local people have unique areas of expertise which collectively provide a better basis for development than either alone'.

1261 92 - 13/59

Erosion and desertification control
Africa, review, bean production, soil fertility, varieties, technology

CIAT

**AFRICAN BEAN-BASED CROPPING SYSTEMS CONSERVE SOIL.**

CIAT Annual Report 1989, pp. 49-52

Low soil fertility is as important as disease in limiting bean production in Africa. This is especially true in areas of high population growth. More people to feed means that land that once could be left fallow and allowed to recover its nutrients must be constantly used. Less good land to farm leads to more cultivation of steep slopes and marginal soils.
In response to the need to increase production and conserve the soil, CIAT is strongly promoting sowing climbing beans in the Great Lakes area. These beans generally yield higher than traditional bush beans; and when climbing beans grow upward rather than spreading across the ground, the plants are better protected from soil-borne pathogens and the damage caused by standing water.
But climbing beans need something to climb on. Having enough vegetative material suitable for making stakes is a major impediment to farmers growing this kind of bean. Appropriate kinds of trees are needed to plant to solve the stake shortage.
These trees or bushes would have several purposes: they would serve as stakes; they would conserve the soil by fixing nitrogen; they would produce organic matter which would be used as green manure or animal feed; and they would counter erosion by stabilizing the soil with their roots and by providing windbreaks.
Research conducted on Rwandan farms has shown that timely manure applications are important in increasing yield and reducing erosion. Studies show that if manure is applied at a certain stage of growth of the bean plants - the third trifoliate stage - yields can be increased by 60%. This can help farmers maximize the benefit of their limited fertilizer resources.
Traditional soil conservation practices are studied so that accepted methods can be used as guidelines for proposing improvements. For example, in Zambia, farmers concentrate soil fertility through dirt mounds consisting of organic compost. On the other hand, Tanzanian farmers dig pits and compost grass to enrich the soil. In other areas, farmers grow their crops on contoured ridges which reduce erosion.
But population pressures on land are threatening these traditional systems and, in turn, increasing soil erosion. Finding solutions to these problems is vital so that the demands on the land do not ultimately destroy the very foundation of farming: the soil itself.



1262 92 - 13/60

Erosion and desertification control
Latin America, Ecuador, study, soil conservation strategies, mountain environment, climatic factor, basic terms, farmer practices, socio-economic factors, DESFIL, USAID

STAVER, C.P. et al.

**REFINING SOIL CONSERVATION STRATEGIES IN THE MOUNTAIN ENVIRONMENT: THE CLIMATIC FACTOR.**

DESFIL Publication; prepared for USAID, USA; 1990, 36 pp. + appendices

The overall objective of this report is to establish simple procedures for the use of climate, soil, and slope data during the design phase of conservation projects with small farmers in the Latin American highlands. Use of these procedures can greatly facilitate the initial selection of soil conservation measures that might be employed.
The authors discuss briefly, but do not analyze, the role of socioeconomic and institutional factors, as they relate to the successful adoption of appropriate soil conservation measures. They set as their task in this report the development of a simple method for determining appropriate soil conservation technologies in areas of steep slopes. They are cognizant of constraints such as patterns of land tenure, social organization of labour, traditional crop preferences, existing traditional technologies, market patterns, and local perceptions of risk and costs versus benefits - to name a few of the more obvious socioeconomic variables - on the successful adoption of non-traditional technologies, no matter how appropriate from a strictly technical standpoint they may be.
The hill and mountain regions of Latin America represent the fragile land resource for innumerable families on small farms. A major threat to their survival is land degradation resulting from soil erosion. Soil conservation projects directed toward this problem have been implemented throughout the region with mixed results, and the design of such projects is the subject of this report.
Section 2.0 begins with a summary of contemporary soil erosion problems in Ecuador, followed by a brief introductory discussion of erosion and sedimentation process in Section 3.0. Section 4.0 provides a summary of the team's field and desk analyses conducted in Ecuador; the resultant decision tree, designed to assist the field manager in the preliminary selection of regionally appropriate erosion control techniques, is discussed in Section 5.0. Socioeconomic parameters of importance to a more effective use of the decision tree are discussed in Section 6.0, followed by a discussion of the study's major conclusions and recommendations in Section 7.0. Appendix 1 shows the average monthly water balance for 12 stations in the Ecuadorian highlands; Appendix 2 provides a method for approximating annual water balance by month; and

