Deutscher Tropentag, October 11-13, 2005, Hohenheim

"The Global Food & Product Chain—
Dynamics, Innovations, Conflicts, Strategies"

Agroecologically sound Agricultural Systems: Can They Provide for the World's Growing Populations?

Norman Uphoff

Cornell University, Cornell International Institute for Food, Agriculture and Development (CIIFAD), United States of America

Abstract

Global food prospects, especially for the tropical regions, are not necessarily optimistic for this new century, despite various current technological advances. Population growth is slowing down, but overall growth will continue at least through the middle of this century. Land and water available per capita for agricultural production will invariably keep declining. To feed the growing populations, the productivity of all factors will need to increase considerably. Unfortunately, future progress with 'modern agriculture' — relying particularly on genetic improvements and increased inputs of exogenous, purchased inputs — is becoming problematic. There has been little improvement in global cereal production over the past decade, while per capita world production of cereals has been stagnant and even declining since the mid-1980s.

What is referred to as 'modern agriculture' is facing many challenges: **(a)** Costs of production are increasing, and market competition has farmers in a price squeeze; **(b)** Government subsidies that have sustained agricultural producers in the U.S., Europe and Japan are contracting, so heavy input-dependence needs to be reconsidered; **(c)** Relying on inputs derived from petroleum – many fertilisers, insecticides, fungicides, etc. – is becoming more uncertain and more costly; **(d)** Adverse environmental impacts from the application of agrochemical inputs are cumulating, with increasing government regulation of their use; **(e)** Global climate change will force reorientations of agricultural production strategies, as global warming will be less of a challenge than greater variability of climate (extreme events). Modes of production that could be successful in the preceding century are becoming less likely to succeed in this one. Already there is a dropoff in the expansion of chemical fertiliser and agrochemical use worldwide.

Biotechnology offers some prospects for dealing with various constraints and creating new opportunities. But its timeframe for creating the expected benefits is uncertain, while the costs of biotech development are very considerable, and regulatory issues associated with biotech present many difficulties, most still unresolved. Further, the use of biotech remains controversial due to varying assessments of environmental risks and hazards.

Agroecology is already available, not something on the horizon — even though it has received only a tiny fraction of the research resources that have been made available for biotech. The costs of developing and extending agroecological practices are much less than those for biotechnology, and regulatory issues are minimal. As seen from the case of the System of Rice Intensification (SRI), agroecological methods can match or outperform the results of biotechnology, making them more cost-effective. Agroecology offers a paradigm

Contact Address: Norman Uphoff, Cornell University, Cornell International Institute for Food, Agriculture and Development (CIIFAD), Cornell, United States of America, e-mail:

for 'post-modern agriculture' in that it represents a next step beyond current agricultural theory and practice. It differs from 'post-modernism' in the humanities and social scientists in that it is not hostile either to 'modernity' or to science. It builds upon the most modern science in the contemporary biological and ecological domains, capitalizing particularly on what is becoming known in the realms of soil biology and soil ecology.

The 'Green Revolution' as the apotheosis of modern agriculture was premised on two main strategies: **(a)** Changing the genetic potentials of plants and animals, and **(b)** Increasing the use of external inputs — water, fertiliser, insecticides, etc. Agroecology does little or none of either, minimising the use of exogenous inputs. It prefers to mobilise the endogenous capabilities of a cropping system and its relevant environment by optimising the management of plants, soil, water and nutrients, to have a beneficial effect on soil biota. In the $G \times E$ interaction (genetic potential $\times$ environment) that determines the phenotypical development of each and every organism, it works on the 'E,' to make the most of any 'G.'

Agroecological management aims in particular to: **(a)** Promote the growth and functioning of root systems, which are the interface between plants and their soil environment, and **(b)** Increase the abundance, diversity and activity of soil organisms, which provide many benefits and services to plants. Having well-developed root systems and active soil biota can reduce water requirements and the costs of production, among other benefits.

The System of Rice Intensification (SRI) is discussed at some length because it represents an agroecological strategy that enhances food production and contributes to food security while at the same time improving the natural resource base on which agriculture and other human activities, as well as life itself, depend. It was developed 20 years ago in Madagascar by Fr. Henri de Laulanié, SJ. His synthesis of innovative, mostly counter-intuitive practices that constitute SRI followed 20 years of working with farmers, making observations and doing experiments, plus some serendipity. SRI benefits have now been seen in at least 22 countries.

