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LEISA

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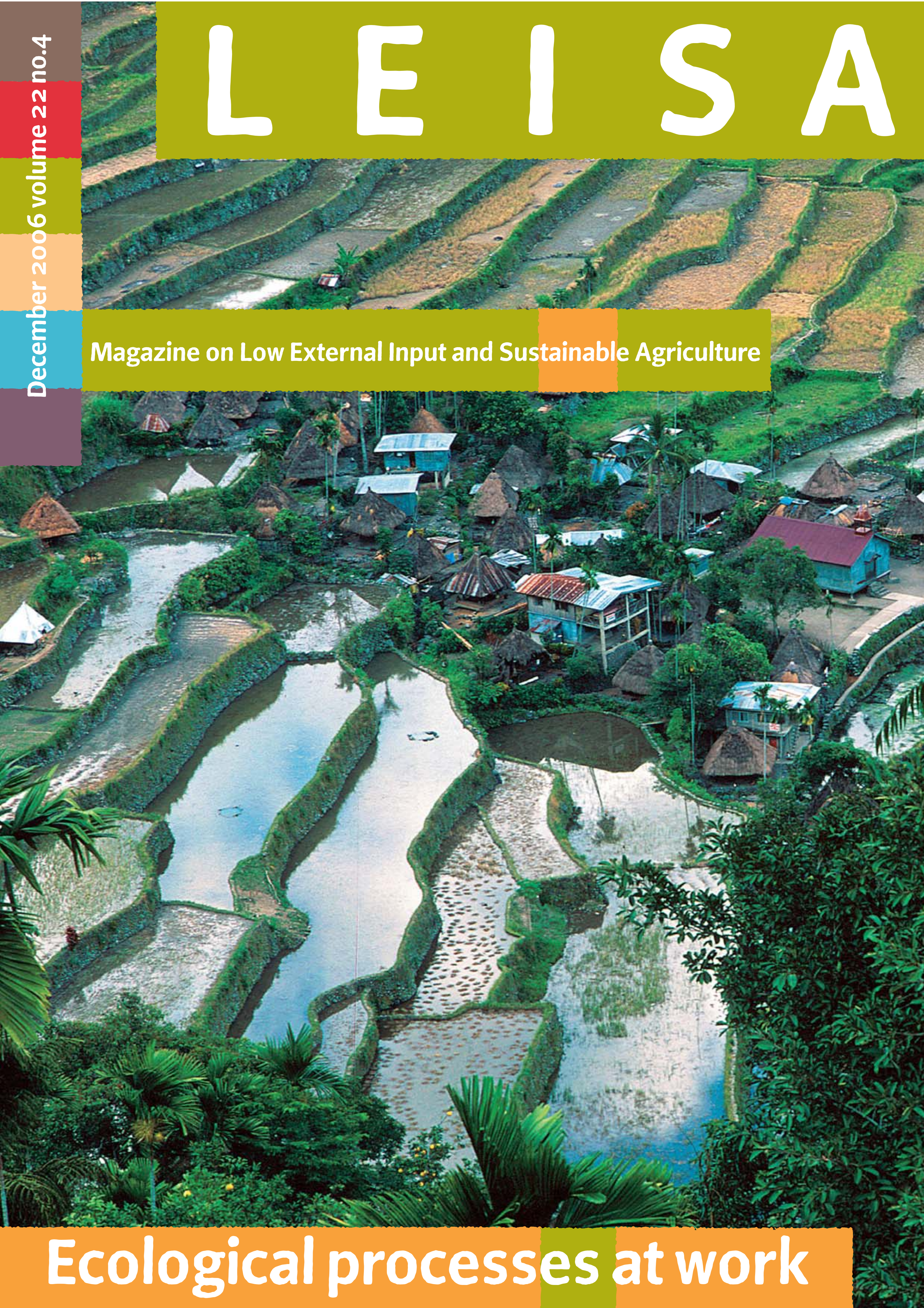

Ecological processes at work

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Magazine on Low External Input and Sustainable Agriculture
December 2006 Volume 22 No. 4

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Address:
P.O. Box 2067, 3800 CB Amersfoort, the Netherlands
Visitors address:
Zuidsingel 16, 3811 HA Amersfoort
Tel: +31 (0)33 467 38 70, Fax: +31 (0)33 463 24 10
E-mail: ileia@ileia.nl

Editorial team
This issue has been compiled by: Jorge Chavez-Tafur, Karen Hampson, Wilma Roem, Rik Thijssen, Anita Ingevall and Nicholas Parrott.

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Administration
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Cover photo
Rice terraces in Banaue, Luzon island, the Philippines.
Photo: Jeremy Horner, Panos Pictures.

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12 Powdered rock to revitalise soils

Edinei de Almeida, Fábio Junior Pereira da Silva and Ricardo Ralisch

Groups of farmer experimenters in the state of Santa Catarina in southern Brazil have been experimenting with different techniques to manage the soil fertility in their fields. One method they have been testing is the use of powdered rocks mixed with different sources of biomass, which has proved successful in revitalising the soils. This method is not about substituting inputs (substituting chemical fertilizers for powdered rock) but involves a change in the way we think about soil fertility management in an agroecosystem. Their results have been very interesting, and the process has also increased their understanding of some ecological processes important in soil fertility management.

22 Ecological processes and farmer livelihoods in shaded coffee production

V. Ernesto Méndez and Christopher M. Bacon

Shade coffee agroecosystems have exceptional potential for the conservation of tropical plant and animal species, in addition to producing high quality coffee. This article shows how this potential is linked to the farmers' livelihood strategies in six co-operatives of El Salvador and Nicaragua. The use of a Participatory Action Research approach facilitated the exchange of information between researchers and farmers. This mutual learning process helped to increase understanding of the ecological processes in shade grown coffee. This greater understanding has made it possible to develop better management practices (specifically in terms of soil fertility, pest and weed management), supporting the co-operatives and the livelihoods of their members.

LEISA is about Low External Input and Sustainable Agriculture. It is about the technical and social options open to farmers who seek to improve productivity and income in an ecologically sound way. LEISA is about the optimal use of local resources and natural processes and, if necessary, the safe and efficient use of external inputs. It is about the empowerment of male and female farmers and the communities who seek to build their future on the basis of their own knowledge, skills, values, culture and institutions. LEISA is also about participatory methodologies to strengthen the capacity of farmers and other actors to improve agriculture and adapt it to changing needs and conditions. LEISA seeks to combine indigenous and scientific knowledge, and to influence policy formulation to create an environment conducive for its further development. LEISA is a concept, an approach and a political message.

ILEIA is the Centre for Information on Low External Input and Sustainable Agriculture. ILEIA seeks to promote the adoption of LEISA through the LEISA magazines and other publications. It also maintains a specialised information database and an informative and interactive website on LEISA (**www.leisa.info**). The website provides access to many other sources of information on the development of sustainable agriculture.

25 SRI takes root in Nepal

Rajendra Uprety

Rice is the crop which contributes most to Nepal's national economy and is the main staple food for its people. But despite a lot of investment and efforts, the productivity of rice in Nepal has remained the lowest within this region. This situation encouraged some development workers to begin testing the System of Rice Intensification (SRI) in 2001, and after a few years of effort by different organisations and individuals, SRI is now becoming popular and establishing its position within the mainstream of agricultural development in the country. This article describes how this was achieved, discusses some of the challenges faced, and shows that for individual farmers, rice cultivation by SRI methods is becoming increasingly attractive due to its greater profitability compared with conventional methods.

DEAR READERS

This year is ending with some very good news: ILEIA's 2007-2010 programme proposal was approved for funding by DGIS, the Dutch Directorate-General for International Cooperation. We are proud of this recognition and also challenged by it. This means we can look forward to more issues of the *LEISA Magazine*, to a greater exchange of information, and to more editions of the regional magazines. We also look forward to working with new partners!

However, at the same time, we are saying good bye to Anita Ingevall, ILEIA's Director for the last six years. She is leaving us to return to her family and life in Sweden. ILEIA has been through many changes during the years she has been with us, and the positive results achieved are mainly due to her enthusiasm and energy. We wish her luck in her new life.

On a more practical level, we are continuously updating our website, and are pleased to announce that most articles are now also available as HTML files, an easier format to download and print. As always, we welcome new subscriptions via the website, the e-mail, SMS (+31 615 351187) or the form in this magazine. However, we are keen to know that the magazine is reaching the right people. We are therefore asking subscribers to stay in touch with us and renew their subscriptions. If you have received a red form, please contact us if you want to continue receiving the magazine.

In this issue you will also find enclosed a calendar for your wall – please display it in a prominent place and encourage others to subscribe. Our best wishes to all for a healthy and prosperous 2007.

The Editors

Ecological processes at work

Editorial

Agriculture is based on the same ecological processes, interactions and ecosystem services that occur in the natural environment – although this fact sometimes appears to have been forgotten in the drive to industrialise agriculture over the past half century. The ecological processes and the delivery of ecosystem services in nature are underpinned by a rich diversity of organisms, adapted to each other and making use of all possible niches in the physical environment. These processes can be positively or negatively influenced by human activities. Good examples of positive influences include some traditional agricultural systems, governed by an intimate understanding of local conditions and respect for the living environment. Negative examples include the intensive pollution of soil and water resources taking place today, and the rapidly increasing degradation of agricultural land.

The increased gulf between production and an understanding of basic ecological relationships has coincided with the increased use of external inputs, and has led to a rapid reduction in the knowledge which used to play a central role in the culture of rural communities. This has occurred partly as a result of the industrialisation of mainstream agricultural production, supported by "advanced" science. However, the science that has supported agricultural industrialisation has only focused on some parts of the production process and has neglected the basic understanding of agriculture as an ecosystem service and part of the Earth's ecology. Knowledge about the workings of ecological processes and how they can best be managed to support agricultural production is far from complete. Much of the existing knowledge is based on the experiences of pioneering farmers and observant agricultural professionals who time and again have shown the tremendous power of harnessing natural processes in agricultural production. By broadening our outlooks, trying out things which at first may not seem viable, and having an open mind, we may discover more than we thought possible.

In this issue of *LEISA Magazine* we present some examples of intensified agricultural production based on ecological processes. These show how production can be intensified in a much more natural way, by changing our perceptions about agriculture and increasing our knowledge of ecological processes. At the same time negative environmental effects can be avoided and other benefits are gained along the way.

Challenging the "known"

Developed in Madagascar more than 20 years ago by an observant development practitioner, the System of Rice Intensification (SRI) is now rapidly gaining acceptance by farmers in many countries. SRI was developed outside the formal agricultural research and development institutions and its spread is a result of information sharing through informal channels and farmer to farmer communication. SRI represents a radical shift in the way the world's most important cereal, rice, can be grown. The practices of SRI go against most conventional recommendations for rice production, yet still lead to increased yields. In this way SRI shows that there are new possibilities in agriculture. By drastically changing the management of soil, water, nutrients and the rice plants, it is possible to create a growing environment in which plants develop better, become stronger and healthier, and produce more –often much more– than the best conventional system. At the same time, this new system of rice production makes large savings on seeds and water requirements, and reacts better to organic manure than to inorganic fertilizers (Uphoff, p. 6, Uprety, p. 25). It is therefore particularly attractive to small scale farmers who have increasing difficulties in meeting the costs for external inputs.

Although many rice farmers are enthusiastically experimenting with SRI and reporting numerous successes, there is not yet any complete scientific explanation of how the system works or the processes through which these successes are achieved. This is one reason why the concept of SRI remains controversial. Uphoff shows that the good results can most likely be accounted for by combinations of ecological processes and mechanisms –some already known about and others not– that, together, support each other and optimise growing conditions for the rice plants.

The System of Rice Intensification represents a radical departure from conventional cropping practices. Yet, in essence the practices that underpin SRI are the same ecological processes that are utilised in ecological agriculture when applied to other crops. The significance of SRI is that the changes give such striking results that it has become difficult for scientists to disregard it. In this way, SRI provides an indication of the possibilities inherent in ecological agriculture, provided we try to understand, combine and manage the ecological processes optimally.

Ecological production

One of the better known and researched ecological processes of importance for agriculture is nitrogen fixation. Symbiotic bacteria associate with roots of leguminous plants, and in a process of mutual exchange, the bacteria provide the plant with nitrogen which they fix from the air, with the plant providing the bacteria with energy built through photosynthesis. Conventional agriculture sometimes makes use of this process when synthetic nitrogen is unavailable. However, this symbiotic relationship does more than just providing nitrogen. It increases the biomass above the soil surface, stimulates the root growth, adds organic matter, increases biological life in the soil and contributes to improving soil structure and fertility. The experiences of farmers from all over the world show that symbiotic nitrogen fixation, like other ecological processes, helps the development of optimal growth conditions for plants, allowing the crops to develop better, grow stronger and healthier, and be capable of producing good yields of qualitatively superior products. By providing good conditions and enabling the interaction of ecological processes, farmers can make these processes work for them. This makes their work more interesting, easier and much more rewarding.

As with SRI, the practices that enhance the functioning of ecological processes sometimes go against what is accepted as good practice in conventional agriculture. Ploughing the soil before establishing a new crop is one example; incorporating organic matter into the soil is another. The article on page 18 describes experiences with Conservation Farming in Zimbabwe. Conservation Farming takes advantage of natural ecological processes to conserve more moisture, enhance soil fertility, improve soil structure and reduce soil erosion. The presence of diseases and pests is also controlled through retaining crop residues on the soil surface, minimal soil disturbance and crop rotation. In addition to ensuring an adequate level of crop production, this technology is appropriate to farmers who lack proper tools and draught power for land preparation, and who, as a result of HIV/AIDS, also face limitations in labour availability.

The ecological explanation for such successful field experiences is that minimal soil disturbance allows existing soil life to provide plant roots with a healthy and fertile environment. It allows, for instance, earthworms and bacteria to play their roles in the decomposition of soil organic matter. In addition, it is increasingly becoming known that mycorrhiza, the long, thin threads of beneficial soil fungi that penetrate and live in mutual symbiosis with the roots of many arable crops, survive better and are more active when the soil in which they live is not disturbed.

A similar example can be found in coffee production. In Mexico and other parts of the world, coffee was traditionally grown more or less "in the forest". Bushes were planted between trees and other vegetation. With the increasing demand for higher yields, new varieties of coffee were developed that could produce these higher yields in full sunlight. Farmers were asked to increase coffee production and to change to modern varieties and a modern way of production which required synthetic inputs – as well as the removal of the forest. These practices increased yields – as long as the synthetic inputs were available at low and subsidised prices. When governments could no longer afford the subsidies, farmers were faced with a crisis in production. Méndez and Bacon (p. 22) report how farmers have managed to resolve this crisis by strengthening some of their traditional practices. Their experiences show that agroecosystems with coffee under shade produce higher quality coffee, and provide farmer families with other services and products of importance to their livelihoods, such as fuelwood, timber and fruits.
The shade grown coffee system closely resembles the original vegetational structure and composition and thus has an exceptional potential for conserving tropical plant and animal species.

Photo: T.M. Radha

Simple devices, such as this weeder, can assist in making the most of ecological processes.

These three examples are only some of the promising approaches to increasing agricultural production, which also help regenerate a degraded environment. All these approaches seek to enhance ecological processes and make them work in a way which does not compromise the environment. The practitioners of organic agriculture have long known that this is a feasible approach and have successfully managed to develop production systems based on the same principles.

The way forward

Ecologically based agriculture is continuously showing its potential to many farmers and consumers around the world. Although we know that it works in practice, much could be done to further explore the ecological processes and the relationships between them in more detail. A better understanding of plant physiology, plant-soil interactions, the contribution of soil micro-organisms to plant development, the interactions between different plant species, pest-predator relationships, and other natural processes and mechanisms is much needed. The better understanding that this would lead to, would help to further develop agroecosystems and optimise management practices within them. This, however, requires a change in direction of agricultural science, giving greater attention to the agro-ecological basis of farming rather than the development of single technologies. This implies a fairly radical shift in the knowledge system which farming is based upon. Such a shift would enable farmers to become more self-reliant in their management practices and would stimulate a stronger environmental awareness within the agricultural sector.

Farmers' management decisions are influenced by a number of factors. These include: tradition, knowledge, the security of their land holdings, economic possibilities, family size, external advice, access to resources and subsidies, risk aversion, alternative employment opportunities, the community in which they live as well as personal aptitude. In most cases, farmers continue to farm as they have learnt to farm, perhaps adopting gradual changes over time. In the article on p. 30, Stoop shows that while farmers may be aware of and interested in ecological crop production, they may not be prepared to adopt the new practices. The reasons for this are many, and farmers' individual circumstances will determine whether they are interested in adopting new practises or not. Their personal aspirations, needs, economic potential and socio-cultural situation are key determinant factors.

However, we all exist within our societies and farmers are no different. Our personal choices are influenced and limited by the framework of rules, regulations and values of the society in which we live. The pattern of resource distribution, access to knowledge and resources, and the prevailing priorities and policies, serve as incentives or disincentives to adopting new approaches. If ecological agriculture were given the same priority, in terms of research, development and promotion that industrialised agriculture has received over the past fifty years or so, then its potential and acceptance could be greatly enhanced. This suggests a strong need for changed policies, a new and different focus in agricultural research, and increased support for rural communities in terms of education, health and rights to resources. Together, these changes could make major contributions to a more sustainable agricultural production, reduced poverty and increased food security. ■


Photo: Edwin van der Maden

SRI initially requires more effort while farmers gain knowledge, skill and confidence. Here members of a self-help group exchange ideas.

The System of Rice Intensification and its implications for agriculture

Norman Uphoff

The System of Rice Intensification (SRI) reported on by several other contributors to this and previous issues of the *LEISA Magazine* is casting new light upon both "modern" agriculture and agroecological alternatives. Just because something is widely believed or practised does not necessarily make it true or optimal. Keeping our minds open to new evidence and new ideas is essential for faring well in the contemporary world.

Some old agricultural truths reconsidered

Twenty years ago, either of the following two statements would have elicited derision and dismay: "Farmers do not need to plough their fields to get the best results", "To get the best yield, farmers growing irrigated rice should not flood their paddies".

Because ploughing fields and flooding rice have been dominant practices for hundreds of years, both these statements would have appeared ludicrous to most farmers and most experts. "Everybody knew" that the statements were wrong. Conventional wisdom was supported by good logic, even though there were scientific reasons for casting some doubt upon it.

In the case of ploughing, agronomic requirements for crop establishment and weed control appeared to dictate it to be a necessary practice – even though agronomists had identified that ploughing had many harmful effects, especially deep ploughing. These included the loss of nitrogen and organic matter from the soil; loss of soil structure; increased wind and water erosion; and a decline in populations of earthworms and other beneficial soil organisms. The assumption of farmers and researchers that ploughing is essential for successful cropping has been revised in recent decades. No-till cultivation or zero-tillage –or their more robust version, Conservation Agriculture– have been proving beneficial for farmers' net incomes and for the environment. In the United States, the heartland of large scale mechanised tillage, more than 30 percent of the cropped area is now under some form of reduced-till or no-till, and globally, more than 70 million hectares are cultivated according to Conservation Agriculture.

Rice was considered in the literature, and by farmers, to be a water-loving plant. A leading text on rice states categorically: "A main reason for flooding a rice field is that most rice varieties maintain better growth and produce higher grain yields when grown in a flooded soil than when grown in a non-flooded soil". This belief has been sustained in the face of growing evidence to the contrary, and knowledge that soils with insufficient oxygen are detrimental to plant roots and most soil organisms. In this context, SRI has provided results that demonstrate that substantially increased yield can be obtained with 25 to 50 percent less water than is commonly used for irrigated production. This is because unflooded soil conditions offer many advantages for the growth of plants and soil fauna.

The lesson to be drawn from both these instances of revised agricultural wisdom is that some long recommended (one might even say, revered) practices can turn out to be constraints if they prevent practitioners and scientists from "thinking outside the box."

Revising the input-dependence of modern agriculture

By achieving higher yields and greater profitability with fewer purchased inputs, SRI is showing that the input-dependence of modern agricultural practices is not necessarily the most productive or the most economic approach. This alternative system manages plants, soil, water and nutrients differently – in ways that increase the abundance and diversity of the soil biota. Farmers are finding that they can get more output by reducing their external inputs, rather than by increasing them.