Appendix 3 discusses a number of soil loss quantification techniques of potential use to ongoing and future projects. A model monitoring plan is also discussed. A brief description of contemporary soil conservation techniques is shown in Appendix 4.
To achieve site-specific project, implementation must take a learning approach. During the initial period, the project must learn what works. This is a period of testing and validation to identify effective soil conservation interventions, effective institutional arrangements, and effective means to collaborate with farm families and communities. In the second phase learning should focus on efficiency, while in the later phases the project must learn to expand and achieve wider coverage. Many projects attempt wide coverage initially, and only by chance identify what works late in project life. Efficiency may never be achieved.
The study includes a decision tree which integrates rainfall, slope, and soil factors in the choice of conservation measures; a discussion of farmer practices and economic and social factors in soil conservation measures; and an appendix on techniques for monitoring soil loss as well as a discussion of monitoring programs.
Given the wide range of physical and social factors of influence to accelerated erosion processes, conservation projects should logically employ a site-specific approach. The development of additional procedures for the systematic consideration of socioeconomic, community, and institutional variables, in conjunction with the technical procedures described here, is highly recommended.



1263

92 - 13/61

Erosion and desertification control
Africa, Zimbabwe, project, land-use pattern, institutional framework, training, research approach, on-farm trials, GTZ

VOGEL, H.

**CONSERVATION TILLAGE FOR SUSTAINABLE CROP PRODUCTION SYSTEMS.**

Project Res. Report, No. 4, Departm. of Agricult. Technical and Ext. Services, Zimbabwe; 1992, pp. 22

"Conservation Tillage for Sustainable Crop Production Systems" is a collaborative programme between the Department of Agricultural Technical and Extension Services (AGRITEX) of Zimbabwe and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH of Germany.
The primary objectives of this technical co-operation project are:
- to assess the soil and water conservation merits and yield potentials of several conservation tillage techniques based on animal traction and/or manual labour,
- to select appropriate cropping systems with smallholders.

Ultimate project purpose is to make adequately tested tillage and cropping technologies available to resource-poor farmers in the Communal Areas of Zimbabwe. This will be done on the basis of synthesized results of complementary on-station and on-farm trials.
In addition to the technical programme, the project also comprises a staff development scheme for Zimbabwean counterparts by providing funds for post-graduate studies overseas and offering on-the-job training.
A major factor causing soil erosion in Zimbabwe is clean tillage involving the mouldboard plough which is often used too late (after the onset of the rainy season) and/or done too shallow (approx. 125 mm) because of a general lack of (suitable) draught animals. In order to alleviate this problem, communal agriculture requires conservation tillage systems which reduce runoff, soil loss and draught power and are both practical and acceptable to the farmer. Although techniques are available, they are yet to be tested and validated for the different agro-ecological regions and the prevailing socio-economic conditions.
A two-pronged approach of complementary on-station and on-farm trials has been adopted by the project, because there is widespread understanding that, in order to assist in the development and adoption of sustainable farming practices, comprehensive approaches are required that interlink the aspects of sustainability (technical and agro-ecological factors) and acceptability.
During the early stages of project formulation, three main treatments were selected for investigation, namely: mouldboard ploughing, ripping into bare ground and no-till tied ridging.
The results of three seasons (1988/89 to 1990/91 of on-station trials showed that no-till tied ridging was best from a soil

