REPORT ON A VISIT TO CHINA TO REVIEW SRI PROGRESS,
August 9-18, 2007 – Norman Uphoff, CIIFAD (draft)

Summary Observations:

1. With evidence accumulating that SRI methods offer significant advantages to Chinese farmers and the country's natural resources, the Ministry of Agriculture has designated SRI as a **key extension method**, recommending SRI for extension promotion at provincial level.

2. Before my visit to China, I had understood that Sichuan Province had 67,000 hectares of SRI rice this year, and that Zhejiang Province had an even larger area under SRI practices. However, in the field, I learned during my visit to Sichuan I learned that SRI there has reached **100,000 ha**, twice as much as the year before. (Later I learned that the figure was 120,000 ha.) Given the results being obtained, this rate of doubling could accelerate in the future.

3. In Zhejiang Province, similar growth is occurring, within a smaller rice area, 110,000 hectares in 2007). This means there are at least 230,000 ha of SRI cultivation in these two provinces. As in Sichuan, researchers and farmers in Zhejiang have concluded that SRI methods significantly enhance the performance of **hybrid varieties**, which are being promoted in the province.

4. SRI methods are reducing farmers' need for **seed** (hybrid seed is expensive) and **water** (an important constraint for many farmers). It also reduces their **costs of production** and even their **labor requirements**. It gives higher yields with an enhancement of rice plants' **resistance to pests, diseases, and lodging**. A district extension director said that SRI is now being promoted to accelerate the use of hybrid varieties, rather than the reverse.

5. Although SRI was originally developed to benefit small, resource-limited farmers and has been promoted particularly to benefit poor households, by its nature it is **scale-neutral**. However, skeptics have stereotyped SRI as a 'labor-intensive' innovation, not suitable for larger farmers. In fact, in Zhejiang the main adopters of SRI methods are large farmers. "Big farmers think SRI is wonderful," one extension director told me in English, in a township where 80% of the rice area is now under hybrids grown with SRI practices. One of their main reasons for the spread is that SRI can become **labor-saving**, contrary to the stereotype that has been attached to it.

6. Chinese farmers and researchers are not yet taking full advantage of the opportunities that SRI offers, to reduce and even eliminate reliance on **chemical inputs** (fertilizers, herbicides, etc.). Non-chemical alternatives (compost, mechanical hand weeding) currently require more labor, which is more costly and scarcer here than in other countries. The other SRI methods – younger seedlings, wider spacing, one per hill, reduced water applications – are beneficial for any rice cultivation. To the extent that ways can be devised to mechanize soil-aerating weeding and to produce and process more biomass, more of SRI's productive potential can be capitalized on.

7. Whether or not the full set of SRI practices ever gets utilized in China will depend on factors that include economics, labor constraints, biomass availability, and mental attitudes. The last factor should not be underestimated as a limitation, although as a more favorable climate of opinion emerges, it should become easier for farmers to change their thinking and methods.

Introduction
In mid-July, **Prof. Zheng Jiaguo**, director of the Crop Cultivation Research Center in the Crop Research Institute of the **Sichuan Academy of Agricultural Sciences** (SAAS), sent me an email inviting me to visit Sichuan Province before mid-August so that I could see before some of the SRI crop before it was harvested. He said it was doing very well and reported that there were at least 67,000 hectares of SRI rice in Sichuan that season. This made the invitation more attractive.

In a subsequent email message, **Dr. Zhu Defeng** at the **China National Rice Research Institute** (CNRRI) in Hangzhou said that even more SRI rice was growing in Zhejiang province, where he and other CNRRI staff have been promoting SRI since 2001. So a visit to China, after being away for two years, was very compelling. Accordingly, I arranged a ten-day visit before fall classes resumed at Cornell, arriving the evening of August 8 in Chengdu, capital of Sichuan Province, where Zheng met me at the airport.

On the way into the city, Zheng told me something that showed how international the SRI initiative has become. Not long before my visit, a deputy director of PhilRice, the Philippine institute for rice research, Dr. Rollie Cruz, had visited Chengdu. In his conversations with Zheng, it became clear that Cruz had a negative view of SRI (something I knew from previous visits to the Philippines). He said that on-station evaluations of SRI at PhilRice had not supported the claims made for SRI methods. So Zheng showed him some of the local SRI rice fields that were prospering. So possibly the work being done on SRI in China may help its progress in the Philippines.

Thursday, August 9
We left for a field trip at 8:30, on the way out of the city picking up **Liu Daiyin** from the Provincial Department of Agriculture (PDA). Liu has been leading the Department's SRI extension effort in Sichuan Province. I learned later that he was one of the first five persons to get involved with SRI work here. We drove about an hour to Guanghan, northwest of Chengdu, and then farther to an SAAS research base office in a nearby village, Bai Li, where farmer-participatory evaluation trials and demonstration with SRI have been carried out for several years. I had visited this place in 2005 so it was familiar.

On one side of the road, there were SRI trials with many different varieties, and on the other side, the same varieties were being evaluated with farmers' usual methods. SRI practices of young seedlings, wide spacing and reduced irrigation were combined with a Sichuan innovation that has expanded the SRI menu: **the 'triangular' spacing method**, developed by Liu Zhibin in Meishan. This planting method preserves the SRI principle of wide spacing between plants while at the same time increasing plant population per square meter by 50%.

With this method, the number of hills is reduced by half, but instead of having just one plant per hill, three plants are transplanted per hill, spaced 8-10 cm apart in a triangular pattern. This spatial arrangement gives all of the rice plants more exposure to sun and air than if they were bunched together in a clump, as is usual practice. Zheng said that this method has been giving good results in Sichuan. When Liu achieved a yield of 16 t/ha with his adaptation of SRI concepts in 2001, this helped to make SRI of greater interest both in the province and in China.

Here at Bai Li, Zheng said, SRI methods have been giving about 700 kg/mu (10.5 t/h) compared to 600 kg/mu (9 t/ha) with farmers' methods. This is already a high-yielding area for rice production, so farmers are trying to 'push the envelope.' No active soil aeration is being done, however, because farmers and researchers feel constrained by the scarcity and cost of labor. Herbicides are used to control weeds instead of the mechanical hand weeder that we recommend as part of SRI practice. I suggested that they do some trials to see whether using the weeder and actively aerating their soil can boost yield enough to justify the added labor cost. Analyses in Madagascar and Nepal have shown such soil-aerating weeding can add 2-3 t/ha to yield, which would more than compensate for the extra cost of labor.