SRI initially requires more effort while farmers gain knowledge, skill and confidence. This initial cost (investment) is offset by reduced requirements for seed (by 80-90 percent), water (by 25-50 percent), and costs of production (by 10-30 percent). Results reported from eastern Indonesia, from 1849 on-farm comparison trials over three years on 1363 hectares, are representative of the productivity gains reported elsewhere: an 84 percent increase in yield achieved with a 40 percent reduction in water and a 25 percent reduction in production costs, which resulted in a five-fold increase in net income. Similar results have been documented in India, and in this issue, Uprety gives data on similar benefits achieved by farmers in Nepal.

Reducing water applications can require physical and organisational capabilities for water control, which are not always available. This can be a constraint to the adoption of SRI, but less than perfect control can still permit improvements from the other technological components of the system. The drastic reduction in plant populations under SRI is the main reason that labour requirements can be decreased over time. This has been documented in evaluations by the International Water Management Institute in India and GTZ in Cambodia, as well as by Cornell University researchers in Madagascar. One Chinese evaluation reported that farmers in Sichuan considered labour-saving to be the most important aspect of SRI.

Agroecological practices usually involve some trade-off between more labour input to achieve reductions in other inputs. The net result is an improvement for farmers and the environment. However, SRI can reduce all the inputs and increase their productivity because it mobilises productive inputs from soil biota, which are inhibited, suppressed or

Advantages and benefits of SRI

Field experiences from all over the world have shown many wider benefits resulting from SRI management:

- SRI practices provide immediate benefits. There is no "transition" period, as necessary with many conversions to a more organic agriculture. After prolonged exposure to synthetic chemicals soil ecosystems often require some time to become fully restored. SRI yields generally improve over time, but there is no initial period of loss: first-season yields are usually higher than before.
- Accessibility for the poor. The lower capital costs of using SRI mean that its economic and other benefits are not limited by access to capital, nor does it require loans and indebtedness. It can thus contribute rapidly to greater food security for the poor. Some initial evidence suggested that labour requirements made SRI less accessible to the poor; but a larger study in Sri Lanka found poorer farmers to be as likely to adopt SRI as richer ones, and less likely to abandon it.
- Human resource development. The recommended strategy for dissemination of SRI emphasises farmer experimentation and encourages farmer innovation in ways that conventional agricultural technology development and extension strategies do not. Father de Laulanié, who first promoted SRI, intended that it should enhance the human condition, not just meet people's material needs.

While most attention has been focused on increases in yield, this is only one consideration among many when assessing production systems:

- No need for mineral fertilizers, which are a major cost in modern agriculture and have adverse environmental impacts. Compost gives better yields.
- Little or no need for other agrochemicals, since SRI plants are more resistant to damage by pests and diseases.
- While more labour is initially required, current documentation shows that SRI can even become labour-saving once farmers have mastered its methods.
- Yield increases of 50 -100 percent are seen, without changing rice varieties. There is no need to buy new seed, since all varieties respond to these methods, although some varieties respond better than others.
- Greater profitability. The costs of production with SRI averaged about 20 percent less per hectare, according to seven evaluations from five countries (Bangladesh, Cambodia, China, India and Sri Lanka). This, along with higher yields, means farmers' incomes from rice production increase by more than just their yield increase.
- Environmental benefits. Reduction in water requirements and reduced reliance on agrochemicals for high yield takes pressure off water-stressed ecosystems and enhances soil and water quality.

In specific agronomic terms, SRI farmers report the following advantages along with their higher yield and profitability:

- Drought resistance. Because SRI rice plants develop larger and healthier root systems, and establish these at an early age, the plants are more resistant to drought and periods of water stress.
- Resistance to lodging. With stronger root systems and tillers, in part due to the greater uptake of silicon when soil is not permanently saturated, SRI plants show remarkable resistance to wind, rain and storm damage.
- Reduced time to maturity. When SRI methods are used properly the time for maturation can be shortened by as much as 15 days, even while yield is being doubled. This reduces farmers' risk of agronomic or economic losses due to extreme weather events, pests or disease and/or frees up the land for other production.
- Resistance to pests and diseases. This has been frequently commented on by farmers and is now being documented by researchers. The China National Rice Research Institute, for example, reported a 70 percent reduction in sheath blight in Zhejiang province.
- Conservation of rice biodiversity. While high-yielding varieties and hybrids have given the highest yields with SRI methods (all SRI yields over 15 t/ha have been achieved with improved cultivars), very respectable yields can be obtained with traditional varieties as SRI plants resist lodging despite their larger panicles. In Sri Lanka, farmers using SRI methods have obtained yields of between 6 and 12 t/ha with "old" varieties. These are more profitable to grow because consumers are willing to pay a higher price for them, preferring their taste, texture and aroma.

Adapted from: Uphoff, N. 2005. **Agroecologically-sound agricultural systems: Can they provide for the world's growing population?** Keynote for the University of Hohenheim's 2005 Tropentag, Hohenheim, Germany.

unbalanced by agrochemical applications or are limited to anaerobic organisms by flooding.

Changing production systems that have heavily utilised chemical inputs to systems that rely primarily on organic fertilisation usually involves a period of adjustment after the inorganic inputs are halted. However, SRI farmers usually achieve year-on-year improvements as soil fertility improves, with no initial penalty for converting to the new practices. However, for long-term sustainability of productivity, continued provision of organic matter to the soil will be necessary. SRI is not unique among more biologically-based production systems in offering substantial productivity gains resulting from a reduction in dependence on external inputs. The SRI experience has prompted more systematic consideration of scientific knowledge about agricultural production systems that are less dependent on chemicals.

SRI in a broader perspective

Two factors underlie the concurrent increases that SRI achieves in the productivity of land, labour, water and capital employed in irrigated rice production. These are quite different from the changes that sparked the Green Revolution. The increases in cereal production accomplished under the Green Revolution depended on a) genetic changes in crop potentials to make them more responsive to external inputs, and b) increases in inputs of water, fertilizer and other agrochemicals.

SRI involves neither of these strategies. Instead, it a) enhances the growth and health of plant roots, which are generally given little attention in crop science, and b) mobilises the services of vast numbers of soil organisms, ranging from the microscopic bacteria and fungi up to earthworms and other macro-fauna. SRI is reminding everyone of the importance of symbiotic relationships between plants and soil organisms – relationships that go back more than 400 million years. Studying these relationships is difficult and demanding, but they represent the next major “frontier” for agricultural scientists.

We know that SRI is still a work in progress, with knowledge and understanding accumulating from season to season, and we expect that SRI performance will attract more interest from researchers, extensionists, policy-makers and, of course, farmers. Farmers in a number of countries are already extrapolating SRI concepts and techniques to other crops such as millet, sugar cane, wheat, cotton, even chickens!

Practitioners of agriculture who have paid close attention to the ways in which their crops grow under different conditions often have a good sense of the linkage between soil fertility and the living status of the soil. The very term “soil” does not reflect adequately the extent to which its fertility is a consequence of the life within it – the abundance, diversity and activity of soil organisms. It would be better to talk and think in terms of “soil systems”, as implied by the motto of organic farmers: “Don’t feed the plant – feed the soil, and the soil will feed the plant”.

This may not sound very scientific to some readers, but the scientific basis of such an agroecological conception of farming is growing every year. The foundations of this knowledge are reviewed in Uphoff *et al.* (2006), and the penultimate chapter suggests that this body of knowledge provides a basis for a “post-modern agriculture”. This is more appropriate to the conditions and realities of the 21st century than many of the technologies currently in use. The emerging paradigm for post-modern agriculture differs from its namesake in the arts and humanities in that it embraces modern science, rather than being hostile to it. Indeed, post-modern agriculture is the most modern agriculture because it builds upon cutting-edge research in microbiology and ecology:

- It is not hostile toward genetic improvement, but it does not regard advances in agriculture as being primarily led by the manipulation or modification of genes. Genetic differences are very important for capitalising on all available inputs, but these differences should be considered in an interactive rather than deterministic fashion.
- There can be a role for soil nutrient amendments to correct deficiencies or imbalances, so it is not “organic” in a doctrinaire way. It does, however, reject efforts to accelerate plant growth by “force feeding” plants, with large amounts of nutrients. This supply-side approach is generally less effective and less efficient than one which nurtures and supports plants’ demand for nutrients.

A general principle of post-modern agriculture is that plant-soil-water-nutrient management practices should foster synergistic relationships between plants and soil organisms. With SRI, when paddies are not kept flooded, weed control becomes a challenge. But the use of a rotary hoe aerates the soil at the same time as it churns weeds back into the soil, where they decompose and their nutrients are retained within the cropping system. Formal studies remain to be done on the effects of this kind of weeding, but substantial data sets from both Madagascar and Nepal show that additional weedings, beyond what is needed just to control weeds, can add between one and two tonnes per hectare to yield, without the application of inorganic nutrients.

The building blocks for this extra growth have to come from somewhere, and they are obviously being mobilised from within soil and plant systems, both of which contain tens of billions of micro-organisms. For example, recent research reported from China has documented how soil rhizobial bacteria migrate into the roots and up through the stem, their presence in leaves adding to the production of chlorophyll and photosynthate and consequently to grain yield.

There is still much more to learn about these relationships and their present and potential contributions to agriculture. My conclusion from a decade of working with SRI and being drawn into the larger realm of agroecology is that, as agricultural scientists, we should expand our thinking beyond the primarily chemical and physical understanding of soil, to encompass and make central the myriad of biological factors, that are at play both in the soil and above it. To achieve this we need to add also a cognitive dimension, as thinking and knowledge are critical for comprehending and making use of these factors in more productive and more sustainable ways.

■

Norman Uphoff. Director, Cornell International Institute for Food, Agriculture and Development (CIIFAD) / Professor, Department of Government, College of Arts and Sciences, Cornell University. Ithaca, New York 14853, U.S.A.
E-mail: ntu1@cornell.edu

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Managing pests through plant diversification

Miguel A. Altieri, Luigi Ponti and Clara I. Nicholls

Agroecology provides guidelines for developing diversified agroecosystems that take advantage of the integration of plant and animal biodiversity. Successful integration of plants and animals can strengthen positive interactions and optimise the functions and processes in the ecosystem, such as the regulation of harmful organisms, recycling of nutrients, biomass production and the build up of organic matter. In this way agroecosystems can become more resilient. Farmers need to identify and support processes that strengthen the functioning of the agroecosystem. These will include:

- natural pest control;
- decreased toxicity through avoiding the use of agrochemicals;
- optimised organic matter decomposition and nutrient cycling;
- balanced regulatory systems such as nutrient cycles, water balance, energy flow and populations of plants and animals;
- enhanced conservation and regeneration of soil and water resources and biodiversity;
- increased and sustain long-term productivity.

Today there is a wide selection of practices and technologies available to improve the functioning of agroecosystems. When these agroecosystems are developed so that they are in tune with existing environmental and socioeconomic conditions, the end result is improved ecological sustainability. By adopting key ecological management practices the farmer can increase the stability and resilience of the agroecosystem. These practices should contribute to:

- increasing the plant species and genetic diversity in time and space;
- enhancing functional biodiversity (for example natural enemies);
- enhancing soil organic matter and biological activity;
- increasing soil cover and crop competitive ability; and
- removing toxic inputs and residues.

In this article we explore one example of agroecology – the restoration and management of agricultural biodiversity for pest control in vineyard monocultures in California, U.S.A. The principles for improving ecologically vulnerable vineyard monocultures can be applied to other simplified cropping systems. Improved biodiversity establishes a sound ecological base where key ecological processes, such as pest regulation, can function effectively. It is also crucial for crop defences: the more diverse the plants, animals and soil-borne organisms within a farming system, the more diverse the community of pest-fighting beneficial organisms.

Photo: M.A. Altieri

Creating habitats for natural enemy species on the least productive parts of the farm is an important strategy. The island of flowering plants, behind the fence in this photo, acts as a push-pull system for natural enemy species.

In vineyards, farmers can enhance biodiversity by:

- increasing plant diversity by growing cash crops between the vines;
- planting cover crops between the vines;
- managing the vegetation in surrounding fields to meet the needs of beneficial organisms;
- designing corridors of plants that make it possible for beneficial organisms to move from nearby forests or natural vegetation towards the centre of the fields; or by
- selecting non-crop plants grown as strips in fields, whose flowers match the requirements of the beneficial organisms.

All these strategies provide food (pollen and nectar), as well as hiding places, for predators and parasitic wasps, thereby increasing the diversity and numbers of natural enemies in vineyards. These factors contribute to optimising a key ecological process: pest regulation.

Biodiversity in vineyards

There are two distinct types of biodiversity in vineyards. The first, called planned biodiversity, includes the vines and other plants grown in the vineyard such as cover crops or corridors. The second type, called associated biodiversity, includes all flora and fauna that come from surrounding environments to live in the vineyard, and which will, under suitable management, thrive there. The relationship between these different types of biodiversity is illustrated in Figure 1.

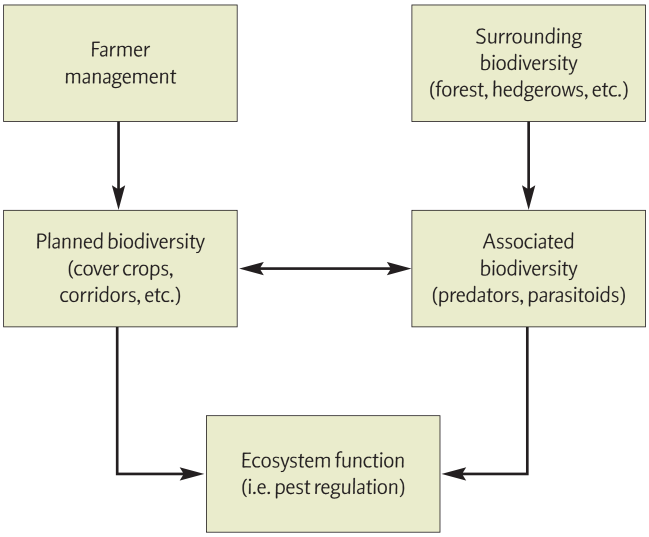

Figure 1. Relationship between several types of biodiversity and their role in pest regulation in a diversified vineyard.

Planned biodiversity has a direct function. For example, cover crops enrich the soil, thus helping vine growth. They have a direct function in enhancing soil fertility. Yet, they also have an indirect function, in that their flowers contain nectar which attracts wasps. These are the natural parasitic wasps of pests that normally attack the vines and are part of the associated biodiversity.

The challenge for farmers is to identify the type of biodiversity that they wish to maintain and enhance on their farms in order to enable specific ecological services (i.e., pest regulation), and then to decide on the best practices for encouraging such biodiversity. In our experience, cover cropping and creation of habitats within and around vineyards are key strategies.

Increasing biodiversity

In California, many farmers either manage ground vegetation or plant cover crops to provide a habitat for natural enemies during the winter. These practices reduce the numbers of mite and grape leafhoppers but are often not sufficient to avoid economic losses from pest attacks. Usually the problem is due to the common practice of mowing or ploughing under the winter cover crops or weedy resident vegetation at the beginning of the growing season. As a result, from late spring on, these vineyards become virtual monocultures without floral diversity at the beginning of the growing season. Pest control is better achieved by providing habitat and food for natural enemies throughout the entire growing season. The green cover should therefore be maintained during spring and summer. One way to achieve this is to sow summer cover crops that flower early and continue to flower throughout the season. This provides a highly consistent, abundant and well-dispersed food source, as well as microhabitats for a diverse community of natural enemies. In this way it is possible to build up the number of natural enemies in the system early in the growing season, which helps keep pest populations at acceptable levels.

In a vineyard near Hopland, northern California, summer cover crops such as buckwheat (*Fagopyrum* sp.) and sunflower were maintained throughout the growing season. This floral diversity increased the associated natural enemies and reduced the abundance of western grape leafhoppers and western flower thrips (see box). During two following years (1996-1997), the areas with flowering cover crops had lower densities of thrips and grape leafhoppers and there were more predators on the vines in the cover-cropped sections than in the monocultures. Generally, the number of predators was low early in the season, but increased as prey became more numerous as the season progressed. Dominant predators included spiders, *Nabis* sp., *Orius* sp., *Geocoris* sp., coccinellids, and *Chrysoperla* sp.

Designing corridors

The abundance and diversity of beneficial insects within a field depends on the diversity of plants in the surrounding vegetation. To take advantage of this insect diversity, some farmers have established corridors composed of several flowering species, which connect to forests near water sources and cut across their vineyards. Such corridors serve as "biological highways" for the movement and dispersal of predators and parasitic wasps into the centre of the vineyards.

Studies conducted in the Hopland organic vineyard showed that predator species, including spiders, were often found on the flowers of the plants in the corridor, demonstrating that populations of key predator species become established and circulate within the corridor. In both years studied (1996-97) the number of harmful adult leafhoppers was clearly lower in the vine rows close to the corridor and gradually increased toward

Key pests in vineyards and their natural enemies

Key pests	Natural enemies
Frankiniella occidentalis (Thrips)	Orius spp. (minute pirate bug), coccinellids, spiders, Nabis sp.
Erythroneura elegantula (Grape leafhoppers)	Anagrus epos (parasitic wasps), spiders, Geocoris sp., chrysopids

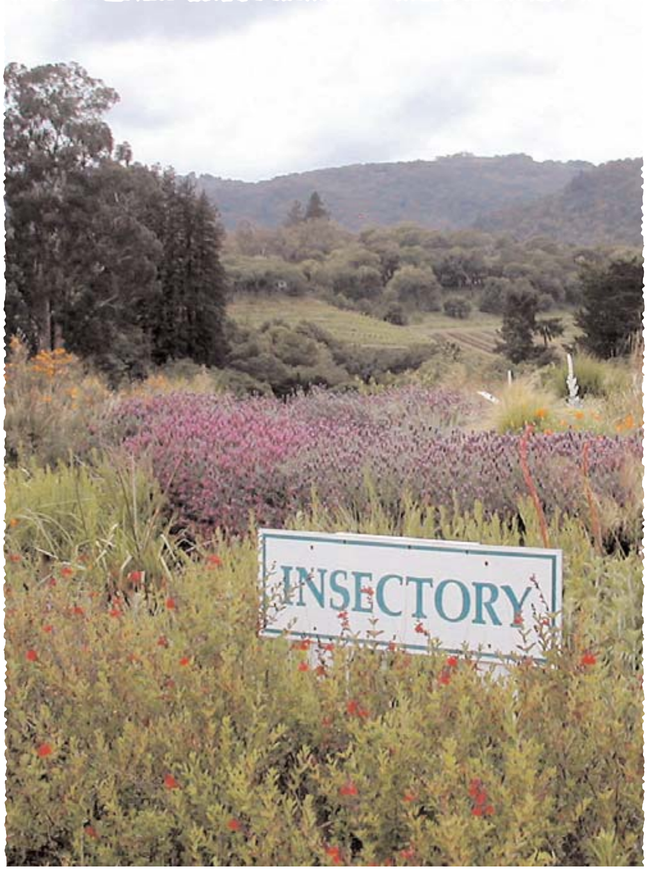

Photo: M.A. Altieri

The size and shape of flowers determine which insects are attracted to the "insectory".

the centre of the field. The highest concentration of leafhoppers and thrips occurred 20 to 25 rows (30 to 40 metres) downwind from the corridor. In both years substantially more thrips were caught in the central rows than in rows near to the corridor.

Flowering islands

Creating habitats on the least productive parts of the farm to concentrate natural enemies is another important strategy. This approach is used in a biodynamic farm in Sonoma County, where an island of flowering shrubs and herbs was created at the centre of the vineyard, which acts as a push-pull system for natural enemy species.

The island provides pollen, nectar and neutral insects from early April to late September for a variety of predators and parasites including *Anagrus* wasps. During the 2004 season, the island was dominated by neutral insects that forage on the various plants, and which provide food for natural enemies. As a result, the natural enemies slowly increased in number in the adjacent vineyard as the season progressed. Many natural enemies moved from the island into the vineyard, a distance of up to 60 metres. *Orius* sp. and coccinellids move to the vineyard at the beginning of the season, followed later in the season by syrphid flies and *Anagrus* wasps. Parasitisation of leafhopper eggs by *Anagrus* wasps was particularly high on the vines near the island, but lower nearer the centre of the vineyard.

