X PLANT PROTECTION

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Plant protection
Africa, Sub-Sahara, IITA, review, biological control, cassava pests
IITA
Working with Nature: Progress in Biological Control of Cassava Pests in Sub-Saharan Africa.

IITA Annual Report and Research Highlights 1987/88, Ibadan, Nigeria, ISSN 03311-4340, 1988, pp. 30-38

Not only does cassava mealybug (*Phenacoccus manihoti*) cause substantial yield losses of a basic food for millions of Africans but another pest - cassava green mite (*Mononychellus tanajoa*) - adds its big share to the damage. Together they can cause yield losses as high as 80%, with an average 30% considered a conservative figure.
Any sizable loss can be catastrophic because cassava (*Manihot esculenta*) grown on an estimated 10 million ha, is a staple food for approximately 200 million people in sub-Saharan Africa. It is a prime source of carbohydrates from the underground roots and proteins and vitamins from the leaves. Of all the food crops in tropical Africa, cassava - a drought tolerant crop - is the greatest source of food energy.
A two-pronged attack, which has become the world's largest biological pest control program, was launched against the two cassava pests by IITA with help of many collaborators and donors in Africa and in other parts of the world.
The size of the threat demanded a rapid solution over an area larger than the United States. The biological control option using natural enemies for control of the two pests was chosen as the fastest, safest, and most appropriate method and a special Africa-wide Biological Control Program (ABCP) was established.
Analyses from several sources illustrate the advantages of working with nature. Checks and balances have evolved in natural systems that keep the proportions of species within narrow ranges during any given period.
Although the cassava mealybug (CM) and the cassava green mite (CGM) can be controlled with frequent applications of highly toxic pesticides, this approach is both ecologically and socially unsound, as well as too expensive.
Successful results with biological control of CM using the parasitic wasp *Epidino carsis lopezi* show this environmental-conscious approach to be a practical strategy for control of the mealybug, especially in sub-Saharan Africa agriculture that is oriented towards low-input, sustainable production of food crops and the maintenance and protection of agro-ecological zones devoid of widespread use of pesticides.
By the end of 1987, the two pests had spread to 31 of 35 countries in the African cassava belt. They are found together in 24

countries and will probably cover all cassava-growing areas within the next two or three years. Originally the CM was considered to be the more important of the two pests, causing devastating damage in Central and West Africa. It has recently moved over the Rift Valley into East and Southern Africa causing great concern. But in the past three years the CGM has been reported as an increasingly serious problem.
Biological control of the CGM - first observed in Uganda in 1971 - is proving to be more difficult and may require consistent, long-term efforts. The complex of efficient natural enemies of the green mite is almost restricted to predatory mites. Because of different behavior and ecological needs of these biological control agents, the introduction of predatory mites from South America and their establishment in African countries appears to be more difficult than of mealybug antagonists.
Because cassava - the main natural host of CM in Africa - was introduced from South America and the genera *Manihot* and *Phenacoccus* are particularly rich in species in that part of the world, the search for natural enemies started there in 1980 as a follow-up of the efforts initiated by the CAB International Institute of Biological Control (CIBC/England).
The exploration has resulted in the identification of more than 60 natural enemies of the two pests, 14 of which have been released in Africa.
However, to date only one parasitoid - *E. lopezi* - has proven to be effective against the mealybug using both aerial and ground releases in many ecological situations. This parasitic wasp has been established in 18 countries over areas of about 1.5 million km². It is estimated that cassava crop losses due to the CM in these areas have already been reduced by half and both IITA and national scientists expect that losses will continue to decrease since *E. lopezi* is known to keep CM population low only after the second year following its establishment.
On the other hand, none of the releases of cassava green mite predators has led to proven establishment. Therefore, CGM research, including rearing of host mites for natural enemies, mass rearing the natural enemies, and experimental releases, is being stepped up.
E. lopezi was discovered quickly and inexpensively, could be mass-reared by techniques developed by research, appears to be capable of permanent establishment over nearly all (if not all) of the cassava belt, disperses effectively and rapidly, and provides good control under a wide variety of conditions. Furthermore, farmers do not have to decide to adopt the technology and it requires neither investment nor maintenance by them.
An integrated problemsolving approach that includes research, training, and development of national programs has been used. Rather than being concentrated only on the pests and their natural enemies, research has included the plant and its environment. Through intensive field and laboratory studies and computer simulation, the cassava agro-ecosystem is analyzed and the impact of manipulations assessed.
National biological control programs are being established in 35 countries of the African cassava belt.

Because biological control is area-wide, it can spread from one country to another. Thus, there is a critical need for African countries sharing similar climatic conditions by the Inter-African Phytosanitary Commission, FAO, and ABCP. In addition, it was emphasized that an authority responsible for the application of these regulations should be established.

437 89 - 10/24

Plant protection
Africa, review, crop protection, small-scale farmers, farming systems, intercropping, research, weed control, striga, yield, pesticides, practical approach
PRINSLEY, R.T. and P.J. TERRY
Crop protection for small-scale farms in East- and Central Africa - a review.

Commonwealth Science Council, Marlborough House, Pall Mall, London SW 15 HX, UK, ISBN 0-85092-3331 X, 1988, £ 6.00

In most countries of Eastern and Central Africa, agricultural production is carried out mainly on small-scale farms; small-scale farming families account for the majority of the population in these countries. On many of these farms, a single family provides the only labour available, and inputs such as pesticides and machinery are not affordable. However, in many of these countries there is an urgent need to improve the productivity of food crops, despite these constraints. For example, extensive yield losses are inflicted upon these crops on small-scale farms by insects, weeds, diseases and nematodes, and improvement of crop protection practices is therefore seen as an important means of raising yields.
"Crop Protection for Small-Scale Farms in Eastern and Central Africa - a Review", is a book devoted to the consideration of this question; it was published by the Commonwealth Science Council in 1988. It was based on an analysis of the farming systems in the Embu district of Kenya and on a workshop held in Embu, which combined systems analysis techniques with farm visits and a detailed study of the area. As a result a coordinated collaborative regional research project was recommended, and further developed at a project planning meeting in Harare in March 1988.
This volume represents a compilation of the review papers presented at this meeting. It is intended as a handbook for the scientists involved in the research programme but will also be of interest to other scientists involved in crop protection for small-scale farms. It provides an extensive review of intercropping and its relation to crop protection; it recommends appropriate research; it discusses major weed control problems in the region and, in particular, looks at potential control methods for Striga: it also looks at intercropping practices.
The available information on yield losses in maize due to maize stalk borer are reviewed and the need for further information

using standardized and quantitative procedures are identified. The final chapters discuss pesticide safety, management and storage, the need to learn from farmers of their approaches to crop protection, and in general terms, how their farming systems work.

438 89 - 10/25

Plant protection
Central America, Mexico, experiment, bean, agroecosystem, fall armyworm, predators, population
RUIZ-ROSADO, O. et al.
Tropical corn-bean agroecosystems: management for insect pest and disease control.

In: Proc. of the 6th Int. Sc. Conf. of IFOAM, California, USA, 1988, pp. 525-531

Tropical ecosystems have long been considered the most productive systems of the world, but their productivity decreases when they are converted into agroecosystems. Following 3 to 4 years of agricultural use, these systems suffer nutrient and soil losses accompanied by weed, insect pest, and disease invasion.
The objective of the field work reported here was to study the population fluctuation of the fall armyworm, *Spodoptera frugiperda*, and its natural predators. The fall armyworm is the primary insect pest in maize monoculture and when associated with a black bean crop. How herbivore insects and disease affect bean pods was also analyzed. Observations were recorded from fields on existing farms managed by the peasants (campesinos).
The intercrop was tested under both traditional and modern conventional management systems. In the conventional system, land was prepared by double discing 30 cm deep; corn and black beans were mixed with BHC (concentrated at 80% of active ingredient) at sowing time to protect them from soil insect pests. In order to control fall armyworm larvae on maize plants, methyl parathion insecticide was sprayed when the crop was 28 days old and the insecticide phoxim was sprayed at 34 days. Maize ears were harvested by hand.
In maize sampling, *S. frugiperda larvae* were recorded without differentiating larval stages. Data were reported by plant and compared under a t-test using paired-sampled hypotheses.
Pest Presence and Damage in Maize:
S. frugiperda larvae presence was one week earlier in the traditionally managed system than in the modern one. Larvae presence followed similar trends in each system. When the maize crop was 33 days old, fall armyworm larvae numbers per plant were lower (0.44) in the traditional system than in the modern system (7.6), with a statistically significant difference at the .01 level. In part, the fall armyworm larvae reduction in the traditional system was due to the larval cannibalism characteristic of this insect species and to the predatory activity of its natural enemies. Families of predatory insects colonized crop plants at different times and attacked *S.*

frugiperda at different larval stages. The presence of predatory insect families in the traditional system remained constant from 33 days to 49 days after crop germination. In the modern system predatory insect populations were initially lower but increased steadily in that time period. At 49 days, numbers of predatory insects in both systems increased; populations in the modern system rose sharply until 57 days, and then decreased to equal the maximum value of the traditional system. When families of predatory insects were analyzed separately, there was no statistically significant difference in numbers of insects in the two systems. But when families were analyzed altogether, there were more insects per plant (9.4) in the traditional system at 57 days than in the modern system (6.4).

The reasons for reducted *S. frugiperda* larvae were different for the traditional and modern systems. In the latter, reduction was mainly due to the methyl parathion and phoxim insecticides applied when the crop was 28 to 34 days old. But the reduction of *S. frugiperda* larvae without insecticides in the traditional system suggests that sprays may not be necessary under traditional management strategies, thus saving campesino farmers money and protecting the environment.

At the beginning of the study, *S. frugiperda* larvae were more numerous in the traditional system than in the modern one, which may have been due to the fact that residue from the previous crop was not burned in the traditional system. The dried crop residue may have protected *S. frugiperda* pupae from natural enemies. In contrast, double discing used in the modern system would have exposed pupae to the sun and to natural enemies. Thus, insect pest infestations may be affected by different soil preparation methods. This may account for the presence of S. frugiperda one week later in the modern system than in the traditional one.

Pest Presence and Damage in Black Beans:

Although beans in the modern system generally produced more pods per plant than those in the traditional system, the difference was not statistically significant. Insect damage to bean pods at 65 days after germination was due primarily to Coleoptera of the Chrysomelidae family and was lower in the modern system than in the traditional system (statistically significant at the .05 level).At 65 days there was no sign of damage by anthracnose, *Colletrotichum lindemuthianum*. Continuous foggy mornings, however, increased relative humidity, stimulating optimal growth and dispersion conditions for anthracnose. At 82 days, damage from anthracnose was observed; in the modern system 35.7% of pods were damaged as compared to only 1.1% in the traditional system (statistically significant at the .01 level). In addition to dispersion by the wind, anthracnose spores may have been spread by herbivore insects visiting and feeding on healthy pods after feeding on infected pods. The percentage of pods damaged by herbivore insects between 65 and 82 days increased by 375% in the modern system and by 17.2% in the traditional one (statistically significant at the .o1 level). Although yield was higher in the modern system than in the traditional, there were more healthy pods per plant in the traditional than in the modern system. Herbivore insect damage in the modern system reached a much higher

level than in the traditional system; it may be that high damage levels stimulated yields in the modern system.

439 89 - 10/26

Plant protection
Latin America, Chile, study, rice, weeds, phenológical development
SAN MARTIN, J. et al.
Estudios fenologicas en malezas de arrozales cultivados en Chile Central. (Phenological studies of rice field weeds in Central Chile.)

Turrialba, 38, 1, 1988, pp. 23-30

Rice fields of Central Chile suffer the invasion of large numbers of aquatic and marsh weeds, which diminish yields. This study compares the phenological development of the most important rice field weeds with that of a rice crop during the 1982-1983 growing season in the region of Pelarco (Talca province, Chile). Cultivation began in August and September with plowing and forming of the rice fields. Rice sowing took place in November. The phenological development of rice as well as the phenological development of 13 weeds in the fields was controlled weekly, for five individuals of each species. The phenophases studied were: emergence, growth, flowering, fruiting and senescence. Several weeds sprouted before the rice, showing a faster development. After rice sprouting, *Carex canescence, Cyperus haspan, Polygonum persicaria, P. aviculare, Ammannia coccinea* and *Typha angustifolia* emerged. *Typha angustifolia*, does not flower in the field. Most weeds flowered before rice. Some are able to set fruit before anthesis of rice occurs. Such is the case for *Echinocloa crusgalli, Cyperus haspan, Lythrum hissopifolia, Polygonum persicaria, P. aviculare, Ammannia coccinea* and *Paspalum distichum*. Five of these weeds were able to flower and set fruit for a second time during the rice growing season, this time in unison with the crop. *Myosotis laxa* ends its life cycle before rice flowering. Almost all weeds produce diaspores before or together with the cultivated plant as a way of ensuring their permanence in the field.

440 89 - 10/27

Plant protection
USA, experiments, study, broccoli, cultivars, cabbage aphid
ALTIERI, M. and L.L. SCHMIDT
Mixing broccoli cultivars reduces cabbage aphid numbers.

California Agriculture, 1987, pp. 25-26

Opportunistic pathogens and insect pests with high adaptability and a wide genetic variability have become an increasing problem in modern, genetically uniform, agricultural systems.

Among the available options, mixing cultivars of different resistances (variety mixtures or multilines) has been found to reduce disease levels (especially rusts) in several grain production systems.
The use of this strategy in insect control has been virtually unexplored.
The presence of resistant plants impedes pathogen spread by increasing the separation between susceptible plants. It is possible that, depending on the degree to which insect pests discriminate between resistant and susceptible cultivars, the intensity of insect attack could be reduced in a field with a wide array of crop cultivars.
The effects of varietal diversity in the field on the population response of the cabbage aphid, *Brevicoryne brassicae* (L.) were examined. Stands of broccoli, *Brassica oleracea botrytis* (L.), composed of a single cultivar or mixed cultivars were used to determine how aphid population densities were affected by variety mixtures, variety proportions, planting arrangements, and planting times of different broccoli varieties. The main objective was to test whether increased cultivar diversity in crops reduces pest populations.
The study consisted of three experiments conducted during 1985-86 at the University of California, Berkeley's Gill Tract in Albany. All plots (5 by 6 meters each) were planted with 80 greenhouse-grown broccoli plants (12 cm tall). Treatments were replicated either three or five times. Each plot had eight rows with 10 plants each, 60 cm between rows, and 50 cm between plants. A 1-meter space between plots was kept free of vegetation by frequent rototilling. Broccoli varieties used were Asgrow's Futura (var.A),, Orion (var.B), Apollo (var.C), and Gem (var.D). This selection was based on the varieties' suitability to environmental conditions at Albany. The densities of winged and wingless aphids on the plants were estimated weekly by counting the numbers on five randomly selected plants of each variety in each plot for eight weeks. The number of aphids, and height and number of leaves of each broccoli plant were also recorded. At harvest time, all sampled plants were cut at soil level to estimate total number of aphids, mummies, plant biomass, and fresh weight of broccoli heads. Plant height and biomass were measured throughout the experiment. Statistical analyses to compare aphid densities between treatments were performed, and so separate significantly different densities resulting from varying cultivar diversity in the field were studied.
Mixing broccoli varieties in various space and time designs resulted in fewer cabbage aphids per plot and per plant than planting a single broccoli variety (Futura, Variety A). Aphid numbers decreased in plots as varietal diversity increased and as the proportion of variety A decreased. Planting of a preferred variety as a border row 15 days earlier than variety A gave significant protection to variety A from aphids.
The observations seem to confirm that increased crop cultivar diversity in a field can result in fewer pests.
While it is difficult to explain the ways in which aphids responded to increased cultivar diversity, it is known that plant

quality differences among closely related varieties can affect aphid population development. It it possible that differences in chemical or visual stimuli emanating from the varieties played a role. Data from the first and second experiments, however, suggest physical differences were important, since the dispersion of short varieties among tall plants restricted aphid settling on short plants. Taller varieties seemed to be more easily located by aphids, and functioned as a protective barrier or trap crop. This "physical interference" was apparent when the taller variety B was planted earlier as borders around variety A plants.
These results are encouraging and need to be studied further in larger plots more representative of farmers' fields.

441 89 - 10/28

Plant protection
Asia, Bangladesh, experiment, neem seed kernel, pulse beetle, storage pest
DAS, G.P and M.A. KARIM
Effectiveness of Neem Seed Kernel Oil as Surface Protectant Against the Pulse Beetle.

Trop. Grain Legume Bull., 33, 1986, pp. 30-33

Pulse beetle, *Callosobruchus chinensis* Linn. is a serious pest of stored pulses whose cicular holes in the seeds make them almost unfit for human consumption. Neem (*Azadirachta indica* A. Juss) leaf and seed kernel powder have been reported by different workers to be effective in reducing the insect pest attack of stored grains.
The present investigation was initiated to test the efficacy of traditionally extracted neem seed kernel oil as surface protectant for three popular pulses of Bangladesh,viz. grasspea (*Lathyrus sativus* L.)., lentil (*Lens culinaris* Medik)., and chickpea (*Cicer arietinum* L.) against the pulse beetle.
Well-dried seeds of grasspea, lentil, and chickpea were kept for eight days in a deep-freeze in sealed bags to destroy any hidden infestation. The moisture contents of the test legumes were 12.1% for grasspea, 12.5% for lentil and 12.3% for chickpea. Matured neem fruits that had dropped from the trees after ripening were collected and dried. They were then decorticated to get the kernels. The kernels were passed through a bullock-drawn, locally designed, wooden oil expeller (locally called "ghani") to give off the neem seed kernel oil. Portions of 400 g seeds of each pulse well-mixed with 4 ml neem seed kernel oil and equal quantities of untreated pulse seeds were kept in individual glass jars (15,5 cm x 13,0 cm as controls). All treatments were replicated three times. Three pairs of newly emerged *C. chinensis* adults were introduced in each glass jar. The top of each jar was covered with cloth to facilitate aeration, but to prevent escape of the insects or entry of other insects from outside. The jars were kept in the laboratory with a temperature of 30 ± 2°C and 80 ± 5% R.H. After 5 months of storage, the total height of the seeds in each glass jar

was divided into three equal portions by visual observation and marking on the glass jar. These three portions were then carefully poured separately on pieces of paper. Seed samples from each of the above three layers of seeds were obtained and the samples mixed after which a portion of seeds was randomly selected. Seed damage was determined by the number of infested (seeds with feeding holes) and noninfested seeds. The viability of treated and untreated (control) seeds was tested by germinating 100 randomly selected seeds from each jar in large petri dishes using moist cotton as a substrate.
Infestation by *C.chinensis* in neem seed kernel oil-treated seeds was zero as compared to 91.00%. 77.33% and 90.33% infestations in untreated seeds of the above three pulses, respectively, after 5 months of storage.
The exact mechanism of protection is not clear but it may result from physical and chemical factors. There was no adverse effect on the germination of seeds treated with seed kernel oil.
From the above results, it is clear that commonly available and cheap neem seed kernel oil can be used as surface protectant of seeds of stored pulses to effectively control pulse beetle infestations with no risk of hazards.

442 89 - 10/29

Plant protection
Asia, India, SAT, study, traditional pest control
BHASKAR RAO, V. and R.A.E. MUELLER
Some traditional pest control practices of SAT farmers.

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India, 1986, pp. 15

Agriculture production in the tropics is exposed to considerable stress from insect pests. Traditional agriculture has coevolved with the insect pests and cropping systems have unfolded that are adapted to local conditions and that benefit farmers. Traditional pest control methods are one manifestation of the coevolution between agricultural production and its environment. These methods have not been designed and recommended by non-farmers, such as researchers or extention agents, but are simply used by farmers with the intention to reduce or eliminate insect pest damage in crops.
This paper serves three purposes. Firstly, pest control practices are likely to change considerably on the small farms in SAT India. Rapid adoption of chemical control has occured in some crops and locations. Many traditional practices will, therefore, soon be part of history and forgotten if not recorded. Because one can only learn about the process of technical change by studying its history, and because one cannot study history without documents, our record of traditional pest control practices may be of use to students of technical change in pest control. Secondly, orthodox entomologists and plant protection specialists, who design and develop protection methods only on experiment stations, may want

to know with which methods their recommended methods may have to compete. The third purpose of this account is to assist pest protection specialists who approach their subject with a farming systems perspective. Various authors have recently emphasized the importance of close and detailed examinations of traditional pest control practices as the basis for research on improved pest control adoptable by small farmers. The study of traditional pest control practices by scientists obviously requires that the scientists know what practices there are. Several accounts of traditional agricultural practices are available for India and the contribution can, therefore, only be marginal in this regard. The intention is not to add to the literature but to complement the very detailed farm and village information that has been assembled for three villages over ten years by ICRISAT's village-level studies.
The data for this note were obtained from two sources. The first source was the recollections and experiences of four ICRISAT village investigators. They had been stationed in four villages and observed farmers' production methods in six villages in three agroclimatic zones of SAT India.
The authors do not believe that any of the traditional pest controls reported here offers an important crystallizing point for further adaptive research. They believe that many of the traditional practices are not very effective and could not compete with judicious chemical control. Perhaps the biggest advantage of the traditional practices, the pseudo-controls in particular, is that they do not cause control resistance building up in the insect population. This characteristic may occassionally be exploited in pest control recommendations. Just like a patient with an undiagnosed illness is best treated with placebos, harmless pseudo-control practices may be suitable for farmers who insist on carrying out some pest control, when actually no authentic pest control can be recommended.
Some of the traditional pest controls require materials that are collected from plants growing on common property land. With increasing population density such lands are gradually vanishing and continously overexploited. With the reduced availability of natural materials the costs of traditional pest control methods are rising and alternative protection measures, such as biological or cultural control, and varietal resistance, should become more economically attractive.

443 89 - 10/30

Plant protection
Latin America, study, cassava, cultivation, weeds, weeding, intercropping, biological balance, purple nutsedge
LEIHNER, D.E. et al.

El coquito (*Cyperus rotundus*) en el cultivo de yuca: interacciones y control. (Purple nutsedge (Cyperus rotundus) in cassava: interactions and control.).