Also, farmers here rely mostly on chemical fertilizers because they feel that there is not enough availability of labor and of biomass to make compost. This may be their best option, taking economics and not just agronomics into account. However, we have seen that fully or mostly organic regimes of fertilization can boost yield above what is achieved with use of chemical fertilizer only. So, if farmers want to 'push the envelope,' they should at least experiment to see what benefits they can get from increasing soil organic matter as part of an SRI strategy.

Here farmers rotate their rice production: either with potatoes, or with vegetables, or with wheat. It is good that they are not doing continuous rice cultivation, as this is good neither for productivity nor for sustainability. A rice-wheat cropping system creates some problems of timing for the transplanting of SRI rice, since if the wheat harvest and subsequent land preparation get delayed, it becomes necessary to use rice seedlings that have become older than 15 days. Transplanting seedling 20, 30 or 40 days old forfeits the yield benefit from using young seedlings, i.e., plants that have not yet embarked upon their fourth phyllochron of growth.

Potatoes have proved to be quite a good crop to alternate with SRI rice, and the rice spacing used here following potatoes is quite wide (35x40 cm). When mushrooms are grown as the alternate crop, the optimal SRI spacing becomes even wider (40x45 cm), because mushrooms make the soil more fertile. This confirms our observation that with SRI methods, when the soil is more fertile (i.e., richer biologically), planting fewer plants rather than more gives a higher yield. This is counter-intuitive but has been validated many times empirically. Wider spacing and less water application are the SRI practices that have become most popular among Sichuan farmers.

When I asked about pests and diseases, Zheng said that farmers routinely spray both SRI and farmer-practice fields, usually three times, but not more. I suggested that possibly they could achieve some economic savings by relying more on fully organic fertilization, which farmers in China have been reluctant to do. In my view, they are practically 'addicted' to chemical fertilizer even though it contributes to the incidence of pest and disease according to the theory of trophobiosis (Chaboussou, 2004). This is an empirical matter that deserves evaluation.

The rice crop here has been subjected to a lot of rain recently, when there should be sunlight now to accelerate crop ripening. All during this field visit, in which were joined by a number of local officials and farmers, there were thunder and ominous clouds. One of the SRI plots had lodging, which is not often seen. Zheng attributed this to the weight of the panicles rather than to weakness in plant tillers. However, it was a reminder that all generalizations have exceptions. For the most part, SRI methods are valued for the strength that they give plants to resist lodging.

In this particular plot, something did not work as usual. Perhaps water control was not well-maintained and soil conditions became too saturated.

One interesting thing seen was an innovative biological control strategy, where a row of 'traditional' glutinous rice is sown every several meters across the large fields of hybrid rice. These plants tower a foot or so above the adjoining hybrid varieties. By increasing in-field genetic diversity, it has been demonstrated that the incidence of blast, a major fungal disease of rice, can be greatly reduced, as reported some years ago in *Nature* magazine (August 17, 2000).

Of particular interest to me were farmers' long-term trials evaluating SRI as part of different cropping systems: rice-vegetable, rice-potato, rice-wheat, and rice-potato intercropped with rapeseed (canola). Rice-rapeseed is considered as the 'control' because this is the predominant cropping system in the area. Farmers are repeating these crop rotations for several years on the same plots, initially randomly selected. The trials that we saw were in their second year, so no firm conclusions could be drawn. But the SRI crop on the rice-potato plots appeared to be growing best.

Zheng said that SAAS does thorough soil chemical analyses on these plots after each harvest to see what, if any, changes in soil characteristics are associated with the different cropping systems. He agreed that it would be good if they could monitor soil biological parameters too. However, this is more difficult than evaluating soil chemistry, a familiar story. I saw also trials with direct-seeding by machine that looked promising, not because they will give the highest yield but because of the labor-saving that is possible from mechanization.

After a tea break in the SAAS research base office, we drove to another location to look at the SRI crop there. The seedlings used here were beyond 15 days of age, because of delays with the alternate wheat crop, but farmers expect to get a 10 t/ha yield with their wider spacing and reduced water applications. The usual yield here has been 7 t/ha, so farmers are with the new system. When they practice vegetable-rice rotation, they are able to use young seedlings as advised. Zheng described the SRI crop alternated with vegetables as "more beautiful."

Our hosts from the Agricultural Bureau in Pengzhou City provided a fine lunch at their office canteen, and then there was some time for relaxation before the next field visit. In the next village we saw once again the benefits of wider spacing (35x40 cm), quite a change from past practice, and of producing healthier seedlings in upland (unflooded) nurseries. Farmers here still use chemical fertilizer, but have reduced their level rather than raised this to get higher yield.

Zheng said that in 2006, the field we were visiting had produced the highest yield in all of the Chengdu Plains (11.82 t/ha), and that it had been visited by **Prof. Yuan Longping**, who is responsible for developing hybrid rice and thus widely known as 'the father of hybrid rice.' This year, a shorter-duration variety was planted here, so the expected yield will not be as high, perhaps 10.8 t/ha. However, this is still considered a very good performance in the area.

Zheng pointed out that the whole area of 20 hectares visible from where we stood was under hybrid varieties using SRI methods. Zheng was pleased to hear the data that I could report from eastern Indonesia, where during the 2006 dry season in Bali, 24 farmers had grown Longping

hybrid rice with SRI methods on 42 hectares -- and had averaged 13.3 t/ha, compared to 8.4 t/ha with their usual practices.

Because growing vegetables is more profitable now, farmers are tending toward a rice-vegetable cropping system. This will probably favor the spread of SRI because using younger seedlings is more feasible when vegetables are the alternate crop. I asked him where in Sichuan Province are SRI practices being most quickly accepted. In the southern part around Luzhou, Zheng replied -- because it is easier to work with young seedlings there, in the warmer climate.

We drove next to the Pengzhou City administrative center, where we met with several local officials. Thanks to the portability of my laptop, I could share with them some of the pictures and tables that I use in my usual powerpoint presentation on SRI. They were interested to see the large benefits that can be achieved from active soil aeration with a mechanical weeder (several tons/ha increase in yield) compared to manual weeding or controlling weeds with herbicides.