Ways forward

A key strategy in agroecology is to enhance biodiversity at the landscape and field level. As in the case of vineyards, diversified agroecosystems develop ecological properties that increase their capacity for self-regulation. The basis for ecological pest management is increased agroecosystem diversity. This serves as a foundation for establishing the beneficial interactions that promote the ecological processes needed for pest regulation.

It is important to establish a diversity of plants to attract an optimal number and mix of natural enemies. The size and shape of the flowers determine which insects are attracted, as only those who are able to access the flowers' pollen and nectar will make use of the food sources provided. For most beneficial insects, including parasitic wasps, the flowers should be small and relatively open. Plants from the Compositae (for example, daisy or sunflower) and Umbelliferae families are especially useful.

The period during which the flowers are available is as important as the size and shape of the flowers. Many beneficial insects are only active as adults and for specific periods during the growing season; they need pollen and nectar during these active periods, particularly in the early season when prey is scarce. With this knowledge farmers can provide mixtures of plants with relatively long, overlapping, flowering times.

Current knowledge about which plants are the most useful sources of pollen, nectar, habitat and other critical needs is far from complete. Clearly, many plants encourage natural enemies, but scientists have much more to learn about which plants are associated with which beneficial insects, and how and when to make desirable plants available. Because beneficial interactions between plants and insects are site-specific, the geographic location and overall farm management are important aspects to consider.

Farm planning

Once farmers have a good knowledge of the characteristics and needs of key pests and their natural enemies on their farm, they can develop a management strategy. A few guidelines need to be considered:

- Consider the size of the habitat which is to be improved (e.g., field or landscape level);
- Understand the predator-parasite behaviour which will be influenced by managing the habitat;
- Decide on the most beneficial arrangement (within or around the fields) of the plants considering local conditions and time of flowering;
- Select the most appropriate plant species; preferably those with multiple benefits, such as improving pest regulation and contributing to soil fertility and weed suppression;
- Be aware that adding new plants to the agroecosystem can affect other agronomic management practices and be prepared to develop ways to manage this.

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Miguel A. Altieri, Luigi Ponti and **Clara I. Nicholls.** University of California, Berkeley. ESPM-Division of Insect Biology, 201 Wellman Hall-3112, Berkeley, California 94720-3112, U.S.A. E-mail: agroeco3@nature.berkeley.edu

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Photo: AS-PTA

Making "independence fertilizer" – the soil is enriched by adding a mixture of different types of manure, powdered rock and various types of carbohydrates.

Powdered rock to revitalise soils

Edinei de Almeida, Fábio Junior Pereira da Silva and Ricardo Ralisch

Small scale farmers in the south of Brazil face similar challenges as farmers in many other regions of the world. The slash and burn system worked well when there was enough land to allow sufficiently long fallows for the land to recover, but with an increasing population and the division of land into smaller pieces with each generation, it is no longer possible to maintain soil fertility. Green Revolution technologies, using mineral fertilisers, have been promoted but are not a viable option for the majority of smallholder farm families due to the high costs. The negative environmental impacts these fertilizers can cause in the longer term is also a concern.

Despite the many differences between modern and traditional methods of managing soil fertility, they are based on the same idea: that nutrients must be made readily available in a form which is easy for the plants to take up. However, when nutrients are easily available, they can also be easily lost through leaching or erosion. They can also become unavailable by being fixed to soil particles. Both methods of soil fertility management therefore depend on the continual replacement of nutrients to support crop production.

Ensuring the maintenance of soil fertility in the long term is one of the principal objectives of managing agroecosystems. In agroecology, the emphasis is on the management of the biological processes that guarantee the continual recycling of nutrients, rather than simply on providing easily available nutrients for direct plant uptake. This approach makes use of locally available natural resources and reduces the need for external inputs in rural communities.

Powdered rock for soil remineralisation

For more than 10 years, the Brazilian NGO *Assessoria e Serviços a Projetos em Agricultura Alternativa* (AS-PTA) has been working with small scale farming families in Paraná and Santa Catarina states, Brazil. At present there are about 400 families, in 52 communities spread across 17 municipalities, who are directly involved in developing and trying out innovative methods in ecological agriculture.

The families have formed groups that are testing the use of powdered rocks mixed with different sources of biomass as a technique to manage soil fertility. The experiments are aimed at remineralising the soils, and encouraging the biological activity which is needed to ensure that nutrients are constantly being recycled in the biomass of the farming system. In this way, the losses of nutrients from the soils are significantly reduced.

It is important to recognise the difference between these two approaches – the powdered rocks are used to accelerate the biological processes in the soils, and not as sources of nutrients to be directly taken up by plants. This method is not about substituting inputs (substituting chemical fertilizers for powdered rock), but involves more of a change in the way we think about soil fertility management in an agroecosystem.

Nutrients are released from the powdered rock through the action of organic acids produced by plants and micro-organisms, and decomposing biomass in the soil. As this is an ecological process directly related to biological activity, powdered rock only enhances soil fertility when the soil life is stimulated by cultivation. Research results show that powdered rock is not very effective in annual crops due to the low solubility of these materials in the soils. These conclusions derive from experiments conducted under the "substitution of inputs" logic, the conventional soil fertility management school of thought. The results found by the farmer-experimenters in this project contradict this widely accepted viewpoint. These conflicting views can be explained by the differences in perception of the purpose of the use of powdered rocks in soil fertility management.

Experimenting with powdered rock

The farmer-experimenters conducted the experiments on their own land. These were not conducted according to conventional scientific practices, such as using repetitions and variables. Instead, the families worked one area of land using their traditional methods, and another part of their land with the new techniques. The conclusions were arrived at through comparative observations of different indicators. Meetings between the farmer-experimenters were arranged so that the observations could be shared by the members of the group, and between groups. By continuing to experiment, and through interaction between farmer-experimenters, continual improvements in knowledge about management practices were generated.

Experimenting with powdered rocks began about ten years ago with the use of phosphate from a source about 300 km from the region. More recently, powdered basalt, the parent material of most soils in the region, has also been used. This is a cheaper and more readily available alternative. It has a good balance of macro- and micronutrients, an important benefit in agricultural terms.

Various strategies have been developed to increase the release of nutrients from the powdered rocks. One of these involves using the powdered rock as one ingredient in making a locally adapted compost known as "independence fertilizer". This consists of a mixture of soil, different types of manure, plant biomass, powdered rock and various types of carbohydrates such as molasses and sweet potato (which would otherwise be waste materials), which is allowed to ferment. The carbohydrates encourage the start of microbial activity. This "independence fertilizer" helps to enrich the soil by reintroducing the various types of micro-organisms, found in forested areas, back into the agricultural areas. On average around 800 kg/ha is applied. The powdered rocks (natural phosphate and basalt) in this formula enrich the environment for the micro-organisms and at the same time, the organic acids produced by these micro-organisms help release nutrients which can then be made use of by the plants.

Another strategy developed by the farmer-experimenters is the use of powdered rock in crop stands of species that are capable of absorbing nutrients that are not very soluble. After these species reach maturity, they decompose, making the nutrients that they have absorbed available to the following crop. Various species of green manure crops have been used effectively in this way. Other species used in the same way have different benefits, for example, the capacity to fix atmospheric nitrogen, making the phosphate fixed in clay soils more available, improving soil structure, or breaking down compacted layers of topsoil. The most commonly used winter green manure species are black oat (*Avena strigosa*), white lupin (*Lupinus albus*), common vetch (*Vicia sativa*), hairy vetch (*Vicia villosa*), and corn spurry (*Spergula arvensis*). Summer species have not been used very much so far, and need more attention from the farmer-experimenter groups.

Observations from the different farmer-experimenter groups have led them to the conclusion that the application of powdered rocks brings positive effects in the same agricultural year. All the groups have observed that the plants are healthier and more vigorous and that total biomass production is higher in the areas where the rock is applied. These observations were recently confirmed through another more formal experiment with the no-tillage cultivation system in Paraná state. This verified the increases in production of biomass of a mixture of winter green manure species, 133 days after the application of powdered basalt. Green manure crops receiving powdered basalt, in doses of 3000 and 4000 kg per hectare produced 69 and 65 percent respectively more biomass than the control plot.

As well as having multiple positive effects on soil fertility the green manures, which also produce a lot of biomass, play another important role. When they are left on the soil as mulch, they act as a layer preventing weeds establishing themselves within the planted crop. This makes it much easier for families to manage large areas of directly planted crops without having to resort to herbicides.

Changing perceptions

Before the use of powdered rocks is more widely accepted as stimulus to soil productivity (and not as a substitute for chemical fertilizers), the traditional view that the productivity of soils is only associated with the availability of plant nutrients in mineral form needs to be overcome. A change in perception and understanding is needed. By working with, and developing innovative techniques in the ecological management of soils, the groups in the region have begun to perceive soil fertility in different and new ways, and gain a better understanding of the ecological processes involved.

To further this change in perception, AS-PTA, in conjunction with the Londrina State University and the Brazilian National Agricultural Research Organisation (EMBRAPA), has been developing a research project to document various soil quality indicators with the local experimenting groups. The objective of this project is to look for correlations between changes in selected biological indicators and the productive capacity of ecologically managed soils.

The effects of the use of powdered rocks in the management of biomass for soil fertility and productivity can clearly be seen when evaluating soil quality. Examining factors such as root growth and profile, soil structure and soil life, the farmers have gained a better understanding of some of the ecological processes that improve soil fertility and can integrate this more complex view into their decision-making processes. For example, many now realise that improving the physical structure of the soils improves the root profile of the crop, meaning that the plants are better able to access the nutrients and water present in the deeper layers of the soils. These new understandings have led farmers to expand their soil management techniques beyond the practices of supplying nutrients and removing weeds that compete with the cultivated crop.

Through participating in these groups, the farmers have also increased their capacities for managing their farms and, as such, the benefits of the whole process are greater than just the results of the experiments. These new understandings and experiences will continue to be developed in the future and will further contribute to improving the livelihoods of farmers in Santa Catarina.

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Production of powdered basalt

Although basalt is abundant and readily available in the region, it must be used in the powdered form to allow for the attack of organic acids which accelerates nutrient release. The raw material comes in the form of small rocks from stonemasons in the area. AS-PTA, in conjunction with FAFI (the College of Philosophy, Science and Languages in Itajubá, Santa Catarina state), has been developing different types of grinders for use by the communities. The machines cost around 3300 euros each, and produce enough powdered basalt for a community of about 80 family farmers. The grinders enable communities and groups to produce powdered basalt themselves, and have greater autonomy over its use. Although there are four grinders currently in use in the region, the production is not enough to meet the growing demand from community groups involved in the agroecological networks in the region.

Edinei de Almeida. AS-PTA, Rua Candelária, No. 9, 6° andar Centro, Rio de Janeiro, RJ 20091-020, Brazil. E-mail: edinei@aspta.org.br

Fábio Junior Pereira da Silva. FAFI - Faculdade de Filosofia, Ciências e Letras de Itajubá (Philosophy, Science and Languages State College), Santa Catarina, Brazil.

Ricardo Ralisch. Universidade Estadual de Londrina (Londrina State University), Londrina, Paraná, 86051-990, Brazil.

The Mambwe mound cultivation system

John Andrew Siame

In the Northern Province of Zambia, many small scale farmers practise shifting cultivation (known locally as *chitemene*) in the *miombo* woodlands. Though farmers are able to grow an average of three successive crops under this practice, soil fertility and crop yields decline after the third year, meaning that farmers have to open new fields. Studies have shown that the *chitemene* system can be sustained so long as the population density does not exceed seven persons per square kilometre. However, with improvements in health and nutrition, rural populations have been growing. Farmers are no longer able to wait for up to 25 years, the length of time fields were traditionally left fallow to restore their natural fertility, before returning to fallowed fields. They now wait around 10 years. This has led to a breakdown in the effectiveness of the *chitemene* system. This breakdown is also due to increased tree felling, which leaves less available biomass to help restore fertility.


Photo: Peter Strømgaard

Planting beans brings additional benefits to the system and provides an early crop for farmers.

Restoring and maintaining soil fertility is therefore a major challenge for sustaining crop and soil productivity in this area. Slash and burn is still widely practiced because it improves soils, although this effect is only short term. One of the problems of practising slash and burn is that the annual cutting of trees to open new areas for cultivation within the *miombo* woodland increases the distances to the fields, and will eventually lead to the disappearance of all the forests. Farmers have had to find alternative cultivation methods, which minimise the walking time to the fields, which can sustain soil and crop productivity from one generation to another, and preserve what is left of the forests.

The Mambwe mound cultivation system

In response to this situation, the Mambwe mound cultivation system has been developed in the north-eastern part of Mbala district, in the Northern Province of Zambia. This system was developed about 100 years ago by the Mambwe tribe, as a strategy for maintaining soil fertility and productivity, as they shifted away from the increasingly destructive *chitemene* cultivation system.

The Mambwe mound cultivation system is a system of in-field composting, on sites that have been left fallow, for example, the secondary grassland that succeeds *miombo* woodland after repeated clearing for cultivation. Mounds of around one metre in height and one metre in diameter are constructed at the end of the cropping season. A heap of grass and other vegetation is made from an area of about one square metre, onto which soil is cut and thrown to make the mound. This is then covered with about 10 cm of topsoil, cut with hoes from the surrounding area, There is never a shortage of ordinary weeds, grasses and vegetation to incorporate in the mounds which are set perpendicular to the slope, along the contour. This system, also known locally as *fundikila* and in Tanzania as *ntumba*, depends on the release of nutrients by the decaying grasses buried in the mounds. In this way farmers can take advantage of the few available resources to benefit their soils.

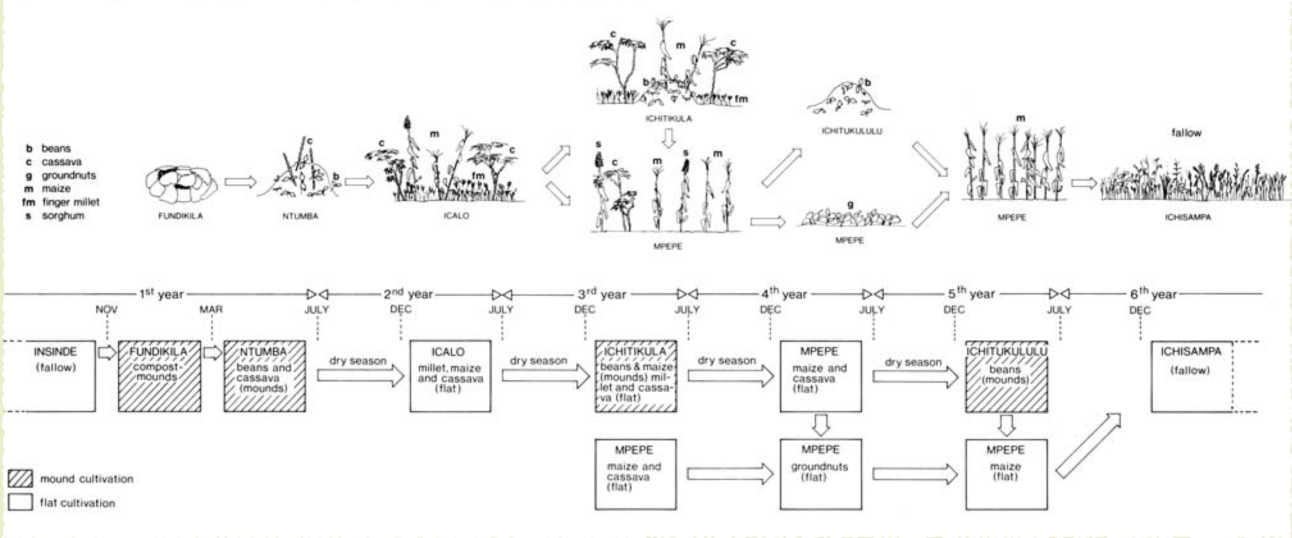
In households with male labour, the mounds are constructed by men. In other cases, women are able to construct the mounds or hire men to do this work, paying them either in cash or in kind, with beer and food through a traditional Mambwe system called *kulimya*. In the following rainy season, the mounds are flattened, the soil inside is spread and important food crops such as finger millet are planted. This may be followed in the second season by other crops such as maize, sweet potatoes, groundnuts, and pumpkins (see box).

The Mambwe mound cultivation system is carefully managed, paying attention to the needs of the soil and the requirements for sustaining the productivity of the entire farming system, rather than any individual crop. Care is exercised when planning which crops to grow in the system. They are chosen according to their nutrient requirements; with heavy feeders such as maize and finger millet (*Eleusine coracana*) being planted in the system earlier, and less nutrient demanding species like common beans (*Phaseolus vulgaris*) and cassava being introduced later in the cropping cycle. Crops are inter-planted: for example, beans are planted between the cassava plants, as the cassava crop remains in the field for up to three years and is selectively harvested. Maize and beans are never grown between the mounds, as there would be inadequate fertility to support their growth. The cropping cycle is most commonly over a period of four or five years.

Improving the mound system

Increasing population pressure in the Northern Province led agricultural scientists working at the Misamfu Regional Research Centre, in the provincial capital Kasama, to begin exploring ways of maintaining soil productivity. Mambwe people keep cattle but livestock numbers have declined due to tick-borne diseases after a serious breakdown in animal disease control programmes. Those farmers who do still own cattle use manure to fertilise their fields. However, most farmers rely heavily on other ways of managing soil fertility. This realisation led to research based on the features of the Mambwe mound system, attempting to improve the quality of the mounds at farm level. This research work was supported by the Norwegian Agency for International Development (NORAD), which funded two research programmes on soil productivity, over a 15 year period (1981-1996). Research showed that the quality of organic material for the mounds could be improved by incorporating easily degradable leguminous plant residues into the mounds. On-farm experiments, conducted in collaboration with farmers, tested the suitability of various leguminous species for the Mambwe mound cultivation system. It was found that the most suitable plant species were those that could be planted with the first rains, in November, and cut and incorporated in the mounds at the end of the season. One useful species was *Stylosanthes guianensis*, a perennial legume which can grow in

The Mambwe mound garden cycle



The first stage involves breaking up the fallow or virgin land, before cultivation. The grasses are cut, piled up and later burned and the mounds are then made during the rainy season from November to March, when the soil is not hard to break but still too heavy to till. The mounds can be left to rot for the rest of the dry season or are planted with beans and cassava in the first year. Farmers who plant beans in these mounds are able to harvest a crop in May or June. The next year, the mounds are flattened and maize and millet are broadcast among the cassava from the first year. At the start of the next rainy season, in November, the mounds are remade and beans or groundnuts are grown on them, with millet and cassava planted between the mounds. Alternatively, if mounds are not made, maize and cassava are grown on the flat land. This is then followed by mpepe (see figure), with maize, cassava and groundnuts being grown on the flat. The farmer may then decide to make the mounds for a third time, to grow beans, or continue with the flat mpepe, this time with groundnuts. During the whole cycle, any weeds or residues from the previous crop are buried, taking care not to disturb any existing cassava. Normally, the garden is left to fallow when it is flattened, as it is recognised locally that a garden abandoned in its mounded stage takes longer to regenerate than a garden abandoned in its flattened stage.

The effects of the mulching and compost-like processes of the system are considerable – they help conserve soil moisture, improve infiltration rate, reduce weeding and weed competition, lower soil temperatures and improve the soil structure. Biological changes include increased activity of soil micro-organisms and animals involved in the decomposition process, while the added organic matter also stimulates decomposition of the existing organic matter in the soil. The nitrogen in the buried organic matter is necessary for the growth of bacteria responsible for further decomposition.

Adapted from Strømgaard, P., 1989. **Adaptive strategies in the breakdown of shifting cultivation: The case of Mambwe, Lamba and Lala of northern Zambia**. Human Ecology, 17: 427-444.

less fertile soil, is adapted to drier conditions and fixes atmospheric nitrogen well. Research showed that this species has the potential to improve fertility and crop performance, through raising soil pH and the nutrient status of the soils. Another species tested was *Crotalaria zanzibarica*, known in many other countries as an agricultural weed. This also grew well, and both species decomposed rapidly within the mounds. The nutrients released supported crop growth during the next cropping season, after the mounds were levelled at the beginning of the rains.

