Future of Plant Science

Comparison of driving forces in sustainable food production and the future of plant biotechnology in Switzerland and China

Zhi-Ping Xie, Lillian Auberson-Huang, Pia Malnoë, Huarong Yao and Othmar Kaeppeli

The concept of sustainability is the basis of environmental ethics and recognizes the close interdependence between human activities and ecosystem function. Sustainability in farming requires the dynamic reconciliation of society's opposing needs to produce enough food and to conserve natural resources – an increasingly pressing issue in the light of the growing imbalance between human numbers and the capacity to produce food. In May 2001, a *Sino–Swiss Seminar on Plant Production with Sustainable Agriculture* was held in Zhuhai, China, to provide a setting to understand and to contrast the national contexts of sustainability in farming for Switzerland and for China, with the aim of creating closer scientific ties between the developing East and the industrialized West.

The seminar examined traditional and modern agricultural practices such as organic farming, biotechnology and integrated production. Integrated production focuses on innovative farming practices that enhance biological processes while reducing negative environmental impacts such as pollution from agricultural chemicals, animal waste and soil erosion.

'Switzerland was the first country to introduce a mandatory declaration of GM content in food.'

Switzerland is one of the world's leading countries for organic agriculture and has a well established national integrated production program. In China, agricultural production varies between two extremes, either a small-scale traditional agricultural production base of vegetable cropping with fishponds or an intensive production system including genetically modified plants. In stark contrast to Europe, China is staunchly promoting the development of the plant biotechnology sector, with an estimated US$112 million spent in 1999 alone. China leads the developing world's biotechnology investments with more than five times the annual expenditure of India for research and development in plant biotechnology [1]. The Zhuhai workshop aimed to evaluate the various farming strategies for their contribution to both ecological and economic sustainability. In addition, examination of agricultural practices in China and Switzerland also provided the basis for understanding the close links that exist between national policies and approaches to sustainability in agriculture.

Sustainable agriculture in Switzerland

Ecological approach

In Switzerland, the 1980s saw a reform of agricultural policy and the development of a national program for holistic farm environmental management in response to the decreasing price of farm products from surpluses and an increasing awareness of negative environmental impacts from intensive agriculture. The national integrated production and organic farming program was launched in 1993. By 1999, 85% of Swiss farmland was cultivated according to integrated production and organic farming guidelines. One of the first results of the ecological farming program was a noticeable reduction in the national annual use of pesticides, nitrogen and phosphorus-fertilizers.

Genetic engineering approach

Like many European countries, Switzerland is faced with a negative public perception of genetically modified (GM) plants. Surveys have shown that this wariness is the result of complex social, political and cultural factors. Further commercial releases of GM crops are currently on hold. Any requests to carry out small-scale field trials with GM crops for research purposes have been consistently denied over the past few years.

However, preparations for a package of Swiss laws on biotechnology in the non-human domain are underway. The proposed laws call for stricter environmental controls for deliberate releases of GM crops and introduce, in particular, a liability clause that would hold the owners of businesses, or facilities that either produce or use GM crops, liable for damages for up to 30 years. In 1999, Switzerland was the first country to introduce a mandatory declaration of GM content in food. Currently, food products containing >1% GM ingredients need to be clearly labeled by the producer.

'With 22% of the world's population and only 7% of the world's cultivated land, China is under pressure to continue to increase the productivity of farmlands...'

Sustainable agriculture in China

With 22% of the world's population and only 7% of the world's cultivated land, China is under pressure to continue to increase the productivity of farmlands while protecting natural resources. In addition to this ecological dimension of sustainability, China is also concerned about the social aspect of sustainability. The Chinese population is still largely rural, with 70–80% of the people working as farmers. Improving farmers' income and living standard are important factors for maintaining the stability of Chinese society.

Ecological approach

China's agricultural tradition dates back thousands of years. The core of these practices, such as silkworm cultivation or fish pond-integrated farming, have been replaced by higher yielding, technological approaches. Although China has been able to cope with producing enough food for a fast growing population since the late 1980s, this has come at a high price for farmers and for the environment. The high crop yields were made possible using

  PII: S1360-1385(02)02340-3

large quantities of pesticides and synthetic fertilizers, which caused serious environmental problems (e.g. increasing soil erosion, development of resistance in pest weeds to agrochemicals, serious contamination of surface and ground water and human health problems). With an average of 210 kg of fertilizer used per hectare of arable land, which is double the average worldwide, China applies more chemical fertilizers than any other country in the world. Because only ~30% of the applied fertilizer is taken up by plants, the remainder ends up in the environment and as residues on food crops, thus decreasing their quality and selling price. Furthermore, because of the relatively high price of agrochemicals, farmers' incomes have not increased proportionally with crop yields.