Revista COMALFI, 7, (3-4), 1980, 3-20

Recent information on the biological balance between purple nutsedge (*Cyperus rotundus*) and cassava is analyzed; the possibilities of influencing this balance to favor cassava are also studied. The slow initial growth of cassava highly favors the development and propagation of *C. rotundus*, resulting in competition between the 2 species during the 1st part of the cassava growth cycle. While competition for light may be of little importance, the allelopathic effect and the large consumption of water and nutrients by the weed may be responsible for cassava production losses. In cassava, mechanical control of *C. rotundus* continues to be the most common practice; however, this can aggravate the problem instead of reducing it. Only mechanical control during the dry season shows some promise. Pre-emergence herbicides or pre-planting incorporated products currently used in cassava are of limited and erratic effectiveness against *C. rotundus*, but chemicals with improved effectiveness have been identified. In the area of postemergence herbicides, glyphosate continues to be the most effective. Since there is still no ideal control system, simple practice, or single herbicide to control and finally erradicate *C. rotundus*, investigation has focussed on integrated control measures that combine mechanical, chemical, and cultural practices. Future investigations will try to establish practical and economical integrated control systems and at the same time determine the factors responsible for yield and quality losses in cassava due to *C. rotundus*, such as allelopathy and competition for water and nutrients..
Author's summary

444 89 - 10/31

Plant protection
Africa, Sahel, pearl millet, insect plant management, FAO, CILSS, USAID
GAHUKAR, R.T.
Problems and perspectives of pest management in the Sahel: a case study of pearl millet.

Trop. Pest Management, 34, 1988, pp. 35-38

Pearl or Bulrush millet (*Pennisetum americanum* (L.) Leeke) is widely grown, along with sorghum, covering over 13 million ha in the sub-saharan region of West Africa. This region is characterized by annual rainfall below 500 mm with its unequal distribution during the crop seasons and droughts are common. Pearl millet is a major food crop. The average yield per ha is about 450 kg, but yields up to 2 tonnes have been obtained through improvement of local or introduced genotypes.
Generally, drought is a major constraint, but weeds, plant diseases, insects and birds cause considerable damage to the crop. In order to reduce yield losses, pest management studies began in 1980-81 under an Integrated Pest Management Project (FAO/CILSS/USAID) in member countries of the CILSS (Comité Permanent Inter-Etats pour la Lutte contre la Sécheresse dans le Sahel).
The present paper reviews the pest complex of pearl millet and discusses pest management strategies in the context of subsistence farming.
In the present situation, chemical control appears impractical and costly, and alternative measures need to be considered. Partial burning of green stems for use in fencing and roofing, destruction of crop residues before the rains, planting of resistant varieties intercropped with grain legumes is recommended for stem borer control. Midge populations may be limited by destruction of infested spikes, avoiding delayed planting and by encouraging larval pupal parasites. Traditional methods applied on varieties with bristles is suggested for the control of blister beetles. Insecticide applications should be used to control sporadic attacks and epidemics of pests. However, the economic injury level should be determined in relation to the grain price, farmers' preferences, the scarcity of food, purchasing power etc. In order to examine the benefits of above recommendations and some of the socio-economic problems, pilot projects have been initiated in Burkina Faso, Senegal, Mali, Gambia and Niger.
Millet is a subsistence crop and the production cost is often unknown. Therefore any cost involved in IPM might be unacceptable to farmers. Extension workers should demonstrate the advantages of IPM and its ability to achieve acceptable results. The IPM system should be modified as government policy, varieties released and pest incidence changed. However, extension technical assistance and finance are necessary for the continuity and adequate progress in IPM. A combination of efficient pest forecasting and monitoring with IPM should help the Sahelian farmer to reduce yield losses in pearl millet and increase the crop production.

445 89 - 10/32

Plant protection
Asia, India, field study, upland rice, crop, weed, competition
SINGH, G. et al.
Crop/weed competition studies in upland rice.

Trop. Pest Management, 33, 1987, 19-21

Direct seeding by broadcasting or drilling (in upland rice) is a common practice of rice cultivation in India. A large area (22·5 million ha) under rice is still occupied by upland rice where yields are extremely low, and it is on account of the upland rice that the average yield of rice has not much increased.
Yield losses due to uncontrolled weeds in upland rice have been reported to be as high as 40-80%, and in many cases, there have been complete crop failures due to severe weed infestation.
The existing practice of manual weeding has to continue since there is no herbicide available which can be used effectively, safely and economically for weed control in upland rice under Indian conditions. Under these circumstances, it is necessary to identify the critical period of weed control in upland rice to make the practice of manual weed control more effective and economical.
The field study was carried out during monsoon seasons from 1981 to 1983. The soil was loam in texture (38,4% sand, 45,2% silt and 16,4% clay), medium in organic carbon (0,58%), very high in available phosphorus (109 kg P/ha) and medium in potassium (201 kg K/ha) content with pH 7,7.
The experiment was laid out in randomized complete block design with four replications in 1981 and three replications in 1982 and 1983 crop seasons. Treatments consisted of weedy conditions for the first 15, 30, 45, 60, 75 days after sowing (d.a.s.) and up to harvesting, and weed-free conditions for the first 15, 30, 45, 60, 75 d.a.s. and up to harvest. Rice cv. Pusa 2-21 was sown in the last week of June every year with a fertiseed-drill at 100 kg seed/ha and a row spacing of 23 cm. Recommended cultural practices were followed to maintain optimum crop growth.
Echinochloa colonum, Scirpus grossus, Dactyloctenium aegyptium, Cyperus rotundus, C. iria and *Trianthema monogyna* were the major weed species. Competition from weeds during the first 15 days after sowing (d.a.s.) had no significant effect on the grain yield of rice. Competition beyond 15 d.a.s. caused drastic reduction in the grain yield. Grain yield of rice increased significantly with the increase in the duration of weed-free period up to 45 d.a.s. during two years. However, further increase in the weed-free period up to 60 d.a.s. caused significant improvement in the grain yield of rice in only one year. Weeds emerging after 45 d.a.s. were lower in density and their growth was suppressed by the crop. Density of weeds emerging between 15 and 30 d.a.s. was high and could compete with the crop resulting in reduced grain yields. The period during 15 to 45 d.a.s. was found to be the most important for crop/weed competition.

446 89 - 10/33

Plant protection
Canada, experiments, fababeans, organic farming, weeds, aphid infestation, intercropping, nitrogen
PATRIQUIN, D.G. et al.
Aphid Infestation of Fababeans on an Organic Farm in Relation to Weeds, Intercrops and added Nitrogen.

Agriculture, Ecosystem and Environment, 20, 1988, 279-288

Intercropping or weedy culture of crops commonly results in reduced numbers of insect pests in comparison with crops grown in strict monoculture. Such reductions have been attributed to higher levels of natural enemies in the diversified systems, non-harvested intercrops or weeds diverting pests from harvested crops, repellent properties of intercrops or weeds, and to effects of intercrops or weeds on visual attractiveness of crops to pests. Pest infestations are affected also by the nitrogen status of the host. Growth and fecundity of insects are commonly stimulated by high levels of protein amino acids, and are inhibited by certain non-protein amino acids. Fertilizing crops with inorganic fertilizers, use of certain pesticides and other stresses on plants may make crops more susceptible to pests through their effects on crop nitrogen metabolism. Organic methods of fertilization may be less damaging.
The possibility that weeds or intercrops might reduce pest infestation by affecting the nitrogen metabolism of crops has apparently not been addressed. Evidence for this sort of interaction was obtained during studies of weed-crop interactions on an organic farm in 1985 and 1986 in Canada.
To test the hypotheses that low levels of soil N contribute to the effective natural control of *Aphis fabae* on fababeans on an organic farm, large plots in a fababean field were fertilized with urea. Aphids settled and/or proliferated differentially in differently treated plots of this experiment, and also in those of experiments set up for other purposes in 1985 and 1986. Aphids were more numerous in fertilized than in unfertilized plots, in weeded than in unweeded plots, and in plots without intercrops than in plots with them; in one experiment in which N and weeding were combined factorially, weeding resulted in increasing numbers of aphids, but addition of N did not. Leaf N, measured in two experiments, was highest in treatments with highest numbers of aphids. It is suggested that in addition to enhancing control of pests through their effects on natural enemies, weeds or intercrops can reduce susceptibility of the host to pests by consuming soil N and restricting luxury uptake of N by the crop.

447

89 - 10/34

Plant protection
Review, insects, diseases, weeds, pesticides, chemical control, alternatives, risks
CTA
Pesticides: une arme à double tranchant (Pesticides: a two-edged sword).

SPORE, 19, 1989, pp. 1-4

Insects, diseases, and weeds account for 40% of the annual crop and harvest losses in the ACP-countries. But the use of pesticides, the most commonly adopted remedy against these problems, has its dangers both for man and environment.
The use of pesticides is considerably lower in developing countries than in industrialized nations, but is rising continuously. Africa still accounts for only 5% of world pesticide use but has increased consumption ninefold in a decade or so. However, Third World countries have a poor safety record, and therefore agrochemicals are frequently condemned and referred to as "Third World poisons".
Lack of care in handling and applying pesticides often causes serious accidents and illegal uses such as fishing and poaching, or even criminal purposes (poisoning, suicide, abortion) all too often increase the mortality figures.
As with any chemical product, the use of pesticides requires precautions to ensure the protection of those applying them, the safety of the consumers of the treated crops, and the preservation of the environment. Storing sacks of pesticides next to foodstuffs in poorly-ventilated depots, handling torn sacks or leaking drums without gloves, and spraying with faulty equipment are some of the most frequent causes of poisoning. The many risks of contamination demand that the basic rules of safety should be followed implicitly. Simple precautions and procedures which are not always put into practice include not checking wind direction and strenghth and washing hands after application. This sort of attitude is sometimes accompanied by careless application.
It is imperative that manufacturer's instructions should be followed exactly. A product that kills locust larvae may not necessarily be the right thing to apply to tomato plants and, when a farmer treats his fields with the product he has at hand or that is available on the market, he risks poisoning himself or others with the crops and vegetables from his farm and garden. Such practices which are too common and difficult to control, can have disastrous consequences on the health of consumers by contaminating food products and polluting water supplies.
Furthermore, farmers do not always get the desired results from products which have to be applied at a precise dose and at a certain growth stage of crop or pest in order to be effective against target species. Herbicides, which are now more commonly used, must be applied at a certain stage in the development of the weed for it to be killed. Usually cash crops are treated with appropriate pesticides whereas food crops, all too often have to

do with products originally intended for other crops grown for export. Farmers themselves are not always primarily responsible for this hazardous state of affairs; they are poorly educated, they do not always know how to use these toxic substances, and often have expectations of performance and safety based on exaggerated claims made by salesmen and even extension staff.
The first pesticides to appear in the 1940s, of which DDT is the best known, are now prohibited almost world-wide. Very long-lasting, they can cause lasting damage to the environment and to human beings. The carbamates and organo-phosphorus compounds were the second generation. They were widely used in agriculture and although these were more easily degradable, they were nonetheless toxic to people and mammals. But it is the third generation insecticides, synthetic pyrethroids, which came on the market in 1975 which are now most widely used. These products are harmless to man and beast and to the environment, and at the same time extremely effective against crop pests, especially *Lepidoptera*. Even though less toxic, they need to be applied at low dose rates: were 1 kg DDT or 400 g parathion were once necessary, now only 10 g of deltamethrine would be required. Unfortunately, repeated use of these pyrethroids induces resistance to them in insects so the selection of insecticides must be varied to extend their span of time. A fourth range of compounds is about to come onto the market. These are growth regulators which act on an insect's metabolism and disturb their development. These are very selective, toxic to their target organisms only, and are effective at a very small dosage. Thus a promising new insecticide, which modifies the transformation mechanism in locust larvae, seems likely to replace the controversial organo-chlorine, dieldrin. But the cost of producing these complex molecules is high, and it will still be several years before their use becomes general in developing countries. Other types of products mimic natural substances and may be used in order to avoid causing serious ecological imbalances. For instance it is possible to synthesize the chemical messages which determine insect's sexual instincts (pheromones), which attract pests to certain plants or which repel them.
Microbiological warfare is being developed on many other fronts: bacteria, viruses and fungi, to which insects are naturally victim, are being formulated and sprayed on crops like chemical pesticides. Their use - as yet not fully developed - will allow the reduction of substition for chemical pesticides. Both biotechnology and using other insects which are hostile to pest species are also possibilities which can be considered in addition to the treatments outlined.
With this wide range of weaponry available to farmers to fight pests, the «all-chemical solution» is no longer the only option. An integrated campaign which combines complementary techniques of chemical and biological control seems to be the solution for the future.

448 89 - 10/35

Plant protection
Review, book, pesticides, traditional methods, pestcontrol, sustainable agriculture
GIPS, T.
Breaking the pesticide habit - Alternatives to 12 hazardous pesticides.

Int. Alliance for Sustainable Agriculture, Newman Center at the Univ. of Minnesota, 1701 Univ. Ave. SE., 55414, USA, 1987,372 pp., US$ 14,95

In 1985, The Pesticide Action Network (PAN), launched a public information campaign against 12 of the world's most hazardous pesticides, the "Dirty Dozen": "the Drins" (Aldrin, Dieldrin and Endrin), EDB, Chlordane/Heptachlor, Parathion, Paraquat, 2.4.5-T, Chlordimeform, DBCP, HCH/Lindane, Camphechlor and PCP.
To bridge the lack of documentation on safe alternatives for the specific pesticides the International Alliance conducted a broad research effort of both chemical and nonchemical alternatives for all of the major uses of the Dirty Dozen, from agriculture to public health. This includes an extensive literature review, as well as a survey of more than two thousand leading scientists, extension officials, farmers and groups worldwide. A Scientific Panel was created with distinguished scientists to help review the work. The conclusion of this research is that alternatives are available for nearly every use of the 12 pesticides. A range of beneficial insects, plants, fish, fowl, fungi, and other natural-occuring organisms can be successfully combined with an array of creative management strategies such as ridge tillage, trap crops, and composting, to manage pests. The proper combination of traditional approaches and modern discoveries can provide an historic opportunity to develop sustainable agriculture and pest control systems worldwide. The book provides a thorough review of the evolution of pest control, the concepts of sustainable agriculture and the impact, status and alternatives of the 12 pesticides. Besides this, recommendations for action by Governments, Research and Extension Institutions, International Agencies and Business and Industries are given. This research must not be seen as a source for quick or even nonchemical replacements, but rather, as the basis for a properly designed, holistic and sustainable agriculture. Alternatives are not alternative products but alternative value systems and associated ways of thinking and behaving. Convincing and inspiring, a must for anyone active in agriculture, policy, business, research or extension, worldwide!
Abstract from ILEIA

449 89 - 10/36

Plant Protection
Central America, Costa Rica, field trial, cassava, weed groundcover, white grub, losses
HRUSKA, A.J.
Weedy groundcover increases damage to cassava by white grubs in Costa Rica.

Trop. Agric. (Trinidad), 64, 3, 1987, 212-215

White grubs, the larvae of *Phyllophaga* spp. (*Coleoptera: Scarabaeidae*), are important pests of temperate and tropical crops and natural grasslands. The beetle larvae of this genus inhabit soil and feed on roots and bark of plants for as long as four years before pupating. This damage can cause complete crop loss, especially if attack occurs when plants are young.
In Costa Rica, white grubs cause economic damage to virtually all important crops, including coffee, sugar cane, rice, maize, sorghum, potatoes, cucurbits, legumes, peanuts, onions, lettuce and cassava. The grubs are pests of cassava wherever it is grown.
Research in temperate regions indicates that rainfall and the extent of weedy groundcover can greatly influence grub population levels. Groundcover may lead to an increase in the white grub population levels by: (1) increasing oviposition by adult beetles, (2) increasing survivorship of eggs, larvae and pupae and/or (3) decreasing egg and larval parasitism and predation.
Chemical control of larvae, once they are in high abundance, is often necessary. Thus there is a growing body of research investigating environmental parameters that could be manipulated for cultural control of white grubs. There is also growing interest in natural enemies of the grubs for use in biological control.
This study, conducted in Costa Rica, examines the relationship between groundcover and cassava plant damage caused by white grubs. It also investigates how plant damage is affected by interactions among weeds and (1) cyanogenic glycoside content of the cassava, (2) plant population density and (3) inter-row variety mixtures.
The damage to cassava was due to root-feeding by white grubs. A significant correlation ($P<0.05$) was found between the amount of groundcover and plant damage due to grub feeding at two plant population densities. The correlations were highly significant ($P>0.01$) in pure stands of either of two varieties of cassava, but were not significant in mixed stands. Possible biological mechanisms responsible for the results are discussed.

450 89 - 10/37

Plant protection
Review, plant diseases, air pollutants, epidemics, examples, logistic model, limitations, computer simulation
MADDEN, L.V. and CAMPBELL, C.L.
Potential Effects of Air Pollutants on Epidemics of Plant Diseases.

Agriculture, Ecosystems and Environment, 18, 1987, 251-262

Usually, plant epidemics consist of an increase in disease intensity with time in a population of plants (i.e., crops) in a greenhouse, field or forest. This definition does not agree with the common lay-person's concept of an epidemic, being the rapid development of a large amount of disease over large areas or in large populations. Occasionally, plant disease epidemics will reach such a high level, but this is the exception rather than the rule; plant epidemics usually develop over an entire growing season for field crops or over a period of years in a stand of trees. Disease levels can stay relatively low, but even low levels of many crop diseases result in substantial yield losses and are important economically.
A plant disease epidemic will not occur unless there is a susceptible host, a virulent pathogen, and a favourable environment. This is known as the disease triangle. Air pollutants could be considered pathogens, but for this purpose, only biotic pathogens (e.g., fungi, viruses, bacteria, nematodes) are considered. Pollutants will be considered as part of the environment, which also includes weather and all other biotic and abiotic factors that influence the dynamic interaction of host and pathogen. With epidemics, time must also be considered; conceptually, the disease triangle can be expanded to a disease pyramid.
Little work has been done on determining the effects of pollutants on disease progression. To understand the potential effect of pollutants or other environmental variables on epidemics, a description of an epidemic more quantitative than the disease pyramid is necessary. A theoretical description of an epidemic using mathematics, based on published results, is given to represent an epidemic with well-defined parameters and variables. A discussion of how pollutants can affect epidemics is then given in the context of the mathematical treatment.
Nonconstancy of the characteristics, due either to changing environment or inherent variability of the population, generally requires computer simulation for a thorough understanding. Spatial variability and pathogen dispersal further complicate the effect of pollutants on plant disease epidemics. Some reported examples of the effects of O_3, SO_2, and acid deposition on epidemic characteristics are discussed.

451 89 - 10/38

Plant protection
USA, experiment, biological control, snap bean, grey mold, *Trichoderma hamatum*
NELSON, M.E. and M.L. POWELSON
Biological Control of Grey Mold of Snap Beans by *Trichoderma hamatum*.

Plant Disease, 1988, pp. 727-729

Grey mold, caused by *Botrytis cinerea* Pers. ex Fr., can be found on all aerial portions of the snap bean *(Phaseolus vulgaris* L.) plant. Economic loss, however, is due primarily to pod rot, which reduces quality and increases processing costs. When conditions are cool and moist, losses from pod rot may be substantial. At the present time, grey mold is managed primarily by application of fungicides. In some cases, however, the application of a fungicide may actually increase the severity of *Botrytis*-caused diseases. This increase is presumably due to the presence of fungicide-resistant strains of *Botrytis* and suppression of natural antagonists by the fungicide. The development of strains of *B. cinerea* resistant to fungicides, coupled with the difficulty of registering new fungicides, has stimulated an interest in biological control.
Grey mold on strawberries was reduced in the field with applications of several species of *Trichoderma*, beginning at early bloom. Other workers also have inhibited grey mold on grapes in the field by applying suspensions of *Trichoderma* spp., *Cladosporium* sp., and *Aureobasidium* sp. beginning at flowering. This study examined the potential of *Trichoderma* spp. recovered from snap bean foliage to suppress grey mold of snap beans.
Isolates of *Trichoderma* spp. from snap bean foliage were tested for their capacity to suppress grey mold of snap bean pods caused by *Botrytis cinerea*. In a detached blossom-pod assay, an isolate of *Trichoderma hamatum* reduced pod rot by 94% compared with the nontreated control, which was comparable to that obtained with a fungicide. Forty-two colony-forming units (cfu) of *T. hamatum* per blossom reduced pod rot by 77% compared with the nontreated control. Control was 97% when 233 cfu per blossom were applied. Grey mold was reduced only when spores of *T. hamatum* were appllied to blossoms before, or simultaneously, with application of conidia of *B. cinerea*. Volatile compounds produced by one isolate of *T. hamatum* reduced mean radial growth of *B. cinerea* to 0.6 mm on potato-dextrose agar, while growth on nontreated plates averaged 23.6 mm. These results suggest the production of inhibitory volatiles as one possible mechanism of biocontrol.

452

89 - 10/39

Plant protection
Africa, Nigeria, trials, tropical rainforst, cassava, maize, intercropping, integrated weed management
UNAMMA, R.P.A. et al.
Integrated weed management for cassava intercropped with maize.

Weed Research, 26, 1986, pp. 9-17

Under the non-mechanized cropping systems of south-eastern Nigeria, intercropping cassava and maize is highly productive and gives better land utilization efficiency and more convenient spread of harvest than sole cropping either of the two crops. This crop combination is widely grown by the farmers of southern Nigeria. Weed control in the mixed cropping systems as practised by farmers is labour intensive, uneconomical and more difficult than weed control in either of the sole crops. About 32% of the farmer's time is expended in hand-hoeing either sole cassava or cassava/maize intercrop. The methods adopted by the farmers have been found to be ineffective mainly because of the problem of untimely weeding. Some herbicides have been used to control weeds effectively and economically in cassava/maize intercrop in some parts of Nigeria. A preliminary investigation had suggested the use of low growing crops in combination with herbicides for effective weed control in cassava/maize intercrop.
Whichever method is adopted for controlling the weeds in cassava/maize intercrop, it is critical to keep the weeds suppressed during the first 8 weeks after planting. Current research aims at developing systems of managing weeds whereby the crop is encouraged to exert such pressure that crop growth is favoured at the expense of the weeds. In this way, relying heavily on herbicides for weed control in cassava/maize intercrop weeds may be minimized by the application of more than one kind of technology in a mutually supportive manner. The objectives of the present work are: (i) to evaluate weed control methods involving manual weeding, herbicides, low growing crops and integrated techniques involving the use of herbicide and low growing crop in cassava/maize intercrop; and (ii) to assess the effect of intercropping cassava and maize on their respective yields.
Trials were conducted in the tropical rainforest zone to compare manual weeding with chemical and integrated weed control systems in cassava (*Manihot esculenta* Krantz)/maize (*Zea mays* L.) intercrop. Uncontrolled weeds reduced cassava and maize component yields by 2-year averages of 49 and 62% respectively; and their combined energy yield by 53% compared with 30.572 kcal ha^{-1} obtained from the control plots hand-hoed at 3 and 8 weeks after planting.
Highest economic returns were obtained from using cowpea (*Vigna unguiculata* (L.) Walp) or Egusi melon (*Colocynthis citrullus* (L.) O.Ktze) which gave 2-year average net returns of ₦ 2843 ha^{-1} and 2944 ha^{-1} compared with ₦ 1598 ha^{-1} generated from the control that received two hand-hoeings. Integrated use of cowpea and pre-emergence application of alachlor at 2·0 or chloremben at 3·4 kg

ai ha^{-1} and pre-emergence application of either fluometuron or chloramben at 2·5 and 3·4 kg ai ha^{-1} respectively or their mixture gave more economic net returns than two hand-hoeings. Under similar management level, intercropping cassava and maize resulted in 36-43% more land being made available to the farmer for other uses than sole cropping.