Given the mechanical ingenuity of Chinese engineers, it should be possible to design weeding implements that can be mounted on two-wheeled tractors. These could weed half a dozen rows at a time, with their power tillage ensuring that soil aeration is well achieved. At 5:30, we all went to a local restaurant for another fine Chinese meal, accompanied by the usual rounds of toasting.

Friday, August 10
Zheng and I left again at 8:30 for a second field trip, traveling with one of his junior colleagues. This time we drove south out of Chengdu, driving an hour to Xin Jin City and then farther to Qiong Lai City. As we traveled, I asked Zheng how he first learned about SRI. In 2001, **Dr. Ren Jun**, now vice-president of SAAS, gave him a copy of a paper translated into Chinese by Prof. Yuan Longping that I had written on SRI in 1999. The ideas made sense to Zheng, so he tried them out through his Crop Cultivation Research Center. He was quite satisfied with the results, and ever since he has become more and more involved with SRI, collaborating with government agencies, universities, local governments, and farmer groups to support its evaluation and spread.

Beyond Giong Lai, we reached the **Chengdu Modern Agricultural Technological Innovation and Transformation Centre**, which gets support from SAAS and in turn assists a large, new agricultural company that has leased the holdings of farmers in the area who want to get out of independent agriculture. Some relocate to urban areas while others become employees of the company. A large production operation has been created that can achieve some economies of scale and can enter competitively into export markets, particularly for mushrooms. As I learned on a previous visit to Sichuan (February 2004), a SRI-mushroom crop rotation system can be very successful in this province (http://ciifad.cornell.edu/sri/countries/china/cnmushrm.html). The Centre has been using SRI methods for its rice production for two years now.

As we started walking through the demonstration plots, we happened to meet SAAS' president, **Dr. Li Yue Jiang**, who was accompanying a large group of professionals around the plots. Zheng joined that group for a while, while his assistant showed me the rest of the rice plots and the mushroom sheds. SRI paddy yield on raised beds where mushrooms have been grown has been as high as 778 kg/mu (11.67 t/ha). I was told that in this area, there are 200 mu (13.3 ha) of SRI-mushroom farming with high productivity.

All together, the company is operating about 5,000 mu (333 ha). To the extent that the company is successful, it may become an organizational model for helping small farmers transition out of agriculture, if they want to, and for giving those who want to remain in the sector a chance to participate in larger-scale, more modernized production, with more reliable incomes than when they are operating separately.

From one perspective, this converts farmers from owner-operators into employees, losing status and independence, something not very desirable. However, it gives them in return the kind of access to capital and machinery that they would not have otherwise. It also provides them with security of income that independent farmers do not have. The company has a 'social welfare' branch that takes care of economic and other problems of farmer-employees and their families, both those who have left the community and those who have stayed. The posters displayed around the Centre and demonstration plots projected attractive images of 'modern' agriculture and market orientation, including one picture connoting Western capitalism symbolized by two men in business suits and ties carrying attaché cases and shaking hands.

On the drive back to Chengdu, Zheng told me an interesting story. In 2004, when preparations were being made by the central and provincial governments to commemorate the centenary of the birth of China's post-Mao ruler Deng Xiaoping, it was decided that there should be a rice field planted in front of Deng's birthplace in the town of Guang'an. There was reluctance to accept responsibility for planting the field, however, because the area was a garden and not a rice paddy, and the harvest was to be timed to occur on Deng's birth date, August 23. The usual harvest date in the area was two weeks earlier. Most imiportant, such an auspicious occasion required that the field of rice be truly splendid! After others declined to take on this task, the governor of the province instructed Zheng as director of the Crop Cultivation Research Centre of SAAS to plant the field.

By 2004, Zheng was well acquainted with SRI and had confidence in its methods, so of course he planted the field using these methods. Even so, he was somewhat apprehensive because this was such an important event, with national publicity. Happily, the SRI crop performed beautifully and gave a harvested yield of 720 kg/mu (10.8 t/ha). This was very good free publicity for SRI, Zheng said, and SRI uptake has since been very good in the Guang'an area. Also, Zheng told me that Prof. Yuan Longping had proposed to the government of Hunan Province, his home province, that if farmers will use his hybrid varieties together with SRI methods, they should be able to get as much yield from 3 mu as they now get from 4 mu -- a 33% increase in production.

In the afternoon at 3, there was a seminar on SRI held at the Crop Research Institute of SAAS. **Liu Daiyin** from the Provincial Department of Agriculture led off with a powerpoint presentation (in Chinese) on the SRI situation in Sichuan, reviewing the agronomic key points, then extension issues and social benefits, and finally prospects for SRI in the province.

Liu reported that the first SRI trials in Sichuan were done in 2001 at the Sichuan Agricultural University. Then from 2002 to 2005, there was cooperation among SAU, SAAS and PDA on research and demonstrations. The Provincial Department of Science and Technology also

became involved. Evaluations were done on water management, transplanting alternatives, fertilization, and weed control. From these various experiments, SRI concepts and practices were adapted to local conditions. By 2005, with the scientific basis well-established, a more active effort at SRI extension was launched.

The five key factors that are emphasized are: young seedlings, transplanted as early as possible; reduced density of plants; reducing water applications to create strong root systems; also water management to control the number of non-productive tillers (draining fields at a critical time in plant growth); and proper fertilization, optimizing between chemical and organic sources.

Researchers have concluded that SRI is suitable for all areas of Sichuan, Liu said, although some adaptations need to be made in things like seedling age according to prevailing temperature. Water is sufficient in practically all areas of the province when water-saving methods are used.

There has been no success using SRI rice as a winter crop because of the colder temperatures. Usually, SRI is alternated with rapeseed, vegetables, potatoes, or wheat. In particular, SRI methods have been found suitable for use with hybrid varieties. One variation in nursery management has been to grow the young seedlings on plastic trays that are easily transportable. This is a practical alternative because only a small number of seedlings are needed.

Land preparation is done pretty much as with other rice cultivation, although zero-tillage is now an option. Young seedlings are transplanted at the 2.5-4 leaf stage, although the 4-5 leaf stage is sometimes necessary in some cropping systems (as learned on the previous day's field trip). Spacing ranges from 25x30cm up to even 50x50cm, depending on soil fertility. When fertility is high, wider spacing is more productive (confirming Fr. de Laulanié's finding 25 years ago).