conservation point of view. Except on one occasion, sheet erosion rates were in the order of only 0,1 to 0,3 t/ha/yr at both research sites. Higher soil loss (2,2 t/ha/yr) from ridge tilled plots was measured in 1989/90 at Domboshawa, when approximately 800 mm of rain fell in a period of just six weeks. At the same time, 9,6 t/ha/yr were lost from the fields ploughed with the mouldboard plough.
The results also revealed that the seasonal influence on yield levels was highly significant. In addition, topsoil depth and soil profile and/or physical characteristics were highly related to maize yield. This interaction was particularly evident with no-till tied ridging.
From the first three years' results it would appear that, in the dry region, tied ridging will meet the criterion of equal or improved yield levels compared to mouldboard ploughing only if existing management practices, in particular with respect to timely planting and first weeding, are improved.
The paper provides an insight into the multiple problems associated with on-farm research, which not only demand close cooperation between the farmers and researchers involved, but also require skills in communication by the researcher and a strong interest in working closely with farmers.



1264 92 - 13/62

Erosion and desertification control
Africa, Tanzania, highlands, technical aspects, soils, crops, macrocontour lines, plant protection, animal traction, agroforestry, livestock keeping, extension, nutrition, integrated approach, GTZ

SCHEINMANN, D.

**CARING FOR THE LAND OF THE USAMBARAS - A GUIDE TO PRESERVING THE ENVIRONMENT THROUGH AGRICULTURE, AGROFORESTRY AND ZERO GRAZING.**

Publ. of TIRDEP-Soil Erosion Control and Agroforestry Project (SECAP), Part.I, Tanzania; GTZ, Eschborn, 1986, pp. 261 + appendices

This book is about farming in the Usambara Mountains, but the suggested techniques are applicable to similar situations in other developing countries. Primary consideration has been given to providing guidance for specific situations encountered by village extension workers in Lushoto District.
The West Usambaras are a mountain range in the north-east of Tanzania. They vary in altitude from 1,400 metres above sea level in the valleys up to about 2,200 metres on the upper mountain slopes. The surrounding lowland plains are only a few hundred metres above sea level. Much of the area was formerly covered with dense forests but over the past decades these have been largely cleared.
Intervention is based on establishing macrocontour lines which run across farmers' fields at prescribed intervals depending on the steepness of the slope. This line of permanent crops (usually fodder grasses and legumes like guatemala, desmodium, and leucaena), and trees provides a solid erosion control structure which slows the speed of run-off rainwater and traps soil particles. The line produces economically valuable outputs like fodder, fruits, firewood, and building materials.
Annual and biannual crops are planted between these macrocontours and these are called microcontours. The project strongly advises all farmers to plant permanent and annual crops across hillsides along contours and never to plant in rows running up and down slopes.
Farmers are also advised to increase soil fertility and improve soil structure by applying organic manures like compost, cow dung, and green manure and to practice mixed cropping since this provides diversification and reduces the risk of crop failure due to drought, pests, or disease.
The goal of the livestock program is to create an economically viable alternative to traditional livestock keeping which, through over stocking and grazing has caused serious erosion problems. The production and output of local animals is very low and they now graze on hillsides since the traditional valley grazing areas are now used for intensive vegetable production.

This alternative is the zero grazing system, whereby animals are confined to a stall and are fed with fodder grown on a macrocontour line. Improved crossbred dairy cattle generate considerable income from milk sales and provide manure which is used to improve soil fertility and improve crop yields.
Forestry included 2 programs; afforestating overgrazed eroded village pastures and planting multipurpose agroforestry species along macrocontour lines and in fields.
Monitoring and evaluation of the work carried out by the community nurseries tends to be insufficient.
This guide is well written.
Specific information on laying contour lines, managing nurseries, planting fruit trees, etc. is presented in easy to read form completed with supporting illustrations. There are also short sections on fish farming, biogas, rabbit rearing, and human nutrition.
The information and advice in this book was collected from farmers, extension workers, researchers, development workers, publications, and by personal observations. The book has been flexibly designed so additions can be made, as necessary.