453

89 - 10/40

Plant protection
USA, trials, field beans, insect incidence, relay intercropping, monoculture
TINGEY, W.M.
Insect abundance in field beans altered by intercropping.

Bull. Ent. Res., 78, 1988, pp. 527-535

Intercropping provides several significant advantages over monoculture including a greater total land productivity as well as insurance against failure or unstable market value of any single crop. In addition, crops grown in an intercropping system are sometimes less prone to outbreaks of insect and disease pests than are those grown in monoculture.
In the USA, where monoculture is widely practiced, double cropping systems have attracted considerable interest in recent years. In double cropping systems, a second crop, usually soybeans, maize, or sorghum is planted immediately following harvest of an earlier crop, usually a cereal grain. Consistent success in double cropping requires a minimal delay between harvest of the first crop and planting of the second crop.
Northern latitudes are subject to the danger that the second crop may be immature at the time of the first killing frost. For these areas, relay intercropping may be more advantageous since two or more crops can be grown together for part of the life-cycle of each. This modification provides buffering against failure of the second crop due to unfavourable soil moisture or early frost.
The objective of the present study was to determine the effect of relay intercropping field beans, *Phaseolus vulgaris*, and winter wheat, *Triticum aestivum*, on the abundance of four insect pests (potato leafhopper, *Empoasca fabae* (Harris); bean aphid, *Aphis fabae* Scopoli; tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), and red headed flea beetle, *Systena frontalis* (F.)) on beans.
Densities of four herbivorous insect species were compared on field beans (*Phaseolus vulgaris*) grown in monoculture and those grown in relay intercropping with winter wheat. In three years of study in New York State, population densities of *Empoasca fabae* (Harris) and *Aphis fabae* Scopoli were significantly less in plots intercropped with winter wheat than in those grown in monoculture. In contrast, intercropping was associated with greater densities of *Lygus lineolaris* (Palisot de Beauvois) and *Systena frontalis* (F.). An increased density of *L. lineolaris* may be an economic risk factor in beans intercropped with wheat because only this

species of the four studied feeds exclusively on the flowers and developing seed pods.

454 89 - 10/41

Plant protection
Review, book, ecological approach, integrated pest management, economic injury level, insect-plant interaction, predators, biological control, plant resistance
HORN, D.J.
Ecolocical Approach to Pest Management.

Guildford Press, 200 Park Avenue South, New York, NY 10003, USA, 1988, pp. 275 + xi, $ 36.00

Ecological approach to pest management is a professional-level overview of the relationships between current ecological theory and practical insect pest management. Principles of sampling theory, population modelling and community ecology are developed and related to current advances in integrated pest management programs. Concepts discussed include: economic injury level, analyses of demographic factors, and insect-plant-predator interactions. Insecticides, biological control, plant resistance, genetic manipulations, and cultural/physical control are discussed separately and then integrated to illustrate applications to agricultural, forest, and urban settings. This book will be useful to all those studying pest management and plant protection and to professionals in agricultural and environmental sciences.
The book contains the following chapters:
1. Introduction. Background. Administration of applied entomology. Professional societies. 2. Insect Pests and Economic Decisions. Economic injury level. Expansion of time frame. Role of entomological research. How insects become pests. 3. Sampling Populations. Theoretical considerations. Practical considerations. Appendix. 4. Single-Species Populations. Simple population models. Stochastic models. Population structure. Utility of life tables. Genetic systems. Responses to environment. 5. Insects in Ecological Communities. Interspecific interactions. Synoptic model of insect population dynamics. Theoretical and ecological islands. Synoptic model with K-strategy. Diversity and stability.
6. Insect-Plant Interactions. Insect impact on plants. Plant effects on insects: nutrion. Plant effects on insects: defense. Plant spacing and insect density. Texture and community stability. 7. Broad-Spectrum Chemical Insecticides. Classification of insecticides. Formulation. Development and testing. Side effects of insecticide application. Using insecticides in ecological pest management. 8. Narrow-Spectrum "Biorational" Management. Microbial insecticides. Insect growth regulators. 9. Biological Control. Importation. Evaluation. Attributes of "ideal" agents. Single versus multiple introductions. Augmentation. Compatibility. Major biocontrol agents. Conclusions. 10. Plant Resistance. Introduction. Mechanisms of resistance. Development of resistance varieties. Application of resistance. 11. Genetic, Cultural, and

Physical Control: Quarantines. Genetic manipulations. Cultural management techniques. Sanitation. Physical controls. Quarantines. 12. Integrated Insect Pest Management. Application of pest management models. Alfalfa: successful development of management models. Cotton pests: developed versus developing economy. Forest insect pest management. Suburban household: subjectivity and aesthetic injury levels. Conclusions and future prospects. Index.

455 89 - 10/42

Plant protection
Africa, Nigeria, experiment, cowpea, insect damage, weeds, weeding, flower thrips, pests, IITA
EZUEH, M.I. and L.O. AMUSAN
Cowpea Insect Damage as Influenced by the Presence of Weeds.

Agriculture, Ecosystems and Environment, 21, 1988, pp. 255-263

Weeds constitute a major constraint in crop production in the tropical and sub-tropical regions. They compete for light, water and nutrients, resulting in reduced crop yields. Crop losses in the tropics caused by weeds are 2-3 times greater than in the temperate zones. Average yield loss due to weeds in cowpeas was estimated at 53% at the International Institute of Tropical Agriculture, Ibadan.
In addition to their repressive effects owing to competition, weeds also act as reservoirs, or alternate hosts, for insects, diseases and nematodes. For example, when cowpea was not weeded, insect damage to developing seeds was reported to have increased by 15,3% compared with the weed-free plots. A greater build up of insects and diseases in cowpea under weed competition was reported.
This paper reports the effects of weed presence on the damage intensity of the major pests of cowpeas in the rainforest zone. The results and conclusions provide a necessary back-up for adequate recommendations on control of weeds and pests of cowpea for this geographic region.
The influence of weeds on insect damage of cowpea was studied using weeding treatments, with one treatment isolating the direct effects of weeds on the grain yield of the crops. Seventeen weed species were identified in the cowpea plots. The results of the study showed that the population of flower thrips *Megalurothrips sjostedti* Trybom and *hemipterous* pests increased significantly ($P<0.05$) in the presence of weeds. The effects of weeding frequency on pod damage by the pod-borers, *Maruca lestulalis* Geyer and *Cydia ptychora* Meyr were not consistent but the presence of weeds seemed to have increased the population of these pests. In the 1981 and 1982 experiments, there were positive correlations between the number of times of weeding and insect damage on seed ($r=0.85$ $P<0.05$; $r=0.99$ $P<0.01$, respectively). In 1986, the results showed a positive correlation between number of undamaged seeds per pod and mean grain yield ($r=0.92$ $P<0.01$). The presence of

weeds was therefore thought to have increased insect damage which led to a yield reduction of about 20% in cowpea.
The importance of keeping the cowpea crop weed free is emphasized by the results of this investigation. It offers practical insect-control possibilities especially at the low level of management prevalent amongst the peasant growers. Three weedings, at fortnightly intervals from date of planting, gave the pest results, in terms of pest reduction and yield increase. The major set-backs in manual weeding are the current cost of labour. However, if the use of herbicides, now proven to be effective for cowpea production is widely adopted, it will drastically reduce the intensity of labour inherent in the traditional hoe-weeding, and will therefore make cowpea production more profitable in the humid tropics by reducing heavy yield losses through adequate weed control.

456 89 - 10/43

Plant protection
USA, survey, apple, integrated pest management, pesticide use
KOVACH, J. and J.P. TETTE
A Survey of the Use of IPM by New York Apple Producers.

Agricult. Ecosystems and Environment, 20, 1988, 101-108

Integrated Pest Management (IPM) is one strategy practised by apple producers to manage the large and varied pest complex found in New York. The concept of an integrated approach is not new, having been used in apple orchards as early as 1942, when Nova Scotian growers developed a pest control program that de-emphasized costly insecticides and used "harmonized" control that relied on more natural pest population regulation and limited use of insecticides. This concept of bringing all pests (weeds, insects, diseases, etc.) into an integrated approach was suggested and implemented. In New York, the pilot project began in 1973, but demonstration of the concept to growers did not begin until 1976. Some states reported quick adoption of IPM concepts, but efforts in crops with high-quality standards have taken place at a slower rate. Some consider the slow rate of adoption to be largely the fault of crop protection scientists, but many of these scientists have been frustrated by their inability to foster change when new IPM methods have become available. To reduce this frustration and bring about increased grower acceptance of IPM, it is necessary to understand who uses IPM methods and to appreciate the differences that exist between IPM users and non-users.
This investigation had several purposes. The first was to determine the background and behavioral characteristics of apple producers who use IPM methods and compare them with those of non-IPM users. The second objective was to determine the major source of pest management information used by growers. The third objective was to determine the economic consequences of using IPM by monitoring pesticide use, cost and effect on fruit quality over an 11-year period.

Results showed that >80% of the apple producers in New York State incorporate some aspect of IPM into their pest control strategies. IPM users were younger and better educated and had less farm experience than non-users. However, agricultural sales persons were also considered useful by the growers for making pest management decisions. Growers that employed comprehensive IPM practises used 30% less insecticides, 47% less miticides and 10% less fungicides than growers that did not use IPM practises. This resulted in 235 kg active ingredient ha^{-1} not having to be absorbed by the environment and saved IPM apple growers an average of US$ 95.80 ha^{-1} $year^{-1}$ over an 11-year period (1976-1986) without significantly affecting fruit quality.

457 89 - 10/44

Plant protection
Africa, Burundi, experiments, potato, bacterial wilt, mixed cropping, disease development
AUTRIQUE, A. and M.J. POTTS
The influence of mixed cropping on the control of potato bacterial wilt (*Pseudomonas solanacearum*).

Ann. appl. Biol., 111, 1987, pp. 125-133

This paper describes an investigation to evaluate the effects of intercropping on disease control and the build-up of inoculum in the soil. The objective was to increase crop yield and also to permit a more efficient method of selection of plants for conservation of tubers as seed, in situations where roguing is not considered acceptable by farmers.
Two major sources of bacterial wilt inoculum exist: infected tubers and infected soil, either through the presence of free-living bacteria or through their presence on potato plant debris. Infected tubers, particularly where the infection is latent, are a major source of dissemination between fields and between seasons. Research into methods of controlling the disease have thus tended towards the investigations on the effect of latent infection of the tuber on the spread of the disease. Methods, such as selection of site, crop rotation and even roguing, are not practised on the very small, intensively cultivated farms of the area, where food is at a premium.
Until such time in which resistant or highly tolerant varieties become available, the use of clean seed, must be considered the principal method of reducing the level of infection. Such a philosophy depends upon the production of adequate quantities of clean seed, the establishment of a new tradition to ensure that only clean seed is planted and a low level of soil infestation. Whilst small quantities of clean seed are now available, it is always likely to be in limited quantities and at a price that farmers cannot afford each season. Thus, until the appropriate varieties become available, methods must be found to enable farmers to keep the inoculum potential in their land as low as possible and enable them to enhance their chances of selecting

clean seed. This suggests that more research is necessary on the spread of the disease within a crop.
Since roguing does not appear to be acceptable to farmers, an alternative method may be to intercrop potatoes with crops not susceptible to race 3 of *P. solanacearum*, since isolation of the potato plants, spatially and by the presence of immune species between them, should reduce root-to-root spread.
The experiments discussed here were carried out on a free draining sandy loam, situated at 2100 m above sea level. Mean temperatures range between 14° and 18°C (average mean maximum 20° to 24°C; mean minimum 10° to 13°C). Total precipitation in the range 1400 to 1700 mm per annum is bimodally distributed, with peaks in November and April, and a dry season from mid-May to mid-September.
The experiments with bacterial wilt (*Pseudomonas solanacearum*) race 3 showed that the practice of intercropping potato with maize or haricot beans markedly reduced the incidence and rate of disease development in the potato crop. This reduction in disease was considered to be an effect of the increased distances between individual potato plants, their spatial arrangement and the presence between potato plants of root systems of other plant species, all of which resulted in a reduction in plant-to-plant transmission, via the roots. The lower potato plant population associated with intercropping resulted in a slower rate of inoculum build-up in the soil and the presence of an intercrop further markedly reduced the inoculum build-up. Where farmers retain tubers for seed, but where roguing of diseased plants is not practised, the isolation of plants through intercropping was considered to facilitate an efficient selection of healthy tubers.

458 89 - 10/45

Plant protection
Africa, experiments, cotton, soybean, bambarra groundnut, Striga, trap crops, screenhouse, intercropping
PARKINSON, V. et al.
Cultures Pièges Permettant de Lutter Contre *Striga* en Afrique (Trap crops as a cultural measure in *Striga* control in Africa).

FAO Plant Prot. Bull., 35, 2, 1987, pp. 51-54

The effects of *Striga* infestation on crop losses in the savannahs of Africa cannot be over-emphasized. Yield losses in sorghum and millet have been estimated to range from 20 to 100 percent; total crop failures have in some cases resulted in relocation of villages. In maize yield reduction, even under good management, has been estimated at 20-90 percent.
These limitations to cereal yields have had serious socioeconomic consequences in many parts of Africa. The problem is further pronounced as new areas are brought under intensive cultivation and Striga seeds are dispersed both by grazing cattle in search of more fertile land and by contaminated crop seeds brought by farmers forced to migrate because of problems such as desertification.

Striga species produce several thousands of microscopic seeds which can remain viable in the soil for up to 20 years. Germination of these seeds takes place only in response to chemical compounds exuding from the host root. The germ tubes then make contact with and penetrate the host root cells, extracting nutrients and moisture from the host, which results in a pathological effect with serious yield loss.
In the absence of a vulnerable host root, the seeds die shortly. Several farmers interviewed during a survey of *Striga* species in Benin and Togo confirmed that the level of infestation was always lower in a cereal crop planted after cotton. In laboratory experiments, cotton seeds always stimulated seeds of the parasite to germinate in vitro, after which they were unable to penetrate and colonize the host root cells. In areas where it can be grown, cotton is thus a desirable crop for controlling *Striga*.
Another logical trap crop might be soybean. Soybean would be planted after and harvested before maize in many environments, and thus the labour requirements of the two crops are complementary. In addition, the maize yield following soybean may be increased because of residual nitrogen contributed by the soybean. Additionally, the high lysine in soybean complements the low lysine in maize. Thus, the two together produce a high-quality protein for both human nutrition and animal feed.
Most *Striga*-infested areas already have a high level of parasite seed in the soil. Yield loss is thus due to more than just the competition for environmental factors (nutrients, moisture, light) triggered by non-parasitic weeds. It is, therefore, essential to look at control measures that aim to reduce the level of *Striga* seed inoculum in the soil in areas where varieties with a level of tolerance to *Striga* are not yet available.
Studies of three methods for reducing the level of Striga inoculum in the soil are reported here, namely:
- screening of trap crops for use either in association or in rotation with cereals to reduce *Striga* seed population;
- field assessment to determine the effect on *Striga* of soybean intercropped with or in rotation with maize; and
- the effect of successive cropping of soybean for three years on the presence of a Striga in a subsequent maize crop.
Results indicated that these crops had the potential to reduce the Striga seed population in the soil. Three years'continuous cropping of soybean in plots originally heavily infested with Striga showed a reduction of the population of the parasite in a subsequent maize (*Zea mays*) crop. Finally, the *Striga* count in maize intercropped or rotated with soybean was much lower than in maize alone.
It now remains for these potential trap crops to be tested in other ecologies with different *Striga* species and morphotypes, and ultimately to be demonstrated to the farmers that this approach offers a solution to the problem.

459 89 - 10/46

Plant protection
Latin America, Honduras, study, sorghum, maize, cropping systems, fall armyworm, natural enemies
CASTRO, M.T. et al.
Populations of fall armyworm, *Spodoptera frugiperda* (J.E. Smith), larvae and associated natural enemies in sorghum and maize cropping systems in southern Honduras.

Trop. Agric. (Trinidad), 66, 3, 1989, pp. 259-263

Sorghum is generally intercropped with maize on small farms in Honduras because it tolerates an adverse environment characterized by erratic rainfall, high temperatures and low soil fertility. When the maize crop fails from drought, resource-scarce farmers often substitute sorghum grain for maize in making tortillas to feed themselves and their families; and the grain and crop residues are fed to livestock.
The intercropping of late maturing, photoperiod-sensitive sorghums with early-maturing maize varieties effectively utilizes the limited land available and soil moisture and nutrients by staggering the reproductive phase of the two crops to reduce competition between them during their respective growth and development.
The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is a principal constraint to sorghum and maize production in southern Honduras. It can cause yield loss by defoliation or as a cutworm by killing plants during the seedling growth stage. The larvae also feed on the grain, but on-farm observations in Honduras suggest that other lepidopterous species are more important as grain feeders. In most agricultural systems lower herbivore populations are observed when one crop species is interplanted with other crop species or intermingled with weed communities.
Since sorghum-maize intercropping is prevalent in Honduras and because maize is more attractive than sorghum to FAW moths for oviposition, the influence of component crops in spatial arrangements and in pure stand on FAW infestations was investigated. Fall armyworm infestations were measured in sorghum and maize in pure stands, sorghum-maize intercrops, pure stand sorghum with a maize trap crop to isolate larval infestations for spatially limited application of control measures, and in a weed-infested sorghum planting system to determine the influence of weeds on FAW infestations. Additionally, parasitization of FAW larvae was determined in the different sorghum and maize cropping systems in southern Honduras. Possible explanations for the observed results and proposals for future studies are presented.
A nematode (Mermithidae) was the most common parasite of the FAW in both years. Parasitization (up to 71%) of larvae by this endoparasitic nematode increased as rainfall increased; precipitation accounted for 93% of the variation in parasitization.

460 89 - 10/47

Plant protection
Latin America, Nicaragua, experiment, intercropping, cotton, maize, beans, weeds, oviposition, green lacewings
SCHULTZ, B.B.
Reduced Ovipositon by Green Lacewings (*Neuroptera: Chrysopidae*) on Cotton Intercropped with Corn, Beans, or Weeds in Nicaragua.

Environmental Entomology, 17, 2, 1988, pp. 229-232

Crop diversification is well known as a potential method for increasing beneficial insect populations in agroecosystems. Crop diversity may be increased by planting more than one crop species in alternate rows or hills within rows (i.e., intercropping, or polyculture), by planting in bands of several rows of each crop (i.e., strip cropping), or by reduced weed control. Entomophagus insect populations may thus be increased if the additional plant species provide them with additional food sources (e.g., alternative prey species, nectar, and pollen) or microhabitats, or both.
Populations of green lacewings (*Neuroptera: Chrysopidae*; mainly Chrysoperla spp.) have been increased in cotton strip cropped with sorghum, corn, or alfalfa. Relatively little work has been done with lacewings in intercrops, where the crop species are planted more closely together. Yet polycultures often offer additional advantages in terms of higher yields, greater stability in yields, and better use of labour and resources.
Nicaragua is currently seeking ways to optimize both the production of cotton and of basic grains (mainly corn, beans, and sorghum), and lacewings are often the most frequently observed natural enemy in these crops. There is also general interest in the potential advantages of reduced tillage, with more limited control of weeds, as well as in integrated pest management. In this paper, results of a study of lacewings populations, as measured by counts of eggs, on cotton planted in monoculture and in polycultures with corn, dry beans (*Phaseolus vulgaris*), or weeds, carried out near Managua, Nicaragua, are presented.
This study was conducted without irrigation during the 1985 rainy season at the Plantel, an experimental farm located near Tipitapa. Major crops in this area are cotton, sorghum, and corn. The rainy season in Nicaragua normally extends from May to November, with a short dry spell in late July and early August. One cycle of rain-fed cotton is usually planted in the Managua region in early July and harvested well after the dry season starts in December. Grain crops are grown from May to August or August to November, or both, and may be grown in the dry season under irrigation.
Significantly fewer eggs were found on cotton plants intercropped with corn and weeds than in cotton monocultures, but cotton plants tended to be smaller in intercrops. The lower egg numbers in cotton intercropped with corn or weeds were significant when adjusted for differences in leaf number per cotton plant and mean cotton leaf area, but not significantly lower on cotton intercropped with beans. Mechanisms are suggested to explain the

reduction in egg numbers in the intercrops, including a decrease in the numbers of prey (aphids) and the presence of other predators.
One potential drawback of this study was that the area between blocks was weedy. If there were any beneficial effects of plant diversity (in this case, weeds), vis-à-vis lacewings or other predators, such effects could have spilled into all plots, causing any advantages of polyculture treatment over monocultures to be overwhelmed and obscured. Thus large-scale polycultures might still be expected to show advantages over monocultures.

461 89 - 10/48

Plant protection
USA, study, integrated pest management, multiple pests, soybean, model, multiple stress factors
BARFIELD, C.S. et al.
Major problems with evaluting multiple stress factors in agriculture.