The 'triangle' method of transplanting has been found particularly useful in many places. (I interrupted to say thank-you to Sichuan Province and to Liu Zhibin for innovating this practice.) Sometimes rectangles or squares are used with single seedlings, Liu Daiyin added. He gave an account of the different fertilization regimes recommended, combining chemical and organic forms, but this was hard for me to parse from the Chinese slides.

For water management, they recommend intermittent irrigation in the early stage, with water kept very shallow; then 2 cm of water are maintained in the middle stage after panicle initiation. When the number of tillers reaches 150,000-180,000/mu (2.25-2.7 million/ha), the field is drained completely to minimize the number of unproductive tillers.

Weed control is done by hand weeding (2-3 times) or by herbicides. Liu acknowledged that most of the time, farmers are using herbicides. They are advised to use IPM practices as much as possible. For nursery management, upland (unflooded) nurseries have been found to be best. Zero tillage is being evaluated, with favorable results so far. This can save farmers cost, reduce labor, and improve soil structure.

There is interest in ratooning with SRI, i.e., letting the harvested crop regrow to get a second crop with no additional labor. On a field where 700 kg/mu (10.5 t/ha) is harvested from a first crop, it is possible to get another 200 kg/mu (3 t/ha) from a second crop with practically no

additional expenditure. Depending on the opportunity cost, i.e., what net value could be produced by growing an off-season crop on the same field, this can be economic for farmers.

Liu's report showed that the Sichuan experience with SRI methods has been very similar to that in other countries. What is different is how rapidly SRI has been extended. Liu showed slides on SRI's spread since 2004. His data are summarized in table below:

Year	Cities	Prefectures	Hectares	Ave. Yield	% Increase
2004	15	26	1,120	9.10	14%
2005	15	58	7,290	9.44	18%
2006	18	80	57,500	8.82	19.5%

Liu explained that 2006 was a drought year, and rice yield suffered across most of the province. However, SRI yields had declined less than those of 'regular' rice.

The data for 2007 have not been finalized yet. But Liu said that the Department estimated that this year there are about **100,000 hectares of SRI** being grown in Sichuan Province -- more than the 67,000 hectares I had been expecting (and less than the 120,000 hectares that were later reported). All together, during 2004-07, SRI was grown on 165.9 thousand hectares, Liu said.

The economic returns to farmers are definitely positive, since SRI methods have been 750 to 2250 yuan per hectare ($100-300). In 2004, the average increase was 1200 yuan ($160), and in 2005-2006, it was 1458 yuan ($195) [conversions made at current exchange rate]. Also, grain quality is superior with SRI methods, Liu said, and reduced pest damage is observed. Less water is used, by about 20-40%, so substantial water saving is another benefit.

Liu said that with SRI there is also more resistance to 'disaster,' referring to climatic problems. Rice plants that are established by early transplanting from upland nurseries are better able to withstand damage from high temperatures at the flowering stage, he said, a frequent problem in Sichuan. In 2006, despite drought conditions, SRI methods increased yields by an average of 0.75 t/ha over 'regular' rice. (These are all benefits from rice that we have seen in other countries many times, but it is good to have this official confirmation by a Provincial Department of Agriculture official.)

On prospects for SRI, Liu said that in 2005, the Department began promoting SRI techniques as a 'key' (i.e., priority) extension activity. Ten million yuan ($65,000) were allocated for SRI extension in 40 prefectures. Also, the Chinese Ministry of Agriculture has endorsed SRI techniques to be used in conjunction with hybrid rice extension, he said.

In December 2006, the Sichuan PDA made a report on SRI to China's Premier Wen Jiabao, and he gave the methods his approval. In 2007, the Ministry of Agriculture designated SRI as a 'key extension technique' to help it move more rapidly. A target of 5 million mu (333,333 hectares) of SRI rice has been set for Sichuan by the PDA to achieve by 2010. They are already almost one-third of the way toward this goal. My guess is that with the kind of benefits that Liu was reporting, meeting this goal should not be difficult, given support through farmer-to-farmer communication and mass media.

When I gave my presentation, I focused on what we have been learning about SRI from experience in other countries, sharing some of the scientific evidence for each of the six key practices (ideas) that we consider as constituting SRI. I emphasized that SRI is best understood and used as an *adjective*, i.e., as a description, rather than as a *noun*, a thing. Also, SRI should be understood more as a matter of *degree* (how much?) rather than as a distinction of *kind* (whether?) even though we generally speak in terms of categories that force things to be seen as "either this or that."

Farmers can benefit from *each* of the respective SRI practices recommended, and from any *combination* of them. I showed factorial trial results from Madagascar from contrasting agroecosystems: temperate climate, 1200m elevation, fairly good soils (N=288) vs. tropical climate, sea level, poor soils (N=240). These trials, with six replications FOR all treatments, documented the same pattern of cumulative response to SRI practices, causing yield to increase about 200% when all practices were used together.

In particular, I discussed the evidence and explanations for increased yield response and other benefits from rice plants (a) that have had their root zones actively aerated with a 'rotating hoe' and (b) that receive mostly or all organic fertilization. These practices have not been taken up very widely with SRI in Sichuan. There are some practical constraints to manual/mechanical weeding and to applying compost – labor costs, availability of biomass. However, based on experience elsewhere, we have reason to believe that farmers would profit from labor invested (a) in weeding and (b) in growing, collecting and processing biomass. If so, farmers should know this and know what income they are forgoing by not using SRI methods fully.

When discussion was invited, Dr. Li Qingxiou, a senior plant breeder in the Crop Research Institute, led off by saying: "SRI is a rice agronomy revolution," adding that it can give even greater results when combined with 'the hybrid revolution in plant breeding' which capitalizes upon the benefits of heterosis. This was agreed, although I pointed out that a traditional variety grown with SRI methods in Sri Lanka has given a yield as high as 13.3 t/ha, the same as the average yield for Longping hybrid varieties grown with SRI methods in Bali last dry season.

There should be no conflict between hybrids or HYVs vs. local varieties. Each has its advantages. The former give highest yield; the latter can bring farmers higher income because they can get a higher price per kg in the market because their qualities are preferred by consumers. In all of our SRI work, rather than prescribe for farmers how they should grow their rice, our objective is to give farmers more choices, and more beneficial choices.