'China applies more chemical fertilizers than any other country in the world.'

Aware of these problems, the State Council of China approved a program giving sustainable agriculture a high priority. Guangdong became the first Chinese province to set up the 'No Harm Foods' regulations. No Harm Food is defined as 'food and agro-products that are free of harmful substances'. Shenzhen city is one of four trial cities that set the objective in 2001 of 'Only No Harm Foods on the Market from 2008'. In addition, in 1992, Guangdong Province set up the Green Food Program (http://www.agri.gov.cn/english/index.htm) for promoting environmentally friendly agriculture through projects, inspections and monitoring of foods for residues from agrochemicals (Table 1). Green Food is defined as 'foods free of contaminants with high quality and rich nutrition'. The Green Food program benefits the farmers, who are able to command higher prices from the sale of better products, and consumers, who can buy food products that are guaranteed to be free of agrochemical residues. However, there are two grades of Green Food categories: Grade A allows the use of a limited amount of synthetic chemicals, whereas grade AA standards are more restrictive on the use of agrochemicals and the products are considered to be organic food grade. Currently, the organic food grade products are intended mainly for the export market.

Genetic engineering approach

Over the past two decades, China has been consistently building up its biotechnology program, strongly supported by the government. To date, six transgenic plants have been approved for commercial use, five of which were developed by Chinese scientists. These crops are *Bt* cotton [cotton containing the biopesticidal genes from *Bacillus thuringiensis* developed by Monsanto (St Louis, MO, USA) and an independent Chinese group], delayed ripening tomato, CHS/*Petunia*, virus-resistant pepper and virus-resistant tomato. China is also focussing on commodities that have been mostly ignored in the laboratories of industrialized countries, such as rice, peanut, cabbage, melon, chilli and papaya, which have also been genetically modified for improved agronomic performance, but are not yet commercialized [1].

In 2001, the State Council issued guidelines to regulate research and commercial uses of GM organisms in China. In January this year, the Ministry of Agriculture issued further regulations that require all GM imports into China to be labeled to certify them as safe for humans, animals and the environment.

Conclusions

The Zhuhai workshop on sustainable agriculture highlighted the importance of national context in the definition of sustainability, taking Switzerland and China as examples. Although both countries have the same goals for producing residue-free farm products with environmentally sensitive agricultural practices, the methods of achieving this are dependent upon agricultural settings and policies, which differ considerably in the two countries. In Switzerland, integrated production and organic farming approaches are advocated through the provision of direct financial rewards for farmers who are willing to comply with the strict controls for plant production and animal welfare. Because of the controversial nature of GM plants in Switzerland, plant biotechnology is not yet considered a potential strategy for sustainable development.

'…six transgenic plants have been approved for commercial use, five of which were developed by Chinese scientists.'

The direct link between government and individual farmers regarding both farm-level monitoring and payments that promote sustainable practices would not be possible in China because of differences in the organization of the agriculture and social structure. Although the Chinese Government has policies and programs, such as Green Food, to promote sustainable agriculture, it has rarely supported farmers with subsidies. According to a prevalent model of agricultural production in Southern China, farmers are usually the employees of private companies, on an arrangement called contract farming, whereby companies offer technology, materials and even capital to farmers in exchange for farm labor. Under this system, farmers produce crops according to the company's directives in exchange for the assurance that their products will be purchased at agreed contract prices. This is a market-driven model of agricultural production that the Chinese Government encourages. Therefore, to introduce sustainability considerations to farming would require targeting the private companies and encouraging change at this level rather than at the individual farmer level.

'Because of the controversial nature of GM plants in Switzerland, plant biotechnology is not yet considered a potential strategy for sustainable development.'

In contrast to Europe, where GM technology still meets widespread rejection, China considers biotechnology to be a valid strategy for securing its future food production. A recent survey has shown that small farmers in China have begun to aggressively adopt GM crops when permitted to do so [1]. Many products are presently under development in the largest plant biotechnology effort outside North America. Chinese scientists are working on >50 plant species, with a wide-ranging list of GM food plants [1].

Table 1. Green Food development in China (2000)

Green Food products	1360
Yield	10 M tons
Monitoring fields, grassland, and water surface	2.7 M ha
Natural products from total yield	25%
Processed food from total yield	75%
Green Food enterprises	742

Researchers from the Guangdong Academy of Agricultural Sciences have identified the rice blast resistance genes, which, in the future, might make it possible to produce rice plants resistant to rice blast, one of the most destructive rice diseases. The publication of the draft genome sequences [2,3] of the two major rice varieties should facilitate the selection of varieties (*Oryza indica* and *Oryza japonica*).