Trop. Pest Management, 33, (2), 1987, pp. 109-118

The purpose of this paper is to stimulate thought on several issues of relevance to modern crop protection scientists worldwide. First, it is known that diverse plant and animal stresses act in ecological concert in nature; yet, the discipline orientation of most scientists evades evaluation of simultaneously acting stresses. Many statistical analyses can rank stress effects but cannot capture the nuances so often providing ecological insight and, thus, more sustainable management strategies.
Despite advances in the use of modelling as a tool to gain biological insights, agriculturists remain virtually of any ability to evaluate the consequence of multiple stress factors, acting simultaneously, on crop systems. If readily available, ability to design management strategies for complexes of pests would be closer to reality.
Agriculture has made progress in abilities to design relevant and more sustainable pest management strategies. Yet, there remain major discrepancies between the principles and practices of IPM. Farmers still obtain crop protection advice along unilateral discipline lines.
This paper presents simulations run with the Soybean Integrated Crop Management (SICM) model under various combinations of pests, water availability, pesticide regime, value for economic threshold, scouting interval, and cost of management operation. These are relevant parameters for all pest management specialists, and apply regardless of culture or economic status of target farmers.
The physiologically-based, validated soybean plant growth model at the core of SICM has provided a framework for coupling effects of multiple stresses at a process level. Combined stress effects from water and three insect species are presented in real economic context relative to soybean growers. The framework is now in place

for adding stresses from weeds, foliar pathogens and nematodes. This approach offers insights into the experimental designs, analyses and potential uses of integrated pest management strategies developed by interdisciplinary scientists; yet, major problems exist in acquisition of model validation data. Conceptual and experimental dilemmas associated with these type efforts are outlined herein.
The ecological system being modeled is complex, not simple. To be serious about simultaneous evaluation of multiple stress factors means more, not less, ecological detail. Validation studies in any particular space and time may not be subjected to the broad range of stresses for which the model was built to cope. This literally means that validators must choose a variety of fields in space and time so that, in combination, they encompass the broad range of stresses and climatic conditions required by the model. In each such field, the above data sets would be required. It is not hard to understand why so few multistress, validated models exist as aids to farmer decision-making. Such requisites are enormous compared to nicely controlled experiments which lend themselves to routine statistical analyses. This is not a complaint; rather, it is a realization which has come from several years of present attempts, and it illustrates what others who profess to be working in interdisciplinary modes toward improved pest management strategies should be comtemplating.

462 89 - 10/49

Plant protection
Africa, Senegal, farmer, experiments, cowpea weevil control
PIERRARD, G.
Control of the cowpea weevil *Callosobruchus maculatus*, at the farmer level in Senegal.

Trop. Pest Management, 32, (3), 1986, pp. 197-200

In Senegal farmers grow cowpea as a food ingredient rather than as a staple. Therefore, the amount of seeds stored by each farmer is not high, about 100-200 kg, but the desired period for storage is very long, up to 10 months. This cannot normally be achieved due to heavy attacks by the cowpea weevil, *Callosobruchus maculatus*, which is the sole insect pest of this stored grain legume in Senegal and all over the Sahelian region. Damages caused by this insect are such that they tend to limit the development of cowpea growing as the grains rapidly become unsuitable for marketing and consumption.
The effectiveness of several insecticides has been tested in two experiments with cowpea samples, and the most effective among them underwent a pre-extension test in villages. Effectiveness controls were periodically made during the test. One of the obvious conditions for the use of the insecticide was that there should be no health hazards.
The groundnut oil treatment and the fumigant carbon tetrachloride failed to give control of this pest. Among eight tested active

ingredients commonly used to protect stored foodstuffs, the pest results were obtained with pirimiphos-methyl. This insecticide treatment at 12.5 ppm has been extended in two farmer pilot area of the Sahelian zone, and is efficacious for six months. In the future, resistant varieties and the use of local plant substances to control cowpea weevil could be alternative control methods or part of integrated pest management.

463 89 - 10/50

Plant protection
Africa, Uganda, experiments, beans, cowpeas, maize, bean flower thrips, planting density
KYAMANYWA, S. and E.M. TUKAHIRWA
Effect of Mixed Cropping Beans, Cowpeas and Maize on Population Densities of Bean Flower Thrips, *Megalurothrips sjostedti* (Trybom) (Thripidae).

Insect Sci. Applic., 9, 2, 1988, pp. 255-259

Entomological studies have indicated that some crop mixtures are characterized by a lower incidence of herbivorous insects compared to sole crops. These and other findings hold the promise that mixed cropping could become a component of integrated pest management (IPM) in tropical countries. This could reduce the trend of increasing dependence on insecticides which are environmental hazards. To fulfil this objective, however, crops to be mixed will have to be selected carefully in order to get combinations and cropping densities that significantly reduce insect abundance. As the authors point out, this will require detailed information on insect/crop interactions in order to indentify those crop combinations which are both agronomically and entomologically more advantageous than individual sole crops. A review of literature indicates that this information is generally lacking for the control of *M. sjostedti*, and the present paper deals with a study aimed at ascertaining crop combinations that significantly reduce pest populations, or indeed those crop combinations that increase the severity of pest damage on each other, and must therefore be excluded from any IPM strategies.
Mixtures of beans, cowpeas and maize were used because these are quite common particularly in Uganda where the work was carried out, but the mixtures are also widespread in the whole of East Africa. Throughout the region, *M. sjostedti* often becomes a major pest of cowpeas and beans, especially whenever their growth coincides with a dry spell.
The experiments were conducted at Makerere University Farm, Kabanyolo, and planting was timed to coincide with the rainy season so as to obviate the need for irrigation. Crop varieties used were those grown locally namely, Kawanda Composite Maize, Emma Cowpeas, and Nambale Beans.
The experimental design was a split plot of 18 subplots of 10 x 10 m each; the subplots carried mixtures of either cowpeas and beans, cowpeas and maize, beans and maize, cowpeas, beans and

maize, or sole-crops of either cowpeas or beans. Each treatment was thus replicated three times. Within the mixed crop plots, crop mixing was formed using the de Wit replacement series technique. For each crop mixture, three different intra-row planting densities were used.
The results show that the level of infestation by *M.sjostedti* in bean or cowpea crop in the cropping patterns used is influenced by the host plant density, and the presence and density of non-host plants. The higher the cropping density, the greater was the level of infestation. The explanation for this is probably simply that the more host plants there are per given area, the greater is the available resource for exploitation by thrips, and therefore the greater their density becomes. This reasoning would explain the lower pest densities recorded for planting densities lower than the optimum.
The results also indicate that the practice of mixed cropping beans with cowpeas, which is common in parts of Uganda, confers no advantage to either crop with respect to attack by *M. sjostedti*. On the contrary, the present data indicate that combining the two crops generated infestation levels similar to those produced by either crop grown in monoculture.
A good pest managment strategy for this pest, therefore, would appear to be the encouragement of non-host-plant-based mixtures of either the beans or cowpeas, and certainly to discourage the present practice of growing either crop in monoculture or combining the two in one stand. This strategy would not be unique to these particular crops and associated pests.
The results of this experiment show that *M. sjostedti* infestations tend to reach their peak during flowering. The crops at their flowering stages, therefore, obviously deserve maximum protection if a good yield is to be realised. This is then the stage when pesticide application can be most beneficial. In the context of IPM, therefore, it would appear that any insecticide applications to control *M. sjostedti* prior to the flowering stage of the crop would not only be less beneficial in increasing yield returns, but such a practice would also merely have adverse effects on the environment.

XI WATER MANAGEMENT

464 89 - 11/7

Water management
Review, article, water harvesting, traditional techniques
SPORE
Water harvesting: reviving ancient techniques.

Spore, 13, pp. 4-6, 1988

The two features common to all water harvesting systems, whether ancient, traditional or modern, are the catchment area and the storage area, or reservoir. Ideally the surface of the catchment area should be impervious to water to allow maximum run-off to occur. In some cases such catchments occur naturally, but in others the catchment surface is treated to improve run-off or an artificial surface may be used.
In less favourable situations run-off can be increased by smoothing and compacting the soil surface. An example is the roaded catchment system, widely used to collect water for livestock in Western Australia. Here road construction equipment is used to compact and camber the soil surface, to form a series of parallel roads measuring between 5 and 12m from crest to crest, on a stretch of sloping ground between 50 and 300 m long. Storm water collects in the furrows between the roads and flows into a channel at the lower end of the catchment, from where it is led into a reservoir.
Soil surfaces which have been compacted for other reasons, such as roads, airstrips and school playgrounds, can sometimes be exploited to provide run-off water for crops or livestock. Careful design and regular maintenance is necessary to avoid soil erosion with compacted catchments, although in some systems the washing down of soil can be beneficial by filling up small depressions in the catchment surface and building up soil fertility in the area where the crop is grown.
Run-off water once collected has to be stored. In most of the traditional systems described, where the water is used for growing crops, the storage area is the soil itself. Deep water-retentive soils are therefore ideal. But if the soil is very free-draining, evaporative losses are high, run-off is excessive or if the water is to be used for cattle or domestic purposes, then a surface reservoir is needed for storage.
Such reservoirs may range from simple pits dug in the ground, sealed by pudding with clay, to more substantial tanks and cisterns. Water losses as a result of evaporation can be reduced by covering the surface of the reservoir with materials such as wax, polystyrene or foamed rubber sheeting.
At the Desert Runoff Farm Unit in the Negev Desert, some of the ancient run-off farming systems have been carefully re-created and now serve as experimental farms. Here, where the scanty and unpredictable rainfall is less than 200 mm a year, a tremendous range of crops has been successfully grown using harvested water

alone. These include grasses and cereals (such as wheat, barley, sorghum and millet), legumes (lentils, chickpeas and novel varieties of beans), grape vines, soft fruit (logan berries) and fruit, nut and fuelwood trees (plums, apricots, peaches, pomegranates, cherries, apples, figs, olives, pistachios, Acacia, Prosopis, Leucaena and Eucalyptus).
In good years yields are comparable with crops grown in irrigated conditions but even in drought years there is usually some yield. Cereals, almonds, pistachios and olives do particularly well. Annual crops which are quick maturing (such as millet) or deep rooting (such as Sorghum) and perennials which can tolerate both drought and occasional inundation are those which do best.
Existing schemes show that water harvesting can do much to improve conditions in drought stricken areas.

465 89 - 11/8

Water management
Review, tropics, developing countries, rainfed agriculture, limitation, potentials, future development, traditional systems
BARROW, C.J.
The present position and future development of rain-fed agriculture in the tropics.

Outlook on Agriculture, 17, 3, 1988, pp. 113-119

Recent estimates suggest that 18 per cent of the world's cropland is irrigated: the rest is rain-fed, of which perhaps a fifth is under shifting cultivation.
Techniques which can be used to improve soil-moisture availability are listed in detail in this paper.
The goal of "direct" rain-fed cultivation is to capture the maximum amount of moisture in the soil and to retain it there for as long as possible to support crops. Rain-fed farming productivity depends heavily on crops that are suited to local rainfall conditions and on the careful timing of their cultivation.
Much of the world's cropland is sloping. Wherever this is the case and rainfall does not quickly infiltrate there is likely to be runoff - namely that portion of rainfall which is neither absorbed into the ground, nor stored on the surface, nor evaporated, but which flows over the land and may be collected from a larger area than that cropped or grazed. This concentration may result from natural conditions or deliberate action by farmers. A wide range of "indirect" rain-fed farming strategies rely upon catching runoff (rainfall collection).
Rain-fed cultivation is widely practised by small farmers, some may also use irigation: a common strategy is to subsist on irrigated rice and to grow a rainfed cash crop.
In Asia as a whole about 10 per cent of rice is rain-fed. Rain-fed rice seldom yields more than 700 kg/ha/y, and as irrigated rice often exceeds 3000 kg/ha/y, there is clearly much scope for improvement.

There has been considerable expansion of rain-fed cultivation since 1918 into tropical and subtropical "marginal lands", much in the form of large-scale, commercial, mechanized wheat and barley production. In many regions where rain-fed-cultivation is practised, crop yields are decreasing due to "development pressures" and, perhaps, environmental change. Not only are yields often decreasing, in many parts of the world the ability to sustain production is under threat because of land degradation (soil erosion, salinization, loss of fertility, etc.).
The maintenance of fertility of rainfed cropland is vital if cropping is to be sustained; also soils which have adequate organic content hold more moisture than degraded soils. Most of the fertilizer used in the tropics is used by irrigated agriculture. Appropriate artificial fertilizers and "green manures" (including the growing of nitrogen-fixing crops) and strategies for their use have to be developed for tropical rain-fed farming. In addition, there is scope for more integration of livestock production and rain-fed cropping.
It is probably worth developing rainfall collection agriculture in areas with at least 300 mm/y and, ideally, 500 to 600 mm/y rainfall.
Promising rain-fed cropping strategies are being developed. Agro-forestry and alley croping have great potential for maintaining soil fertility, reducing soil erosion, and, by creating a favourable microclimate, improving moisture availability.

466 89 - 11/9

Water management
Review, developing countries, irrigation systems, farmer, management, resources, public policy
COWARD, E.W. and E. MARTIN
Resource Mobilization in Farmer-Managed Irrigation Systems: Needs and Lessons.

In: Technical Papers from the Expert Consultation on Irrigation Water Charges Vol. I, FAO/USAID, Rome, Italy, 1987, pp. 177-190

There is presently widespread interest in the topic of appropriate government funding for irrigation development, including both the initial and continuing costs. With restricted budgets, and a worldwide ethos of reduced government involvement in various sectors, there is increased interest in inducing the mobilization of irrigation development resources in the private sector.
In most instances concern with mobilizing resources for irrigation development has focused exclusively on that sector of irrigated agriculture served by the hydraulic works owned and operated by the State.
There has been less attention to the matter of resources for the irrigation that lie outside the State sector and are managed by farmers themselves, the farmer-managed irrigation systems (FMIS).

In a number of countries, FMIS serve a very significant portion of the national irrigated command.
FMIS represent important cases of farmer mobilization of resources for both system development and system operation. In this paper two important public policy questions related to mobilizing resources for irrigation development have been explored. The first question deals with the matter of appropriate public policies in support of the resource mobilization processes that already occur in many FMIS. The importance of reexamining present public policies for assisting FMIS has been noted, some of which have the effect of discouraging continued resource mobilization by these groups. The second question dealt with is the relevance of resource mobilization processes in FMIS as a model for increasing resource mobilization in State-operated systems. On this point, it has been noted that farmers were likely to increase their mobilization only if they were granted more involvement in and control over both operations and maintenance activities, and in cases where construction is being planned, involvement in design and layout as well as construction activities. In short, increasing resource mobilization by farmers in State systems needs to be complemented by significant farmer control of selected activities of those systems.

467 89 - 11/10

Water management
Asia, India, irrigation systems, study, economics, semi-arid tropics, smallholder, farming systems research
ENGELHARDT T.
Economics of traditional smallholder irrigation systems in the semi-arid tropics of South India.

Diss. Institut für Agrar- und Sozialökonomie in den Tropen und Subtropen, Stuttgart-Hohenheim, 1984, 173 pp. + Annex

The climate of the semi-arid tropics of Southern India is characterized by highly erratic rainfall. Owing to transpiration, the crops' large water requirements, and the shallow soils with, little water-retention capacity, water is one of the restrictive factors for crop production on alfisols.
Irrigation may be capable of overcoming this constraint caused by limited water. The net income from rain-fed crops (sorghum mix) is only 16% of that from wetland crops (paddy). In addition to its effects upon production, irrigation also has a considerable impact upon employment: 1 ha of paddy requires 7.7 times as much labour input as 1 ha of rain-fed sorghum mixtures. The same area of irrigated dry crops (groundnuts) requires 4.3 times as much labour input as rain-fed sorghum mix but provides a net income which, on an average, is 4.5 times greater.
The traditional sources of irrigation in the hard rock regions of Southern India are open dug wells and surface reservoirs (tanks). The wells' water yield is sometimes improved by means of in-well bores. The area irrigated by tanks has been declining while that

irrigated by wells has increased considerably. Since 1950 the area under well irrigation has risen by 148% while the area under tank irrigation has fallen by 6%. The wells are usually rectangular. They are excavated manually and have an average volume of 772 m3. The water is generally raised by electric pumps. An open dug well may irrigate several hectares, depending upon the amount of available water, but the average area irrigated from open dug wells in the survey region is 2.5 ha per well. The cropping intensity with well irrigation is 114% with paddy as the main kharif crop (28%). During the rabi other crops, such as groundnuts, vegetables and wheat, are grown with paddy (19%) in the well command area. Paddy's total water requirements are 14 mm/day during the kharif and 19 mm/day during the rabi. The value of an open dug well is determined by its volume but averages 24,800 Rs (1982prices). Investment in wells is profitable for the farmers: using market prices for the costs and benefits, the IRR averages 14%.

Surface reservoirs (tanks) are not so popular with the farming community: they occupy valuable land and it is difficult to arrange equitable distribution of the water. Wasteful application of water is common. Surface reservoirs do, however, recharge the ground water; although the infiltration from reservoirs varies according to the ground water level, the filling and the water depth in the reservoir, it was possible to estimate from field survey data that traditional tanks have a seepage rate of 0-15 mm/day. Newly-built reservoirs may supply an average of 8-40 mm/day percolation water to the ground water.

Since the farmers greatly prefer open dug wells as a reliable and flexible source of water, the number of wells is rapidly increasing. The individual well-owner does not maximize the current value of the community-owned resource - ground water - over a period of time but uses the water as if its marginal value equals the variable cost of raising it. Consequently, ground water is overdrawn in various parts of Southern India and its level is falling at a disturbingly rapid rate. So water becomes more expensive to raise. Well-deepening requires additional investment and sometimes the wells run dry.

Surface reservoirs and wells should be regarded as a single unit for supplying irrigation water. This composite watershed management system makes it possible to combine the benefits of privately-owned open dug wells with the advantages of surface reservoirs (ground water recharge).

The complexity of the water balance and the reciprocal influence of irrigation, cropping pattern and the hydrological infrastructure in a region make it necessary to prepare a model for the system which combines all the important elements.

A discrete stochastic linear programming model was designed which permitted optimization of agricultural production in an alfisol watershed in the hard rock region of the SAT in Southern India.

The model results indicated that the profitability of artificial ground water recharge by means of percolation reservoirs depends to a very large extent upon how much ground water is drawn. With a low well density (e.g. 5 wells/100 ha) a composite watershed management system, as described in this study, has little effect

upon production and employment, but an increase in the well density, will make it profitable to build percolation tanks. An increase in production and in employment opportunities can be expected. It was possible to quantify the impact of artificial ground water recharge upon risk in an E-V context. Yet the cost of building percolation tanks should not exceed 3 Rs per m3 of storage volume; if it does, the opportunity cost of the submerged arable land plus the construction costs are greater than the benefit of additional ground water.

The system of percolation reservoirs combined with wells makes it possible to employ a simple management tool which may help to control over-drawings from the ground water. Since almost all the wells are operated by electricity, any increase in electricity prices should induce more judicious use of the water by the farmer. The model demonstrated that parametric changes in electricity prices within a realistic range causes a downward-sloping demand curve for water.

Watershed management should take account of the dynamic nature of a developing irrigated agricultural system. In the initial stages, private enterprise for well-digging could be encouraged and supported by employing scientific methods to search for ground water. Ground water recharging structures (percolation reservoirs) should not be built until the ground water becomes limited. If the well density is further increased and irrigable land rather than water becomes a major constraint, a rise in electricity prices combined with the consequent change in the cropping pattern from wet to dry crops should be envisaged.

Needless to say, some aspects of agricultural production - particularly the dynamics of ground water flow between the surface and the aquifer - could not be satisfactorily expressed in the model. Nor was it possible to include contraints such as crop rotations, labour availability, home consumption, etc. Consequently, the model results do not fully reflect the real situation and especially with regard to paddy production in lowlying areas. Further research could incorporate these constraints to give the model more actuality and to obtain more realistic results.

Discrete stochastic linear programming models offer the possibility of transforming pay-offs into suitable utility levels but this operation requires a utility function and thus knowledge of the decision-maker's risk preference. Analysis of a real farm decision (in-well boring) showed that most farmers are averse to risk with a partial risk aversion coefficient of 0.87062. The absolute risk aversion averaged 0.00016 with negative correlations to wealth, even though the coefficient was not significant.

Further research should endeavour to establish a utility function which is defined for losses and makes it possible to accomodate higher moments besides mean and variance. That utility function should then be incorporated in the model so that pay-offs can be transformed into utility measures.

A composite watershed management system seems to offer promising prospects if it is analysed by employing the discrete stochastic linear programming model developed in this study. It may, however, prove beneficial to combine agricultural optimization models with

hydrological simulation models which provide a more consistent definition of the hydrology and especially the water flow. In addition, on-going percolation tank construction programmes should also be monitored so that their effect upon the ground water and agricultural production, income and employment can be measured.
Author's summary

468 89 - 11/11

Water management
Asia, Thailand, study, technical paper, irrigation design, management, constraints, on-farm development
PLUQUELLEC, H.L. and T.WICKHAM
Irrigation Design and Management - Experience in Thailand and its General Applicability - .

World Bank Technical Paper No. 40, Washington, D.C., USA, ISBN 0-8213-0532-08, 1985, 68 pp. + maps

The degree of performance achieved in managing irrigation projects depends on a number of physical, social and institutional factors and to a large extent on the basic physical infrastructure provided. The first four chapters of this paper examine how these various factors affect the irrigation system performance in one country - Thailand - which has a long history of irrigation. The paper first briefly describes the physical characteristics of Thailand which affect irrigated agriculture, then gives an overview of Thailand's irrigation development and the objectives which have determined system design, and finally analyzes the various factors now constraining system performance throughout the country.
The concluding chapters explore the general topics of main system improvement and tertiary system development, and are implicitly aimed at the controversial question of whether irrigation performance can be improved solely through improved management or whether physical facilities need to be upgraded as well. This section of the report reviews the main approaches now available to improve canal system management in new and rehabilitated projects. It indicates that each approach has different managerial and financial requirements and should not be used indiscriminately. The paper goes on to examine the impact of design and management on water distribution at the farm level and the relation of the tertiary system to the main system. In general, the paper finds that management alone may not substantially improve irrigation performance but, if combined with physical improvements at a modest cost, it may have a major impact on performance.
The paper can be of interest to irrigation project planners, designers and managers since the lessons learned from the Thai experience are applicable to many countries, particularly those in the humid tropics. The paper also provides a general review of the technological and other options available to improve irrigation system performance and thus has widespread applicability.
Author's summary, amended

469 89 - 11/12

Water management
Africa, Nigeria, study, semi-arid zone, farming systems research, smallholder productivity, irrigation, agriculture, water supply, crops, yield
EZIAKOR, I.G.
Towards Improving Smallholder Productivity: The Case of Irrigated Agriculture in Bauchi State of Nigeria.