Another key improvement was to plant a bean crop on the mounds once they have been prepared at the end of the rainy season. Planting at this time yields more than planting earlier, at the onset of rains. This is because the crop develops under relatively drier conditions and suffers less from foliar bacterial and fungal diseases. It draws its water requirements from late rains, residual moisture and morning dew. The crop is harvested around June/July each year, when the weather is generally cool and more suitable for harvesting beans, as bean pods shatter if they are overheated by the sun.

The research programmes also investigated the suitability of various treatments as alternatives to the *chitemene* system. Experiments, with finger millet and groundnut showed that the Mambwe mound cultivation system achieved similar yield levels to those obtained under the traditional *chitemene* system of cultivation, demonstrating that the Mambwe mound cultivation system is a suitable alternative to the *chitemene* system of cultivation. Research results strongly supported the transition from slash and burn to a more settled type of agriculture for local inhabitants. The extension system of the Ministry of Agriculture and Cooperatives has worked closely with scientists and farmers to promote the Mambwe mound cultivation system.

The Mambwe mound cultivation system, which includes a cereal-legume rotation on mounds, alternating with cultivation on flat land, has been practiced for a long time. This shows that the system is resilient and can support intensive crop production to meet the food and nutritional security requirements of local inhabitants. It is an indigenous system and has proved to be a practical and sustainable alternative to the environmentally destructive slash and burn cultivation system.

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John Andrew Siame. Farming Systems Agronomist. Private Bag E 891, Post Net 502, Manda Hill, Lusaka, Zambia. E-mail: ajsiame@yahoo.com

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Managing organic resources for soil amendment

Ken Giller, Michael Misiko and Pablo Tittonell

Soil fertility management is a key issue for sustaining agricultural production in the tropics. Organic resources are important for short-term nutrient availability, as well as for longer-term maintenance of soil organic matter. For smallholder farmers, organic materials are an important source of nutrients, and necessary to manage soil fertility. However, the amount of organic material available on-farm is often limited in supply, and differs widely in quality. This is why the little that is available needs to be used as efficiently as possible.

Did you ever wonder why some leaves of plants just seem to vanish as soon as they fall to the ground? Or why you can still find remains of maize stalks a year after they were turned into the soil? There are many different types of organic matter and to use these effectively as soil amendments it is important to understand how to manage them for nutrient supply or soil cover. The "quality" of organic resources determines their effectiveness for different uses; quality indicators are the carbon-to-nitrogen ratio, the lignin and tannin (polyphenol) contents. Through working together with smallholder farmers in Africa some tools have been developed that can be used in joint-learning research. Here we describe our experiences and important lessons learned.

Creating decision trees

The importance of the "quality" of plant residues in governing rates of decomposition and effects on soil fertility has long been recognised. A decision tree was developed to guide the use of organic resources based on our understanding of the critical concentrations of nitrogen, lignin and tannins (see Figure 1). This simple diagram summarises knowledge of the relationships between the chemical quality of plant leaves and litter and their rates of decomposition and nitrogen release. Scientists may feel the need for a laboratory to analyse the quality of the residues, but simple characteristics can be used instead of some chemical tests. Nitrogen concentrations of leaves and litters can be estimated simply on the basis of their colour. If a leaf can be crushed to a powder when dry this indicates it contains little lignin as leaves rich in lignin are stiffer and more fibrous. Farmers in Zimbabwe, when asked which multi-purpose legume tree species they would value as a fodder for their cattle, simply tasted them and readily identified those rich in reactive polyphenols. This "tongue test" is due to the bitter, astringent taste caused by the polyphenols binding with salivary proteins, and clearly separates out species with strong protein-binding capacity.


Photo: Michael Misiko

Lucy Aojata, a local farmer in Chakol, western Kenya, explains local understanding of quality of organic resources before farmers and researchers started a joint experiment.

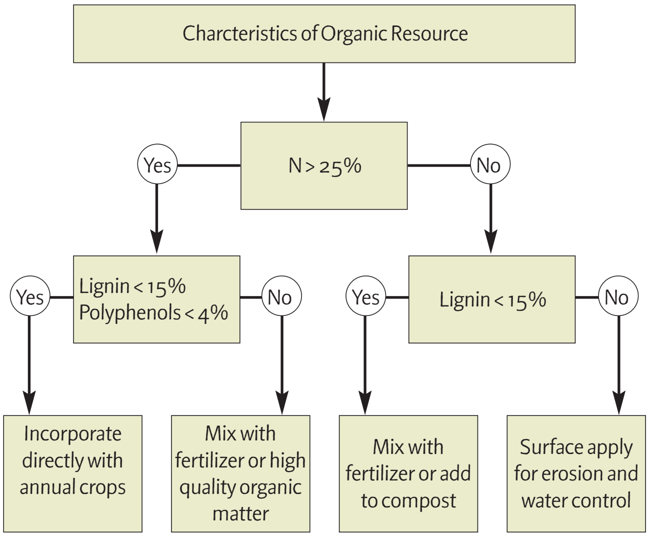

Figure 1. A decision tree to assist management of organic resources in agriculture (from Palm et al., 2001).

Such simple field tests made it possible to create a decision tree that can be used as a tool to discuss litter/fodder quality directly with farmers in participatory research. This tool can also be explained in pictures (Figure 2). Farmer field schools in western Kenya have been experimenting with different qualities of organic residues for soil amendment and growing maize, vegetables and other crops. They planted experiments comparing maize production when organic residues were applied to the soil that belonged to the four classes identified in the decision tree. This certainly led to an increase in understanding of the principles of resource quality and decomposition. For instance, farmers picked fresh green leaves of hedgerow plants little by little and incorporated them into compost heaps to speed up decay and get hotter. A hot compost "cooks" faster. After the experiments, participating farmers also knew that hot composts comprising resources that break down easily took shorter periods to "cook well".

Nitrogen-rich organic residues were in very short supply for these farmers. The most popular use of nitrogen-rich organic materials was with tomatoes and cabbage that fetch a good price at the market. The major problems identified with using organic residues as soil amendments were the extra work involved, and the lack of sufficient quantities, particularly of the types of organic material suitable for immediate application. There were also competing uses for residues poor in nitrogen such as maize stover: one farmer proposed "Give me a cow, I will feed it and

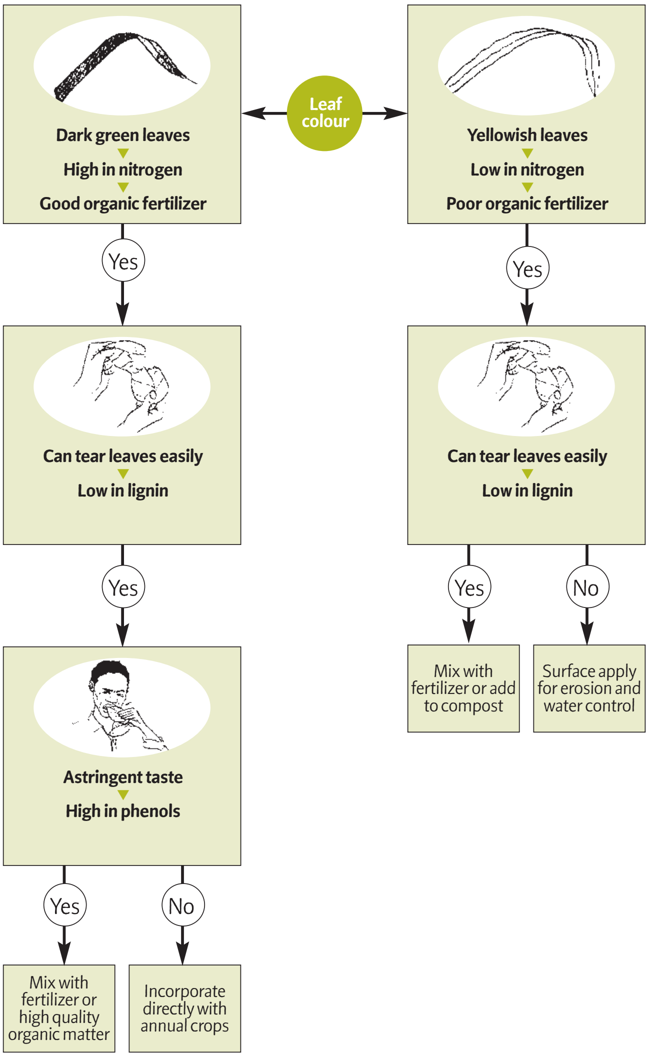

Figure 2. A pictorial translation of the decision tree (IIRR, 1998).

use its manure to do soil fertility management!" Maize stover was used as fuel for cooking, particularly by poorer households. Farmers with sufficient quantities of poor-quality organic materials used them for bedding for cattle and thus eventually adding to the manure heap, or for mulch to assist in soil conservation. The farmers also observed that more succulent and fibrous leaves or material such as sisal and plants belonging to the genus *Euphorbia* decayed slowly and were hard to crush. They were also difficult to compost and therefore of little use for nutrient management. From their experiments, the farmers concluded that it was useful to know how to manage their organic residues alongside the mineral fertilizers that are in short supply and difficult to get hold of. As farmers learnt new skills and gained better perspectives on research knowledge, they increasingly changed their old practices such as burning stover.

Understanding the concepts

Microorganisms, bacteria and fungi are responsible for breaking down all types of organic residues to release the nitrogen they contain –the process of "nitrogen mineralisation"– and make it available in a mineral form that can be absorbed by plants. When micro-organisms break down organic material that provides a lot of energy, as sugars or other carbon compounds that are rapidly broken down, then they need more nitrogen to grow than is released from the organic material itself. To satisfy their hunger for nitrogen the micro-organisms absorb this extra nitrogen from the soil, in a process known as "nitrogen immobilization". We often talk of the carbon-to-nitrogen ratio as being an important indicator of whether a plant residue will make a good organic manure. When the organic materials are rich in nitrogen (when the C-to-N ratio is less than 25) there is "net nitrogen mineralisation". Conversely, when the rates of nitrogen immobilisation are faster than nitrogen mineralisation (when the C-to-N ratio is greater than about 25), there is "net nitrogen immobilisation".

Some other aspects of the "quality" of organic residues are also important. Woody twigs and branches and older leaves break down more slowly than young green leaves. This is partly due to the wider C-to-N ratio, but the rate of breakdown is also strongly influenced by the greater proportion of lignin in woody materials. Another aspect of organic residue quality is the presence of secondary compounds in the leaves, such as tannins. These are complex molecules that slow down or prevent decomposition and release of the mineral nitrogen by binding to nitrogen-rich proteins when the leaves are cut.

Earthworms, termites and other soil animals help to break down plant material, but the role of the earthworms is to render the residues into small pieces. The micro-organisms are able to attack plant residues more easily if they are first broken into smaller pieces, so decomposition is faster when the plant residues are broken up. Plant residues that are woody are harder to break up into smaller pieces and decompose more slowly because of this. The focus is on nitrogen as few plant materials contain enough of the other major nutrients, phosphorus and potassium, to be important sources of these nutrients for crop production.

Test the principles behind the decision trees yourself

Many farmers are now trying out these ideas, and experimenting. When you grow maize plants, you could try it too – add some green manure biomass (rich in nitrogen) in some plots and add maize or wheat straw in some other plots. As a check, sow some plots with maize but do not add any extra organic matter here. You could also include a plot with some mineral fertilizer added for comparison. The plants growing in plots to which straw is added will be clearly more yellow and less vigorous than if they are fed with the green leaves.

Decomposition and nitrogen release are determined by the quality of organic matter which regulates their susceptibility to attack by microbes. This explains why some leaves just vanish when they fall to the ground while maize stalks can remain in the field a year after they were turned into the soil. Farmers can use these concepts to make decisions as to the best ways to manage organic resources for fodder, for nutrient supply, for composting or for mulch.

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Ken Giller. Professor, Plant Production Systems. Department of Plant Sciences, Wageningen University. P.O. Box 430, 6700 AK Wageningen, The Netherlands.
E-mail: ken.giller@wur.nl

Michael Misiko and **Pablo Tittonell.** Tropical Soil Biology and Fertility Institute (TSBF-CIAT). P.O. Box 30677, Gigiri, Nairobi, Kenya.
E-mails: michael.misiko@wur.nl ; pablo.tittonell@wur.nl

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Conservation Farming in rural Zimbabwe


Photo: Lovemore Dumba

Farmers are already seeing big increases in yield by using Conservation Farming methods.

Carolyn W. Fanelli and Lovemore Dumba

> *"Conservation Farming allows me to begin my land preparation as soon as I harvest. This allows me to do early planting at the onset of the rainy season, and hence my labour is spread over months."*
> Mrs. Lupane, a widow caring for her three orphaned grandchildren

> *"Tilling the land the conventional way causes many risks, namely compaction of the soil and exposure of the soil to water and wind erosion by removing the earth's blanket."*
> Mr. Chipunza, a Farmer Field School facilitator

Mrs. Lupane and Mr. Chipunza are two members of the more than 5000 rural Zimbabwean households practising conservation farming as a result of the inputs and training provided by Catholic Relief Services (CRS) and its community-based partner organisations. Their comments highlight two key benefits of Conservation Farming in comparison to other farming techniques – its low labour input and its effective utilisation of natural ecological processes. This article provides an overview of the Conservation Farming methodology and describes how CRS/Zimbabwe has successfully piloted conservation farming over the past three years. It outlines the lessons the organisation has learnt during this pilot programme and how these lessons are informing plans to scale-up the intervention to benefit more community members.

Conservation Farming

There are five main components to successful Conservation Farming: preparing land properly, following regionally-specific planting standards, controlling weeds, mulching, and rotating crops. With Conservation Farming, farmers do not till all available arable land, but instead prepare land by opening planting basins as holes or furrows. Then, farmers follow technical guidance regarding planting standards –such as seeds per station and spacing– that are appropriate to the soil and other natural factors in their particular area. They also keep these permanent planting basins weed-free to optimise soil use. Farmers rotate production of cereal and legume crops, retaining at least 20 percent of the crop residues on the soil surface – the more the better.

Conservation Farming takes advantage of natural ecological processes to conserve moisture, enhance soil fertility, and improve soil structure, and to reduce soil erosion and the presence of diseases and pests. It does this in three main ways – through minimal soil disturbance, the retention of crop residues and crop rotation. Ploughing and burning disturb the soil and the micro-biota that live there. In contrast, Conservation Farming involves very little soil disturbance, enabling naturally-occurring soil flora and fauna to flourish. These micro-biota decompose the crop residues that farmers retain as soil cover, thus adding nutrients to the soil and improving the soil's crumb structure. In addition, conservation farmers are able to make better use of the rain because undisturbed land covered with crop residues allows more rain to infiltrate into the soil and reduces evaporation. When there is low rainfall, the farmers' basins capture the available moisture. Soil cover also reduces run-off which, combined with the improved soil structure, reduces soil erosion from water or wind. Finally, crop rotation takes advantage of natural ecological processes by disrupting the disease and pest cycle and using legumes to fix nitrogen in the soil. Over the long-term, Conservation Farming's use of natural ecological processes reduces farmers' need to use fertilizers and pesticides, thus enhancing the low-input nature of the approach.

Conservation Farming has important strengths as a technique for farmers in Zimbabwe – a country with widespread poverty and a high rate of HIV/AIDS infection. Even very poor families can use Conservation Farming because it does not require draft power or tractors, simply hand hoes. And, because of the low labour input required, the technique is well-suited to households and communities affected by HIV/AIDS.

Implementing the programme

The promotion of Conservation Farming is one strand within CRS/Zimbabwe's Protecting Vulnerable Livelihoods Programme, which works in partnership with well-established community-based organisations and is funded by the U.K.'s Department for International Development (DFID). CRS provides training, technical support and resources, while its partner organisations implement the programme at the community level. Extensive liaising occurred with relevant government stakeholders, such as the Agricultural Extension Service, throughout the implementation, monitoring and evaluation of the pilot project in order to maximise the appropriateness and sustainability of the project.

During the 2003/4 season, Conservation Farming was piloted in three districts, with the aim of increasing food production and improving beneficiaries' nutrition levels. Strict targeting criteria were used to select 650 vulnerable households and identify six "lead farmers" – well-respected community members who were already engaged in farming activities and could host project participants on a communal plot. The inclusion of lead farmers in the project was a strategic decision designed to overcome one considerable challenge – the reluctance of some community members to use hand hoes when they had previously used draft power or tractors.

Training in Conservation Farming was provided to the partner organisations who, in turn, trained household members and lead farmers. The training programme included basic record-keeping, in recognition of the fact that successful conservation farming requires solid planning skills, which, in turn, demands accurate records. The record-keeping process was initiated by getting farmers to list their broad intentions and activities, and then dividing these activities into smaller components. All activities carried out on the trial plots were recorded in a diary, including information about seed, fertilizer, labour, rainfall, wages, yield, food consumption, transport, medical bills, illnesses and deaths among the group.

Beneficiaries were provided with local seeds and hybrids as well as fertilizer for micro-dosing. Each conservation farmer had a third of a hectare plot, with most of it reserved for cereal and a small portion for legumes.

The results from this pilot season were quite favourable, and other community members took note of the conservation farmers' successes. In the following season, additional training was offered to the original group of 650 households, as well as to another 117 interested households who were not part of the targeted group. Some of these "volunteer" participants did not have the necessary minimum amount of crop residue in their first year of Conservation Farming. They were, however, still able to make the necessary basins. Overall, the 767 households who practised these techniques successfully harvested crops in what proved to be a drought year – thus improving their food security.

More community members noticed the success of the project and, in some of the pilot areas, large numbers of people spontaneously adopted the technique, with no direct support from the programme. By the end of July 2006, more than 1045 households in the three districts were practising Conservation Farming and more than 5000 households had been trained in the technique – numbers which greatly exceeded the project's initial targets. As a result, between the 2004/5 and 2005/6 seasons, there was a 230 percent increase in the land on which Conservation Farming was being practised. Monitoring and evaluation indicated that, in all the districts, Conservation Farming led to higher yields for maize, sorghum, soybean and cowpeas. Some of the yield increases were quite dramatic. For example, in Murewa district maize yields were 4 t/ha, compared to half a tonne per hectare where the techniques had not been adopted. In nearby Mutoko, maize yields under Conservation Farming were 5 t/ha, compared to one t/ha. One farmer in this district who had participated in the project since the beginning achieved a yield of 7 t/ha.

Typically, most cereals and legumes grown in these areas are consumed in the household, with any surplus being sold to pay for household expenses, such as children's school fees. In the 2005/6 season the project piloted distributing soya bean seed among the targeted vulnerable households so that they could begin growing this cash crop. The hope is that this cash crop, combined with the sale of surplus cereals and legumes, will eventually enable these households to purchase their own inputs, thus eliminating their need for external support. This self-sufficiency will be aided by the likelihood that as the Conservation Farming practices improve soil fertility over the next 5-10 years, the farmers' need for fertilizer is likely to be eliminated. As targeted households become self-sufficient, the project will identify new vulnerable community members to work with.

Lessons learnt

The three-year life span of the pilot project provided many lessons about implementing Conservation Farming:

- Although Conservation Farming is low-labour input agriculture, there are still some HIV/AIDS-affected households that do not have sufficient labour resources to succeed on their own, especially during peak labour periods, such as basin making and harvesting. These households are likely to include those headed by elderly people, those with few members, and those with chronically ill members who require constant care. To address this challenge, some communities have created "work teams" of community members who provide voluntary labour to vulnerable households that need help.
- Introducing Conservation Farming to community members requires patience, understanding and careful explanation. Some aspects of Conservation Farming may initially seem unusual to community members, and it may take time for them to overcome their scepticism and understand the approach. For example, farmers were initially concerned about the presence of termites feeding on the dry stover because they thought that the termites would go on to destroy their green crops. However, after observing the termites at work and seeing their positive impact on the soil, community members accepted termites' vital role.
- Lead farmers were vital to the project, as was originally anticipated. In particular, they have played a critical role in relaying information about Conservation Farming to household participants and in providing technical support. They also help motivate community members and assist in project monitoring.
- Conservation Farming is particularly beneficial for female farmers, who are often heads of their households but lack draft power or sufficient labour to engage in other farming techniques. More than 80 percent of participants in the project are female farmers.
- Including community members outside of the targeted beneficiary group in the trainings has helped increase the programme's impact and improve the overall food and livelihood security of the community. Although these community members do not receive inputs from the project, their uptake of Conservation Farming has been impressive.
- The involvement of government extension officials has helped in monitoring the activities and their impact on communities.
- Conservation Farming is resulting in substantial yield increases for most crops.
- The project has highlighted the value of sorghum as a drought resistant crop. Unlike other crops such as maize, sorghum has the ability to re-sprout when moisture conditions become favourable. In one district, Chiredzi, this second crop yielded more grain than the initial crop, which was affected by a mid-season dry spell.
- Soya beans have potential as a cash crop that conservation farmers can use to enhance their livelihood security and become self-sufficient.