1265

92 - 13/63

Erosion and desertification control
Review, book, Asia, India, soil and water conservation, farmer practices, vetiver grass

GRIMSHAW, R.G.

**VETIVER GRASS (*VETIVERIA ZIZANIOIDES*) - A METHOD OF VEGETATIVE SOIL AND MOISTURE CONSERVATION.**

Publ. of World Bank, Agriculture Divison, New Dehli; 1988, 72 pp.

Soil conservation is a world problem.
Soil erosion has reached crisis proportions in India. Over half of India's crop land is losing productivity because top soil is being washed or blown away faster than natural forces can replace it. Reducing the topsoil layer causes part of the subsoil to be cultivated, meaning that plants will have reduced access to essential nutrients and water.
Changes in farming practices have accelerated this erosion in recent years, as farmers switched from traditional rotations to continuous row cropping in response to a growing need for grain.
Top level policy makers recognize the problem exists and have already spent Rs. 1,200 M on earthworks as preventative measures. But this has only covered a few million of India's 328 M hectares, 90% of which is afflicted with soil erosion.
The costs of constructed soil conservation measures would outrun the short-term benefits by three or four times, and these practices not only cost money, they also cut production. Farmers do not look kindly on these practices.
On the other hand, vegetative soil and moisture conservation measures are not only extremely cheap (less than 1/10-1/100 the cost of constructed banks and waterways) but the farmers can do the work themselves, and, if they have the planting material, at no cost. Once vegetative hedges are established (this usually takes two to three seasons) they are permanent. When they are followed as contour guidelines for cultivation and planting, the resulting "in-situ" moisture conservation increases yields by at least 50% over traditional methods.
Vegetative conservation measures hold the runoff water on the slopes longer than other methods, giving it a chance to soak in over a wide area and recharge the aquifers: Constructed measures are designed to dispose of runoff as fast as practicable, thus reducing any change of recharge. Dams rarely recharge aquifers; if they did, it would be considered that they were leaking.
The farmers regard the fodder value of vetiver grass as an additional merit. 3-4 cuttings can be obtained at an interval of 45 days, mainly during and shortly after the monsoon, yielding enough green fodder for two animals for 6 months in a year.
The farmers have developed their own ways of multiplying and propagating the grass. On sloped land, they form small section bunds across the slope and plant 2-3 slips per rill 20-30 cm apart on the upstream side. In flat fields, the slips are simply planted

in the plough furrow. In either case, they chop off the top of the plant and avoid planting inflorescence axles. The grass establishes well if planted after the first monsoon shower. Even without irrigation, the lines form hedges in about year. The slips for further planting are taken from 3-year-old bunds. When waste-weirs or drop structures are to be treated, even clumps of the grass are taken and placed at appropriate locations.
Vetiver has long been used by Indian farmers, but most scientists are still unaware of this. The indigenous knowledge of Indian farmers has not been appreciated. The knowledge they have gained in dealing with khus-based soil conservation systems needs to be documented and the other uses of khus, e.g. for fodder, should be studied.
This handbook has been prepared to support field workers and farmers in developing appropriate soil and moisture conservation measures using vegetative systems. Experience in India and in other countries has shown that conventional earth bunding systems on small farms have been expensive to develop and have in many cases proved ineffective. Vegetative systems of soil and moisture conservation have proved cheaper and more effective when implemented correctly.



1266

92 - 13/64

Erosion and desertification control
Latin America, Colombia, Andes, hillside farming, water erosion, cassava, cropping systems, small scale agriculture, CIAT

REINING, L.