Agric., Admin. & Extension, 30, 1988, 269-279

Especially in the arid and semi-arid regions of Nigeria, the unreliability and erratic nature of rainfall patterns clearly demonstrate the imperativeness of providing supplementary water supplies for irrigation purposes. Although the supply of water is recognized as a fundamental prerequisite for crop production, studies show that the moisture demand for crop growth and development is not evenly spread over the length of the growing season. While consumptive use is low at the beginning of the growing season, it increases as plant foliage develops and expands as the days become warmer. But the demand for water by most arable crops reaches its peak during flowering and fruit formation, and rapidly declines again during ripening.
The overwhelming majority of the farming population in Bauchi State consists of small-scale, peasant farmers and their families whose accessibility to a variety of improved technologies and agricultural innovations is severely limited.
Since water supply has been identified as a limiting and usually costly production resource, especially in semi-arid and drought-prone areas of Bauchi State, it has become necessary to analyse the general strategies for planning irrigation for the maximization of crop yield per unit of water applied.
In general, the degree of accessibility of small farmers to supplementary water sources for irrigation is remarkably low, with less than 10 per cent of the sampled population having access to, and, therefore, utilizing, supplemental water supply for cropping. However, even though the farmers who applied irrigation realized consistently higher yields than those who did not irrigate their crops, the yield differences were not statistically significant at the 5 per cent level.
The following observations and recommendations are considered important:
- There is a substantial scope for increasing productivity and aggregate food production through the promotion of small-scale irrigation based on ground water development, utilizing either hand-operated or small-motor pumps.
- A profitable irrigation practice is one that is not only adapted to the nature of the crops(s) being grown, but is also integrated with the prevailling soil, climatic, and socio-economic conditions of the specified agro-ecological zone.
- In the semi-arid and drought-prone areas of Bauchi State where

water scarcity is usually a limiting production resource, it is essential to plan irrigation so as to maximize crop yield per unit of water applied. Thus irrigation water should be applied only at such times and in such precise quantities as to produce the desired crop growth and development.
- Proper irrigation practice cannot be seen as a substitute for, but only complementary to the provision of a package of improved production technologies (including improved seeds and crop varieties, fertilizers, herbicides and pesticides). Access to irrigation can only be beneficial to smallholders if other production constraints (such as access to credit, improved harvesting , storage, processing, transport, and marketing) are eliminated.

470 89 - 11/13

Water management
Review, manual, developing countries, irrigation schemes, smallholders, maintenance, operation, water distribution, on-farm, off-farm, drainage, health, management
STERN, P.H.
Operation and Maintenance of Small Irrigation Schemes.

Intermediate Techn. Publ. Ltd., 103/105 Southampton Row, London WC 1B 4 HH, UK, ISBN 0-946688-74-5, 1988, 36 pp.

Currently world-wide attention is being given to the poor performance of so many irrigation developments, including both well-established schemes and new projects.
The quality and organization of maintenance can be the single most important factor in the success of irrigation schemes. This short, practical manual deals with the problems of operation and maintenance at the source of supply and in the conveying of water in pipes or open channels. Water distribution is described both on- and off-farm and the maintenance of irrigation systems and devices - and advice is given on drainage, health and general management problems.
The book contains the following chapters:

This book has been written to supplement the author's "Small-scale Irrigation" which was first published in 1979, and is intended for those who are concerned with the development of irrigated cultivation on a small scale, with limited technical and financial resources.
This book will make some contribution to the success of small-scale irrigation.

471 89 - 11/14

Water management
Review, developing countries, tropics, irrigation, water management, agriculture, agroecology, basin irrigation, furrow irrigation, soils, cropping systems, sustainability
PLUSQUELLEC, H.
Crop Diversification in Irrigated Agriculture: Water Management Constraints.

In: World Bank 7th Agric. Sect. Symp.: Sustainability Issues in Agric. Developm., Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 313-321

This paper deals with the physical constraints imposed by the irrigation system both at the distribution level and a farm level. The issue of crop diversification will be limited to surface irrigation which is the predominant method used for more than 90

percent of the 275 million ha currently irrigated in the world. In the vast areas of lands irrigated in Asia surface irrigation methods are used almost exclusively for both paddy and upland crops. The scope for pressurized irrigation will remain limited to very high value crops in specific areas. Conversion to drip and sprinkler methods will progress slowly and where it will take place, diversification to non-paddy-crops will be irreversible. In sum, surface irrigation will remain dominant in the foreseeable future.
This paper reviews the different water requirements of paddy and upland crops and reviews the general technical features of the two dominant surface irrigation methods, basin and furrow irrigation used in developing countries. Then the paper discusses the issue of improving irrigation facilities to make possible the shift from paddy cultivation to other crops and/or the adoption of mixed cropping. This review will be limited to the aspects relevant to crop diversification and does not pretend to fully cover the above subjects even in a condensed form.
The issue of improvement/modernization of irrigation systems to permit crop diversification has been complicated by the sharp drop in projection rice prices that occured since 1982. The 1990 rice price projections dropped from about 600 US$ in 1982 to 339 US$ in 1984/85 and recently below 250 US$. Most of the rice irrigation project were viable in the early 80s including those for which all the infrastructure from storage or diversion works down to the on-farm water delivery works have to be built. Under the 1984/85 economic conditions, the viable investments in rice projects were those taking advantage of sunk costs in existing infrastructure.
The precise water control needed for diversified field crops requires in general extension of the tertiary networks, improvement and modernization of the main and distribution system, and in some areas improvement of the drainage and flood control conditions.
With the price projections, a detailed analysis of each project would be needed because of the sensitivity of the rate of return at these low rice prices. Investments required to improve the tertiary system together with improvement of the distribution system may no longer be jusified unless there is a substantial increase in yields (above 1 ton per ha/ and/or an increase in cropping intensity by making use of the water saved through more efficient operation). The conclusion is that in a number of cases the improvement of irrigation systems at both the tertiary and distribution level may not be economically justified for increasing rice production alone, without diversification to higher value crops. The investments required for crop diversification would have to be undertaken only when there is sufficient indication that all the other preconditions for crop diversification are met: market, marketing facilities, extension services, etc.

472 89 - 11/15

Water management
Africa, Subsahara, review, irrigation management, small-scale technology, NGO's, water use
VAN STEEKELENBURG, P.N.G.
Developments in Irrigation Management in Subsaharan Africa.

entwicklung und ländlicher raum, 2, 1989, pp. 20-21

In Sub-Saharan Africa where traditional rainfed production is in many countries becoming insufficient to feed the rapidly increasing population. Apart from agency-managed systems, the spontaneous development of small-scale simple technology irrigation is becoming a regular phenomenon. Non-governmental organizations are strongly involved in these self-managed operations. Presently, main themes are the emphasis on improving the results of existing schemes, the strengthening of water user associations, and efforts to reduce irrigation agencies' tasks and annual deficits.
As regards the management of these government-controlled irrigation systems, there is an increasing emphasis on self-management by the irrigators.
Very interesting results in delegating tasks to water co-operatives can be found in Niger, where delegation was preceded by political decision-making and farmer training. Increasing self-management is sought especially in the medium-sized and large irrigation systems where management problems are most evident (low yields, low intensity, low payment rates of water charges, rapid deterioration of the system, high annual costs to the government). One can say that at present attempts are being made to transfer the attractive concept of self-management, which was and still is successful in traditional and in small-scale systems, to large systems. One of the requirements is that the large system be converted into smaller-sized hydraulic units which can be fairly independently operated.
The main reason for this change is the soaring charge of recurrent costs to the government to keep the systems operating, and the low production levels. If farmers were to take more responsibilities while other tasks were delegated to the private sector, the generally large, overstaffed, bureaucratic Irrigation Agencies could become much lighter, could perform better the fewer tasks, and thus could become less expensive. If on top of that they could be converted from being static and mechanistic into being more customer-oriented and adaptive, the results in terms of effectiveness and reduced costs would even be better.
In recent years a quite spectacular growth of horticulture (especially vegetables) around capitals and other cities is to be noted. This "gardening" often starts as an off-season activity, and is mainly for urban supply with some for exports. This development has invariably started without any government initiative; very often non-governmental organizations (NGO) play an important role in such developments. "Gardening" is no longer limited to the immediate environment of cities: where enough water

and suitable soils can be brought together and as far as the transport infrastructure permits timely delivery to the markets, it can be found.
Many governments have come to realize that irrigation, as an increasingly important sector of the national economy, is in need of sector management and institutional co-ordination. In order to facilitate correct project selection, preparation, and scheme management, a policy is needed, and a planning framework has to be agreed upon and applied. This is one of the important steps needed to diminish the large number of external and internal insecurities and uncontrollable elements which irrigation management in Sub-Saharan Africa faces every day.

473 89 - 11/16

Water management
Asia, India, water conservation, soil conservation, research, contour farming, water collecting, recycling runoff, fuel-fodder plantation, technology transfer, ICRISAT, UNEP, sustained food production
DHRUVA NARAYANA, V.V,
Soil and Water Conservation Research in India.

In: Summ. Proc. of an Exp. Meeting, ICRISAT, India and UNEP, Kenya, ISBN 92-9066-115-1, 1986, pp. 23-24

In India, where population pressures on the land are high, rational utilization of soil resources assumes great importance for optimum and sustained food production. This involves proper land utilization, protecting the land from deterioration, building and maintaining soil fertility, conserving water for farm use, provision of proper drainage, flood protection and erosion control. Out of the 328 million ha of India's land area, nearly 175 million ha (whereas 140 million ha are under cultivation) are subject to soil erosion, out of which nearly 70 million ha suffer from serious hazards, such as sheet, gully, and hillside erosion. The Indian government has organized large-scale soil and water conservation programs. Beginning with contour-bunding programs in the early phases, the concepts of integrated land-use planning on a watershed basis were introduced through a chain of Soil Conservation Research Demonstration and Training Centres.
Soil and water conservation practices include: contour farming, mulching, intercropping, bunding, graded bunding and bench terracing on steep slopes, and the harvesting storage, and recycling of runoff water.
Soil loss from areas having slopes as high as 25% was reduced, for example, from 39 to 15 ha^{-1} when potato farming was done on contours. Some cultural practices that reduced soil loss were closer plant spacings, intercropping, and mulching.
On deep lateritic soils in high rainfall areas with average slopes of 25%, bench terraces with lengths of 100 m, longitudinal grades of 0.2 to 0.8%, and inward grades of 1%, conserved the soil and moisture relatively more efficiently and also produced higher yields of potato.
Collecting runoff is necessary and possible for the better utilization of rainfall, control of erosion, and the provision of life-saving irrigation during droughts and for growing a second crop. The development of seepage control techniques (especially important in alluvial soils) for farm ponds is still in the experimental stage. But the cost of lining small farm ponds with bricks and cement mortar, and cement concrete, appears to be justified, particularly in areas where there is no other source of irrigation water.
Establishment of vegetative cover is one of the effective ways of conserving soil and water. Growing trees helps in the interception of 14-26% of the precipitation, and reduces its impact on the soil surface.
Fuel-fodder requirements are progressively increasing in India. Experiments conducted at several locations with fuel-fodder plantations have been successful.
Ravine areas, which occupy nearly 4 million ha, require special soil conservation measures. Techniques have been developed for use in areas having gullies of varying depths. By closing the ravine lands to grazing and other biotic interferences, it was observed that poor and inconsequential annual plant species were replaced by more useful species. These ecological changes have also resulted in a natural reduction in runoff and soil loss from the area, along with improvement in the quantity and quality of grass yields.
The transfer of technology, based on the concept of watershed management, is important in soil conservation work.
Soil and water conservation practices are expected to generate three benefits in a watershed: (1) increased production of food, fodder, fuel, timber, etc.; (2) sedimentation control; and (3) a favourable water regime.
An economic analysis of each of the soil and water conservation measures in agricultural land, as well as their combined effect have shown that the benefit: cost (B:C) ratios range from 1.8 to 3.6. The highest B:C ratios are obtained for water storage and recycling in rainfed lands, thus emphasizing that adoption of soil and water conservation measures will not only protect a development area but increase its productivity.
The solution lies in the development of methods of land use that are both profitable to the local community and also give a better control of the flow-regime in the watershed, and to get these methods adopted by the local community.

474 89 - 11/17

Water management
Africa, tropics, ILCA, water supply, livestock, traditional methods, land-use, animal production, water management, research
SANDFORD, S.
Organisation and management of water supplies in tropical Africa.

ILCA Research Report No. 8, 1983, 46 pp.

This report, one of a series of three on livestock and water in Africa, defines the major agricultural production zones of tropical Africa with some account of the importance of land, livestock and water in each zone.
Organisation and management are elastic terms and in this report they are widely stretched to include not only formal organisational structures and the details of administrative procedures, but also people's behaviour and decisions and the factors which determine these. Although this report is mainly concerned with the drier zones of tropical Africa some attention is paid to other zones and their production systems, since comparisons can throw more light on the situation in the drier zones.
Chapter 1 starts with a brief definition of the major agricultural production zones of tropical Africa and of different kinds of water supplies, with some account of the endowment of land and livestock and of the importance of water supplies in each zone. This is followed by a section which distinguishes six livestock production systems of which three are of particular interest in terms of the need for and use of water.
Chapter 2 discusses the traditional strategies to overcome water shortage which have been adopted by societies in Africa without much access to external resources. The chapter distinguishes five main strategies and, focusing on these, briefly cites examples where they have been adopted.
Chapter 3 describes in detail the way in which particular human societies, selected to exemplify different livestock production systems, have sought to overcome water shortage, and this illustrates how strategies are adopted. The chapter ends with a discussion of the factors that determine which traditional strategies are adopted in different societies, systems and zones.
In chapter 4 modern strategies are discussed, which are defined as at least partially dependent on inputs originating outside Africa. Two principal strategies are discussed together with the factors which determine their adoption.
In chapter 5 the focus switches to the experience of programmes for the development of water supplies. The technical, administrative and environmental problems experienced in the past are discussed as well as the relationship between technology, equity, management and control.
Chapter 6 considers the implications of past experience for planning water development in the future. Attention is focused particularly on technology, on decisions about the appropriate

capacity and density of water points and on organisation and management.
Chapter 7 lists some proposals for more research in the future which could lead to the formulation of better policies and development programmes than in the past.
The appendix to the report recommends a nomenclature for different kinds of water resources which, if generally adopted, would lead to greater precision and clarity in discussion of water management.
Author's summary

475 89 - 11/18

Water management
Review, book, symposium, report, water conservation, soil conservation, history
HELMS, D. and S.L. FLADER
The history of soil and water conservation.

Univ. of California Press, Berkeley, Agriculture History, Vol. 59, No. 2, 1985, 242 pp.

The editors of this 242 pages symposium report provide the essentials of each of the 18 papers presented there in their introduction. A reviewer can therefore do two things: reduce their introduction again to the size of a book review or choose the electical method. The latter approach applies here because, in fact, the title of this publication is somewhat misleading. As much as 13 papers deal for the largest part with aspects of the history of soil and water conservation in the United States or part of it only. Certainly, the North-Americans were the innovators of organized modern soil conservation and every research scientists in this field working there should have this volume. Undeniably also others could learn from these experiences, but the location specificness is in most cases too high to attempt a review of what could be learned from these papers for outside the US conditions.
A notable expection is one of the conclusions of Kelly's paper on "Anthropology in the soil conservation service" where he demonstrates how the first comprehensive soil rehabilitation program on the badly overgrazed Navajo Indian reservation, more than fifty years ago "led to the realization that scientific and engineering good works could not succeed unless consideration was given to the people whose land was being saved and to the culture that predetermined their response to soil conservation". But this same conclusion can be drawn from Kay's more general introductional paper on "Preconditions of natural resource conservation", which on the other hand skillfully centers around the theme that if one wants to use environmental beliefs of people to explain their ecological impacts, the problem remains that human beliefs alone constitute only a small part of the factors that influence environmental change. To end up with the conclusion that until future research reveals the grand theme which ties

together the case studies, the best we can hope for are conservation strategies tailored for individual societies, taking into account their own environmental and cultural attributes. Which would be a perfect conclusion too for Stocking's paper "Soil conservation policy in colonial Africa" with respect to what we may hope for. The main lesson formulated in that paper is that soil conservation is as much a socio-cultural challenge as it is a technical exercise. From the considerations given at the end of the paper, this reviewer concludes that agroforestry as it is these days advocated certainly is among the few practices with soil conservation aspects that appear to have learned from history when it takes the local population directly involved centrally in its approach.
Subsequently, two more general technical papers ask for attention: "Soil erosion by water: the research experience" by Meyer and Moldenhauer and "Predicting and controlling wind erosion" by Lyles. Of these two the latter is far the most useful from a basic review point of view, because it puts less emphasis on (American) history and more on causes and effects. Moreover, techniques of wind protection appear in most cases more suitable for undapted transfer than those for prevention of soil erosion by water. This is due to the larger role differences of soil and climate and of scale and type of agronomic practices play in soil erosion by water and to a better understanding of the (somewhat simpler) initiating, transport and transport prevention mechanisms in wind erosion. There exist obvious differences such as in the role drought plays but the conservation attempts meet each other these days in a common interest in the beneficial role of conservation (i.e. minimum, mulch or no) tillage farming, of surface residues and cover, and of strip farming, including trees. From both papers it is clear that, because of mechanical farming becoming impossible in such cases, there is an obvious gap, in both conservation fields, with respect to knowledge on the mechanisms of scattered trees and bushes and woodlots as protection agents.
Finally this reviewer wants to pay attention to Hudson's closing paper "A world view of the development of soil conservation". Was is not for Stocking's and Lyles" papers referred to above, it was for this one I would have liked to obtain this booklet. After a surprising opening by cautioning against a historical trend of exaggeration of a situation which is already alarming enough by itself, the conclusions remain that:
- the devastations we see today are primarily man-made phenomena;
- the effective ingredient of counter-movements may well be the self-interest of a significant porportion of landowners;
- every one of a series of spelled out conditions that helped in a positive trend towards soil conservation in North America is reversed in developing tropical countries;
- there are few, if any, developing countries where up till now the anyway very recent conservation movement has been substantially transformed by external assistance;
- attempts to develop an alternative technology for the third world are hampered by the lack of money and trained personnel, so that some method of assessing the relative merits of programs is necessary.

To end with the general conclusion that progress in the development of soil conservation has been uneven, and less than satisfactory, largely as a result of the constraints and difficulties that beset soil conservation in developing countries.
Abstract by C.J. Stigter, shortened

476 89 - 11/19

Water management
Review, book, tropics, developing countries, water resources, agricultural development, water management, appropriate technology, water supply, groundwater, irrigation development
BARROW, Ch.
Water resources and agricultural development in the tropics.

Longman Scientific & Technical, Longman Group UK Ltd., Essex, England, ISBN 0-582-302137-8, 1987, 344 pp.

This book to provides a broad interdisciplinary introduction. The first five chapters consider background and principles, the character of tropical agriculture and water resource systems and broadly how they might be managed. Chapters 6 to 10 review the technology and practice of water resources and agricultural development in the tropics, concentrating on where water may be obtained, where savings might be made or moisture better used. Irrigation methods are briefly examined, especially those which may be adopted by farmers in developing countries, and the problems associated with water supply, conveyance, application and disposal are considered.
The book contains the following chapters:
- Part I Water Resources and Agricultural Development: Background and Principles
- Chapter 1 Factors affecting tropical agricultural development
- Chapter 2 The water resource management system
- Chapter 3 Water resources in the tropics
- Chapter 4 Systems of water management in the tropics
- Chapter 5 Assessment of water resource plans
- Part II: Water Resources and Agricultural Development: Technology and Practice
- Chapter 6 Using rainfall, runoff and floodwater, fog, mist and dew
- Chapter 7 Irrigation
- Chapter 8 Irrigation water supply: groundwater
- Chapter 9 Irrigation water supply: large impoundments and diversion of streamflow
- Chapter 10 The biogeophysical and human consequences of irrigation development.

This book has been written for students of geography, economics, development studies and agricultural management, administrators, planners and aid agency staff.

XII SOIL FERTILITY

477 89 - 12/15

Soil fertility
Africa, Burkina Faso, study, land-use, soil properties, land types
STOOP, W.A
Variation in soil properties along three toposequences in Burkina Faso and implication for the development of improved cropping systems.

Agric. Ecosystems and Environment, 19, 1987, 241-264

A large variability in crop stands and low average crop productivity are typical phenomena of farming in the West African semiarid tropics. Crop productivity tends to decrease along the toposequence from the valleys to the generally unfertile uplands, or from the more assured rainfall areas in the south to the low and erratic rainfall areas in the north.
Farmers, most of whom farm without mechanization, employ an ecological strategy in matching their major crops (millet, sorghum, maize, rice, cowpea and groundnuts) and cropping systems with different land types, thereby minimizing the risks of total crop failure and exploiting localized variations in soil fertility to a maximum. The use of fertilizer inputs and manure is minimal because of their high costs and relative scarcity. The pressures on these local systems are steadily increasing with the expanding human and livestock populations: fallow periods are shortened and marginal lands, generally the upper and mid-slopes, are taken into production at an increasing rate. These processes, in addition to a continuing decline in rainfall, have started the current accelerated land degradation around towns and on the densely populated Mossi-plateau.
However, vast upland areas throughout the Sudanian and Sahelian zones of West Africa are threatened in the same way, and a better understanding of the degradation and fertility problems is, therefore, important in developing more stable and sustainable systems of farming for this region.
Soil genesis and soil management factors responsible for the large soil variability in farmer's fields have been studied for three toposequences that are at various stages of degradation. The land types associated with these toposequences are common to large parts of the Sudanian zone and are easiliy recognized in the gently undulating landscape. Attention is given to the soil fertility and crop production aspects of these land types, in particular the fertility management of the upland, upper- and mid-slope soils, which at present are the most prone to degradation. Soil fertility problems, such as acidification and multiple nutrient deficiencies (N, P, K, Ca, Mg among others), are readily induced following intensification of agricultural production because of the low buffering capacities of these highly weathered sandy soils. In addition the serious labour and economic constraints under which farmers in the area are operating were

considered while formulating alternatives for cultural practices, including rotations of cereal/cereal with cereal/legume cropping systems. These alternatives, although aimed at increasing the sustainability of farming on upland soils, also have direct implications for the long-term land use of the lower land types.
Owing to their low initial fertility, most soils of uplands and upper and mid-slopes are prone to rapid degradation when cultivation is intensified and fallow periods are shortened due to growing populations and the presence of growing animal herds. Once the permanent vegetation has been removed, these soils tend to develop dense surface crusts which reduce moisture infiltration, therely increasing runoff and erosion as well as the risks of drought. By contrast, the soils of the lower slopes are more fertile and their moisture availability is more assured. The lowland soils are generally the most fertile but may suffer from occasional waterlogging. The local agriculture will often permanently occupy the lower slopes and lowland fields, whereas the higher fields will be in fallow systems. The cropping systems vary simultaneously among different land types. Based on the soil studies and crop adaption patterns to toposequence land types, certain modification to the present cropping systems and cultural practices are proposed to develop more stable and sustainable production systems for upland areas in particular.