Future plans

CRS/Zimbabwe completed a self-assessment of its Programme in August 2006. One recommendation that emerged from this assessment was that additional emphasis should be placed on promoting Conservation Farming. Given limited resources, this will be accomplished by inviting non-targeted beneficiaries to also attend trainings. In addition, CRS intends to more closely integrate Conservation Farming with other activities such as Farmer Field Schools, Junior Farmer Field Schools, seed voucher distribution and food security support for orphans and other vulnerable children. Consideration is being given to ways of expanding adoption of the "work team" concept in order to help HIV/AIDS-affected households who struggle to provide the necessary labour for Conservation Farming. One option being considered is providing these households with vouchers that they can redeem for labour. Finally, there are plans to extend the provision of soya bean seed to more vulnerable households for cash cropping.

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Carolyn W. Fanelli and **Lovemore Dumba.** Catholic Relief Services/Zimbabwe. Box CY 1111 Causeway, Zimbabwe. E-mails: cfanelli@crszim.org.zw ; ldumba@crsert.org.zw

Improving the jhum system in Bangladesh

Stephan Mantel, Mohammed Mohiuddin, M. Khairul Alam, José Ramon Olarieta, Mozaharul Alam and Fida Malik A. Khan

The Chittagong Hill Tracts in Bangladesh differ in many respects to the rest of the country. A mountainous area, it is geographically part of the Hindu Kush-Himalaya region. Demographic and environmental conditions have changed drastically in the last decades, mainly as a result of the dam built on the Karnafuli River (which inundated more than 20 000 hectares of cultivated land) and twenty years of armed conflict that ended in 1997. These changes, together with the scarcity of suitable land, have meant that the traditional slash and burn farming system locally known as *jhum* has become unsustainable. Combined with other factors, such as forest overexploitation, it is one cause of increased land degradation, resulting in diminishing yields and decreased biodiversity.

In 2005, four institutes started the Chittagong Hill Tracts Improved Natural Resources Management project (CHARM). This project aims at building local capacities in natural resource management and planning, through the provision of improved information for decision making. It aims to contribute to the formulation of alternative strategies for sustainable management at both the field and policy levels.

Jhum farming systems in the Chittagong Hill Tracts

Temporary clearing and burning of forest vegetation for cropping is characteristic for shifting cultivation and is seen as an alternative nutrient management strategy. Clearing and burning releases the nutrients in the vegetation. After cropping, the fallow quickly recovers into secondary forest from coppices, underground rhizomes, root suckers and the soil seed bank. Tribal people in the Chittagong Hill Tracts practice *jhum* in an area for one year and keep the land fallow after that to allow it to rejuvenate. The most frequent cycle involves one year of cropping and 4 to 5 years fallow.

The main species grown in *jhum* cultivation are rice, turmeric, cucumber, chilli and ginger, although many others are also frequently intercropped. In general, farmers cultivate more than 40 species in their fields, while approximately 50 wild plant species are collected by women. In this way, farmers meet all their day-to-day demands except for salt. Many crops grown in the *jhum* system have a potential commercial value such as cereals, medicinal plants, aromatic plants, spices or condiments, and various legumes.

But most farmers acknowledge that there has been a 50 percent decline in productivity of *jhum* land over the past 10 to 12 years, even though more than half of the farmers use pesticides and fertilizers. With decreasing yields, the average 4 to 5 years fallow seems to be too short to be sustainable. Fallows of 5 years or less do not allow for sufficient vegetation growth and biomass production, while mineralisation of organic matter occurs rapidly due to the open conditions. Soil quality recovery is therefore incomplete. Not surprisingly, the *jhum* system is commonly blamed for land and forest degradation.

Photo: J.R. Olarieta

Jhum farmer planting seeds in the Chittagong Hill Tracts.

"Manipulated" fallows

The need for self-sufficiency, the difficulties that farmers have in reaching markets, the lack of infrastructure and the overall situation in the Chittagong Hill Tracts, all determine that *jhum* is likely to continue as a fundamental land use system in the region. Improving the sustainable management of the natural resources in this area must therefore consider sustainable alternatives within *jhum* farming. The use of "manipulated" or improved fallows provides a range of techniques which make better use of the ecological processes, leading to more sustainable practices. These improvements are based on farmers own knowledge and experience. Some of the improved techniques that have been observed being used by farmers in the Chittagong Hill Tracts are detailed below.

Using mulch for soil protection

Erosion, declining soil fertility, and increased emergence of weeds affect production when fallows are shortened. Zero-tillage and mulching are ways that help prevent soil degradation and excessive weed emergence. This technique is used by farmers growing ginger and taro in hilly areas of this region. Innovative farmers in the village of Sharon Para grow ginger in a zero-tillage system, planting in small holes rather than hoeing the whole field. Mulching is also widely used in the cultivation of these two crops, using old sun grass, rice straw and other lops and tops of trees as mulch. According to farmers, mulch controls weeds, minimises soil erosion and adds humus after decomposition. The use of mulch safeguards the topsoil against excessive soil temperatures and favours seed germination. It keeps the soils loose so that the rhizomes and tubers grow better, and hence enhances production. Moreover, mulching reduces weeding frequency and costs.

Managing trees for biodiversity conservation

Some farmers keep important plants like *Ficus, Derris, Albizzia* and other leguminous trees while clearing away other vegetation during the preparation of their fields. Maintaining trees in the field, in combination with cover crops, helps reduce soil erosion, and contributes to plant conservation. Leguminous plants enhance crop growth. While preparing their fields, farmers cut the trees about one-metre above ground height to coppice it.

As the stumps coppice generally at that height, the shoots remain out of reach of browsing animals. Farmers in the tribal village of Empu Para do not remove the large trees from their *jhum* field, but lop the branches for more light penetration.

Managing the coppices of some tree species
Gamar (*Gmelina arborea*) is one of the most important forest timber species in the Chittagong Hill Tracts, but is only harvested after 10-12 years. Farmers in the village of Sharon Para have their own technology for doing this, which makes better use of this tree. Trees are cut in February (before spring), 15 cm above ground level, using a handsaw. The stumps of the felled and harvested trees are kept in the field undisturbed. Profuse coppice shoots regenerate from these stumps within 15 to 30 days, reaching a height of one metre within two to three months. Farmers allow coppice shoot growth up to mid-July, maintaining the bunches of coppice shoots to decrease the speed of the wind. Shoots are thinned when wind velocities decrease (after mid-July), as this reduces the risk of breaking coppice shoots. Generally, farmers keep two or three healthy timber shoots for the first year and finally select the best coppice shoot to get a healthy coppice tree. They also reported that *gamar* grows better when coppiced in this fashion then when grown from seed. The coppice shoots produce marketable timber within six to seven years.

In general terms, an improved *jhum* can be created by selectively weeding the fields and enriching them by planting species that increase the rate of return of organic matter to the soil and have some commercial interest for the farmer (such as commercial bamboos and various leguminous shrubs). Further improvement is also possible after cropping, when fields quickly turn into secondary forests. Many farmers plant teak and other timber species as a way to claim land-use rights, even though regulations and permits make it difficult to reach the timber markets. Management during the cropping phase may also be improved, especially in terms of erosion control. Weeding is practised three times per cropping season, but the weeds are often simply disposed of. The resulting biomass can provide a good source of compost or mulch.

Knowledge exchange for innovation

Traditional knowledge in the Chittagong Hill Tracts is closely interlinked with the economy, livelihood and culture of the population. It can, in contrast to general belief, have positive effects on the conservation of local biodiversity at different levels, and can contribute to enhanced production. Farmers display considerable knowledge about their environments and how best to use their resources, but despite the improvements already seen, more can be done in working towards sustainable systems. Furthermore, traditional knowledge is currently being lost at an alarming rate due to changes in land use, population increase, interaction with people from outside, deforestation, and loss of social norms and rules.

The exchange of information between generations within farmer communities and families has been an important mechanism in the development of sustainable land management systems that are adapted to the local environment. Access to information on successful land management approaches and technologies, both indigenous or traditional and "scientific" or newly acquired knowledge, allows land managers to select viable options for specific locations. Knowledge of the experience of others in similar environments can help farmers to cope with changing conditions and try out new practices. On the basis of these ideas, CHARM aims to strengthen the capacity of local government institutions, NGOs, and other beneficiaries in planning and implementing sustainable land management. It co-operates with local institutes and expert groups, such as the professional association of soil and water conservation BANCAT (Bangladesh Conservation Approaches and Technologies).

Information access and decision support

A decision support system has been designed based on a comprehensive assessment of the information needs of various stakeholder groups. It draws on the various digital maps and databases compiled on the environment of the Chittagong Hill Tracts, and land management technologies. The system allows users to identify an area in the region and retrieve information on themes such as land cover, soil type, slope, and landform. The system can identify a broad land management class for each location and recommend suitable land management priorities, ranging between conservation and uninhibited production. More specific practices can be selected within a given environment and location. In other words, the system facilitates identifying interesting and appropriate land management options which have proven to be effective in similar situations. These are tailored to meet the priorities of the users, such as improving production or conservation. This system is currently being tested with user-groups in a pilot area. The recommendations from these pilots will be used to improve the information system before dissemination. A regional plan is being devised which will indicate priorities for conservation and alternative practices and the resulting discussion is intended to strengthen resource management practices.

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CHARM project:
Stephan Mantel. Coordinator CHARM project and NRM decision support, ISRIC-World Soil Information. P.O. Box 353, 6700 AJ Wageningen, The Netherlands. E-mail: stephan.mantel@wur.nl
José Ramon Olarieta. Land management practices inventory, Department of Environment and Soil Science, University of Lleida. Rovira Roure, 177, 25198 Lleida, Spain. E-mail: jramon.olarieta@macs.udl.es
Mozaharul Alam. Research Fellow, stakeholder interaction. Bangladesh Centre for Advanced Studies (BCAS). House No. 10, Road No. 16 A, Gulshan 1, Dhaka 1212, Bangladesh. E-mail: mozaharul.alam@bcas.net
Fida Malik A. Khan. Environmental assessment and information system. Center for Environmental & Geographic Information Services (CEGIS), House No. 6, Road No. 23/C, Gulshan 1, Dhaka 1212, Bangladesh. E-mail: mkhan@cegisbd.com

BANCAT professional association/ Bangladesh Forest Research Institute:
Mohammed Mohiuddin. Sr. Research Officer, Bangladesh Forest Research Institute (BFRI), P.O. Box 273, Chittagong 4000. E-mail: uddinm@ctpath.net
M. Khairul Alam. Divisional Officer, Bangladesh Forest Research Institute (BFRI), P.O. Box 273, Chittagong 4000. E-mail: mkalam@click-online.net

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Ecological processes and farmer livelihoods in shaded coffee production

V. Ernesto Méndez and Christopher M. Bacon

Most tropical primary forests have been transformed into landscapes containing many different types of land uses. The challenge to maintain and conserve some of the original biodiversity of these forests has resulted in a need for farming systems to develop and manage biodiversity. Recent research, as well as the experiences of farmers in many parts of the world, shows that shaded coffee agroecosystems have exceptional potential for the conservation of tropical plant and animal species, in addition to producing high quality coffee. This article shows how this potential is linked to farmers' livelihood strategies in six co-operatives in El Salvador and Nicaragua. The article is based on work carried out by these co-operatives together with two local non-governmental partners, the *Central de Cooperativas Cafetaleras del Norte* (CECOCAFEN) in Nicaragua, and *Asesoría e Investigación Interdisciplinaria para el Desarrollo Local y la Conservación* (ASINDEC) in El Salvador.

In El Salvador we worked with three coffee co-operatives in the municipality of Tacuba, in the western part of the country. These farms are of high ecological importance as they surround the *El Imposible* National Park, the largest protected area in the country. The farms are situated at elevations ranging between 650 and 1400 meters above sea level, and the co-operatives grow two varieties of shade coffee ("Borbon" and "Pacas"), which both produce high quality beans, although their productivity is much lower than that of full sun coffee varieties. In Nicaragua we also worked with three co-operatives in the communities of Yasika Sur and Yúcul. These farms are located about 25 kilometres from the city of Matagalpa, in the northern part of the country. Coffee varieties found here include "Tipica", "Maragogipe", "Borbon" and "Caturra", with a few farmers having also planted newer hybrid varieties such as "Catuai" and "Catimor". Yields in Nicaragua range from 140 kg/ha among certified organic farmers to as much as 285 kg/ha among conventional producers.

Photo: Ernesto Mendez

Members of the "La Concordia" cooperative in El Salvador were keen to learn about the ecological processes taking place in their fields, recognising the potential these have for improving their livelihoods.

Ecological processes and livelihoods

In 2000 we started using a Participatory Action Research approach, trying to involve a wide diversity of stakeholders as active participants in the research activities and to integrate research into an action agenda that would contribute to local development and increase biodiversity conservation. The aim of this approach was to foster a mutual learning process which would help improve management of on-farm ecological processes and support farmer livelihood strategies.

Work ranged from developing rigorous inventories of the diversity of shade trees on-farm; to providing training on ecological management and support for marketing efforts. We supported farmers through the processes of organic certification, and trained individuals from the co-operatives on ecological methods for identifying, monitoring and managing shade trees. In addition, we have continually supported the efforts of these farmers to incorporate different forms of agroecotourism within their livelihood strategies. In both countries, organic certification and agroecotourism have the potential for increasing the incomes of the organisations and their members. This, however, requires making connections with different local and international networks. Success, though, has come slowly and with many obstacles. The obstacles have included the costs of organic certification, the difficulties in marketing and the cost of constructing the necessary infrastructure for agroecotourism.

Advantages and disadvantages

Although coffee is traditionally grown under shade, farmers in many countries have been encouraged to shift to coffee varieties which need full sun, as this reduces fungal infections and increases yields. Emphasis on faster maturation and higher yields, however, overlooks other aspects. In shade grown coffee, shade trees protect sensitive coffee bushes from harsh winds and excessive light; protect the soil against erosion, and regulate temperature and humidity. The shade trees have multiple uses (timber, fruit production, fuel wood, medicines) and most important, there is growing evidence that shade positively affects coffee quality.

Shade trees also have other effects. They improve nutrient cycling by absorbing nutrients through the roots at lower depths in the soil and depositing leaf litter on the surface. They reduce the growth of weeds and also increase local biodiversity by providing food or shelter for many other species, such as birds and insects.

Farmers' interest in better understanding the ecological processes occurring on their farms is closely linked to the direct impact that this learning and management can have on improving their livelihoods. Our work focused mainly on how to manage the shade trees and coffee plants, i.e. the competition between different plant species within a cropping system, and on developing ecological management practices for organic production.

Shaded coffee management

Shade coffee agroecosystems have a high potential for strengthening ecological processes. This is partly due to the similarity between the structure of shaded coffee farms, and the natural forest ecosystems that they have displaced. Ecological processes such as nutrient and water cycling, energy flows and population regulation mechanisms function in a manner that is similar to those occurring in tropical forests. Our focus therefore was on the management of shade species in coffee plantations, particularly in terms of biodiversity and on-farm agroforestry management.

Tree biodiversity conservation
Agroecology places a high value on the conservation of biodiversity as a tool for managing competition and pests. In shaded coffee, it is especially important to assess the existing tree biodiversity since, in providing shelter to other species, trees multiply the biodiversity levels of a farm and its surrounding areas. In the Nicaraguan coffee co-operatives we found 106 tree species used for shade. In El Salvador we identified 123 species, from 46 families. The number of shade tree species found on the coffee farms was similar to the number of species found in sample plots in the *El Imposible* National Park. However, the species themselves were very different, and reflected the farmers' preferences for useful species, instead of rare, endangered forest species.

Shade tree management
The similar results from Nicaragua and El Salvador reflect similar management practices in both countries. Farmers manage the shade tree canopy so as to optimise coffee production while maximising the use of the different tree species. This means that all shade trees are pruned once or twice every year, aiming to leave a 40 to 50 percent shade cover. During this yearly activity tree heights are also controlled so that they remain at between five and ten metres. Sometimes farmers leave larger trees in place, to use for construction timber. Weeding is done manually with *machetes* at least twice a year and farmers always take care to leave naturally regenerated tree seedlings to grow. They are left to grow to provide additional shade in a specific area (regardless of the species), or until they can be identified. Farmers often uproot and transplant desirable, naturally regenerating, trees.

Individual small scale farmers also tend to plant a high diversity of trees to meet the family's needs of firewood, fruit, and timber. This is less common in collectively managed co-operatives, where the shade trees are used for firewood or timber. Co-operatives do not make as much use of fruit trees because there is no clear definition of the responsibilities for taking care of them, nor of ownership of the produce.

Shade management is directly linked to the yields obtained. Although "full sun" coffee varieties have the potential to produce more coffee beans per plant, they require high levels of synthetic fertilizers and pesticides to do so. The co-operatives cannot afford this type of management, nor the cost of replacing their shade-loving varieties with those resistant to full sun. Instead, farmers are improving production without changing the shade tree system. Examples of improved management include replanting coffee in areas where the plants are too old, improving fertility management, and following basic agronomic practices like the regular pruning of the coffee plants.

Supporting agroecological management

The use of Participatory Action Research has helped us reach a better understanding of the ecological processes in shade grown coffee in the co-operatives, and this understanding has made it possible to develop better management practices. The action agenda facilitated exchange of information between researchers and farmers. In this way, the understanding developed during research can be used to support co-operatives and their members' livelihoods.

Table 1: The most abundant shade species and their multiple uses

	Tree Species	Common name	Uses
El Salvador			
	Croton reflexifolius	Copalchí	firewood, windbreak
	Cordia alliodora	Laurel	timber, shade, fruit
	Mangifera indica	Mango	firewood, fruit, shade
	Eugenia jambos	Manzana rosa	firewood, fruit, windbreak
	Inga punctata	Pepeto	shade, firewood
	Inga oerstediana	Cuje purito	shade, firewood
	Ricinus communis	Higuerillo	shade
	Critonia morifolia	Vara negra	shade, firewood
	Inga pavoniana	Cuje cuadrado	shade, firewood
	Eugenia salamensis	Guayabillo	timber, shade
Nicaragua			
	Inga edulis	Guaba roja	shade, firewood
	Cordia alliodora	Laurel	timber, firewood
	Inga punctata	Guaba negra	shade, firewood
	Guazuma ulmifolia	Guasimo	timber, firewood
	Lippia myriocephala	Mampas	firewood
	Juglans olancha	Nogal	timber
	Citrus sinensis	Naranja dulce	fruit
	Persea americana	Aguacate	fruit
	Mangifera indica	Mango	fruit, firewood
	Vernonia patens	Tatascame	firewood

We believe that agroecological management offers great possibilities to achieve both production and conservation goals in co-operative coffee plantations, but there are several key issues that require immediate attention. To improve production, co-operatives need access to financial and technical assistance. Secondly, they need help in finding better markets for coffee that support the conservation of biodiversity. Finally, a comprehensive approach is needed to assist the co-operatives in diversifying their livelihoods through improved food production and agroecotourism. This development will require solid partnerships with a diversity of actors. In our role as the Participatory Action Research partners, we are strongly supporting the co-operatives in finding and developing the partners and networks that will work best for them.

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V. Ernesto Méndez. Environmental Program and Department of Plant & Soil Science, The Bittersweet, 153 South Prospect St., University of Vermont, Burlington, Vermont 05401, U.S.A. E-mail: emendez@uvm.edu

Christopher M. Bacon. 2830 Magowan Drive, Santa Rosa, California 95405, U.S.A. E-mail: christophermbacon@gmail.com

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Farmers' understanding of soil processes

Julie Grossman

Coffee production in the state of Chiapas, Mexico, is a means of survival for many indigenous farmers. Since the early 1990s, when government loans for fertilizer dried up, most small-scale farmers in this state have not been able to afford synthetic fertilizers or pesticides. This, together with declining yields, soil quality, and personal health, has encouraged many farmers to revert back to chemical-free coffee production systems. To increase profits, they began certifying their farms as organic. Since organic coffee producers are restricted from using agrochemicals, they depend heavily upon soil management techniques to provide the necessary nutrients to their crop. We investigated the farmers' knowledge of these processes through in-depth interviews with groups of organic farmers with different lengths of experience as organic farmers.