**EROSION IN ANDEAN HILLSIDE FARMING.**

Hohenheim Tropical Agricultural Series 1; Verlag J. Margraf, P.O.B. 105, 6992 Weikersheim, FRG; ISBN 3-8236-1211-5; 1992, 219 pp., price DM 35,00/USD 27.00

The investigations reported here were carried out to provide some basic information on characteristics of soil erosion processess in the Andean zone of Colombia. The effect of cultural practices in cassava cultivation systems on the process of soil erosion was investigated.
The research reported here aims to collect basic information on the characteristics of erosion processes in a defined area of the Andean zone of Colombia. Furthermore, conventional and improved cassava cropping systems adapted to local smallholder conditions were to be tested to obtain knowledge based on the influence of management practices on erosion processes. Erosion trials were established on slopes with a gradient of 7-20% at two locations in southern Colombia.
As expected, the greatest soil losses were found in the clean tilled fallow system. However, at the beginning of the growing period the greatest soil losses were measured where rill erosion was predominant. This was especially evident in plots with cassava on ridges down the slope where greater soil losses were recorded during the first months after planting than in the plots with clean tilled fallow. These results show that soil conservation measures must be directed especially towards the reduction of surface runoff during the first months after planting. In this context those cropping systems were the most efficient which reduced the velocity and the quantity of runoff by physical barriers. This is especially evident for the contour ridges and to a limited extent also for the contour grass strips. Also, a high initial percentage of ground cover reduced effectively the surface runoff and prevented rill erosion.
Based on these site characteristics, a tolerable amount of a yearly soil loss of 1-5 $t/ha^{-1}$ was calculated.
Under the test conditions the cropping systems with sole cropped cassava and cassava planted between contour strips of grass produced relatively high yields.
The results suggest that management practices such as planting on contour ridges or contour strips markedly reduce soil loss while producing optimum cassava yields.
This book is well worth the attention of those working with soil and water conservation in mountain areas. All chapters are well, documented and the conclusions drawn are verified by the text, graphs and tables.

1267 92 - 13/65

Erosion and desertification control
Review, USA, soil and water conservation, tillage systems

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

**CONSERVATION TILLAGE SYSTEMS.**

Adv. Agron., 33, 1981, pp. 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. For our purposes 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 width 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.



1268 92 - 13/66

Erosion and desertification control
Asia, Indonesia, highlands, study, water runoff, erosion control practices, small plots, steep slopes

SIEBERT, S.F. and J.P. LASSOIE

**SOIL EROSION, WATER RUNOFF AND THEIR CONTROL ON STEEP SLOPES IN SUMATRA.**

Trop. Agric. (Trinidad), 68, No. 4, 1991, pp. 321-324

In this paper soil erosion research and water runoff rates under conventional cultivation (i.e., without soil conservation practices) and when several soil conservation measures were used on steep, intensively-cultivated slopes in Sumatra, Indonesia are examined. Erosion-inducted effects on selected soil physical and chemical properties and on crop yields were also examined. Based on these results, recommendations were developed for the introduction of appropriate soil conservation measures.
This study was conducted in the highland valley of Kerinci, Sumatra, Indonesia. Irrigated rice cultivation is the dominant land use in the valley; annual and perennial cash crops are cultivated on the hills above the valley floor. Most farmers in Kerinci cultivate both a rice field and one or more hillside farms.
Soils in Kerinci are complex red-yellow podzolics.
Soil erosion and water runoff losses associated with conventional and conservation farming practices were measured on enclosed runoff plots, using a randomized complete block design with three replications.
Five practices (treatments) were selected for study:
- control by conventional cultivation (corn planted two seeds per hole at 75 cm intervals) with no soil conservation measures employed;
- conventional cultivation at increased planting density (corn planted one seed per hole at 25 cm intervals) and NPK fertilizer application (groundnut, with 100 kg TSP $ha^{-1}$ and 50 kg KCl $ha^{-1}$; corn, with 100 kg urea $ha^{-1}$, 100 kg TSP $ha^{-1}$ and 50 kg KCl $ha^{-1}$);
- level bench terraces, with three terraces per 10 m plot, risers 75 cm tall and planted to *Setaria* sp. grass at 30 cm intervals;
- grass contour bunds, with three bunds per plot, each 15 cm tall and planted to double rows of *Setaria* sp. at 30 cm spacing; and
- grass and *Gliricidia sepium* (Jacq.) Kunth ex Griseb. (an N-fixing leguminous tree) contour bunds with mulch, two bunds per plot, each 15 cm tall and planted to one row of *Setaria* sp. and one row of *G. sepium*, each at 30 cm intervals. Mulch cover was maintained at approximately 50% ground cover by periodically adding *G. sepium* leaves following an initial application of 0.5kg $m^{-2}$ (5000 kg $ha^{-1}$).