478 89 - 12/16

Soil fertility
Africa, Egypt, appropriate technology, small-holdings, soil cultivation, equipment, ICT, ATSAF
ABO-HABAGA, M. and EICHHORN, H.
Test on the suitability of different types of soil cultivation equipment for farming on smallholdings in Egypt.

Highlights of German Res. Projects in the Tropics and Subtropics; ICT-International Cooperation and Transfer GmbH, Berlin in Coop. with ATSAF, Bonn, 1988, pp. 53-61

The insufficient supply of food available to the Egyptian population from domestic production necessitates further intensification of agriculture.
Depending on the crop rotation of the particular agricultural area, the natural and climatic conditions of the Nile Delta allows several growing periods with the help of irrigation. Normally there are already one and a half to two annual harvests, but an increase to three is necessary and possible. Because the interval between harvest and sowing the next crop is accordingly greatly reduced, the work cannot be carried out in the traditional ways.
It is possible, particularly in the field of sol tillage including methods of seed bed preparation, to achieve a considerable cost reduction using appropriate technology. Suitable solutions for this have been taken into account for the illustrated crop rotation proposal.

With regard to increased mechanization, the preservation of the fertility of the soil is a special problem requiring consideration. During the last ten years the soil has depeted alarmingly. The reasons for this are both manmade and natural. A natural influence arises from the country's position in relation to the Mediteranean Sea. The Nile Delta lies directly on the sea and because the soil rinsing effects through Nile flooding have caesed to exist since the Assuan Dam was built, the salt level in the Nile Delta is rising rapigly.
The other causes are the intensive cultivation of the land and the irrigation system which has been used in Egypt for many years to safeguard and increase the harvest. Farming does indeed reduce soil salinization in general, however only slightly increased concentrations are no longer tolerable for most cultivated plants.
The best way of obtaining reproducible results is by testing machines with various equipment in the field. Accordingly, experimental fields were laid out, in the form of long strip, at different locations in the Nile Delta to serve as the site for plant growing, pedological and microbiological experiments.
One can draw the conclusion from the described experiments that cultivating machinery can be improved and save time by only breaking, loosening and essentially surface crumbling in the special conditions of the Nile Delta. Under no circumstances should a mixing of the soil layers by striven for.
Therefore, feasible solutions for the future, even for small areas, will be combinations of broad cutting cultivators and power takeoff-driven rotary tined equipment to achieve a track covering cultivation.
The chisel plough is the most suitable equipment for soil cultivation in Egypt. Its implementation prevents salt concentration during cultivation. For secondary tillage the most suitable machines are the rotary tiller and the tined rotor in order to produce a sufficiently level seedbed.

479 89 - 12/17

Soil fertility
Review, tropics, soil fertility, acid soils, organic matter, low-input-systems
SANCHEZ, P.A. and R.H. MILLER
Organic matter and soil fertility management in acid soils of the tropics.

Paper XIII Congress of Int. Soc. of Soil Science, Hamburg, FRG, VI, 1986, pp., 609-625

The purpose of this paper is to review some aspects of practical organic matter management of acid soils of the tropics.
Although it has been established that plants grow normally in soils devoid of organic matter, the maintenance of soil organic matter (SOM) is a sound management objective in sustained agriculture. The known beneficial effects of SOM to crop production were summarized as follows: SOM is 1) a source of

inorganic nutrients to plants, 2) a substrate for microorganisms, 3) an ion exchange material, 4) a factor in soil aggregation and root development, and consequently 5) a factor in soil and water conservation.
Many of these favourable effects can be attained by producing high yielding crops with appropriate fertilization, liming, tillage and crop rotation practices that do not include organic inputs from outside the field. Such practices have maintained and increased SOM contents in temperate climates. This happens because the amounts of above-and below-ground inputs from crop residues equal or exceed SOM decomposition rates. A similar situation can be expected to occur in intensively managed, stable agricultural systems in the tropics where crop yields are high enough to return large quantities of above-ground and root residue to the soil. But many of the new lands in the tropics are likely to be initially managed with low-input systems due to the limited availability of fertilizers, farm machinery, credit and markets. In such cases, the management of SOM may have to be deliberate, and not just a consequence of intensive, fertilizer-based farming.
The management of organic inputs and soil organic matter (SOM) is of particular importance to low-input systems in the tropics. Considerable confusion exists about the value of the different practices, partly due to the misapplication of temperate region concepts developed primarily on high base status soils and partly from the lack of quantitative parameters that agronomists can manage. Soil organic matter contents differ little between tropical and temperate regions. Oxisols and Mollisols have similar SOM ranges. Fractionation of SOM into functional groupings may help evaluate the role of SOM on acid tropical soils as a nutrient source, and as a source of cation exchange. Quality or organic inputs affects the effectiveness of such materials not only in terms of N release but possibly in complexing Al.
The contribution of SOM to effective cation exchange capacity (ECEC) may be low in highly acid soils. Increasing ECEC is of questionable value in soils where Al is the dominant cation. Quantitative parameters for the practical management of organic inputs need to be developed to help agronomists in a similar way as parameters now in use for chemical fertilizer management. Joint research by soil biologists and soil fertility specialists could improve the understanding of the processes involved and thus help identify the needed parameters.

480 89 - 12/18

Soil fertility
USA, study, soil biotechnology, sustainable agricultural systems, economics, fertilization, soil analysis, growth factors, tillage methods, recycling nutrients, water management, mineral balance, soil temperature, on-farm research
STOUT, A.L.
The Potential of Soil Biotechnology in the Development of Profitable and Sustainable Agriculture Systems.

In: Proc. of the Sixth Int. Sc. Conf. of IFOAM, Santa Cruz, California, 1988, pp. 647-649

On-farm research has been conducted to analyze the effectiveness of biological soil enhancement products and the conditions affecting their action. Results have indicated that research in soil biotechnology to enhance beneficial biological functions in the soil could have great potential in the development of profitable and sustainable agricultural systems.
The research with biological fermentation products containing various vitamins, hormones, enzymes and other unidentified growth factors indicated that beneficial biological action can be stimulated in soils to increase the availability of soil and fertilizer nutrients; improve soil pH, tilth, water absorption, and retention; and reduce waste of water and fuel, as well as dependence on chemical fertilizers and other petrochemicals used in agriculture.
Soil analyses were performed. Paired sample data from the field trials were analyzed by using the paired-t correlation.
As the results show, soils treated with the biological vitamin-hormone preparation had higher nutrient levels which translate into reduced fertilizer requirements and/or increased yields. Soil hardness was reduced by treatments which often resulted in reduced power and fuel requirements in tillage. Better water infiltration occurred in soils treated with the biological preparation and resulted in reduced erosion, reduced water loss, and more efficient irrigation. Results in Arizona on cotton showed 45% reduced water requirement, saving approximately $125 per acre in irrigation costs and increasing yields by up to 30.8%.
In addition, biological treatments significantly enhanced crop-quality characteristics, including protein, test weight, oil content, and sugar content.
In many of the biologically treated soils it has been observed better weed control (even using reduced amounts of herbicide) and fewer insect and disease problems, resulting in reduced costs for weed, pest, and disease control. Although the overall significance of biological soil treatment was very positive using paired trials, the data revealed many variations and some negative results indicating specific limiting factors. Products of biotechnology are not and never will be a panacea which can replace good management practices; in fact, these products require good management if they are to be effective.

The major factors important to obtaining good results from soil biotechnology are listed below in the paper.
Further research and development in soil biotechnology comprises a positive step in the development of appropriate and sustainable agricultural technology.

481 89 - 12/19

Soil fertility
Review, tropics, developing countries, acid soils, phosphorus, fertilization, efficiency, soil tests, phosphate rocks, fertilizer application, lime, mycorrhiza, agricultural practices.
ARCA, M.
Efficient use of phosphorus fertilization in acid tropical soils.

In: Proc. of an IBSRAM Workshop on management of Acid Tropical Soils for Sustainable Agriculture, Bangkok, Thailand, ISBN 974-7614-39-1, 1987, pp. 179-186

Acid soils of the tropics are usually deficient in available P. This is the result of low P reserves and the dominance of occluded and organic forms over more active forms of P.
Fairly constant ratios are reported among the various forms of P for highly weathered tropical soils: active forms account for 10-20% of the total P; organic forms account for another 10-20%; and occluded forms account for 50-80%.
The potential for increasing P availability by water-soluble phosphate application is limited by the high P-fixing capacity of highly weathered soils of the tropics with topsoil of loamy or clayey textures. Although utilization of fixed P by plants, following P application, depends on the nature of the chemical and mineralogical species formed, it is generally accepted that "fixed"-P availability to plants is limited. Biological immobilization of P also occurs as a result of P incorporation into microbial bodies and parts of living plants, but this process is reversible and contributes to increased P availability upon decomposition.
Another factor that contributes to limited use by plants of P reserves in acid soils is the limited volume of soil explored by roots of nonacid-tolerant species. This is mainly the result of the practical difficulty of deep lime incorporation necessary for a good root system development. Moreover, due to high ambient temperature and udic soil moisture regimes often encountered in tropical environments, high crop growth rates cause high P requirements during part of the growth cycle. To meet the requirements of fast-growing crops, a rather large pool of soil P must be present, with a potential for fast rate of transfer of P from the soil surface to the soil solution.
Considering phosphate rocks as a nonrenewable resource of which there are limited reserves on earth, maximum efficiency in their use should be made in selecting the method of utilization.
Some phosphate rocks become more efficient with time, possibly being as efficient as superphosphate after 3 or 4 years.

In soils with high P-fixing capacity, banded application of P fertilizers has been recommended as a way to reduce P fixation. However, it has been shown that banded P fertilizer, applied on maize growing in extremely P-deficient Oxisols could reduce yield when soil water availability is limited. Combining broadcast and banded applications increased efficiency of low rates of P applied as ordinary superphosphate as well as phosphate rock as measured by soybean yield growing in Ceradi soils.
It has been suggested that mycorrhiza control the evolution of roots and that many crops cannot take up sufficient P from low-P soils unless their roots become infected with efficient strains of mycorrhiza. These fungi form an extensive system of external hyphae through which they absorb P from soil solution outside the P-depletion zone around roots.
Although the role of mycorrhiza fungi in improving uptake and plant growth in nutrient-deficient soils has been well established, the influence of edaphic factors on the mycorrhizal symbiosis is less well understood. The soil conditions most suitable for maximum mycorrhizal growth must be identified if plant growth response to mycorrhizal inoculation is to be predicted under field conditions.
Besides the improved efficiency in P uses that can be obtained by selecting the best sources and rates of P fertilizers and the most efficient method of application, considerable gains could be obtained by developing farming systems that make more efficient use of fertilizers.
Since the amount of P extracted from soil by most common crops is only a rather small amount of P applied, emphasis should be given to farming systems that better utilize residual fertilizers or provide opportunities for recycling of P in plant residues.
The use of perennial crops probably provides the best opportunity for P recycling in humid tropical environments as a result of the continued addition of plant residues to the soil and the consequent addition of P and other nutrients. In addition, grazed pastures can be expected to contribute to P recycling and efficient use of residual P fertilizers in both the humid tropics and acid savannas. Crop pasture rotations could offer good opportunities for better use of fertilizers previously applied to crops and the return of important quantities of P to soil by grazing animals or pasture plant residues.
Intercropping annuals and perennials or forest trees offers other alternatives for maximum efficiency of P fertilizer use.

482 89 - 12/20

Soil fertility
Africa, review, humid tropics, Savanna highlands, low altitudes, fertilization, alternative approaches, inoculation, research needs, IBSRAM
PIERI, C.
Management of Acid Tropical Soils in Africa.

In: Proc. of an IBSRAM Workshop of Management of Acid Tropical Soils for Sustainable Agriculture, Bangkok, Thailand, 1987, pp. 41-61

Acid soils in the humid tropical zones of Africa cover several hundred million hectares and most often support a marginal agriculture due to their natural low fertility. The coastal zone of the Benin Gulf, the Adamaoua Plateau of Cameroon, the Congo Basin, the high plateaus of Madagascar, and the highlands dividing the Congo and Nile basins support mainly shifting agriculture, although some areas (such as the Ivory Coast and Cameroon) also support large and intensive agro-industrial farms of perennial crops (oil palm, coffee, rubber, and pineapple, among others). These crops are more tolerant to acid soils than the majority of the staple food crops.
In West Africa, however, acidified Alfisols are more frequent than naturally acid soils (Oxisols and Ultisols). The process of soil acidification is common in the humid zone as well as in the semiarid zone of West Africa where sandy soils with low organic-matter content are dominant. Management of these low-buffered soils differs from that suitable for the acid soils.
Different technologies adapted to acid and acidified soils of Africa have been studied for many years by various research organizations. A review of what has been done for the last 20 years in the Francophone countries is partially presented in this paper, with emphasis on the management of soils under subsistence agriculture. The paper addresses the management of (1) acid soils in the humid tropics, (2) acid soils in the savannas, and (3) acidified soils.
Application of initial corective fertilization - using heavy rates of N, P, K - and lime, drastically increases the productivity of the acid soils from Africa. This productivity can be maintained under continuous cropping through annual fertilizer applications that match crop nutrient requirements. This technology - called "investment fertilization" or "maintenance fertilization" - although agronomically sound, is generally not adapted to African conditions, due to the high risks it induces for the small farmer in terms of erosion and potential nonprofitability.
This paper presents some low-input technologies and indicates the need for more research on evaluation of lime requirements, availability of P-fertilizer in high P-fixing soils, crop tolerance to Al in soil solution, and physical properties of the acid soils.
Low fertility sandy soils of western Africa are highly sensitive to acidification, as a consequence of current farming practices

that induce nutrient imbalance in the soils. The low levels of fertilization, erosion, leaching, and intensive organic-matter mineralization that occur in the semiarid zones are the main causes of soil degradation and acidification.
From the specific point of view of soil chemical fertility maintenance, the local socioeconomic conditions emphasize the need for more research not only on soil acidity as mentioned above, but also on the feasibility of the maintenance of nitrogen and organic-matter balance and other nutrient balance at the farmer's level. This can be achieved by:
- Promoting a more efficient recycling of crop residues,
- Increasing the nitrogen-fixation efficiency of legume crops,
- Improving the efficiency of mineral nitrogen fertilizers and local sources of rock phosphates.

Little will be achieved if agricultural policies are not consistently implemented in these countries where, most often, food crop production is limited by the weakness of marketing and credit organizations.

483

89 - 12/21

Soil fertility
Review, book, acid rain, acid soil, environment, ecology, air pollution, nitrogen, sulphur, ecosystems, nitric acids, sulphuric acids
KENNEDY, I.R.
Acid Soil and Acid Rain. The Impact on the Environment of Nitrogen and Sulphur Cycling.

Research Studies Press Ltd., Letchworth; Distributor J. Wiley & Sons, Chichester, hardcover, ISBN 0-471-91251-4, 1986, XV+ 234 pp.

This is an unusual book on a well-covered topic, and has a refreshing approach to the understanding of the significance of acid rain for the environment, not least, perhaps, because the author resides in Australia - a country that is not generally associated with air pollution problems. The book falls into two distinct entities, after a brief introductory chapter on the cycling of nitrogen and sulphur in ecosystems, which highlights some of the similarities in the chemical behaviour of these elements and their formation of nitric and sulphuric acids. The next seven chapters are concerned with the physical and chemical processes by which acidity is generated or consumed naturally within ecosystems, including at the physiological level. The general reader may find these rather heavy going, with their strong emphasis on thermodynamics and long lists of equations. Nevertheless, it is here that the real value of this book lies. A thorough understanding of natural acidification processes is vital for the elucidation of the changes induced in ecosystems by the deposition of acid pollutants. This section sets the scene for the remaining four chapters, which are concerned with the environmental impacts of acid deposition and draw heavily on the more fundamental information provided earlier. Unfortunately, as

perhaps might be expected from an author whose research interests clearly lie outside the field of air pollution, there are a number of important developments taking place in both Europe and North America which are omitted.
Chapter 2 is concerned with the characteristics of acidity and the properties of buffers with respect to their potential significance for the control of environmental acidity. This is followed by a longer chapter on the energetics of life processes, which places particular emphasis on considering the non-equilibrium states prevailing in nature and contrasting these with the fact that most studies on thermodynamics have been based on equilibrium conditions. The next two chapters are concerned with the biochemistry of nitrogen and sulphur utilisation, respectively. The similarities between the behaviour of nitrogen and sulphur in ecosystems is emphasised, together with the major role played by micro-organisms. Chapter 6 discusses the regulation of cell-pH and is biochemical in nature. It includes a fascinating (to me) list of foods which are either acidic or basic with respect to their metabolism in the human body and hints at the possibility of heart disease being associated with an excess of the former - an interesting addition to the long list of evil effects of acids in the world. The final chapter in the first section is concerned with ionic imbalances in plants, particularly with respect to those induced by uptake of nitrogen and sulphur compounds from the soil.
The first chapter in the concluding section is entitled "Acid Rain" and attempts to give an overview of the history, production and toxic effects of this phenomenon. It is obvious that the author is not really familiar with much of the relevant literature, e.g. the role of hydrocarbons in O_3-formation is not at all clear, while the concentrations of gaseous pollutants claimed to cause injury reflect the beliefs of 20 years ago. No mention is made of the work of Tamm and others which is now building up a picture of widespread long-term acidification of sensitive European soils. Chapter 9 is concerned specifically with acid soils and gives careful consideration to the various natural and anthropogenic processes leading to increases in acidity; the latter include Australian ley farming practices, where increased nitrogen levels, arising from fixation by clovers, are reducing soil pH and increasing its organic matter. Some consideration is given to the consequences of applying ammonium fertilisers to soil, but no mention is made of the increasing concern in certain parts of Europe over acidification problems arising from the deposition of NH_3 and its derivates from The atmosphere, originating from livestock production. the penultimate chapter is entitled "Neutralising Impacts of Nitrogen and Sulphur Cycling", which is somewhat ambiguous in a book on environmental acidity and turns out to be concerned with various ameliorative measures, such as liming and adjustment of cropping regimes. The last chapter describes methods for predicting the impacts on acidification of modifying nitrogen and sulphur cycles, and includes a number of case studies for different agricultural and forestry regimes. Perhaps the philosophy of this book can best be summed up in the author's statement in Chapter 8 that oxidation processes involving

nitrogen and sulphur are the prime causes of acidity and that, as such, oxygen should be considered a dangerous chemical which if newly manufactured would not pass environmental impact assessments! It is this lateral approach which makes this book a pleasure to read and which, despite some misgivings over the second section, I am happy to recommend.
Abstract by J.N.B. Bell, UK

484 89 - 12/22

Soil fertility
Review, tropics, socioeconomy, soil research, acid soils, people, plants, interaction, human behaviour, IBSRAM
MORAN, E.F.
Socioeconomic Considerations in Acid Tropical Soils Research.

In: Proc. of an IBSRAM workshop on management of acid tropical soils for sustainable agriculture, Bangkok, Thailand, 1987, 227-244

A growing number of social scientists, however, are defining their long-term research interests by studying the potential of the humid tropics for intensive agriculture. This potential has considerable significance for both agronomy and anthropology, for anthropology especially because much of the existing literature suggested that the humid tropics could not support human societies above the level of the small, isolated village.
This paper illustrates the value of attention to the interaction between people and the soils and plants they manage. This value lies not only in facilitating final acceptance of technological packages that might be proposed to farmers, but also in providing a faster flow of information from farmer to soil scientists that may be worth experimenting with.
Integral systems are those used by populations who for long periods of time held rights to land in an area that they had come to know with great preciseness of detail. In contrast, pioneer systems were those in which the populations were recent settlers and in which the social organization and integrity of cultural knowledge had been disrupted by either external or internal forces. Evidence for such disruption could be seen in the simplification of shifting cultivation practices, the shortening of fallows, and the declining rates of intercropping.
This distinction between integral and pioneer systems did not have much impact upon subsequent work in the social sciences. Anthropologists have tended to take the position that native people know their physical environment and that it is unnecessary to test the accuracy of native knowledge. Although still dominant, such a view is increasingly being questioned. Now it is seen that most native people's traditional forms of social organization, cultural knowledge, and familiarity with the environment have been disrupted by resettlement and adoption of nonnative knowledge and technology, which has resulted in the loss of traditional expertise.

Socioeconomic considerations are therefore relevant to the management of acid tropical soils, primarily because the term "management" refers to the behavior of farmers toward crops and soils. This behavior, in turn, is a function of (1) past behaviors, (2) current constraints of land, labour, capital, and technology, and (3) the opportunity costs of the individual household.
Pioneering systems in the first decade after resettlement tend to be characterized by subsistence agriculture because of poor infrastructure development, scarity of labour and capital, low yields, and the dominant role of the market for land. Thus, emphasis in the early years of frontier settlement ought to be on baseline research, both agricultural and socioeconomic, rather than on credit, extension, and crop commercialization. After the first decade, the area's potential is clearer, land speculation may decrease, and a growing number of farmers arrive to produce crops - a population more receptive to agricultural technology and production than the earlier one. These conclusions are based on a comparative analysis of the U.S. frontier in the 17th and 19th centuries, and on the Amazonian frontier of the past 2 decades. There is evidence that it may apply to Africa and Asia, but few cases from those areas have been analyzed.
The choices made by local populations about soils and crop choices are the result of a complex calculus that includes agronomic considerations, nutritional needs of the household, the need for cash in the household, and social/religious obligations. Thus, the selection of given soils or crop varieties in pre-market or areas poorly articulated to markets is rarely based on the primacy of yield and more on the need to get security of yield under existing constraints at the lowest possible labour cost. Thus, it is inappropriate to test native varieties against newly introduced varieties using yield as the measure. Rather, the proper measure should be how the two varieties perform in fulfilling these multiple needs of households at low levels of input - and perhaps moving the population toward greater security of income.
For example, the native Amazonians plant their fields 90% with cassava (*Manihot esculenta*) and they plant very small areas in maize and beans. Such a choice reflects the better performance of cassava in acid soils of the humid tropics and the well-known agronomic problems in achieving acceptable yields for maize and preventing disease and insect infestations in beans of the genus *Phaseolus*. The crops chosen also acknowledge the difficulties of providing fertilizers and lime at reasonable cost in most of the Amazon region.