The basic practices are **(1)** Start with young seedlings, transplanted when they are <15 days old, grown in an unflooded, garden-like nursery; **(2)** Plant seedlings singly, rather than in clumps, widely spaced in a square pattern, and very carefully to avoid trauma to the roots; **(3)** Apply reduced water, just the minimum needed by the plant, keeping the soil mostly aerobic; **(4)** To control weeds, farmers are advised to weed with a 'rotating hoe', which aerates the soil at the same time that it churns weeds into the soil to decompose; and **(5)** Provide as much organic matter as possible, for the soil organisms as well as the plant.

SRI has been producing some remarkable results: **(1)** Immediate benefits from these practices, with no period of 'transition' as is common with many conversions to 'organic agriculture'; **(2)** Yield increases of usually 50–100 %, and often more, without changing rice varieties; **(3)** No need for mineral fertilisers, since compost gives better yields; **(4)** Little or no need for agrochemicals, since SRI plants are more resistant to damage by pests and diseases; **(5)** Less water required, usually 25–50 % less, and also seed saving as this need is reduced by 80–90 % due to the dramatic cut back in plant population; **(6)** While more labour is required initially — the main limitation on SRI adoption, along with the need for reliable water control to get best results — SRI can even become labor-saving once farmers have mastered its methods.

This all sounds 'too good to be true', and it has come under some attack in the agronomic literature in recent years. However, SRI should be put to empirical tests, rather than being dismissed or ignored on grounds of logic, preconceptions or prejudice. An evaluation of SRI in Cambodia, commissioned by GTZ and reported by Anthofer at the Tropentag 2004, confirmed what had been learned about SRI and reported from other countries.

General benefits resulting from SRI include: **(1)** Accessibility by the poor, since SRI has minimal capital costs; **(2)** Greater profitability, with costs of production averaging 20 % less; **(3)** Reduction in economic risk, documented in evaluations done in Cambodia and Sri Lanka for GTZ and IWMI; **(4)** Environmental benefits from the reduction in water requirements and from reduced use of agrochemicals; **(5)** Human resource development due to its strategy for dissemination which emphasises farmer experimentation and encourages farmer innovation in ways that conventional agricultural technology development does not.

In specific agronomic terms, SRI farmers report the following advantages accompanying higher yield and profitability: **(1)** Drought resistance; **(2)** Resistance to lodging; **(3)** Reduced time to maturity; **(4)** Resistance to pests and diseases (which can probably be explained by the theory of trophobiosis proposed by Francis Chaboussou in 2004; **(5)** Conservation of rice biodiversity. Perhaps the most interesting development with SRI is the extrapolations that farmers have been making of its concepts and methods to other crops besides irrigated rice, e.g., upland (rainfed) rice in the Philippines; finger millet (ragi) and sugar cane in India; winter wheat in Poland; and even chicken production in Cambodia (explained in the presentation and paper).

With SRI methods, farmers have seen that 'less can produce more' if biological processes are understood and capitalized upon: **(1)** Smaller, younger rice seedlings become larger, more productive mature plants when combined with other SRI practices; **(2)** Fewer rice plants per hill and per m^2 give higher yield when used with other SRI practices; **(3)** Half as much water can produce more rice because aerobic soil conditions are more supportive of root health and plant growth than are anaerobic (hypoxic) conditions; and **(4)** Greater output is possible with fewer or no chemical inputs because these increase plants' susceptibility to pests and diseases.

There are sound, scientifically-respectable explanations for the performance of SRI. There is nothing magical, mysterious or miraculous about it. However, most of the factors explaining SRI productivity are at present still hypotheses, derived from well-established knowledge in the agronomic and microbiological literature, but not yet proven. Only a few scientists have become engaged with the research issues and opportunities that SRI raises; but this work has begun.

There are many ways in which biological processes could be contributing to the SRI results reported above. Not all of them need to be operative to construct an adequate accounting for the overall effects of SRI practices. SRI is still a rather 'young' innovation. Because its methods fit into a larger body of theory and practice known as agroecology, most of its proponents are concerned with how to make the agricultural sector as a whole more productive and sustainable.

The challenge is to learn how to capitalize upon the possibilities that SRI has demonstrated: that 'more' can be produced from 'less' by capitalizing upon existing biological potentials and processes. This does not mean that research and experimentation on other methods should not proceed; there are some problems that may best be solved with genetic modifications, by conventional or other means. But certainly more attention and investment are due to agroecological approaches than they now receive if world food needs are to be met in the future.