A variety of soil conservation practices are used on small farms throughout the tropics. Some of the more common practices include: contour ploughing, conservation tillage, the use of cover crops

and mulches, grass and leguminous shrub plantings along the contour, grassed runoff channels, contour bunds, ditches and bench terraces.
Agronomic soil conservation techniques are generally preferred to engineering methods (e.g., bench terraces) by low-income or subsistence farmers because of lower capital and labour requirements. The construction of bench terraces can result in reducing crop yields where shallow topsoils overlie undesirable subsoils.
In this study, the use of bench terraces, grass bunds and grass plus *Gliricidia sepium* bunds with mulch resulted in significant ($P<0.05$) reductions in soil loss and water runoff in comparison with conventional cultivation methods on steep hillside farms in Sumatra. No significant differences in soil erosion rates were observed between conservation treatments.
No significant differences in mean groundnut yields and total above ground biomass production were observed between the conservation or control treatments (on a per plant basis).
This research suggests that agronomic soil conservation practices known to be effective on gentle (less than 15%) slopes may also be suited to some steep tropical slopes. Simple agronomic conservation farming measures warrant careful consideration and empirical field-testing in soil conservation and watershed management projects throughout the tropics.



## XIV POTENTIAL CROPS

1269

92 - 14/30

Potential crops
Latin America, Andes, review, book, root crops, tuber crops, grains, legumes, vegetables, fruits, nuts, research contacts

BOSTID

**LOST CROPS OF THE INCAS.**

Report of an Ad Hoc Panel of the Advisory Committee on Techn. Innovation; Board on Science and Technology for International Development; National Academy Press; USA; Repr. 1990, 415 pp., ISBN 0-309-04264-X, Price £17.15

This book focuses on 30 of the "forgotten" Incan crops that show promise not only for the Andes, but for warm-temperate, subtropical, and upland tropical regions in many parts of the world.
It is aimed at informing administrators and research scientists in both developing and developed countries of the existence of these 'lost' plants which, in fact, still exist but which have been overlooked by agronomists in recent years, after being cultivated to a high level of efficiency and distributed throughout the Andean region of the Inca Empire.
More than 600 people from 56 countries (see Research Contacts) have directly contributed to this book. A few species described - capuli cherry and zambo squash, for example - are not Andean natives but are included because the Andean types have much to offer the rest of the world.
The main objective of this publication is to contribute to the raising of nutritional levels and the creation of economic opportunities for the further development of these plants. This claim appears to be fully justified for the more than 30 crops covered in the text.
The division of the text into the traditional agronomic groupings of Roots and Tubers, Grains, Legumes, Vegetables, Fruit and Nuts is logical and provides ready reference to the common or vernacular names of the crops.
The text is devoted to roots and tubers, reflecting the importance which still exists in some Andean regions of the numerous members of the Cannaceae, Leguminosae, Cruciferae, Solanaceae, Basellaceae and other families which have edible roots or tubers. The second most important section is the fruits which include many commodities which are now becoming, or are likely to become, important in international markets.
Most crop sections have an introduction which contains general comments on their importance and potential usefulness, followed by lists of species and cultivars, where applicable, the future prospects for the crop, nutrition, agronomy, environmental limitations, harvesting information and research needs.