485 89 - 12/23

Soil fertility
Review, tropics, developing countries, soil management, land development, sustainability, IBSRAM, IITA, ICRISAT, environmental degradation, low-input systems, small farmers
LATHAM, M.
Soil Management A Necessary Tool for Land Development in the Tropics

entwicklung + ländlicher raum, 22, 4, 1988, pp. 16-17

Successful technological packages have been adopted on most of the fertile soils in traditional agricultural areas. In less-favoured areas, the green revolution has usually had less impact. Yields have stagnated, and in turn a growing population has attempted to make a living from marginal lands. The agricultural problems and environmental degradation which usually follow the development of such infertile, fragile marginal environments poses a new challenge to agricultural and soil management research.
Soil conservation, soil physical aspects, and an extreme variability in the ecosystems often prevent the use of mechanized, high-input systems. Besides, the high inputs and modern technologies which would be necessary for these areas to achieve high production are not available to smallholders in developing countries due to cash limitations, badly organized credit facilities, and poor communications.
This being the case, there is a need for adapted technologies using low inputs. Some of them have recently proved successful.
Experiments on soil management conducted collaboratively by the National Agricultural Research Institute of Peru with the help of Tropsoils - an Association of US Universities - have shown that on Amazonian acid soils, a rice-cowpea system could be maintained, given proper soil management techniques, for three years without fertilizer. A total of 13.8 tons of grains were recorded in comparison to the 2.8 tons normally harvested by shifting cultivation.
Scientists of the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria have demonstrated that proper land-clearing methods using manual clearing and postclearing such as in situ mulch, live mulch, shrub fallows or alley cropping, soil management techniques can bring about a notable improvement in crop production on lateritic soils or Paleustalfs compared to traditional shifting cultivation practices, and make it more sustainable. These few examples and others show that some new technologies exist, but they need to be adapted to particular agroenvironments and promoted in the localities they are intended to serve.
Up to now, results of research on the discrete components affecting soil fertility have had little impact on farmers'practices. For example, slash-and-burn shifting cultivation is still the basic soil management practice of the humid tropics. Even though a good number of experiments have been

conducted on liming, fertilization, the use of new varieties, and the introduction of N-fixing legumes, there is still an urgent need to adapt and test the existing knowledge in various technological combinations in different agroenvironments.
It is now recognized that the major role of national research organizations should be to adapt on-farm soil management research. However, limited staff and financial resources are major constraints in conducting such operations - and it is precisely to minimize these constraints that the network concept has been put forward. Networks are initiated by informing the participating national organizations of existing knowledge and of the need for its adaption to local conditions. Networks lead to the sharing of new findings by collaborators working on the same problems, and help to coordinate development efforts. For this reason, the International Board for Soil Research and Management (IBSRAM) has encouraged the formation of soil management networks, and is continuing to promote network developments in various tropical regions.
These networks use a common methodology to test and validate different cropping systems in common-core experiments, where high and low cash input options are compared to the farmers' traditional practices. Particular attention is paid to the monitoring of sustainability. The different experiments are intended to asses erosion, soil fertility evolution, and the spreading of weeds or pests and diseases. This assessment is completed by monitoring socioeconomic factors such as the profitability of farmers. The experimental work will be followed by on-farm demonstrations in situations similar to those pertaining in the experimental site and by disseminating validated techniques to the farmers.
In conclusion, soil management research in the tropics is oriented towards the adaptation of improved and sustainable technologies to different agroenvironments. This procedure,which is already well advanced on fertile soils where the green revolution has taken place, has to be extended to more marginal soils, which are being increasingly utilized by poor farmers as a result of population pressure.

486 89 - 12/24

Soil fertility
Asia, India, experiments, biofertilizer, desert ecosystem, legumes, low-input system
RAO, A.V. and B. VENKATESWARLU
Use of Biofertilisers in the Desert Ecosystem.

Indian Farming, 4-1987, pp. 21-22

The Indian deserts spread over four states, Punjab, Haryana, Rajasthan and Gujarat. Most of it, that is about 61 per cent is in Rajasthan. It is characterised by low and erratic rainfall and high temperature coupled with intense solar radiation besides low soil fertility. The production of plant biomass in the desert

ecosystem is limited among other factors by the low available nutrient pool of the soils. The use of chemical fertilizers has not become popular largely due to the inherent risk in arid zone farming besides the high cost of fertilizers. Under such conditions the obvious alternative would be to use the biofertilizers, a low-cost input to supplement the nutrient deficiency.
Experiments were conducted to isolate strains of rhizobium that could suit crops like guar, moth bean, etc. grown in the region of Rajasthan. It has been found that the grain yield of guar can be increased by about 6 to 13 per cent by inoculation with different rhizobial strains. Similarly, very good results were achieved by inoculation in the case of moth and bean. Concluding, farmers in the desert region can enhance their crop yields by the use of biofertilisers.

487 89 - 12/25

Soil fertility
Asia, Philippines, field trial, IRRI, azolla, green manure, nitrogen fertilizer substitution, wetland soils
LALES, J.S. and R.S. MARTE
Long-Term Utilization of Azolla as Organic Fertilizer for Lowland Rice.
Phil. Agric., 69, 1986, pp. 459-464

Evidences accumulated through a number of short-term experiments show the possibility of reducing the commercial nitrogen fertilizer input for lowland rice by as much as 25 to 30% through the use of azolla as green manure in wetland soils. This implies reduction of production cost as well as less dependence upon fuel-based commercial nitrogen fertilizers.
Decomposition studies conducted at the International Rice Research Institute indicate that complete decomposition of azolla incorporated after transplanting may not be attained within the growing period of the rice crop. In about 8 weeks after flooding, only 73% of the organic nitrogen in azolla was mineralized. Continuous green manuring with azolla may therefore gradually increase the organic matter content of the soil which in due time might reach a level where the application of commercial nitrogen fertilizers becomes unnecessary.
This paper presents partial results of the long-term evaluation of the effects of continuous green manuring with azolla at varying levels on lowland rice yield and soil fertility.
For five consecutive cropping periods, replacing 50% of the total commercial nitrogen fertilizer input for lowland rice with azolla gave grain yield similar to that given by 90 kg N/ha from urea. Without any addition of inorganic nitrogen fertilizer, at least three azolla incorporations (equivalent to about 26 t fresh azolla/ha) during the entire cropping period were found necessary to attain grain yield comparable to that of the standard treatment. Slight increases in inorganic matter content of the soil have been observed at the end of each cropping period but

there was no significant change in soil inorganic matter content after six consecutive cropping seasons and continuous utilization of azolla as green manure.

89 - 12/26

488

Soil fertility
Pacific, Samoa, study, farming techniques, tillage methods, cowpea, no-tillage farming
TOFINGA, M.
Comparison of the No-tillage and Tillage Farming Techniques in the Production of Cowpea (*Vigna unguiculata* L.) in Western Samoa.

Alafua Agric. Bull., 10, (2), 1985, pp. 47-51

In the South Pacific region, the concept of no-tillage farming is not new. Many traditional crops such as taro (*Colocasia esculenta* (L.) have been grown successfully by farmers using the no-tillage technique. The farmer usually clears the forest of trees, shrubs and undergrowth, burns the dry debris and plants the taro by using a pointed stake ("oso") to make a hole large enough for planting the apex (tiapula") of the shoot.
The planting sites cleared from forests are, at this stage, free of weeds because there is a thick mulch deposited over the years. Farmers often face a serious weed problem when they plant successive crops on the same land, previously cleared of forest. The yields of the crops gradually decline. Earlier in time, this problem was solved by shifting to another site or allowing the forest to regenerate for a few years before cultivating it again. Recent increases in population make shifting cultivation and bush-fallow techniques impractical in relation to land shortage.
Farmers began to use imported chemicals, as herbicides, to control weeds before planting taro and found the results succesful. Tillage methods were also introduced and benefits, besides weed control, were the improvement of soil tilth, better soil aeration, and the more rapid availability of soil nutrients. Farmers began to adopt this practice and then found several adverse effects. The most important was the degradation of the soil and its loss through erosion.
Moreover, the high energy inputs with machinery are not easy to provide. Other inputs such as fertilizers and pesticides are costly, and are not readily available to most of the farmers in the tropics, particularly those in the South Pacific Islands. A need to compare tillage versus no-tillage techniques in the South Pacific countries was accordingly felt.
This study is a part of a long-term project aimed at comparing the tillage and no-tillage techniques on the production of cereals and pulses in suitable rotations. This paper reports the results with cowpea (*Vigna unguiculata* L.). Yield and weed dry weights of two successive crops of cowpea were assessed in this part of the study. Plot sizes, treatments, and husbandry practices were the same for both the crops.

For both the cowpea crops, the no-tillage treatments had advantage over the tillage treatments. No-tillage treatments gave higher yields and generally low weed dry weights.
It appears that the higher yields of the no-tillage treatments in comparison with the tillage treatments are related to the low weed infestation. Repeated tillage can be expected to promote the incidence and growth of weeds. No-tillage has the opposite effect reducing weeds thereby.
In this study, the additional advantage of the no-tillage treatments is the absence of the high energy input of using machinery which is expensive and commonly not available in the tropics. No-tillage also conserves the soil together with its physical and chemical properties from soil erosion and depletion.
The trials should be continued to confirm the results of the tillage and no-tillage treatments on the yield of crops, weed control and input requirements, as well as to determine the effects on the nutrient status of the soil. An economic assessment of the methods will also be considered.

489 89 - 12/27

Soil fertility
Latin America, Brazil, glasshouse experiment, mycorrhiza, maize, efficiency, phosphorus sources
DIEDERICHS, Ch.
Influenca de different fontes de fósfato na eficacia de different espécies de fungos micorrizicos no crescimento de milho. (Influence of different P sources on the efficiency of several tropical endomycorrhizal fungi on growth of *Zea mays* L.).

Turrialba, San José. Costa Rica, 1990, 20 pp.

The Cerrado region of the Central Plateau of Brazil is characterized by soil-related constraints which inhibit satisfactory crop production, unless expensive inputs such as mineral fertilizers are applied. Phosphorus is the most deficient plant nutrient in the Cerrado soils.
In addition to acidity and low-nutrient status, these soils also present high phosphate sorption capacities. Therefore, large amounts of P-fertilizer are indispensable to obtain adequate economic returns. The application of soluble P-fertilizers by local farmers, however, is seldom practiced, due to limited financial resources. In order to meet these limitations agricultural practices are being tested to improve the efficiency of applied P-fertilizers, viz: application of dolomitic lime to minimize phosphorus fixation, introduction of legumes into crop rotation, determination of the best P fertilizer rates and placement methods, and evaluation of local cheap P-sources (rock phosphate).
The purpose of the present research work was to examine the efficiency of various local and foreign endomycorrhizal fungi on growth of *Zea mays* fertilized with two P-fertilizers of different solubility.

The evaluation of fourteen endomycorhizal species belonging to the genera *Gigaspora, Scutellospora, Glomus, Acaulospora* and *Entrophospora* was conducted under glasshouse conditions in an unsterilized tropical virgin soil using two P-sources with different solubility. In both P-treatments indigenous mycorhiza species enhanced growth of *Zea mays*. Introducing other species modified the growth pattern of maize. Using a low-grade rock phosphate (Patos de Minas) from Brazil all endophytes with exception of *Gigaspora margarita, Scutellospora verrucosa, Scutellospora gregaria, Entrophospora colombiana* and *Glomus pallidum* enhanced shoot dry weight. In the treatment with single superphosphate, dry matter production was not significantly improved by *Gigaspora margarita, Gigaspora gigantea, Scutellospora verrucosa, Scutellospora reticulata, Scutellospora gilmorei* and *Glomus manihotis*. Root fresh weights were enhanced only by three endophytes when rock phosphate was added but in no case with single superphosphate. The percentage of P in shoots was almost equal in uninoculated and inoculated plants and yield responses did not always followed the pattern of P-uptake. Mycorhizal root infection was always highest in the treatment with single superphosphate and in most cases a correlation with plant growth was found. The present results show that different foreign introduced mycorhiza species differently promote growth of *Zea mays* according to their adaptability to the P-source and to their capability to compete with native VAM-endophytes.

490 89 - 12/28

Soil fertility
Latin America, Peru, humid tropics, Ultisols, experiment, rock phosphate, fertilization, tillage system, no-tillage system, low-input system
GICHURU, M.P. and P.A. SANCHEZ
Posphate Rock Fertilization in Tilled and No-Till Low-Input Systems in the Humid Tropics.

Agron.J., 80, 1988, pp. 943-947

The Ultisols of the Amazon basin of Peru are generally acidic and deficient in P, although soil fertility problems can be corrected by using liming.
Socioeconomic constraints often limit the application of fertilizer-based continuous crop production in areas where farmers still practice shifting cultivation. The low-input approach to food production is an alternative to shifting cultivation in areas where fallow periods are too short and continuous cultivation technology is limited by lack of market infrastructure. This approach is based on acid tolerant cultivars, minimum tillage, minimum use of purchased inputs and maximum nutrient receycling.
Application of phosphate rock is an attractive possibility for low-input systems because it is less expensive than superphosphates. The use of acid-tolerant crops may permit more efficient utilization of P from phosphate rock, because the plants

will grow under acid conditions that favor dissolution of apatite. In addition to reducing energy costs and promoting soil conservation, surface applications of P may also facilitate a gradual transition from shifting to continuous cultivation, while fertilizer incorporation is difficult in fields that still have fallen logs and tree stumps. Although surface application of P-fertilizers has been found to be comparable to incorporating them into nonacid soils, little information is available on surface application of phosphate rock to annual food crops under acid soil conditions.
The objective of this work was to determine the relationships between P-sources and tillage methods in a low-input systems using acid-tolerant crops.
The study was directed toward determining the effects of these two P-sources under no-till and rotovation tillage systems on crop production in a fine-loamy siliceous, isohyperthermic Typic Paleudult. A rotation of Al-tolerant cultivars of rice (*Oryza sativa* L.) and cowpea (*Vigna unguiculata*) was followed for seven consecutive harvests. Grain yields increased with rotovation in the first crop, were not affected by tillage methods during the second and third crops, but decreased with rotation from the third to the seventh crops. Phosphate rock at a soil pH of 4.5 was as effective as superphosphate in supplying available P.A total of 13.9 Mg ha^{-1} of rice and 2.5 M ha^{-1} of cowpea grain was produced in seven harvests in newly cleared fields without lime or P-application. There were significant responses to P-fertilization in one rice crop and in both cowpea crops. On the average, however, rice yield did not respond to P.A single application of 22 kg P ha^{-1} was sufficient to produce 85% of the maximum yield of cowpea for 2 years. The results with cowpea indicate that broadcast phosphate rock is a good source of P for low-input systems on acid soils where acid-tolerant cultivars are used.

491 89 - 12/29

Soil fertility
Asia, Indonesia, review, tropics, marginal lands, development, sustainability
CONWAY, G.R. et al.
The development of marginal lands in the tropics.

Nature, 304, 1983, pp. 392

The past decade has seen great progress in the agricultural development of the irrigable lands of the tropics, particularly in South-East Asia.
Attention is turning to the development of those lands which, on various criteria, are more marginal.
In Indonesia there are three major categories of marginal land: the tidal swamplands, primarily of Kalimantan and Sumatra (approximately 35 million ha); grasslands covered by alang-alang *(Imperata cylindrica*; about 15 million ha); and "critical" uplands, mostly on Java and Bali, which are defined as lands

suffering from severe degradation because of erosion (between 10 and 40 million ha).
In total these lands may cover as much as one-third of Indonesia's land surface, encompassing a wide range of ecological and socio-economic conditions. Thus whereas the development of the better-endowed lowlands has been achieved by disseminating widely adapted crop varieties and cropping techniques, the more diverse and severely constrained marginal lands require a more finely tuned approach.
The land should be zoned not only according to agroecological factors, but also in terms of socio-economic criteria. Alang-alang land, for example, should be characterized not only by climate, soil and topography but also by who owns or cultivates the land, their cultural and economic circumstance and, in particular, whether they view alang-alang as a weed to be eradicated or as an asset to be preserved.
Marginality arises partly from limiting factors, for example acid sulphate soils in the tidal swamps, low levels of soil nutrients in alang-alang land and steep slopes in the critical uplands; and partly from their inherent environmental instability. Tidal swamplands are subject to considerable seasonal and daily fluctuactions in levels of water and salinity. Alang-alang lands experience frequent burning and, in some areas, severe drought, while critical uplands suffer from periods of intensive rainfall.
Such variability tends to be viewed as a constraint, but it can also provide opportunities for development. For example, the critical problem in the tidal swamps is that excessive drainage leads to destruction of the surface peat layers followed by acidification of the underlying soil and the production of toxic aluminium. Expensive engineering works which carefully control the water level are one solution, but in Indonesia areas for rice production have been successfully opened using simple communally operated gates which permit tidal flows to flush away the acids yet retain sufficient water to prevent oxidation.
A similarly simple and inexpensive solution is the use of burning to manage alang-alang. Although often an indicator of degraded and apparently abandoned land, anthropologists argue that in many cases alang-alang is a productive resource. In South Kalimantan alang-alang is an essential part of a rice-fallow system; on Sumbawa island it supports productive game hunting - the deer being attracted by the regrowth after burning - and in Bali it is an important cash crop, providing the materials for traditional thatched roofs which are coming back into favour.
Many of these traditional agricultural systems, although not highly productive are sustainable. But under the demands of population pressure and economic necessity they may give way to less appropriate systems. The challenge is how to increase the productivity while retaining sustainability.
A particularly productive and apparently sustainable cropping system has been designed for the red-yellow podzolic soils which occupy about 15 per cent of Indonesia's land area. Traditional cultivation consists of a mixture of crops followed by a fallow of alang-alang. The new system developed comprises a more organized inter- and relay cropping, grown in a continuous cycle without a

fallow. About 1 ton per ha of burned limestone is applied initially, phosphorus is spread in the furrows, nitrogen and potassium are placed below and beside the seed, and all crop residues are returned as mulch. The benefits lie in the evenness of labour demand and the steady flow of produce and income. Five years of such continuous cropping have produced yields, in food calorie terms, of 12-25 tons per ha per year of paddy rice equivalent.
The development of sustainable systems for the critical uplands will be more difficult.
An alternative strategy is to develop and extend traditional agro-forestry systems, such as the home and forest gardens. These are typically multistoried and highly diverse cultivation systems with perennial tree crops and a rotation of mixed annuals underneath. They provide the farmer with a steady flow of food, fibre, wood and cash crops, and because of the high degree of nutrient recycling and the completeness of the ground cover they also conserve the soil even on fairly steep slopes.

492 89 - 12/30

Soil fertility
Review, booklet, tropics, subtropics, soils, composting, soil fertility, organic material
AGROMISA
The preparation and use of compost.

Agrodok 8, ISBN 90-72746-04-X, 1983, 20 pp.; Agromisa, P.O.B. 41, 6700 Wageningen, The Netherlands

One of the major problems of small farmers in tropical and subtropical countries is the maintenance of soil fertility. This has been a problem for centuries, but in the last decennia it has become more and more serious, as the growing population demands more from the soil, than ever before. As a result of the increasing demand for food, the soil has to yield a higher quantity of products.
Because of the fact, that fertile areas are scarce, people are forced to farm less fertile soils, which, once they are in use, degenerate quickly. Usually the poorest farmers have to grow their crops on the worst soils, and here the result of the degeneration of the soil is that they become even poorer. The question of how to handle the soil in such way that its fertility is maintained or improved is therefore a very essential one.
A step in the right direction is to try to make better use of things, that are already present,either at the farm or in the neighbourhood. All sorts of organic material, that are usually considered as waste, and may be thrown away or burnt, can be used to help improve the soil.
This booklet discussed here deals with composting. In fact composting is a method of turning all kinds of organic wastes into a substance that is beneficial to the soil, and therefore to the plants that grow there.

The main aim of all these different methods is to increase the amount of organic matter in the ground. The reason why organic matter is important to the soil, is explained in chapter 2. Chapter 3 deals with the principles of composting: what happens during the composting process, and which aspects are important?
In Chapter 4, the practice of composting is described step by step. It must be borne in mind, however, that a universal recipe for the ideal compost heap cannot be given. Differences in climate, available material, labour, implements and needs will result in different heaps. It takes experiences to find out, which is the most suitable way of your specific conditions, and the booklet can be no more than an indication.

493 89 - 12/31

Soil fertility
Asia, India, study, soil classification, farmers
ICRISAT
Soil classification by farmers.

ICRISAT Ann. Report, 1988, pp. 167-169

ICRISAT intensively examined indigenous systems of soil classification in three study villages of peninsular India. The indigenous classifications were drawn up solely from interviews with farmers and were based on their perceptions of edaphic characteristics in fields where input and production data had been collected since 1975.
Major differences in farmers' systems of soil clasification were evident between villages with red and black soils. In the Alfisol region, soil categories were very distinct and were organized nonhierarchically on multiple characteristics. In the two villages representative of Vertisol regions, the farmers' classification was based on the deviation form of an "ideal" soil type. Thus, farmers in the Vertisol areas viewed their soils as less distinct than farmers in the Alfisols region. These fundamental differences are reflected in variations in crop and soil management practices between fields within the village. This source of management variation can be summarized as an adjustment to central principles in the Vertisol tracts and as the targeting of cropping systems and groups of practices to the diverse soil types in the regions.
The laboratory analyses generally supported the farmers' way of thinking about their soils. In the red-soil village, all analyzed chemical and physical properties, with the exception of available P, were significantly different ($P<0.05$) for the five major soil groups. In the black-soil villages, differences in chemical and physical characteristics of major soil groups within a village were not as marked. In Shirapur the major soil groups differed significantly in available water and exchange cations (Ca, Mg, K, and Na). With the exception of exchangeable Ca, the problem soils ranked lowest for every trait. In Kanzara CEC, organic C, available P, and exchangeable K distinguished the main soil groups ($P<0.05$).