Small scale coffee farmers in Chiapas have developed complex agroecological systems that include intercropping coffee with fruit crops and leguminous shade trees. Soil erosion is controlled by terracing and accumulating leaf litter in a protective mulch layer. Observing that retention of surface litter reduces topsoil losses, many farmers build live shrub terraces to trap this litter. Many farmers have a detailed knowledge about the benefits of differently sized and shaped leaves, and how each contributes to topsoil preservation when used as surface mulch.

Farmers engage in many activities to strengthen ecological processes in their agroecosystems. They manage the leguminous *Inga* shade trees for both their potential to add nitrogen to the soil and erosion control by their large leaves. Other organic coffee management practices include weeding the coffee plots (2 to 3 times annually), pruning the coffee (once annually, between February and May), pruning the shade trees to regulate the light available to coffee, and applying compost (once annually between June and August). Finished compost is applied around the base of the coffee bushes. Most farmers chop the pruned shade and coffee tree branches and leave them on the soil surface after removing the usable firewood for home cooking. More than half of interviewed farmers stated that they left prunings specifically for their fertilization potential.

In such agroecological systems, the farmers' understanding of soil biological processes such as leaf litter decomposition and biological nitrogen fixation are important for crop yield maintenance. A thorough understanding of soil fertility interactions can offer farmers tools for making management decisions and engaging in their own experimentation. In Chiapas, individual communities made up of 10-50 farmers each are grouped under larger umbrella co-operatives that facilitate trainings and external certification. A team of organic agronomists give workshops and "promoters", capable farmers who are members of the co-operatives, help other farmers to understand the technical information. Each group plays an important role in further developing ecological knowledge.

Understanding soil biological activities

Organic coffee producers in Chiapas have a good understanding of many ecological processes, while others remain a mystery to them. Farmers observe improved soil health where leguminous tree mulch decomposes, and have a strong grasp of the idea that soil is partially derived from leaf litter. Farmers can also quickly describe the observable improvement in the health of coffee plants beneath *Inga* trees that deposit great amounts of decomposing litter. However, despite this understanding of nutrient release through decomposition and observation of improved coffee plant growth, farmers lack the understanding or the vocabulary to describe the concept of nutrient uptake. Farmers' ability to "see" the decomposition process in action over time may aid in their understanding of its relation to coffee plant health.

Of the many factors influencing decomposition rate, including temperature, oxygen level, and biological activity, coffee farmers emphasise only the biological aspects. Farmer knowledge of the biological component of the soil is basically limited to organisms that are visible with the human eye, such as earthworms, centipedes, white grubs, ants, and crickets. More than half of the farmers interviewed mentioned that soil was superior where soil macro-fauna were present. Earthworms are the most commonly mentioned soil macro-fauna with farmers noting that they "build tunnels", "mix", "make fertilizer", or "eat" the soil. Almost all farmers who mentioned earthworm presence see the "tunnels" or "paths" created by the earthworms, and several reason that the roots of the coffee grow into these tunnels, facilitating growth of the coffee.

Soil micro-organisms are, for perhaps obvious reasons, almost never mentioned when coffee farmers describe soil biological activity. Farmers in Chiapas appear to have a limited understanding of the existence of soil micro-organisms, and few can describe their role in the decomposition of vegetative matter. Farmers who do use the word "micro-organism" in their description of soil biology appear to lack a clear picture of the role of micro-organisms in the decomposition process.This perhaps indicates an only partially-successful outcome of organic training workshops. Farmers' responses indicate that they associate certain words with the concept of biological nitrogen fixation. Although most have seen root nodules, about 25 percent think that they are a plant disease. However, it is worth noting that all of those who could not describe the function of the nodules were from a community that had been certified organic for only one year and hence had had the least training in organic production.

Training and outreach

Organic coffee producers in Chiapas have built on their practical and historical experiences to help them understand and manage complex ecological processes and to optimise the interaction of these processes in the soil, coffee plants and associated agroforestry species within their particular farming system. However, despite outreach and training attempts to increase the understanding of relevant ecological processes, farmers still have knowledge gaps regarding phenomena that they cannot see. As farmers obviously have the capacity to understand processes that are visible, such gaps could perhaps be best filled by workshops specifically focusing on "invisible" ecosystem processes, such as micro-organism activity. Training that includes hands-on activities such as videotapes showing soil microbial activity, laboratory tours, inoculation and litter bag experiments, or "bottle biology" decomposition experiments, could help increase understanding. Such activities will provide farmers with the knowledge required to further develop and manage their complex agroecological systems. In order to do this, trainers must first understand farmers' knowledge of their local ecological systems. Future field training activities in soil health and biology should place greater emphasis on being attuned to the knowledge base and context of the farmers themselves. ■

Julie Grossman. NSF Postdoctoral Fellow, Department of Crop and Soil Sciences, Cornell University. 722 Bradfield Hall, Ithaca, New York 14853-2701, U.S.A.
E-mail: jmg225@cornell.edu

Photo: Author

SRI seedlings are planted at the recommended spacing with the help of a string.

SRI takes root in Nepal

Rajendra Uprety

The System of Rice Intensification (SRI) is now spreading widely around the world, being further developed and modified as more experience is gained and new conditions are encountered. It is proving to be a very dynamic approach to rice cultivation, and should not be regarded as a finished or fixed technology. SRI was introduced into Nepal around 1999 by some researchers in the Nepal Agricultural Research Council (NARC), but they did not get very encouraging results when they first tried it out at the Khumaltar research station.

In 2001, various development workers started testing SRI in their own areas. The National Wheat Research Programme and the NGO Appropriate Technology Asia began working with SRI methods in Bhairahawa and the Kathmandu valley. In 2002, different technical advisors tried out SRI methods in the Sunsari-Morang irrigation system in the districts of Morang and Sunsari via Farmer Field Schools operating there under a DFID-funded project. Farmers were encouraged enough by the results from the trials to continue with their SRI activities.

From 2003 onwards, the District Agriculture Development Office for Morang began evaluating SRI and disseminating it among farmers. Very impressive results rapidly spurred the growth of the SRI movement in Nepal. Contributory factors included the active participation of farmers and high levels of awareness of SRI among farmers, the media and policy makers. Every opportunity was used to publicise the successes achieved. This illustrates how effective communication and use of the media can be in disseminating an innovation such as SRI over a larger area.

There was some initial resistance and criticism from senior scientists, agriculturists and policymakers who had heard about the disappointing results from the Khumaltar trials and who had little other information about SRI. However, with a favourable and growing response from farmers to this new opportunity, the innovation has "taken root". Whenever possible, we have brought senior officials, journalists and media personnel to see our SRI fields in person. Together with publications, the positive impressions formed during these visits have created curiosity among agriculturists and development workers about SRI. As more concrete results emerged, earlier opposition was overcome and was followed by encouragement and support from the Department of Agriculture and other organisations. Even the BBC World Service has run a short feature on SRI results from Morang in its "Asia Today" programme (September 2005).

From a small start on a plot of 100 m^2, which first showed the effect of SRI practices, we were able to disseminate SRI in first three and then 15 Village Development Committee areas within Morang district in 2004. This expansion of activities meant that we had insufficient financial resources for sustaining our support activities, but additional funding enabled us to expand our work within Morang and Panchthar districts (see issue 21.2 of the *LEISA Magazine*). This money was used to prepare and publish new SRI information materials (booklets, posters and a video) to reach a much wider audience. We also started broadcasting agricultural programmes about SRI through the local FM radio. This strategy created more demand for training among farmers, resulting in more SRI experiences in the districts.

Difficulties in scaling up

Other District Agriculture Development Offices and NGOs have started promoting SRI activities in their own areas. Further trials and demonstrations are giving more people confidence in SRI methods and encouraging them to disseminate them. But with increased expansion of SRI farming, some difficulties also arose. Among the problems affecting the scaling up of SRI, weeding is the most prominent.

Manual weeding is expensive and if farmers use hired labour, it is not very effective, as hired-in labourers are careless when removing weeds. They often leave the roots of the weeds in the soil, so the weeds emerge again within a few days. This creates problems and makes weed management expensive. Small farmers cultivating their own land themselves do not face such problems as they do the work with more care. Another difficulty arises when weeding is done late. This allows weeds to become established and makes removing them more difficult. To counter these difficulties, we supplied some rotary hoe weeders for mechanical hand weeding and provided training in timely weed management. This helped resolve the weeding problems and reduced production costs.

With SRI, the amount of labour required makes manual weeding twice as expensive as in conventional rice production. However, by using a mechanical hand weeder (rotary hoe), the cost of weeding can be reduced to less than under conventional methods, even when doing three weedings instead of one. Additional weedings add as much as 2 t/ha to the yield, which substantially increases the profitability of SRI (see Table 1). A field kept free of weeds during the first month gives early tillering, leading to more (and bigger) panicles. We also think that the yield enhancement results from the effects of soil aeration on soil biological activity.

Other problems encountered relate to water management. Our farmers found that the standard SRI water management recommendation was not appropriate for all types of soil. The practice of alternatively wetting and drying the soil up to the cracking stage was very effective together with the other SRI practices, provided that their soil was loose and friable or that had high organic matter content.

However, with heavy clay soil, this alternative system of wetting and drying was seen to be harmful during the vegetative growth stage because when such a soil dries to the cracking stage, it becomes very hard, inhibiting the plants' root development and nutrient absorption. This has led us to change our recommendation for SRI water management and to adapt the recommendations to different soil types. This has brought positive results regarding water management.

Varietal differences have also been found to be important with SRI methods. Generally, most local or indigenous varieties have

Photo: Author

Preparation of a nursery bed.

Table 1. Yield increment with additional weeding by SRI and conventional methods

Number of weedings with SRI	Average productivity with SRI (t/ha)	Cost of manual weeding (Rs./ha)	Cost of mechanical weeding (Rs./ha)	Calculated differences in net income (Rs./ha)	
				MW	RW
One	5.2	2250	450	30 786	32 586
Two	5.8	3750	900	36 296	39 146
Three	7.8	4500	1350	55 184	58 334
Conventional	3.1	2250	-	8288	

MW: Manual weeding; RW: Use of rotary weeder performed well with SRI techniques. But the results of a few recently released improved varieties (like Hardinath 1) were not as good. Such varieties perform well with close spacing and high input application, but not as well with SRI practices due to their low tillering growth habits. So we need to assess the responses of different varieties and to make specific varietal recommendations for use with SRI practices.

There are several learning experiences that we have gained about SRI through our fieldwork, both from farmers' reactions and from experience-sharing workshops with other people and organisations working within the SRI movement in Nepal. In 2005, we shared experiences in a workshop organised by ICIMOD (the International Centre for Integrated Mountain Development) in Kathmandu, with representatives of many different organisations.

SRI is becoming popular

After 3 to 4 years of effort by different organisations and individuals, SRI is becoming popular and establishing a position within the mainstream of agriculture development in Nepal. For individual farmers, SRI is becoming attractive due to its greater profitability compared to conventional methods. Conventional rice production, with its high reliance on purchased inputs, is less attractive because of low productivity relative to the high production costs. The prices of inputs (improved seed, fuel, fertilizers and pesticides) have increased two to three fold over the last 10-15 years, and these increased production costs have cut into the profit margins of rice cultivation.

Through SRI methods, farmers are able to get 3 to 4 times as much profit than from conventional methods and this gives farmers an incentive to take up the new practices. These are initially more labour-intensive while farmers are learning the new methods. But once the skills and experience are acquired, and taking advantage of mechanical hand weeders to reduce labour input, farmers can turn SRI into a labour-saving methodology that is good for them, for consumers and for the environment.

A farmer's comparison

Shree Narayan Dhami is a member of the Motipur Village Development Committee Ward No.4, in Morang district. As a farmer, he has been growing rice for many years. Having heard about SRI, he decided to try it out in the 2006 early season (between March and July). He planted 6.5 kathas (approximately 2160 m^2) with seedlings of the Chaite-2 variety and followed all the SRI principles. He sowed a similar field in the conventional way. His SRI crop was sowed in lines so that he could use a rotary hoe weeder, which he could not use in the conventional field. He produced 260 kg rice grains per katha in the SRI field, and only 100 kg/katha in the conventional field. He sold half of his SRI product for seed, for a high price (because the grain size and quality was very good). He found that the rotary weeder was very easy to use and very effective, needing no more help than that of his young son. Having seen and analysed the results, he plans to grow SRI rice on all of his 1.5 hectares of land in the 2007 season, saying that many of his neighbours in Motipur plan to so as well.

Practice/purchase	Costs, SRI rice (Rs./ha)	Costs, conventional rice (Rs./ha)	Difference (Rs./ha)
Seed	125	1250	1125
Nursery preparation	50	500	450
Land preparation	7500	7500	0
Compost	4800	2400	-2400
Fertilizers	1500	3000	1500
Transplanting	1250	1500	250
Irrigation	200	400	200
Weeding	750	1350	600
Pesticide	0	500	500
Harvesting	1750	1500	-250
Total cost	17 925	19 900	1975
Revenue, grain	60 450	23 250	37 200
Revenue, by-product	3000	3000	0
Total revenue	63 450	26 250	37 200
Net profit	45 525	6350	39 175

Conclusions

Rice is the most important crop in Nepal, in terms of sales volume and as the main staple food for Nepalese people. Despite much investment and efforts, the productivity of rice production in Nepal has remained the lowest within the region. Production has failed to keep pace with population growth, and the country has now become a net food importer with an annual deficit of more that 150 000 tons. Increasing rice production can solve this food-deficit problem and save millions of rupees now spent by the government every year in bringing grains to food-deficit areas. The performance of SRI raises the hope among policy makers, development workers and farmers of solving this national problem.

SRI is a very dynamic method which is being developed further on the basis of local experiences and findings. Within a very short time span it is starting to spread rapidly within Nepal and other parts of the world. As a new method, its promoters have faced several difficulties, because it differs markedly from conventional rice farming methods. But with continued effort, further experience and adjustment of practices to suit local situations, SRI is becoming popular and spreading across the country.

Initially, just a few people took an interest in SRI. But today, there are a growing number of District Development Offices, NGOs and private sector actors coming forward to promote SRI methods within Nepal. Farmer initiatives in spreading SRI are also expanding. The main attraction behind SRI is its suitability for a resource-poor country like Nepal. Farmers find the approach advantageous because of SRI's greater productivity and higher profits due to lower requirements for seed, fertilizers, pesticides, and irrigation water. In addition to saving water, SRI helps reduce soil and water pollution and conserve rice biodiversity for sustainable development. In Nepal, SRI is becoming seen as the best solution for its food-deficit problems and for enhancing food security in remote areas where modern inputs are costly and difficult to obtain.

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Rajendra Uprety. Agriculture Extension Officer, District Agriculture Development Office, Morang, Nepal. E-mail: dadomorang@wlink.com.np

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Adapting SRI in Tamil Nadu, India

T.M. Thiyagarajan

Tamil Nadu is India's southernmost state. About two million hectares of rice is grown, mostly under irrigation, with an average yield of 5 t/ha. Average rice productivity is the highest in the country. There is consensus, however, about the need to improve production, as water shortages are becoming increasingly severe, and overall production has stagnated in recent years.

The System of Rice Intensification, or SRI, was introduced only five years ago, and is currently the subject of much debate among agricultural scientists. But farmers are adopting it without bothering about the controversies raised. This is basically because of the visible results that SRI farmers achieve. By employing different principles which includes younger seedlings and wider spacing, SRI offers higher yields and incomes, lower cultivation costs, and other benefits. This article describes these principles on the basis of the experiences of farmers in this state.

Younger seedlings

In conventional rice production, farmers are recommended to transplant seedlings at between 25 and 30 days. In practice, seedlings are often transplanted later, depending on the availability of water or labour. When older seedlings are planted, the main tiller produces a poor early panicle, and the other tillers produce panicles later. This reduces crop growth and yields. SRI involves using younger seedlings. But, when advised to use 9-12 day old seedlings, farmers immediately become concerned, fearing that they may not be sufficiently strong to withstand being pulled out and transplanted. However, experience shows that not only are these young seedlings strong enough to withstand transplanting, they are also in a better condition to do so.

Nursery

Farmers in Tamil Nadu usually have a specific field earmarked for a nursery, which receives more manure. Sprouted seeds are broadcast in a well puddled and levelled nursery field. While seed rates of 20 kg per hectare are commonly recommended, farmers often use seed rates which are 3 to 5 times higher. This means that the seedlings are densely spaced, and as a result, less healthy. SRI practitioners recommend a 20 x 20 cm spacing and only one seedling per hill (see below), so only 25 seedlings are required per m^2, instead of 150 to 200. The wider spacing and single seedling per hill drastically reduces the seed requirements in the nursery, with only 7.5 kg of seed required per hectare instead of 20 kg. As a result, the nursery size can be reduced from 800 m^2 to 100 m^2.

In conventional cultivation, seedlings are uprooted, washed, bundled and transported to the main field. Quite often, the main fields are far away, so there is a long time gap between uprooting and planting. SRI practitioners try to avoid any establishment delays, and/or to remove the seedlings with the base medium, thus minimising any root damage and possible transplanting shock. This might appear to require more time and energy, but in fact it does not, as farmers use far fewer seedlings. Another positive aspect is that it is possible to have the nursery in one corner of the main field so that transfer time can be minimised. The experience of Tamil Nadu farmers has shown that these apparently small changes have a large impact on the final outcome.

Plant density

In Tamil Nadu planting distances of 15 x 10 cm and of 20 x 10 cm are conventionally recommended for short and long duration rice respectively. These recommendations suggest a density of two or three seedlings per hill, although farmers generally plant 4 to 6 seedlings. By contrast, SRI farmers leave wider spaces between the hills, and plant a single seedling in each. Farmers are apprehensive about whether there will be enough panicles per unit area, but rice has a self-adjusting mechanism with regard to tillering: closer planting reduces the tillering of individual plants and wider spacing enables higher tillering rates (depending in both cases on the fertility of the soil).

Photo: Edwin van der Maden

Nurseries can be smaller as less seedlings are needed under SRI practices.

Rice plants have a growth stage referred to as "time of the last productive tiller", which means that only tillers present at that time will become productive. This occurs between 20 and 35 days after planting in conventional cultivation. The goal then is to obtain the desired number of tillers before this time. When single seedlings of less than 14 days are planted at a wider spacing, each has nearly 10 days more for tillering. The wider spacing also gives the seedlings a larger zone from which to draw their nutrients. A spacing wider than 20 x 20 cm is appropriate if soil fertility is good. Some experiments in Tamil Nadu have shown spacings of 25 x 25cm to be better, and similar distances are recommended in Andhra Pradesh.

Transplanting

One of the major hurdles in the adoption of SRI lies in the transplanting process. In contrast to conventional rice production, transplanting in SRI needs to facilitate later weeding. So seedlings need to be placed in rows, preferably following what is known as "square planting": a model which allows weeders to pass in both directions. Farmers in Tamil Nadu do this in different ways, the simplest of which is to use nylon ropes to mark the correct spacing. Matchsticks or small pieces of coloured cloth are inserted in the nylon rope at the desired spacing, facilitating an even spacing along the row. Wooden rods with markings at the desired spacing are fixed at either end of the field to shift the lines.

The Acharya N.G. Ranga Agricultural University in Andhra Pradesh has worked with farmers to develop a hand-drawn marker used to make marks in a square pattern every 25 cm. The marker is now very popular in this state. But while this can save some labour and time compared to line sowing, its effectiveness depends on the field conditions. If the soil is too wet, the marker will sink and not mark the spaces corrrectly. This reduces the effectiveness of using the weeder. The marker is best used a few days after puddling, when the soil has settled and moisture levels are not too high. Efforts are currently being made to develop a floating arrangement to avoid the marker sinking.