There are useful appendices which include Research Contacts for individual crops and selected references under specific crop headings.
This report has been written for dissemination to administrators, entrepreneurs, and researchers in developing countries as well as in North America, Europe, and Australasia. It is not a handbook or scientific monograph: references are provided for readers seeking additional information. Its purpose is to provide a brief introduction to the plants selected, and it is intended as a tool for economic development rather than a textbook or survey of andean botany of agriculture. The ultimate aim is to raise nutritional levels and create economic opportunities, particularly in the Andes. The report, however, deliberately describes the promise of these plants for markets in industrialized nations. It is in these countries (where a concentration of research facilities and discretionary research funds may be found) that many important research contributions are likely to be made.
This book will be of considerable value to anyone wishing to promote the cultivation of these crops which have been overlooked for such a considerable period.
This book has been produced under the auspices of the Advisory Committee on Technology Innovation (ACTI) of the Board on Science and Technology for International Development, National Research Council. ACTI is mandated to assess innovative scientific and technological advances, particularly emphasizing those appropriate for developing countries. Since its founding in 1971, it has produced almost 40 reports identifying unconventional scientific subjects of promise for developing countries.



1270

92 - 14/31

Potential crops
Review, article, agriculture, forestry, plants, food crops, legumes, fruits, trees, schrubs, BOSTID

VIETMEYER, N.D.

**LESSER-KNOWN PLANTS OF POTENTIAL USE IN AGRICULTURE AND FORESTRY.**

Science, 232, 1986, pp. 1379-1384

The purpose of this article is to give a sense of the remarkable plants that still have not been exploited, as well as to highlight particular global problems where underexploited plants seem notably promising. It results from knowledge gained in a small program at the National Research Council, which for the past 15 years has been evaluating under-recognized resources that could help developing nations.
The lesser-known food crops that remain outside the fold of science have not been rejected because of any inherent inferiority. Many have been overlooked merely because they are native to the tropics, a region generally neglected because the world's research resources are concentrated in the temperate zones.
While many food crops are neglected because they are in the tropics, even more are negelected because they are scorned as "poor people's plants". Peanuts, potatoes, and many other common crops once suffered from this same discrimination.
A remarkable collection of poor people's crops also suffering rejection is to be found in the highlands of South America. The Indians there are among the poorest people in the Western Hemisphere and, except for the potato, their crops remain outside the mainstream of agronomic science.
When Francisco Pizarro and the Conquistadores invaded Peru in 1531 they initiated events that 70 years later brought the potato to Europe. However, they ignored several dozen other crops and these were virtually lost in the collapse of the Inca culture.
This review of some underexploited tropical crops, highlights promising food crops such as the oil palm *Jessenia polycarpa*, the grain amaranths (*Amaranthus* spp.), quinoa (*Chenopodium quinoa*) and oca (*Oxalis tuberosa*) which have been largely overlooked by research resources in the temperate zones. Among the legumes discussed, the groundnuts (*Apios americanum* and Voandzeia [*Vigna*] *subterranea*), yam beans (*Pachyrrhizus* spp.), winged beans (*Psophocarpus tetragonolobus*) and adzuki bean (*Vigna angularis*) are considered to warrant further development. Notes are given on the potential of some more obscure tropical fruits, including those belonging to the Solanacea and Ammonaceae, arid zone crops including tepary beans (*Phaseolus acutifolius*) and marama beans (*Tylosema esculentum*), valuable resource shrubs and such N-fixing trees as *Leucaena leucocephala*, *Acacia mangium*, *Mimosa scabrella* and *Calliandra calothyrsus*.