After the seminar concluded, we drove to a nice restaurant in the center of Chengdu for dinner. The director of the Crop Research Institute was ill and unable to come, but the SAAS vice-president, **Dr. Ren Guang Jin**, who was responsible for bringing Zheng into SRI work, was there and served as host. In our discussion, I particularly urged SAAS to put more resources into understanding soil biology and root growth better. On this, there was no disagreement.

Saturday, August 11

This morning was unscheduled because Zheng was attending the funeral of a CRI director who recently expired. This gave me time for working on this trip report and catching up on email. In the afternoon, **Prof. Ma Jun** from the Rice Research Institute of Sichuan Agricultural University and a junior colleague of his picked me up at 2 to drive to **Meishan**, an hour west of Chengdu.

Ma and I first met in August 2004, when we both participated in the 10th National Conference on Theory and Practice for High-Quality, High-Yielding Rice in China in Harbin, Heilongjiong. He had presented a paper reporting on SRI's impact on rice quality, showing large reductions in the chalkiness of grains and a 16-17% increase in milled rice outturn when SRI methods are used. 'Outturn' is the amount of milled rice produced from paddy (unmilled) rice, calculated in terms of kg of polished rice produced per bushel of harvested rice, going from a measure of volume to a measure of weight.

During the drive, I was able to learn some more from how SRI had gotten started in Sichuan since Ma was involved from the outset. SRI got started in Sichuan in 2000 when Prof. Yuan Longping circulated his own translation into Chinese of one of the first papers that I wrote on SRI. It was based solely on experience in Madagascar and mostly summarized the conclusions of Fr. de Laulanié.[1] At that time, there was neither knowledge or nor experience with SRI outside of Madagascar. That Prof. Yuan indicated his personal interest in the paper's ideas carried a lot of weight since he was and is the most eminent rice scientist in China, receiving in 2001 the Chinese equivalent of the Nobel prize for science and technology (with a $1 million prize) and then in 2004 the World Food Prize for his leadership in developing hybrid rice.

The provincial government formed a working group of five persons in 2001, with Prof. Ma as its chair. Liu Daiying, who traveled with us on Thursday and made a presentation on SRI at the SAAS seminar on Friday, was a second member, representing the Provincial Department of Agriculture. Liu Zhibin from Prof. Yuan's seed multiplication farm in Meishan, whom we were traveling to visit, was a third member. The other two members were from the SAAS: Xu Fuxiang from its Rice Research Institute and Lu Shihua from its Soil and Fertilizer Institute. (Lu was later in communication with Dr. Zhang Fusuo at China Agricultural University in Beijing and got him involved with SRI evaluations in Sichuan early on; Zhang contributed a chapter on rhizosphere management to the book that I edited on biological approaches to sustainable soil systems.)

At the same time the working group established trials and demonstrations in 2001, Zheng also started trials through the SAAS Crop Cultivation Research Centre which he directs. All these efforts contributed to an accumulation of knowledge about how to utilize SRI concepts and methods under Sichuan conditions. Fortunately, there was a spirit of cooperation rather than a spirit of competition that kept all of these individuals and institutions working together.

[1] Prof. Yuan had received a copy of this paper from a former staff member of his China National Hybrid Rice Research and Development Center, Xie Fangming, who had joined the private American company RiceTech in Texas . Fang was given a copy of the paper by Dr. Henry (Hank) Beachell, who for many years was a rice breeder at IRRI and now was now retired and working with RiceTech. I had given Hank a copy of the paper in June 2000 when he attended a symposium on rice research held at Cornell in honor of Dr. Robert Chandler, first director-general of IRRI. Such was the complicated and fortuitous route of information from Ithaca, NY to Chinese rice scientists.

When we reached the seed multiplication farm beyond Meishan City, **Liu Zhibin** was waiting for us in a car at the gate. We drove to the center of the farm's rice fields and began walking around plots in the hot afternoon sun. One of the first that Liu pointed out was a high-protein rice with 16% protein content in the grain, more than double the usual amount and potentially a very valuable improvement in the rice crop. The fifth plot that we came to was almost entirely lodged -- flattened by a recent rain storm. This was dismaying since lodging is rarely seen with SRI rice.

I asked Liu about this plot: what happened here? He said: "This plot is CK." It took me a moment to recall that CK is the term used in China for 'check' (control) plot. The rice plants in all the SRI fields around were standing upright. So this control plot was indeed showed how a storm that could flatten a 'normal' rice field had no effect on SRI rice crops.

The next plot was one from which Liu picked a panicle and stripped off the husks from some grains to show me what high-quality rice it was. "Like jasmine," he said in his limited English. The most interesting were some ratooned plots, where rice plants were regrowing vigorously after harvest. So far, second crops have been yielding about 20% of the first crop, Liu said. I told him of one Peruvian trial where a first crop of 8 t/ha was followed by a second of 5.5 t/ha -- 70% as much. This has not been replicated, but maybe with more attention to agronomic practices that promote root growth, we can move ratoon crops up to 30 or 40%, which would be a boon.

The most impressive plot was one where the panicles were less mature but very upright and large. Liu said that he calculated it had 4.5 million effective panicles/ha and this crop could possibly give a yield of 15 t/ha. The leaves were some of the deepest green color I have seen. I asked what nutrient amendments were made on this plot. Liu calculated: 450 kg N/ha, 320 kg P/ha, and 450 kg K/ha. Such high rates of fertilization seemed to contradict our recommendation that organic fertilization should be used for the best results with SRI methods.

So I asked Liu: what if any *organic* soil amendments were made to this plot? He responded, matter of factly: "Sixty percent of the nutrients applied were from organic sources." So this field had have a majority of its fertilization in organic form. The nutrient levels he cited were total amounts, all carefully calculated. Liu has recognized all along that best results come from relying particularly on organic nutrients that 'feed the soil.' He said that there was 90% effective tillering in this field, meaning that almost all the tillers produced by the plant were bearing grain.

The last plot that we inspected was one where Liu was experimenting with crop establishment through broadcasting, together with other SRI practices. It looked promising although the yield could not yet be known. Liu explained to me that he has an idea to put seeds, in properly spaced triangular patterns, on a thin plastic film, to be spread on a well-prepared field to sprout and take root. Whether this will work remains to be seen.

Liu apologized that he needed to leave for Chengdu for a business meeting, but said was glad that I had been able to make this third visit to his farm. He said that there are 4000 hectares of SRI rice in the immediate area. I knew previously that Liu had made major contributions to the development and spread of SRI in Sichuan Province by achieving a 16 t/ha yield in 2001 and by devising the triangular method of plant spacing. Now I knew that he had been part of the original team that got SRI launched in the province.