Sustainable agriculture attempts to achieve a balance between environmental conservation, economics and social acceptability. However, what is understood as sustainability and the means for achieving it can vary according to context, although the end targets and results might be the same.

Acknowledgement

We thank Christian Staehelin for his valuable comments on this manuscript. A limited number of abstract books of the Sino–Swiss Seminar on Plant Production is available and can be requested from Zhi-Ping Xie.

References

1 Huang, J. *et al.* (2002) Plant biotechnology in China. *Science* 295, 674–676

2 Yu, J. *et al.* (2002) A draft sequence of the rice genome (*Oryza sativa* L. ssp. *Indica*). *Science* 296, 79–92

3 Goff, S.A. *et al.* (2002) A draft sequence of the rice genome (*Oryza sativa* L. ssp. *japonica*). *Science* 296, 92–100

Zhi-Ping Xie

EUCHINUS Ltd, Rheinschanze 8, CH-4056 Basel, Switzerland.
e-mail: info@euchinus.ch

Lillian Auberson-Huang

InterNutrition, Swiss Food and Seed Industry Association, PO Box 556, CH-8034 Zürich, Switzerland.

Pia Malnoë

Station Fédérale de Recherche en Production Végétale de Changins, CH-1260 Nyon, Switzerland.

Huarong Yao

Guangdong Dept of Science and Technology, Guangzhou, China.

Othmar Kaeppeli

BATS (Biosafety and Transdisciplinary Sustainability Management), Clarastrasse 13, CH-4056 Basel, Switzerland.

Published online: 12 August 2002

Institute Profile

Science and politics: Hans Stubbe and the Institute of Plant Genetics and Crop Plant Research at Gatersleben

Ulrich Wobus and Ingo Schubert

In March 2002, the Institute for Plant Genetics and Crop Plant Research (IPK, Institut für Pflanzengenetik und Kulturpflanzenforschung) hosted the 6th International Gatersleben Research Conference on ‘Plant Genetic Resources in the Genomic Era: Genetic Diversity, Genome Evolution and New Applications’. The organizers dedicated the conference to the centenary of Hans Stubbe (1902–1989), the founder of the Gatersleben Institute and a pioneer in plant genetics and conservation.

The IPK (http://www.ipk-gatersleben.de) in Gatersleben is situated in the central region of Germany, known as the cradle of German plant breeding and seed production. The institute has experienced dramatic periods and difficult changes since it was founded almost 60 years ago. In the late 1930s, Fritz von Wettstein, Erwin Baur and Hans Stubbe, scientists working at Germany’s primary research institution at the time, the Kaiser-Wilhelm-Society (which became the Max-Planck-Society after World War II), planned to establish a new institute. The aim was to gather scientists from different disciplines to carry out basic and applied research on crop plants and related plant species.

Fig. 1. Hans Stubbe in a now symbolic gesture supervising building activities at the Gatersleben institute in 1956. (Photograph by N. Franke, IPK archive.)

However, this idea had to overcome many hurdles, including quarrels with the authorities and collaborating colleagues in Nazi Germany over Stubbe’s political non-conformity. But, eventually, in 1943, Hans Stubbe became the first director of the *Institut für Kulturpflanzenforschung* (Institute for Research on Cultivated Plants) near Vienna. Seven years earlier, Max Planck, the president of the Kaiser-Wilhelm-Society, had appointed Stubbe as director of the Kaiser Wilhelm Institute (KWI) of Breeding Research in Müncheberg near Berlin after the death of Erwin Baur. However, the Nazi party thwarted this appointment and in 1936 even dismissed Stubbe and his friends Hermann Kuckuck and Rudolf Schick from the Institute. However, Fritz von Wettstein offered Stubbe a position within his KWI for Biology in Berlin-Dahlem (for an extensive biography of Hans Stubbe, see Ref. [1]).

Stubbe’s scientific work at the time was inspired by Erwin Baur, Hermann Joseph Muller and Nikolai Vavilov. Early on, Stubbe recognized the importance of experimental mutagenesis and focused on questions such as (1) how and by which agents can mutations be induced, (2) can mutation research contribute to elucidating the nature of genes and (3) what role do mutations play during evolution [2]? Stimulated by Vavilov’s work on the evolution of crop plants in ‘geographic gene centres’, Stubbe put great emphasis on the collection, maintenance and analysis of plant genetic resources as a strategy to exploit genetic variability for basic genetic research and crop improvement. During 1941–1942, Stubbe,

  PII: S1360-1385(02)02333-6