Weeder use

Different evaluations have shown that weeding is one of the most important factors in SRI. This represents a major change in rice cultivation, and has a noticeable effect on the growth of the plants. Farmers in Tamil Nadu use two types of weeders. One is the rotary weeder, which is light (2 kg) and can therefore be used by women labourers. It can be used in plant spacings of 20 x 20 cm or wider, and is very useful for small scale and marginal farmers who can do the weeding without having to hire labourers. The other model, the cono-weeder, is used with wider spacings. It weighs approximately 7 kg and is mostly suitable for use by men. It has two cones which stir the soil thoroughly. Large farms have also introduced motorised weeders, though these are only successful if the square planting and lines are perfect.

Existing weeds are incorporated into the soil when the weeders are used every 10 days. This results in a considerable incorporation of biomass (more than 700 kg/ha according to different studies) and, more importantly, the maintenance of nutrients within the soil. Studies have also shown that weeder use causes an “earthing up” action which helps new roots to be formed. Further studies are required to analyse common farming practices, such as allowing animal grazing during fallow periods in fields where weed infestation is low, and the advantages and possibilities of green manure.

Shallow and intermittent irrigation

In Tamil Nadu, rice is grown in many different conditions, with water availability dictated by the monsoon rains. The north east monsoon season (between October and December) is the main rice season in both irrigated and rainfed environments. Farmers adopting SRI initially considered irrigating the fields in the evenings and draining the excess water the following morning. This, however, proved to be time consuming and labour intensive. At the same time, water scarcity led scientists to focus on other ways of saving water in agriculture, looking in particular at the possibilities of “improving” SRI.

In conventional rice production in Tamil Nadu it is generally recommended to flood the field with a layer of water up to 5 cm deep, one day after the disappearance of flood water. However, adoption of this recommendation by farmers is poor, due mainly to problems associated with water availability. No definite recommendation is given for irrigation under SRI, except that the soil should remain as aerobic as possible. Current practice among SRI farmers is to provide a water layer of up to 2.5 cm after cracks develop in the surface of the soil up to the panicle initiation stage. After that they provide the same depth one day after the surface water has disappeared. Development of surface cracks does not imply that the soil is dry or that the cracks will be deep enough to cause nutrient losses. Rather, it happens due to the formation of small hairline cracks in soil which is still moist but has no standing water. The soil is not allowed to dry out. This approach requires regular monitoring of the field, which is especially important in cascade irrigation areas and during the monsoon.

A comparative evaluation

The positive effects of SRI on rice production and water saving has prompted the submission of a policy note to the Government of Tamil Nadu. In a swift decision making process, the State Government sanctioned 25 million rupees to evaluate SRI in two major rice growing areas of the state: the Cauvery Delta and the Tamiraparani river basin in south Tamil Nadu. This was carried out through 100 Adaptive Research Trials in selected farmers’ fields during the wet season of 2003-2004.

The trials compared SRI with conventional cultivation on 1000 m^2 plots without replication. All participating farmers were supplied with the required inputs and a weeder, and were asked to follow the different component parts of SRI. Grain yields were recorded carefully by collecting all the panicles from five randomly selected 1 m^2 areas from both the SRI and the conventional plots, and recording the grain weight after threshing and cleaning. The yield was reported at a 14% moisture level.

In the Tamiraparani basin, the grain yields recorded under SRI ranged from 4214 to 10 655 kg/ha and those from conventional cultivation between 3887 to 8730 kg/ha. Average results showed a yield advantage of 1570 kg/ha under SRI. Thirty-one farmers recorded yields of more than 8 t/ha under SRI, while only three farmers obtained those yields using conventional cultivation. Yield increase was associated with an increased number of panicles per m^2 and an increased number of filled grains per panicle. Of the 10 varieties used by the farmers, three were found to perform very well under SRI. Square planting was the only constraint faced by the farmers as they found that their former practice of random planting was much quicker.

Results in the Cauvery Delta area were similar. The additional yield advantage from SRI ranged from 500 to 1500 kg/ha. Increased grain yield under SRI was mainly attributed to a greater number of lengthy and productive tillers with an increased number of filled grains per panicle, and to fewer unfilled grains. Between 300 to 400 mm of water was reported to be saved through intermittent irrigation.

Adoption of SRI by farmers

SRI is attractive to small and marginal farmers because of the higher yields, the lower seed requirement and the relative ease of weed management. Results obtained by farmers throughout the state have convinced the Tamil Nadu State Department of Agriculture to actively promote SRI through its extension service. They set up demonstration trials in major rice producing areas of the state in the 2004, 2005 and 2006 rice seasons. Extension has helped spread SRI to farmers, as have the more informal farmer-to-farmer exchanges. The benefits of using younger seedlings, wider spacing and weeder use are best demonstrated by the visible results, which once seen by farmers lead to high uptake. Many NGOs are also taking a keen interest in this approach. ■

T.M. Thiyagarajan. Rice Research Station/Krishi Vigyan Kendra, Tirur 602 025, Tiruvallur District, Tamil Nadu, India. E-mail: tmthiyagarajan@yahoo.com

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SRI in context: lessons from the field

Willem A. Stoop

The development of the System of Rice Intensification (SRI) over the past two decades has generated a variety of responses from farmers and scientists. These responses are illustrative of the gap that exists between the conventional policies and attitudes towards agricultural research and development, and the agricultural development taking place in the field. This highlights the need for scientists and development personnel to consider a much broader range of technologies than the conventional modern technological packages that are widely promoted as the only means of resolving the world food problem.

SRI has proved to be an important development which provides new technological options for many farmers. The efforts of Father de Laulanié in Madagascar to improve rice farming provide an illustration of the enormous potential of a very modest, yet well-focused agricultural development effort. However, as De Laulanié showed, there is much more to development than just introducing a new technology or a different practice. His views, presented more than 20 years ago, remain highly relevant. For example, he considered that the transition from a traditional (i.e., a closed, internally-focused) society towards communities that are more open, and therefore externally-oriented in terms of knowledge and trade, involves a slow and long-term process of development. He also recognised that sustainable development requires a major emphasis on education in a broad sense, including an exposure to the principles of biology (crops and animals), the environment (climate, water and soils), and of child and health care. Lastly, he stressed the diversity in people's aptitudes towards, for instance, agriculture. His estimate was that around 80 percent of the rural population carry out agriculture on a traditional, routine basis. For only a minority of farmers is agriculture a full-time "profession". It is only this small group that is initially inclined to experiment, closely observe the crop and to adopt new practices. Responses to the System of Rice Intensification in Madagascar show the importance of taking these points into account.

SRI is often presented as a very sophisticated and labour-intensive approach, requiring strict water control (irrigation as well as drainage), well-levelled fields, ample supplies of compost or manure, and much labour to ensure timely transplanting and frequent weeding, both of which are the most critical field operations. The realities in the field, however, differ quite substantially from this presumed "ideal" image.

Farmer responses in Madagascar

Field observations and discussions with Malgache farmers have repeatedly confirmed that SRI indeed has the potential to produce extraordinary grain yields (above 10 tons/ha), provided the farmer has mastered the techniques, and in particular the timing of operations. In addition to increased grain yields, farmers emphasise two other major advantages: large savings on seed (SRI requires as little as 10 percent of the usually amount) and a greater tolerance to drought compared with recommended conventional and traditional technologies. This greater drought resistance is due to the larger and better-functioning root systems of plants grown under SRI.

SRI farmers have won all the prizes in all the rice-yield competitions held over the last three years (22 regional and one national). This has convinced the Minister of Agriculture, and even the President, to give full support to the promotion of SRI.

Yet, many farmers are not adopting SRI, even if they are aware of the possibilities. Field interviews showed a number of reasons why the SRI approach is not being practised more widely, in spite of its obvious potentials. First of all, traditional rice farming in Madagascar is a centuries-old practice, closely interwoven with many traditional and cultural beliefs. Changing traditional practices is not readily done. Most farmers adopting SRI therefore show some common characteristics which the non-adopters lack: they are highly motivated, better educated (some having completed tertiary education), take a keen interest in observing their fields and are efficiently organised. In short, they are very interested in farming. The majority of these farmers keep cattle close to the house and produce ample supplies of farmyard manure and compost. In all cases, their SRI plots were located relatively near to the house, making close observation and timely management possible. By contrast many non-adopters live in the towns, have no cattle and visit their fields only occasionally. They face time and labour constraints, excessive weed problems, and no or inadequate control over irrigation water.

Thus, it is not merely the agronomic potential of SRI itself that influences farmers' decisions about uptake. Many other aspects, ranging from technical, cultural, psychological and even political considerations also play an important role in the equation.

Photo: Edwin van der Maden

Although weeding means extra work, it contributes to higher yields as one of the key components of SRI.

SRI and agricultural development policies

SRI practices have a significance that goes beyond the immediate benefits in productivity. They point to important, so-far under-exploited, potentials in crop production. Occasionally, SRI crop yields have been recorded that far exceed what are believed to be yield ceilings, derived from theoretical crop modelling efforts. These models are based primarily on photosynthetic rates, translocation of nutrients within the canopy and other above-ground relationships. The soil environment and root development factors, including the possible contributions of symbiotic soil organisms to plant growth and health are generally ignored by these models. However, high SRI yields have been recorded with modern varieties as well as with traditional, full-season, local varieties, many of which are characterised by the research establishment as inefficient and unable to respond effectively to intensification practices.

Comments by farmers, development personnel and scientists confirmed that SRI should be considered mostly as an empirical approach which is largely based on field experiences rather than theoretical understanding. However, to fully exploit its potential, including effective dissemination and adaptation to other agro-ecological environments, it is imperative for researchers to clarify the biological and ecological mechanisms and processes involved. Observations on farmers' fields indicate that the potential of SRI is rarely fully exploited. This may be due to the use of available rather than optimal varieties, sub-optimal water and fertility management, or inadequate plant spacings.

The potential of SRI can be better realised if it is integrated into a long-term development effort in which research, together with education and participatory learning –through, for example, Farmer Field Schools– play a vital role. Small farmers have developed an empirical package of practices for rice that in many ways run contrary to conventional wisdom (introducing single plants, wide spacing, very young transplants, and intermittent drainage rather than continuous irrigation). This in itself should be of considerable interest to agricultural scientists. To seize on this obvious opportunity, researchers need to match the agricultural professionalism shown by some Malgache farmers and increasingly by farmers in other parts of the world.

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Willem A. Stoop, Akkerweg 13A, 3972 AA Driebergen-R, the Netherlands.
E-mail: willem.stoop@planet.nl

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Beyond technical solutions

Edwin van der Maden

The majority of farms in Tamil Nadu, India, are less than two hectares in size, and the family depends on successful rice production for food. Therefore, risk is central to many aspects of rice cultivation and "risk aversion" plays a major role in the farmers' decision-making processes. These small farms are especially vulnerable to unexpected changes and unstable conditions, and the increasingly limited availability and irregular supply of water is a major problem in crop production. As the System of Rice Intensification (SRI) requires less water than conventional rice cultivation, it is an interesting option which could help to resolve the problems of water availability.

Farmers in Tamil Nadu have started to try out SRI. The level of adaptation will depend not only on its technical feasibility but equally on its social viability. In 2004, a study was undertaken to analyse the social suitability of SRI. Farm surveys were conducted in the Tambiraparani river basin (Tirunelveli and Tuticoring districts) in Tamil Nadu; interviews at Government departments, field visits and literature research provided additional sources of information.

Risk and uncertainty

The farmers who tried out SRI for the first time were generally surprised and positive about the method and its results: higher yields with reduced water usage. Despite these positive reactions and awareness of the advantages, relatively few farmers practice SRI or are motivated to fully switch over to SRI. They remain sceptical, and perceive SRI practices as relatively difficult compared to conventional rice cultivation practices. Most farmers say that they are not familiar enough with the SRI technique to practise the system independently. They feel insecure about the practices and fear that poor implementation of the practices could lead to crop failure. At the same time, they are highly skilled in the conventional system and know what to expect from it. It may be expected that large, wealthy farmers with a good education level are likely to be the first adopters of SRI, as they are better positioned to deal with a certain level of risk. If SRI is seen to be effective and successful, without increasing the risk of crop failure, then the majority of the smaller and poorer farmers may follow.

External influences

The government extension service works with selected progressive farmers, as they find it impossible to reach all farmers directly. In practice, many small and marginalised farmers are unreachable. The quality of the extension services differs greatly between and within regions, although communication between farmers and extension agents is mostly one-way (top-down). All these conditions mean that farmers are often not as well supported as they could be.

When the System of Rice Intensification was introduced in Tamil Nadu, it encountered a different social-technical environment from the farming environment of Madagascar where it was originally developed. The influence of the Green Revolution is clearly visible in Tamil Nadu, whereas in Madagascar it is not. As a result, several adjustments to the system have already been developed and implemented, such as the introduction of the nursery mat, mechanical weeding in combination with line and square planting and direct seeding techniques. The main focus of interest in SRI in Tamil Nadu is its potential to reduce water usage. The other practices are of lesser interest but are necessary to achieve desirable results. In Tamil Nadu, SRI practices are a combination of those developed in Madagascar with the Green Revolution practices already existing in the area. Initial experiments and field trials suggest that this combination offers promise for Tamil Nadu, combining increased yields with less water use.

A promising option

The System of Rice Intensification is a promising option for addressing the problem of limited and irregular water availability for crop irrigation in Tamil Nadu. However, any solution needs to consider more than just the technical aspects. The study showed that successful introduction of an innovation like SRI goes far beyond the technical level and is closely interwoven with the socio-technical environment which significantly influences uptake and therefore must be given equal consideration.

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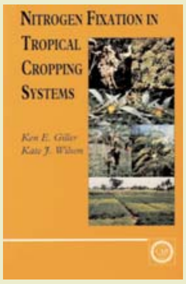
Edwin van der Maden, MSc student Plant Sciences, Wageningen University, The Netherlands.
E-mail: Edwin.vandermaden@wur.nl

SOURCES

Agroecology and the search for a truly sustainable agriculture by Miguel A. Altieri and Clara I. Nicholls, 2005. 279 pp. ISBN 9687913355. UNEP, Environmental Training Network for Latin America and the Caribbean. Boulevard de los Virreyes 155, Colonia Lomas de Virreyes 11000, Mexico D.F., Mexico. Downloadable from http://www.agroeco.org/doc/agroecology-engl-PNUMA.pdf, also in Spanish.

The subject of this book is sustainable agriculture and its importance to sustainable development in general. The book analyses the problems of mainstream agriculture and offers tools to enable a more ecologically rational use of soils, land, biodiversity and natural resources, to preserve and enhance sustainable productivity in order to ensure food security and sustainable agriculture. This book explores the features and ecological, social and economic benefits of sustainable agriculture. It seeks to root sustainable agricultural production in ecological potentials and cultural values, to open a dialogue between scientific knowledge and traditional wisdoms, and to empower farmers as social actors to renew their community based productive practices.

Nitrogen fixation in tropical cropping systems by Ken E. Giller and Kate J. Wilson, 1991. 313 pp. CAB International, Wallingford, Oxon OX10 8DE, U.K.



Although fifteen years old, this book gives a comprehensive review of the processes of nitrogen fixation, showing how the inputs of nitrogen can be utilised for sustainable agricultural production. It looks at the existing nitrogen fixing organisms in the tropics, and at their role in various cropping systems (including pastures, agroforestry systems, wetland rice and others). Building on the necessary measurements of nitrogen fixation in the field, the book includes a whole section on optimising the process, focusing on the environmental constraints most commonly observed, and on the successes and failures of past approaches.

Resource capture by crops by J.L. Monteith, R.K. Scott and M.H. Unsworth (eds.), 1994. 470 pp. ISBN 1897676212. Nottingham University Press, Manor Farm, Church Lane, Thrumpton, Nottingham NG11 0AX, U.K.

"Resource capture" is a concept frequently applied in agricultural science and in ecology to integrate understanding of the mechanisms by which leaves and roots capture the resources necessary for growth – light, water, carbon dioxide and mineral nutrients. The concept is also useful for investigating how careful management and breeding could increase the efficiency of crop production and minimise pollution of the natural environment. This book includes a review of the main principles at the organ and crop stand level. It also presents various case studies of particular systems, showing examples where competition for light and water in arable crops is strong, the complementarity of resource use in intercropping and agroforestry systems, or the relationship between light interception and nitrogen requirements. A main advantage is its interdisciplinary approach.

Water for food, water for life: A comprehensive assessment of water management in agriculture, 2006. 310 pp. To be published by Earthscan, 8-12 Camden High Street, London NW1 0JH, U.K. E-mail: orders@earthscan.co.uk

The comprehensive assessment of water management in agriculture is a five-year initiative to analyse the benefits, costs, and impacts of the past 50 years of water development and management in agriculture, to identify present and future challenges, and to evaluate possible solutions. The report is being finalised and will be available at the end of 2006. For more information, visit this address: http://www.iwmi.cgiar.org/assessment or send an e-mail to: comp.assessment@cgiar.org

Biological approaches to sustainable soil systems by Norman Uphoff, Andrew S. Ball, Erick Fernandes, Hans Herren, Olivier Husson, Mark Laing, Cheryl Palm, Jules Pretty and Pedro Sanchez (eds.), 2006. 784 pp. ISBN 1574445839. CRC Press / Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, Florida 33487-2742, U.S.A. http://www.crcpress.com

This book includes the work of both researchers and practitioners from around the world. It explores problems and solutions for sustainable soil-system management in a variety of climatic conditions. The text is thorough and detailed, and discusses the importance of symbiotic relationships between plants and soil organisms, looking at crops as integral and interdependent participants in ecosystems. It seeks to reduce the distance between scientific research and agricultural practice, and examines pest and disease control, climatic change, methods for fertility restoration, and measurement, monitoring and modeling to improve soil-system management. The different chapters look at innovation in soil system strategies in tropical and temperate regions, and present a variety of ways to produce more crops with less dependence on external inputs.

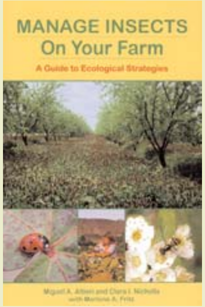
Agri-Culture: Reconnecting people, land and nature by Jules Pretty, 2002. 240 pp. ISBN 1853839256. Earthscan / James & James, 8-12 Camden High Street, London NW1 0JH, U.K. E-mail: orders@earthscan.co.uk

This book presents a "sustainable agriculture revolution" based on many stories of successful agricultural transformation. After showing how modern societies have become "disconnected" from nature and the agricultural and food systems, the author focuses on a thorough economic analysis, considering how the real price of food should incorporate the damage done to environments and human health. The book concentrates then on the possibilities of eliminating poverty with a more sustainable agriculture, leading to the need to "reconnect" whole food systems.

Assessments of the System of Rice Intensification (SRI): Proceedings of the International Conference held in Sanya, China, April 2002, edited by Norman Uphoff, Erick Fernandes, Yuan Longping, Peng Jiming, Sebastien Rafaralahy and Justin Rabenandrasana. Downloadable from http://ciifad.cornell.edu/sri/proc1/index.html

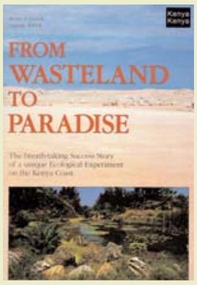
This international conference, organised by the Cornell International Institute for Food, Agriculture and Development (CIIFAD) and the China National Hybrid research and Development Center, was presented as a "first attempt to assess cross-nationally the opportunities and limitations that are presented by this remarkable methodology for increasing rice production". Participants analysed their experiences with SRI in different countries. The different papers present how SRI is being elaborated and modified under diverse conditions, responding to different farmers' constraints and to their specific objectives.

Manage insects on your farm: A guide to ecological strategies by Miguel A. Altieri, Clara I. Nicholls and Marlene A. Fritz, 2005. 128 pp. Sustainable Agriculture Network (SAN) Publications, P.O. Box 753, Waldorf, Maryland 20604-0753, U.S.A. E-mail: sanpubs@sare.org Downloadable from http://www.sare.org/publications/insect/insect.pdf



While every farming system is unique, the principles of ecological pest management apply universally. "Manage insects on your farm” highlights the ecological strategies that improve a farm’s natural defences and encourage beneficial insects to attack pests. This book presents how ecologically based pest management works, showing the strategies used by farmers around the world to address insect problems. As part of the principles of ecologically based pest management, it describes how to manage soils to minimise the presence of pests, and describes the most common “beneficial agents” on a farm.