Ma and I followed a carful of SAU staff members to several more locations not far around Meishan, where SAU maintains on-farm trials and demonstrations. At the village of **Tai He**, we saw a large poster on a farm building wall describing the various practices being evaluated and demonstrated: seedling age (14, 30 and 40 days); no-till vs. conventional land preparation; transplanting distances (20x25cm up to 40x45cm); mulching with straw for weed control; fertilizer (various applications); water management; disease and pest control (including trials using BT applications); and hybrid varieties. The aim is to achieve yields over 12 t/ha. Most farmers in the area are using some combination of SRI practices, Ma said. There are 60,000 ha under these practices in the areas where SAU is working. They have been getting average yields of 9 t/ha fairly reliably, up about 20% from conventional practice which is already quite high.

There can be some additional costs to be considered, but it struck me that cost reduction is not very prominent in researchers' thinking. When I discussed this with Ma, he agreed, saying that the priority is to raise production, to have sufficient rice to feed the still-growing population. This is a government objective, however, which is not the same as the farmers' objective, which is to maximize net income. I suggested that SAU pay more attention to net income effects.

As we walked through the fields, I was struck by how tall and robust the rice plants were. Part of this is an SRI effect, with very vigorous and deep-green growth; but part is also due to varietal development, including hybrids. The early thrust of the Green Revolution was to introduce short-stalked varieties, intended to give maximum panicle size with minimal vegetative growth (maximizing the harvest index, was the justification for this plant-breeding strategy). Short plants were supposed to respond well to additional fertilizer inputs without lodging (falling over). That conception seems to have been dissipated over the years, to where whole-plant growth gets more attention (though still, with little attention to roots), not a narrow focus on panicles.

At the next village, **Yue Xin**, we saw some lodging of SRI rice at the edge of one field. I was told that there had been very heavy rains here recently. But still, I thought, the plants should have performed better. I asked about nitrogen applications here, and Ma said they were 12 kg/mu (180 kg/hectare). So I went to a lodged area and pulled up one of the plants to look at its roots. They were not particularly long or deep, and while their color was not black, indicative of necrosis, they were not very white, which would indicate health. It appears that water management early in the crop cycle was not very careful, and hypoxia had stunted the roots. SRI plants cannot be expected to withstand wind and rain unless they have good root growth. Ma waved his hand toward the horizon and said that this large area of rice was "all SRI." Less than 1% of it had succumbed to the rain.

In still a third village, we saw nice SRI crops grown in rotation with rapeseed. Because of timing issues, the seedlings used in one field were 40 days old, much older than we recommend for SRI; but their growth was very good. Across the road was a field of SRI rice that had been started from 7-day seedlings. Ma and I debated which would give the higher yield. I thought there were more and larger panicles in the 7-day-seedling field, but he thought that the field started with older seedlings would produce as well or better. In any case, there was not a clear advantage. This raised a question about how necessary young seedlings are; maybe they are not as critical as our experiences elsewhere (and factorial trials) have indicated.

As we drove back to Meishan for dinner, I asked Ma how much of his time he now spends on SRI. He estimated about 80%. Jokingly, I suggested that he, like so many others in our SRI network, has been "infected by SRI," adding that "this is a benign infection." He agreed. We had dinner at a restaurant in this rural-based city, one of the most modern in appearance that I can recall. That Meishan had 'mushroomed' in recent years was reflected in the lack of road signs that could help our driver find his way to the expressway which would take us back to Chengdu. Twice we took wrong turns that had to be retraced. China is indeed growing rapidly, and not just in the major cities. However, our farm visits also showed that there is still a lot to be done to raise productivity and living standards in many rural areas.

Sunday, August 12
The morning was unscheduled and a time for working on this report. At 11:30, Zheng came to the hotel to get me checked out (SAAS provided full hospitality for the visit) and to take me to the airport with a nice lunch en route. I flew in the afternoon from Chengdu to Hangzhou, where I was met at the airport by **Dr. Lin Xianqing** from the **China National Rice Research Institute** (CNRRI). On the drive into Hangzhou, Lin told me that the governor for Zhejiang Province, of which Hangzhou is the capitol, is making a particular push now to raise rice production, so there is a good climate for SRI extension.

Lin did not know the current extent of SRI cropping, but said we would find out from officials. He confirmed that they are seeing consistent resistance to lodging in SRI plants. This is an important consideration in Zhejiang, which often gets hit by typhoons during the summer. He recalled how in 2005, one of the best SRI farmers in the province, **Nie Fuqu** in Tian Tai country, was able to harvest a yield of 11.38 t/ha even after his area was hit by three typhoons and most of his neighbors' crops were practically wiped out by lodging.

Resistance to lodging is attainable, however, only when farmers used all the recommended SRI practices well, Lin noted. Other farmers who did not implement SRI as well as Nie had done did not enjoy the same success, Lin said. Just the previous week, he had visited Tien Tai and Nie's rice farm. Nie is again doing direct-seeding within the conceptual framework of SRI, Lin reported, and is using a mechanical seeder of his own manufacture. The crop looks very promising. When I visited Nie in 2005, he reported direct-seeding yields with zero-tillage of >10 t/ha. Nie has a good grasp not just of SRI practices but also of its concepts and principles. Unfortunately, there was not time to visit Tien Tai on this trip. CNRRI colleagues had planned a field trip to a different area on Tuesday to get direct acquaintance with SRI experience there.

Monday, August 13
A CNRRI staff member met me at the hotel at 7 to take me to the nearby bus stop where a shuttle bus takes staff from central Hangzhou to the CNRRI headquarters, an hour's drive away. By coincidence, I was able to sit and talk with Dr. Tao Longxing, who did some of the first work on physiological changes induced in rice plants by SRI methods, making phenotypes more productive, as reported in the Sanya proceedings (http://ciifad.cornell.edu/sri/proc1/sri_29.pdf).