1271 92 - 14/32

Potential crops
Review, article, Africa, areals, sorghum, millets, indigenous food, yield, technology transfer, ICRISAT, IDRC, SAFGRAD,NRC

SPORE

**SORGHUM AND MILLET NEW ROLES FOR OLD GRAINS.**

SPORE, 29, 1992, p. 6

As Africa strives to close the gap between population and food production, sorghum and millet will become of increasing importance. This will be especially so where weather patterns are unpredictable because maize is much less adaptable to inadequate erratic rainfall.
There are two broad categories of sorghum; red or brown sorghums, which often contain bitter tasting tannins in the seed coat, and white sorghums, which do not. The tannins deter predators but must be removed in order to make grain acceptable for human consumption.
Sorghum is both drought-resistant and able to tolerate waterlogging better than maize because of its deep and well-branched root system. It is also remarkably pest-resistant, but unfortunately the compounds that help protect the crop from birds and insects make the grain and the stover less palatable and less digestible for people and livestock.
There are also two major types of millet; finger millet and bulrush millet. They are very different in appearance. The grain of finger millet is contained in a "hand" of digits (hence the name) and the plant seldom grows higher than 1.3 metres. Bulrush millet can grow to 3 metres. Millets are even more drought resistant than sorghum and can give good yields on infertile, sandy soil which would be unsuitable for most cereals. But millets are very susceptible to bird damage and, as more children attend school and are not available to scare birds, this can cause considerable losses. Farmers are also inclined to switch to maize, as has happened in Kenya and Tanzania, because millets and sorghum demand a great deal more work to harvest, store and process.
Sorghum and millet are very similar to maize in their nutritional value. Traditionally both grains are prepared by pounding to remove the husks but, millet and sorghum flour does not keep well and fresh flour has to be prepared regularly. New techniques for easier processing are urgently needed and there have been some promising developments in mechanical decortication.
A dry abrasive technique for milling of the husk off sorghum was developed from a Canadian design and promoted by the International Development Research Centre (IRDC). About 40 machines were made locally and installed in Botswana, and trials and demonstrations set up in several other SADCC countries. These decorticators proved well-suited to small-scale operations, as the cost of equipment is low. The cost of transportation of grain and products to and from the mill is minimized, employment is created in rural



areas and, when milling a reasonably pure strain of white sorghum, a high yield of excellent quality product can be obtained. However, it is more difficult to process mixed crops to acceptable levels of colour and taste.
An alternative technique for semi-wet milling of sorghum has been developed by the UK Natural Resources Institute (NRI). The whole sorghum grain is wetted with up to 25% water and after 12 hours the conditioned grain is milled in a roller mill in the same way as maize or wheat. Even in highly bird resistant varieties of red sorghum the endosperm is normally white, and using this technique the white endosperm is effectively separated, leaving the bran and most of the coloured layers clean and almost intact.
Semi-wet milling is not the answer for all situations, however, since it is unlikely that the process will be economically viable at a throughout of less than two tonnes per hour. Also, the meal produced has over 20% moisture and is unsuitable for long-term storage.
If techniques can be perfected to make sustainable use of much larger quantities of millet and sorghum (particularly red sorghum), which can be grown on the extensive and still under-utilized semi-arid lands of Africa, the consequences will be profound and far reaching: on food security, on rural employment and on agricultural income in many parts of the continent.
Pearl millet (*Pennisetum glaucum*) f.e. like sorghum was domesticated in Africa but can withstand more heat and drought stress and yet reliably produce a nutritious grain crop. While new advances can be made in the forage crop using recently discovered low lignin *bmr* genes, pearl millet has many attributes which are being used to transform it into a summer combine grain crop for temperate agriculture. These include a very large and varied germplasm resource base, a high growth rate, efficient nutrient utilization, major dwarfing genes, earliness, good heterosis, and several cytoplasmic-genic malesterile systems for hybrid seed production. Seed is produced commercially in India of semi-dwarf grain hybrids which cover 2 million ha annually. Under optimum conditions, the yield potential of these early maturing (85-90 days) hybrids is high - 5000 kg/ha.