This classification system by farmers to the descriptive soil taxonomy used in the ICRISAT Village Lever Studies (VLS) was compared. Soil depth and colour figure prominently in the VLS soil classes, which are similar to those used to elaborate the 1968 Soil Map of India. In comparing the farmers' assessment to this more formal system of classifying soils, cross classification was generally inconsistent, i.e., fields within a major farmers' soil group were frequently placed in several of the VLS soil groups. Land perceived by farmers as having problem soils was often not identified as such by the VLS soil descriptors.
Summing up, the indigenous systems appear to provide an informative and compact base for indexing variation in land quality. Farmers' soil classification would also appear to have the potential to hasten the process of technology generation and transfer. Additional research is needed on the extent to which a farmers' system of classification from a representative village can be extrapolated to a larger area.

XIII EROSION CONTROL

494 89 - 13/13

Erosion and desertification control
Tropics, review, soil degradation, soil management, sustained productivity, soil fertility, yield stability, low input strategies, IITA
LAL, R.
Surface soil degradation and management strategies for sustained productivity in the tropics.

In: IBSRAM Proc. No. 2; Management of acid tropical soil for sustainable agriculture, Bangkok, Thailand; ISBN 974-7614-39-1, 1987, pp. 167-177

The tropics cover about 40% of the earth's surface, and land resources are sufficient to produce food for the present and future populations. Of the total potentially arable land area of 3419 million ha in the world, 789 million are in Africa and 819 million are in South America. Only about 231 and 15% of the potentially cultivable land area is currently being cultivated in Africa and South America, respectively. Considering the possibilities of multiple and double cropping, the gross arable land area is considerably higher.
The predominant soils of the tropics are Oxisols (23%), Ultisols (20%), Entisols (16%), Alfisols (15%), Inceptisols (14%), Vertisols (5%), and others (7%). Oxisols and Ultisols are leached acid soils of relatively low chemical fertility. Alfisols, in contrast, have better nutrient status but often poor physical properties. In general many Entisols and Inceptisols have favourable chemical fertility.
The results of soil degradation are the direct consequence of the degradative processes. Soil mismanagement results in a decline in soil organic-matter content and the effective cation-exchange capacity, reduction in water- and nutrient-holding capacity, overall soil compaction and decline in macroporosity and transmission pores, lack of oxygen in the root zone, and frequent occurence of moisture deficit. This degradation process is set in motion by man's intervention in his quest for producing more food and is further accentuated by accelerated erosion.
The soil degradation process is set in motion by the drastic change in soil and microclimatic factors caused by cultural practices that result in soil exposure and disturbance of the soil-vegetation-climate equilibrium. This implies that the protective native vegetation cover should be removed with the least possible disturbance. Furthermore, as the soil is protected when covered by the forest canopy, it should be continuously covered after the forest cover is removed and during the cultivation phase. This can be achieved by replacing the forest canopy with a low canopy cover that will protect the soil against impacting raindrops but not shade the seasonal crops. Furthermore, the soil should not be disturbed by mechanical manipulation.

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XIII EROSION CONTROL

494 89 - 13/13

Erosion and desertification control
Tropics, review, soil degradation, soil management, sustained productivity, soil fertility, yield stability, low input strategies, IITA
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active soil organic matter is an important factor
the fertility level of the soil, stabilizing soil
stimulating biological activity, including that of
is more effective to leave organic matter on the
than to incorporate it into the soil by plowing or
cal operations. Deep-rooted perennials should be
iation with the shallow-rooted annuals so that they
er and nutrients from different horizons. An orderly
annuals with perennials may help facilitate farm
crop management.
ie socioeconomic conditions and financial resources
ale farmers concerned, the emphasis is on low-input,
g, and ecologically compatible technologies. The
nd-use and soil management systems are those that
ic yields rather than those that produce only short-
irns. The objectives of soil surface management are
r restore and sustain soil productivity, maintain
ility, and optimize biophysical environments, by
to the specific soil environments.
nciple is the least disturbance of the soil-plant-
brium. This can be achieved by replacement of a
by a ground cover such as mulch or a cover crop,
mit food crop production without exposing the soil
s of the weather.
holders in the tropics and subtropics it is vital to
dependence on agrochemicals and other capital
ts. While it is true that high yields cannot be
ut these inputs, agronomic practices should be
can drastically reduce the fertilizer and chemical
esticides, etc.) needs and yet maintain good yields.
es have proven successful on research farms and
d on-farm plots. Their effectiveness needs to be
a wide range of ecologies by adaptive problem-
rch. Improved cultivars and chemicals are easily
ctive conservation measures are not adopted.
potentially useful agronomic techniques listed need
ed and adapted for a wide range of soils and
The best production potential of the tropics can be
od production can be dramatically increased.

89 - 13/14

sertification control
, report, NORAD, IUCN, UNEP, environmental
soil degradation, drought, ecology,
ecodevelopment, integrated strategy

This report has been produced by the Conservation for Development Centre of the International Union for Conservation of Nature and Natural Resources (IUCN).
The scope of this report is the Sahel and other drought-affected regions of Africa. In view of time and cost constraints it primarily covers the "climatic Sahel" but it is hoped that other regions of drought-affected Africa will receive a balanced treatment in the future.
This report has been written for the use of national, regional and international bodies, development assistance organizations, non-governmental organizations and IUCN's own constituent centres and commissions.
Environmental degradation ("desertification") is distinguished from cyclical successional change. Exploiting any ecosystems can cause changes to become non-cyclical. Rehabilitation is possible with time, resources and reduced exploitation, but is harder as thresholds are crossed. In dry zones loss of the herb layer is critical, even when reduced competition favours tree growth.
In the drought-affected regions of Africa, human livelihood security and environmental rehabilitation are inextricably linked. A dual strategy approach is required, to promote ecodevelopment at the local level and to address national, regional and international causes of environmental degradation:
- Linked ecodevelopment projects for local rural communities
- Promoting new styles of development at the national and international levels.

The Action Plan is intended to operate over the remaining 15 years of this century. This report outlines a framework for the first three years. The principal focus of the programme is a series of community based ecodevelopment projects aimed at conserving and better managing the living natural resources on which the communities depend. Starting with a small core of cooperating NGOS, with one serving as a focal point in each of the target countries, it is anticipated that, over the years, the number of partner NGOS, the number of projects supported and the range of ecodevelopment activities represented will grow.

496 89 - 13/15

Erosion and desertification control
Review, tropics, IITA, farmign systems, soil erosion, agroecology, sustainability, traditional systems, development
LAL, R.
Impact of farming systems on soil erosion in the tropics.

ıd and labour, both of which are becoming scarce.
ation and related bush fallow systems which rely
g forest fallow for soil fertility restorations are
t on purchased inputs. These systems have been
d-surplus economies. With mounting pressure on land
necessary to transform the resource-based systems
d systems. This transition phase has been marked by
ood deficit, particularly in tropical Africa. The
intensive landuse systems has also resulted in
tion of resources. A principal cause of soil
the tropics is accelerated soil erosion.
there are broadly two systems of land and soil
the traditional shifting cultivation system and
ming systems:

ivation and Related Bush Fallow Systems:

ming systems, based on natural fallow for fertility
e widely practiced in the Highlands of Northeastern
Thailand, Philippines, Outer Islands of Indonesia,
Africa and South America.
il erosion losses are generally low, if the
tems are based on short periods of cultivation
ng periods on natural fallow. Sediment and water
r, increase with increasing length of the
se because of the progressive degradation of the
ion properties of surface soil.
the duration of cultivation and fallow phases,
in traditional systems can be drastically high when
are cleared for slash-and-burn agriculture. Shallow
terrain in regions of torrential tropical rains,
hed away even during the first year of cultivation
w.
the erosion hazard, the resource-based extensive
s must be replaced by more productive and
ble farming systems. For the alternate farming
eed, it is imperative that soil erosion and
iminized.

rming Systems:

rming systems must achieve economic and sustained
oduction while preserving the resource base and
gh environmental quality. Some introduced systems,
sful elsewhere, have caused severe soil erosion
tropics. For example, mechanized forest clearing
ensive mechanized cultivation for grain crops cause
and erosion-induced soil degradation from

497 89 - 13/16

Erosion and desertification control
Review, book, soil erosion, conservation practices, psychology, physiology, biology, physics, population density, land-use, socioeconomic factors, guidelines
HALLWORTH, E.G.
Anatomy, physiology and psychology of erosion.

John Wiley & Sons, Chichester, hardcover, ISBN 0-471-91212-3, 1987, 176 pp.

In 1974, the International Federation of Institutes of Advanced Study (IFIAS) initiated a project to investigate the problem of soil degradation, especially that occuring in Third World countries. Professor Gordon Hallsworth, the author of this book, was project leader.
The major subjects covered include the following: the interaction of man and erosion; anatomy of erosion; physiology of erosion; the extracellular system; traditional soil conservation methods; the effects of the human component on erosion; the effects of extracellular system processes on intracellular ones; psychology of erosion; guidelines for the future. The content of some chapters, such as the anatomy and physiology of erosion and extracellular and intracellular system processes, is not self-evident. Thus, anatomy refers to the structure of soils and physiology deals with organic processes of the soil system. Extra- and intracellular aspects of erosion refer to factors affecting erosion and soil formation within a land system or those coming from areas external to the particular land system.
The three chapters devoted to the structure, biology and physics of soil erosion are outstanding in clarity and detail. However, when Hallsworth reports that an average soil erosion is 20 t ha^{-1} $year^{-1}$, the reader needs to understand the significance of such a loss. Given the fact that soil is reformed at a slow rate of about 1 t ha^{-1} $year^{-1}$, the magnitude of the loss is clear and emphasizes the need for action to curtail erosion.
The author presents convincing evidence that various soil conservation practices have been employed during the last 1000 years. One of the most commonly used practices through time is terracing. Other conservation technologies that have been used for centuries include: trenches; contour planting; mixing cropping; live fences; stone barriers and other types of barrier constructed on the contour to catch soil moving down the slope; mulching using vegetation (a form of no-till). Hallsworth currently emphasizes that vegetative cover is the most effective way of protecting soil

. conservation practices by farmers. Hallsworth
trained extension personnel play a major role in
use of conservation technology. In addition, he
e financial incentives and credits encourage and
in using needed conservation technologies. The
d that, based on his observations, "chap food"
vernments that exploit rural farmers tend to
land management practices. Based on field data
study team, literacy and the size of the farm had
erosion and employment of conservation.
several tangible barriers to the control of soil
hor also discusses several psychological factors,
ld beliefs, that are barriers to initiating
tices.
chapter on guidelines for the future, he concludes
be done to halt the rapid growth of the human
use it is associated with over-exploitation of
nd the concomitant reduction in vegetative cover,
are bound to increase. Thus, the only way for
rotect soil resources is to encourage farmers to
nservation practices in producing crops and

ggests that farmers will use soil conservation
nen they see it will provide them with profit and
ty. Hallsworth explains that the best way to
er to use soil conservation technology is to
value of conservation on his land. This means that
practice must be suitable for his land, his crops
. Clearly, getting the involvement of people at a
time and patience. It also requires sound plans
and effective extension agents. Most scientists
Hallsworth that no government in the world has
evise and implement a sound soil conservation
only hope that policy makers and agricultural
ionals will give priority to the eight guidelines
sworth to develop an effective soil conservation

e of this book and that of some of the chapters
misleading, the basic information on erosion
book is excellent. The author writes clearly,
ables to substantiate his explanations, and each
eferenced. Scientists, students and policy makers
biology, physics, sociology and politics of soil
rvation will find this book a valuable resource.
97% of the food of the human population is grown
vital that our soil resource and indeed our

498 89 - 13/17

Erosion and desertification control
Review, case studies, Ethiopia, Thailand, soil erosion, soil formation, ecosystem, soil loss, yield stability, sustainability, soil degradation ratio
HURNI, H.
L'érosion des sols et la formation de sols dans les systémes écologiques agraires: les cas de l'Ethiopie et de la Thailande septentrionale. (Soil Erosion and Soil Formation in Agricultural Ecosystems-Ethiopia and Northern Thailand-.)

Mountain Res. and Development, 3, No.2, 1983, pp. 131-142

The term soil erosion is generally used to describe the adverse effects of man's utilization of the soil, with soil being a precious, natural resource which is renewed extremely slowly.
Soil erosion is by definition a process induced by man's impact on a landscape, whether he acts to remove the forest cover, to cultivate, or to introduce his own structures. Soil erosion, however, is not restricted to the formation of gullies, badlands, and landslides, as is sometimes inferred. The most dangerous form of soil erosion is sheet and rill erosion, resulting in an almost invisible but steady degradation of large areas under cultivation. Also, soil erosion may not be negative in all cases, and man not necessarily destabilize an ecosystem irreversibly.
This paper emphasises the study of soil erosion effects on agricultural ecosystems which differ in terms of land-use practices, natural prerequisites, and human responses to soil erosion. Sheet and rill erosion is considered to be the most harmful of all soil erosion forms since it may be unnoticed or ignored by the peasant cultivating his land, yet it can result in damages which cannot be reversed. The assessment of soil loss rates alone, however, will not be sufficient for evaluation of the destabilizing effects of soil erosion. It is also necessary to define and describe all related terms, such as mean annual soil loss due to sheet and rill erosion, soil loss tolerance, soil formation rate, and soil degradation ratio.
Two case studies, one in the Ethiopian high mountains and one in the mountains of Northern Thailand, are used to demonstrate the role of the various factors that influence stability. Despite moderate erosion rates, the ecosystems in Ethiopia have suffered the greatest ecological damage through soil degradation processes. This threatens the food security of the present-day inhabitants. Reasons for this can be found in the inaccurate perception of soil erosion as a problem, and in the low soil loss tolerances of this

radation ratio, defined as the soil loss divided
tolerance, was found to be a practical method of
destabilizing potential of soil erosion in
stems.
ion ratio, D, of a cultivated slope, soil, or
defined as:

$$D = \frac{A}{T}$$

n soil loss ($t \cdot ha^{-1}$) for a defined period (e.g.,
.s the soil loss tolerance ($t \cdot ha^{-1}$ as a function
rates for the same period).
sure of the destabilizing effect of soil erosion
l ecosystem. High figures for D indicate more
tion.
an 1.0 indicate that a cultivated slope is being
oil conservation measures are required. D-values
nat the rapid soil formation processes act as a
considerable soil losses. If D equals 1.0, soil
led, but the resistance of the ecosystem in the
soil losses, such as will occur if population
reduction in the fallow period, is small.
ts for soil erosion studies, therefore, include
mean soil loss) F (soil formation) T (soil loss
soil degradation ratio) and at least one year of
ts for each watershed selected for study.

89 - 13/18

fication control
n, theory, stability of soil

on-preventive stability of soils.

s of the Int. Soc. of Soil Science, Hamburg, V,

function of five factors, namely, climate,
rties, parent and bedding rocks (in case of
etation and man economic activities. Effect of
erosion should be viewed from two angles:
volume and velocity depend to a large extent on
secondly, soil resistance to outwash seriously
ensity when the runoff has already been formed.
thstand the outwash action of the water flow or
of the water flow and

horizons of soils of different genetic types under a thick overgrowth of perennial and annual grasses have a scouring velocity of 30-50 cm sec^{-1} and more. A positive effect of vegetation is however most clearly expressed when the root density approaches 0.15%. Weakly developed grasses do not have noticeable influence.
Influence of various factors of erosion-preventive stability has been reflected in some degree in the proposed classification of soils according to their erosion-preventive stability.
Data are to be used in predicting water erosion of soils and in planning counter-erosive measures. A scouring velocity of the flow together with the velocity of water movement along the slope, are essential arguments in the formulas describing soil outwash.

500 89 - 13/19

Erosion and desertification control
Review, book, soil degradation, society, case studies, Nepal, North America, Indonesia, Pacific, China, India, Europe
BLAIKIE, P. and H. BROOKFIELD
Land degradation and society.

Univ. Paperbacks, Methuen, 11 New Fetter Lane, London EC4P 4EE, England, ISBN 0-416-40150-3, 1987, 296 pp. dfl. 50.40

Piers Blaikie has led a radical re-think of the issue of environmental degradation. In this volume, which reflects the useful collaboration he established with Brookfield and others at the Australian National University, his arguments become more realistic and, consequently, pessimistic.
The departure point of the book is that the environmental movement has had a marginal impact upon the continuing exploitation of nature for short-term gain. This volume argues that there is a need for a combination of natural and social science in order to address the problem of land degradation. In particular, the authors argue that social understanding of land degradation is poorly developed so much that the environment is frequently only considered as a stage, a passive background, to human action. The argument of the volume is that people produce nature through complex methods of land management. To capture the physical complexity of nature, the authors discuss the notion of sensitivity and resilience in land systems; sensitivity refers to to environmental damage and resilience refers to the ability of land to reproduce its capability after interference. The volume usefully summarises the frequency/magnitude problem in measurement and the issues of scale. In addition, there is a brief and clear

ngly antifundamentalist, not seeking to preserve
or the sake of the environment: it strongly
y is the cause of poor land management and poor
eepens the environmental crisis. Such a social
seful, if pessimistic, departure point for
issues of land degradation.
A

89 - 13/20

ification control
, farming systems, soil degradation, arid lands,
humid tropics

ming systems to prevent soil degradation.

of an Experts Meeting, ICRISAT Center, India,
02 324, 1986, ISBN 92-9066-115-1, pp. 7-8

includes physical, biological, and chemical
as decline in soil fertility, decline in
ion, erosion, adverse changes in salinity,
inity, and the effect of toxic chemical,
cessive inundation. It is estimated that 5-7
ltivated lands are being completely lost for
tion every year through soil degradation.
n developing countries, where most of the soil
ce, will double in the next 20-30 years. For
riod, the needed increase in agricultural
ve to come from the existing cultivated land,
ch are already subject to degradation. It is
op farming systems that permit greater food
the same time, enhance the potential of the
re food, fodder, fuel, and fiber. Many such
developed for the arid, semi-arid, and humid
al and international agricultural research
ent recommends improvements in farming systems
ions and describes areas in which further
It provides guidelines based on the improved
ble to be observed when it is planned to
stems on arable land in order to feed the
tion.

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Erosion and desertification control
Africa, book, review, desertification, climate, CILSS, strategies, methods, rural participation
BONFILS, M.
Halte à la désertification: Guide méthodologique. (Stop desertification: A methodologic guide).

C.T.A. Karthala, 1988, 263 p., available at Ed. Karthala, 22-24 Bd. Arago, F-75013, Paris, France

A good half of West African territories are affected with desertification. More than a progression of desert,it is a landscape which degrades. The climatic factor (successive droughts) is one reason, but it is amazing to learn that the demographic factor, causing a soil overexploitation through men and animals, is much more responsible for this desertification: in fact, it is a degradation coming from inside and not from outside influence which makes an urgent solution necessary.
The different governments are conscious of this fact (e.g. CILSS, International Committee for Control of Drought in the Sahel) but they are still in a phase of wishes and sectorial activities than in a state of global and participative action. Strategies and techniques of control exist already, but methods are lacking: methodology in rural participation, governments' support, soil management etc.
Many pages about participation, but nothing very concrete, only general statements, except for one account about "participating activities in a village", which gives a real practical contribution on this subject.
In fact, there are very few new elements to be found. There are in the first part of this guide some references and comparative assessments of different techniques in desertification's control (protection, tree plantations, dune fixation, crops etc.).
The book ends with a sort of "credo" underlining three key principles: reduction of areas for traditional crops, intensification of cultural methods, and effort of rural communities in accepting changes.
Abstract from Agricultures actualité

Use: There are two types, one with bitter tasting fruits and the other with fruits which are not bitter. The green unripe fruit of both types is eaten raw or cooked.
Cultivation: In Zambia planting is done between August and September. The seed are broadcast and will germinate when the rain starts. The first fruits are harvested after 3 to 4 months before they become yellow.
Pests feed on all parts of the plant and leaf spot is common.
Green vegetables that are not mucilaginous are chopped finely before washing. Then the leaves are boiled in water. If the flavour of the type of vegetable is too strong or bitter the water is discarded. Generally, vegetables are cooked for a long time and groundnuts or cooking oil is added.
In the case of mucilaginous vegetables like cat's whiskers, they are cooked with soda and are not washed. No cooking oil is added but sometimes groundnuts are.
There are two disadvantages in preparing the food like this:
- Washing after cutting and prolonged cooking will cause a loss of watersoluble vitamins (Vit. C).
- Cooking with soda destroys much of the protein.

In spite of the obvious advantages of these vegetables they suffer several shortcomings:
- They are considered the food of the poor.
- Preparation methods are not always suitable for their full nutritional exploitation.
- Their market value is low and they are not exported.
- Many children do not especially like leafy vegetables.
- Some types are eaten by certain ethnical groups only and are not acceptable for others.
- Data on yields, nutritive value or antinutritive value are scarce.
- Little selection on local types has been done.

While much emphasis in research is directed towards the adaptation of exotic vegetables and fruits to tropical conditions, very little is done to improve those crops that are already adapted and liked by the majority of the people.
More detailed information is needed on their yields and the diseases affecting these crops. It would be worthwhile to compare local types of the same species in order to find out which are the most suitable for further promotion.

1. GEOGRAPHICAL INDEX

2. SUBJECT INDEX

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3. AUTHOR INDEX

This is the second edition called "Abstracts on Sustainable Agriculture". In view of the good experience made with the "Abstracts on Intercropping", GTZ intends to continue making the documentation available. Intercropping remains an important aspect of the abstracts but will now be treated as an integral component of sustainable agriculture.

These abstracts are more comprehensive than the usual type of annotated bibliography but they cannot substitute the original publication. For details it is advisable to refer to the original.

The abstracts are divided into different sections, e. g. integrated systems, agroecology, homegardens, soil fertility, water management etc. The subject index, based on key-words, the geographical indices as well as the index of authors help the reader to find abstracts on specific aspects of sustainable agriculture easily.

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