Zhu Defeng met me in his office at CNRRI, having returned just the day before from a three-month assignment with a rice program in Spain. We discussed how the research being done in China on SRI, and written up in Chinese, can be made accessible to readers outside the country. The book that he edited and published last year, pulling together research from CNRRI scientists and colleagues in other provinces (*The Theory and Practice of SRI*, Chinese Press for Science and Technology in Agriculture, Beijing, 2006), is too long and detailed to be easily translated for English readers, in his view; and there is already much knowledge about SRI produced since the book was published that should be disseminated. So, we gave up the idea of making a translation. Zhu said that it has had good circulation in China and has served its purpose.

Instead, we discussed preparing three journal articles that can reach a wider English-reading audience. One has already been drafted by Lin, with Zhu and **Dr. Cheng Shihua**, CNRRI's director-general, as co-authors. I was invited to join as a co-author. This article is based on two years of evaluation data, detailed and well-controlled, comparing rice plants grown with *mostly SRI methods* (younger seedlings, wider spacing, alternate wetting and drying of the field, and equal fertilization from organic and inorganic nutrients) with rice plants grown with *standard methods* (older seedlings, closer spacing, continuous flooding, and all chemical fertilization).

The first set of plants produced more yield with *smaller* rather than larger plant populations (in fact, 2.5 t/ha more rice with a low population of only 150,000 plants/ha) and also higher yield with any given amount of N fertilization applied, ranging from 120 to 210 kg N/ha (plants with 120 kg N/ha produced as much rice as ones with 210 kg N/ha). This should be a very significant article for skeptics because it demonstrates with indisputable data that plants grown according to SRI principles function very differently and represent more productive *phenotypes*. Lin and I had discussed this article on the drive in from the airport on Sunday, so this project can and should proceed quickly. The other two articles planned concern the impact of water management alternatives on root growth and functioning, and the impact of different management practices on soil microorganisms and crop diseases. Both should be valuable contributions to the literature.

Before lunch, we made a tour of the CNRRI test plots, many of them evaluating SRI practices, usually individually rather than as a set. Several junior researchers and PhD candidates accompanied us. I was struck by the assumption being made that rice plants are essentially all the same, except as differentiated by genotype, rather than being products of their prior management. We saw an impressive set of trials evaluating the impact on yield of water stress at different stages of plant growth – panicle initiation, initial heading, etc. This assumed that plants' response to water stress at any particular later stage of growth is an intrinsic characteristic of the plants themselves -- not affected by how they had been previously managed, e.g., whether their root systems had been constrained and degenerated by continuous flooding.

I would hypothesize that if plants that have had an SRI water regime during their vegetative growth phase, and thus have larger and healthier root systems, would have a different response to water stress at different stages of crop maturation than plants that had been grown under continuous flooding, and thus have smaller and degenerated root systems. The effect of a variable like water stress, I would propose, is contingent on the plant's growth history, rather than being an invariable impact that results from the fact of stress itself. Impacts of stress, I am pretty sure, are influenced, mediated or mitigated by the plant's phenotypical status, which

reflects its prior interactions with its environment. The research design here did not reflect this understanding of rice development, however. Such observations made for an interesting discussion with the young researchers, with Zhu translating fairly complicated ideas into Chinese.

After lunch, Zhu and I talked about adaptations that are being made in the original SRI concepts and practices for Chinese conditions. It has been found that SRI methods are particularly suited for what is known in China as 'super-rice,' those varieties, both hybrid and inbred, that have been selected for particularly high yield potential. This potential does not get realized with standard methods of rice crop management, but it gets expressed with younger seedlings, single seedlings, wider spacing and unflooded soil. As in Sichuan, the two SRI practices that are not being utilized much in Zhejiang are active soil aeration (herbicides are used instead of mechanical weeders) and organic fertilization of the soil.

There is no disagreement that these two practices would be agronomically desirable. There is a lot of research and theory to support our SRI recommendations. But they are resisted on economic grounds, that labor (and biomass) is too scarce or too expensive to make these further improvements in crops' growth environment. Zhu confirmed that the Ministry of Agriculture in Beijing has recommended that SRI practices be promoted as a 'companion technology' with the promotion of 'super-rice' in China. This designation of SRI as a 'technology' is not one that we particularly like, but it fits into the government's way of thinking and proceeding, so there should be more widespread use of SRI methods (at least some of them) in the future.

Research has confirmed that when the soil is more fertile, higher yield can be obtained with lower plant populations, a counter-intuitive finding. Also, farmers find that when they are doing single-season rice with no winter crop, the best results come with *fewer plants* (8,000 plants/mu, or 120,000 plants/ha). If they double-crop, however, i.e., grow wheat, vegetables or potatoes in the off season, they will get more rice from 14,000-16,000 plants/mu (210,000-240,000 plants/ha). Also, Zhu said, rice varieties that have medium-size panicles, rather than large panicles, benefit from having more hills and maybe 1.5-2 plants/hill instead of single plants.

Where sunlight is less intense, as in Sichuan or Guizhou, wider spacing is more beneficial, to let more radiation reach the plants' lower leaves. If solar radiation is more intense, higher yield can be attained from somewhat *closer spacing*. We talked about CNRRI establishing an English-language internet website for SRI. This would make CNRRI and other Chinese findings on SRI accessible to the rest of the world and could link with the CIIFAD-operated SRI home page.

Later in the afternoon, I gave a seminar on SRI, to which about 45 CNRRI staff came. I focused on the reasons why the full set of SRI practices are recommended, based on factorial trial results and with data relevant to each practice. Not enough systematic work has been done yet on these various issues, but there is enough evidence accumulated that the recommendations should be taken seriously – and further evaluated and adapted to local conditions. I particularly tried to interest the researchers in investigating the benefits that we have seen and documented from active soil aeration and from getting more organic matter into the soil.

The latter is a problem for all of Chinese agriculture, not just rice production. I encouraged CNRRI to work on developing appropriate implements for 'weeding' (soil-aeration) to be

attached to the relatively inexpensive and versatile two-wheeled tractor that China has developed (and exported widely). Also I encouraged research on plant species, on management practices, and on tools and implements that could enable Chinese farmers to grow more biomass on non-arable land areas and process and apply compost more easily and cheaply, increasing labor productivity in these processes 'to the max.' I don't know whether this opportunity will be seized.