From wasteland to paradise by René D. Haller and Sabine Baer, 1995. 120 pp.
Planting a seed. Regeneration in rural Africa, 2006, video 15 minutes on DVD. The Haller Foundation, 7 Hungershall Park, Tunbridge Wells, Kent TN4 8NE, U.K. Email: hallerfoundation@aol.com ; http://www.thehallerfoundation.com



In the early 1970s, the Bamburi Cement Company gave René Haller the mandate to try to restore the scarred landscapes left by the limestone quarrying used in the manufacture of cement in the coastal region of Kenya. Using an entirely sustainable approach, 250 hectares of quarried land which was completely inhospitable, and which would have taken hundreds of years to regenerate, have been restored. The book shows the ecological processes involved in the regeneration of this area on the East African coast and explains the difficulties and successes. The film, recently shot, shows how people now live and work on the regenerated land.

Tropical Agroforestry by Peter Huxley, 1999. 384 pp. ISBN 0632040475
Blackwell Science Ltd P.O. Box 269, Abingdon, Oxford, OX14 4YN, U.K.
http://www.blackwell-science.com

This comprehensive book provides analytical descriptions of the principles of agroforestry, as well as their practical implications. It considers farmers’ viewpoints alongside technical issues, and also discusses some of the trade-offs which often need to be made in agroforestry systems. It is written in an easily accessible style, and is separated into six sections, covering technical topics such as competition, how trees and crops interact and arranging plant mixtures for best resource use. It goes on to discuss the place of agroforestry in sustainable land use. This book can be of use to students, development field staff and researchers, and it uses many examples and diagrams to illustrate the text.

Biodiversity and pest management in agroecosystems by Miguel A. Altieri and Clara I. Nicholls, 2004, 224 pp. ISBN 1560229233. The Haworth Press Inc., 10 Alice St., Binghamton, New York 13904, U.S.A. E-mail: barnold@haworthpress.com

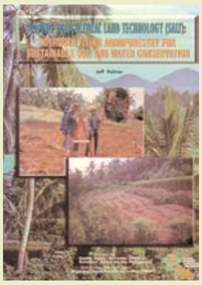
This is the second edition of this book, which has been revised and updated to include new findings and strategies for pest management. It shows how pests can be managed by enhancing beneficial biodiversity using agroecological diversification methods. It firstly provides an overview of the role of biodiversity in agriculture and moves on to give details of methods for making agricultural systems less susceptible to insect pests. It provides the theory and practice of enhancing biological pest control in agricultural systems by managing vegetational diversity through multiple cropping, cover cropping, rotations, and other spatial and temporal designs. With examples of intercropping, cover cropping, weed management, and crop-field border vegetation manipulation, this book covers the effects of these diverse systems on pest population density and the mechanisms underlying pest reduction.

Realizing community futures: A practical guide to harnessing natural resources by Jerry Vanclay, Ravi Prabhu and Fergus Sinclair, 2006, 162 pp, ISBN 1844073831 Earthscan / James & James, 8-12 Camden High Street, London NW1 0JH, U.K. E-mail: orders@earthscan.co.uk

This new book brings together many ideas, tools and examples related to community-based natural resource management. It shows how communities and people involved in managing natural resources can work together, through building visions and exploring alternatives, to turn their ideas into reality. The text draws heavily on two case studies, from Zimbabwe and India, and through these cases outlines the techniques and principles used, which can be applied in communities around the world. In this sense it is a practical, and clearly written manual which can be of use for successful sustainable community development and prosperity in many situations.

Manual on contour hedgerow inter-cropping technology by T. Ya and A. Pandey (eds.), 1999. 29 pp. International Centre for Integrated Mountain Development (ICIMOD), G.P.O. 3226, Kathmandu, Nepal. E-mail: distri@icimod.org ; http://www.icimod.org

This small manual on hedgerow intercropping explains the benefits of the system for sloping land and for the farmer in an illustrative way, explaining the technology for hedgerow planting and management. The contour hedgerow intercropping technology is a soil-conserving technique. It involves planting double hedgerows of nitrogen-fixing plants along the contour lines of the slope at a distance of four to six metres. The space between the contour hedgerows is used for food and cash crops. The plants for the hedgerows are selected according to the need for fuel or fodder and for their soil-conserving attributes.



Sloping Agricultural Land Technology (SALT): Nitrogen fixing agroforestry for sustainable soil and water conservation by John Jeff Palmer, 1998. 80 pp. Mindanao Baptist Rural Life Center (MBRLC), P.O. Box 41, Bansalan, 8005 Davao del Sur, the Philippines.
E-mail: mbrlc@mozcom.com ;
http://mozcom.com/~mbrlc/

This manual on agroforestry systems provides information and technologies on the use of nitrogen fixing trees and crop species on farms with the objective of enhancing the sustainability of the system. Other manuals on SALT are available at very reasonable prices from the website.

Outgrowing the Earth: The food security challenge in an age of falling water tables and rising temperatures by Lester R. Brown, 2004. 239 pp. ISBN 0393327256. W.W. Norton & Co Ltd., Castle House, 75/76 Wells Street, London W1T 3QT, U.K.
Website: http://www.earth-policy.org

This book documents the ways in which human demands are outstripping Earth’s natural capacities and the resulting environmental damage is undermining food production. The ability to provide enough food depends not only on efforts within agriculture but also on energy policies that stabilize climate, efforts to raise water productivity, the evolution of land-efficient transport systems, and population policies that seek a humane balance between population and food. These and other issues are discussed in separate chapters providing an overview of the challenges facing global food security.

Soil remineralisation

http://www.remineralize.org

This website is the home of Remineralize the Earth, Inc., a non-profit organisation which aims to disseminate ideas and practices about soil remineralisation throughout the world. There is a lot of background information about soil remineralisation in agriculture and gardening, with case studies from all over the world. There is also an online magazine, many links to other remineralisation sites, and updates on current research. Remineralize the Earth is connected to a community grassroots network that stretches to every continent, and is a good starting point for finding out more about this topic.

Tefy Saina

http://www.tefysaina.org

This is the website of the NGO in Madagascar that first began working on the System of Rice Intensification. Sections on the website describe the history of the development of SRI, as well as the founding of Tefy Saina to build on the work of Henri De Laulanié with local farmers. Their current activities are also outlined. The website is in French, but there is an SRI manual available to download in English (http://www.tefysaina.org/manuelSRI-us.pdf).

SRI Website

http://ciifad.cornell.edu/sri

A collaborative effort of Tefy Saina and Cornell University's CIIFAD, this website reports on improvements in SRI that are continually being made, including better implements and techniques, which farmers are encouraged to consider and further improve upon. It provides the opportunity to join discussion groups as well as to enlist to SRI-UPDATE-L, an electronic mailing list for those interested in receiving periodic updates about SRI. There are links to the websites of the Cornell International Institute for Food, Agriculture and Development (CIIFAD); the Tropical Soil Cover and Organic Resource Exchange (TropSCORE) with its Worldwide Portal to Information on Soil Health, and of the Management of Organic Inputs in Soils of the Tropics (MOIST) group.

Community Agroecology Network

http://www.communityagroecology.net

Community Agroecology Network (CAN) is an international network of rural communities and consumers committed to sustaining rural livelihoods and environments by integrating research, education and trade innovations. The network provides rural communities with the tools to become economically viable through sustainable farming practices while also benefiting the environment. Through this website visitors can order coffee directly from a farmer co-op, learn more about immersion internships with farm families in Latin America, explore the communities that CAN works with, become a CAN member and help support the work of CAN.

African Conservation Tillage Network

http://www.act.org.zw

The African Conservation Tillage Network (ACT) is an international association of players and stakeholders –private, public and NGO sectors, including farmers, input and machinery manufacturers and suppliers, researchers and extensionists– who believe that the adoption of conservation tillage principles and practices in Africa can not only reduce but reverse the environmental degradation that is devastating the continent. ACT promotes and facilitates sharing of information and experiences across sectors, disciplines and geographical boundaries among players and stakeholders involved in promoting adaptation and adoption of conservation farming principles and practices in Africa. Various documents and information can be found on the site, as well as the principles of Conservation Tillage, and a mailing list discussion forum.

The Community-Based Natural Resource Management Network

http://www.cbnrm.net

Worldwide, people working on Community-Based Natural Resource Management (CBNRM) as practitioners, managers and researchers, are increasingly requesting better communication capabilities. Such communication and networking capabilities can make it possible for people to exchange experiences, manage relevant knowledge, and support learning across countries, sectors, cultures, and languages, and in this way achieve better results. CBNRM Net was conceived to respond to this. The site has a comprehensive Resources section, with many links and a lot of reference and background information.

Soil Biodiversity portal of the FAO

http://www.fao.org/ag/agl/agll/soilbiod/default.stm

This website provides information about the meaning and significance of soil biodiversity for agriculture, emphasising the need for an integrated soil biological management. It aims to encourage the exchange of information, provide case studies, and to highlight research findings and expertise for agricultural development programmes, networks and ultimately farmers. There are links to on-line databases, background papers and other relevant programmes. This all provides a framework under which soil biodiversity can be assessed, managed and conserved, showing examples of successful and unsuccessful practices which have been used in various regions of the world to manage soil biodiversity.

Agroecology Home

http://www.agroecology.org

This website is an information resource for developing sustainable agroecosystems, emphasizing international training, research, and application of agroecological science to solving real world problems. Building on an agroecology textbook written by Stephen R. Gliessman, this site offers agroecological knowledge to anyone concerned with sustainable food systems. It provides tools for understanding principles of agroecology using a series of case studies, and a glossary of agroecological terms.

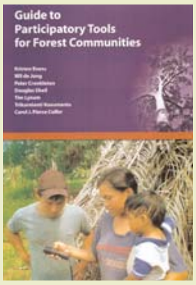
CHARM

http://www.charmbd.com

The Chittagong Hill Tracts Improved Natural Resources Management (CHARM) project aims to establish sustainable natural resources management through the provision of improved access to knowledge and information on the environment of Chittagong Hill Tracts and sustainable land management alternatives. By documenting land management approaches and technologies, both indigenous and scientific or newly acquired knowledge, and making it available through different media, the learning cycle of trial and error in adaptation of local land use systems towards a new sustainable practice fitting changed and new conditions, is facilitated. This website describes the area in detail and provides links to summaries of outputs.

NEW BOOKS

Guide to participatory tools for forest communities by Kristen Evans et al., 2006. 37 pp. ISBN 9792446567. Center for International Forestry Research (CIFOR), P.O. Box 6596 JKPWB, Jakarta 10065, Indonesia. E-mail: cifor@cgiar.org Downloadable at: http://www.cifor.cgiar.org/publications/pdf_files/Books/BKristen0601.pdf



This toolkit contains a collection of participatory tools for environment and development practitioners, researchers, and local government leaders. Some of these tools are adaptations of existing methods; others were created specifically for work with forest-dependent communities, for promoting sustainable forest management and empowerment of these and other natural resource dependent communities. The tools have many applications, including stakeholder identification, decision making, planning, conflict management, and information collection. The guide gives an idea of each tool's basic capabilities, in order to help identify the most appropriate tool for a given situation. References for further information are provided, as the guide does not provide an exhaustive description of how to use each tool. It is intended as an introduction and comparative overview, to guide readers. The methods have been used and tested in communities in many countries, including Indonesia, Vietnam, Nepal, Zimbabwe, Cameroon, Malawi, Brazil and Bolivia.

Cities farming for the future: Urban agriculture for green and productive cities by René van Veenhuizen (ed.), 2006. 474 pp. ISBN 1552502163. IIRR/RUAF/IDRC, IIRR, Y.C James Yen Center, Silang, Cavite 4118, the Philippines. E-mail: bookstore@iirr.org Downloadable at: http://www.ruaf.org/node/961

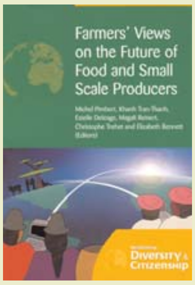
With increased urbanisation, agriculture in urban areas has received increased attention in the past few years, from development organisations and national and local authorities in developing countries. The books sets out to show how urban agriculture can play a role in urban poverty alleviation and social inclusion, urban food security, urban waste management and urban greening. The chapters of this book (each of which are downloadable at no cost from the website) cover urban horticulture, livestock keeping, waste water use, financing and investment, gender, how urban agriculture can contribute to the building of communities, among many others. Each chapter draws heavily on examples and also includes three short case studies from different parts of the world. In this way, the book is a very up-to-date and relevant collection of experience-based developments in sustainable urban agriculture.

Rainwater harvesting for domestic use
by Janette Worm and Tim van Hattum, 2006, 84pp. Agrodok 43, CTA and Agromisa Foundation, P.O. Box 41, 6700 AA Wageningen, the Netherlands. E-mail: agromisa@agromisa.org

This booklet explains how to collect, store and purify rainwater for direct use at household level. It is a practical guide to creating a rainwater harvesting infrastructure from design to implementation that is illustrated with pictures, tables and examples. However, the authors state that it is by no means comprehensive, since there are numerous specialised RWH techniques determined by local circumstances such as rainfall, culture, materials and costs. This Agrodok will be helpful to households as well as to community-based organisations, NGOs, local government staff and extension workers in both rural and urban areas.

Farmers' views on the future of food and small scale producers
by Michel Pimbert et al. (eds.), 2006. 75 pp. ISBN 184369588x. IIED, Progressio, Tebtebba, Small and Family Farms Alliance and the U.K. Food Group. Endsleigh Street, London WC1H 0DD, U.K. E-mail: info@iied.org

The outcomes of an electronic conference are presented in this report, as part of the Reclaiming Diversity and Citizenship series from IIED. The e-conference aimed to give more "voice" to people whose views are rarely heard in policy discussions. Various question were posed, and over 200 participants from more than 40 countries contributed to discussions in French, Spanish and English. This book is a summary of all the written contributions received, and provides interesting insights from different regions into topics such as "What needs to change to allow small scale producers to achieve their vision?" Participants were primarily from farming, indigenous and fishing communities, with invited contributions from selected scholars and policy analysts. The views and analysis presented offers a deep understanding of alternative movements in rural and urban areas. The book also examines the process of organising the e-conference, as a method which contrasts sharply with more conventional models.



Food is different: Why we must get the WTO out of agriculture by Peter M. Rosset, 2006 163 pp, ISBN 1842777556, Zed Books Ltd., 7 Cynthia Street, London N1 9JF, U.K. E-mail: sales@zedbooks.net ; http://www.zedbooks.co.uk

The global debate about trade and subsidies is critical but can be confusing. This book aims to explain the key points and look at some alternative policies. The author reviews recent trade negotiations and liberalisation policies, and examines the key differences in opinion. He goes on to present examples of the effects of trade agreements for farmers and communities in Mexico and Africa. The book is dedicated to Lee Kyung Hae, the peasant farm leader from South Korea, who took his own life during protests at the World Trade Organisation talks in Mexico in 2003. The message of the book is that food is not like any other commodity that is traded across borders, but is different because of the way it is produced – for small scale farmers, food is farming, which means rural livelihoods and cultures. Choices about the way the trade in food is governed will affect local regional and national economic development.

The future of small farms: Proceedings of a research workshop, 2005. 360 pp. International Food Policy Research Institute (IFPRI), 2033 K Street NW, 20006-1002 Washington D.C., U.S.A. E-mail: ifpri@cgiar.org ; http://www.ifpri.org Downloadable free of charge.

This summary report of the proceedings of the Future of Small Farms workshop held on 26-29 June 2005 in Wye, U.K., provides all the presented papers and discussion reports of the workshop. If the UN Millennium Development Goals for poverty and hunger are to be achieved, governments and donors need to shift their attention to developing agriculture in general and strengthen small farms in particular. The workshop focused on marketing opportunities; smallholder farming in difficult circumstances; productivity of small farms; and policies and politics for smallholder agriculture. Given the research orientation of the workshop, its key objective was to obtain a detailed overview of the main debates around the issue of small farms. The workshop was designed to shed light on the debate and to stimulate further research as well as contribute to informed policy making for pro-poor growth strategies.

Introducing a new partner

The Center for Biodiversity and Indigenous Knowledge (CBIK)

CBIK is a Chinese NGO based in Yunnan province. Established in 1995, it currently has 22 staff, and more than 100 members. CBIK is dedicated to promoting the sustainable utilisation of biodiversity to support livelihoods among ethnic minority peoples in Yunnan and southwest China. The main way we seek to achieve this is by doing action-research with ethnic minority communities, the government and other non-government agencies. CBIK is known within China as one of the early practitioners and promoters of participatory approaches, such as Participatory Technology Development, which have been applied in agriculture, animal husbandry and forestry. CBIK also serves as a centre for information exchange on issues relating to livelihoods and resource management in ethnic minority areas of southwest China. It has produced several dozen Chinese language publications, and convened national and international meetings that promote exchange and collaboration on relevant issues.

China is one of the largest agricultural nations in the world. Rapid economic growth and social development has brought many changes for rural communities in China, and many new challenges. Despite economic growth, several million people still live in poverty. Ecologically sustainable agricultural production that contributes to improved livelihoods for China's millions of rural inhabitants is a development priority. As such, there is a great need to develop effective approaches to resource management and livelihood development and promote their adoption throughout China.


Photo: Andreas Wilkes

CBIK plans to contribute to this by producing a Chinese edition of the *LEISA Magazine*. In 2007 we will produce a translation of the global edition, while gradually building a readership and soliciting Chinese language contributions. From 2008, we will produce a magazine which draws on both international and Chinese experiences. We look forward to being able to introduce your experiences to Chinese farmers and those who work to support them. Later on, we hope to be able to provide you with more informative experiences from China.

■

Andreas Wilkes. CBIK, 3rd Floor, Building A, Zhonghuandasha, Yanjiadi, Kunming, Yunnan 650034, People's Republic of China.

Call for articles

June 2007, Issue 23.2

Seeds and planting material

All farming depends on a continuous supply of good quality seeds and planting materials. Traditionally, farmers select the best grains from their harvest and store these for use in the following cropping season. By choosing seeds which perform best in their particular farming conditions, they have, over time, developed local varieties and breeds most suited to their specific conditions and preferences. In this way they have not only maintained but also increased the rich biodiversity on which small-scale agriculture is based. For example, there are thousands of rice varieties, and it is still common for farmers in the Andes to know more than a hundred different varieties of local potato by name.

But having enough reproduction or propagation material for the coming season is becoming increasingly difficult for small-scale farmers. A drop in yield, and the resulting food shortage can make it difficult to save enough seeds for the next season. As the social cohesion of most rural communities is being weakened, so are the opportunities to use local mechanisms to replace lost planting material. The remaining option is to turn to commercially produced seeds. Although they may be of good quality and high yielding, the use of these seeds increases the risk for sustainable small scale farming. These seeds are developed to give high yields under favourable conditions where the demands of the plants are met by external inputs, primarily fertilizers. Over time, increased reliance on fewer species and varieties leads to a gradual loss of biodiversity, thereby reducing the possibilities for agriculture to respond to the changing agro-climatic and social conditions. Issues around intellectual property rights with regard to seeds and planting material also pose increasing difficulties for small scale farmers.

This issue of the *LEISA Magazine* will focus on the availability of seeds and planting materials for low external input and sustainable agriculture. We are interested in experiences that show how farmers select and conserve the species or varieties they are most interested in and how communities organise themselves to meet the need for good planting material.
Deadline for submission of articles: 1 March 2007

September 2007, Issue 23.3

Low external input and sustainable agriculture and health

Traditional subsistence agriculture has, in most cases, provided adequate nutrition for the people depending on it. Ideally, it should positively contribute to the health of individual farmers and consumers, the plants, animals and the soil, as well as maintaining the functions of the ecosystem as a whole. But the increasing industrialisation of agriculture and the whole food system has meant that the food most of us now eat is primarily produced to attract buyers, is often processed, has been stored or treated, and its nutritional content is at best a secondary concern. This has given rise to an increase in nutrition-related diseases such as diabetes and obesity. In recent years there has been a growing interest in the link between food, food production and health, and there is now a greater demand for healthy food products. This development provides an opportunity for many producers to move toward a more sustainable production system and to improve their own health.

This issue aims to present examples of how the linkages between health and agriculture have been addressed, and we are looking for examples where a shift towards sustainable agriculture has been chosen as a response to health concerns.
Deadline for submission of articles:
1 June 2007