I was particularly pleased to make the acquaintance after the seminar of **Dr. Huang Shiwhen**, a pest and biocontrol specialist at CNRRI and Director of its Phytopathology Laboratory. He has done some work with Zhu and others on SRI and informed me that in some of their soil assessments, they found in SRI soils a higher population of **actinomycetes**, gram-positive bacteria that have significant antibiotic effects. Laboratory evaluations subsequently showed these actinomycetes inhibiting the fungus that causes **sheath blight**, a major disease in rice. I recalled that during a previous visit to Tian Tai township, Zhu Defeng informed me that CNRRI had found sheath blight to be 70% less in SRI fields.

Huang was interested in the data that I showed him from the National IPM Program in Vietnam. It has evaluated the impact of SRI practices on pests and diseases in trials across nine provinces. The Vietnamese data showed sheath blight to be 63.0% less in the spring season and 73.7% less in the summer on SRI plots, compared to neighboring control plots. This is a very important line of research to be further pursued. When I took the shuttle bus back to Hangzhou at 4:10, I thus had some interesting new information to reflect on.

Tuesday, August 14

At 8:15, Lin Xianqing picked me up for a field trip to **Jia Xing**, more than an hour's drive north of Hangzhou. Jia Xing has the distinction in Chinese history of being the locality where the Chinese Communist Party was founded in 1921. It is one of the best rice-growing areas in Zhejiang province, and Lin told me that hybrid rice had been widely adopted there.

En route we met up with **Gao Song Lin**, director of the Technology Extension Center serving Xiu Zhou country, and followed his vehicle to our first destination: Wang Dian village in Jia Xing district, adjacent to Jia Xing city. The farm of **Gan Young Pei** was one of the most attractive and orderly farms that I had ever visited. It is quite large, about 400 mu (26 ha), most leased from former farmers who now prefer to work in the urban or rural-industrial sector. It was impressive to see so many vegetable plants along most of the paddy field bunds. This reflected intensive and careful management. Lin said that Gan manages this whole operation by himself with the help of one full-time laborer and then employment of seasonal laborers when needed. For Gan, minimizing labor is a major consideration, and SRI has become labor-saving for him.

One innovation that first impressed us was Gan's use of **ducks with SRI**. This reduces weeding costs. It is not something really new because farmers have known for a long time that they can control weeds by raising ducks in their rice paddies. When ducks are put into paddies after the rice plants have gotten started, they nibble the young weeds as they come up because these are more succulent; older, tougher rice plants are left alone. With SRI rice, Gan waits until 20 days after transplanting, so that the tiny seedlings have gotten a good start. He then uses very young ducklings that will not trample the small plants so much. If he gets the timing right, this virtually

eliminates his need to weed, and it gives him a valuable sideline production activity: duck eggs and duck meat for sale.

Gan aims for a plant population of 110,000 plants/ha and has lowered his seed rate down to 0.7 kg per mu (10.5 kg/ha). He transplants at the 2-leaf stage, younger than most Chinese farmers who take up SRI. His crop is Japonica rice, not the more common Indica varieties, so his plants were is not as high-tillering as I was used to seeing. Gao told me that with Japonica rice, getting 15-16 tillers per plant with SRI methods is very impressive.

This is Gao's third year with SRI, and it has enabled him to harvest over 700 kg/mu (>10.5 t/ha). SRI is giving him a 1000-to-1 return on his investment of seed. The first year (2005) he got 715 kg/mu, and last year (2006) 725 kg/mu. This year he expects at least this much, or more. But since this is his first year with duck-rice farming system, he can't be as sure what he will get. Average Japonica yield in Jia Xing is 570 kg/mu (8.55 tha), one of the highest averages in China.

Gan likes being able to produce rice with less chemicals, and also likes being able to use less seed, less water, and less labor. To reduce labor requirements, he is trying direct seeding. Last year he got 786 kg/mu (11.84 t/ha) from one directed-seeded plot with adapted SRI methods.

On one large field, Gao pointed out varietal trials that Gan is conducting this season, 102 plots distributed over 15 mu (1 hectare) with randomized replications. Gan also has fertilizer trials on other plots. We looked closely at four long-term trials that he has going, now in their second year. Four treatments are being evaluated: (a) usual fertilizer applications with no organic material added; (b) manure added; (c) organic matter added (barley and rice straw); and (d) nothing added, as a control. The same amounts of nitrogen were being added to (a), (b) and (c), and also the same amounts of P and K, so he is evaluating the source of nutrients, not their amount. We noted more stem borer damage on (b), while there was little difference between (c) and (a). The plants in (d) were shorter and definitely yellowed, reflecting N deficiency.

Gan is a progressive farmer who has chosen to remain in agriculture, while other farmers 'exit' from the sector for industrial or other employment. Land area in this region is contracting as both housing and urban development expand, so Gao supports SRI as a way to increase productivity on the remaining land. As we drove back to Jia Xing city, we passed many large industrial areas that were absorbing the labor power that is leaving the land. Lin asked if I was impressed by Gan's farm, and I responded: "Very impressed. It was beautiful, efficient and innovative. What more can one ask for?"

When I asked Gao the extent of SRI use in Zhejiang province this season, he said that 5 million mu, out of 15 million mu of rice area, are being cultivated with some version of SRI methods. This means that one-third of the province's rice area is under SRI methods in some form (although a later report from CNRRI said that this was a cumulative figure, and that the area that can be considered 'under SRI' in 2007 was 110,000 hectares). The idea of using single seedlings and younger seedlings has caught on widely, Gao said, although not all farmers use seedlings as young as Gan does. Many have gone to broadcasting (direct-seeding) to save labor, so there is not much square transplanting of seedlings and little use of mechanical weeders as herbicides are used instead.

However, water applications have been greatly reduced, and farmers now use more organic fertilization, relying less on chemical fertilizer. This is both costly and not good either for soil or human health. (Lin and I discussed the huge buildup of nitrates in China's groundwater supply.) More and more farmers are utilizing animal wastes and crop residues and are also transferring muck from ditches and ponds to enrich their soil. They also collect weeds and mix these into the soil. So, while SRI practice here is not fully organic, it is moving in that direction.

At Gu Tou village in You Che Gong township, we met **Zheng Zu Wu** at his farm. Like Gan, he cultivates >400 mu (26 hectares), land consolidated by leasing and other arrangements with farmers who want to leave agriculture. I commented that although SRI was developed for small farmers, it seems to be working well here for bigger farmers. Gao responded: "Big farmers, SRI no problem. Big farmers think SRI is wonderful."

Direct seeding has become the norm for most of the SRI area in this district, Gao explained. Farmers now sow just 1.25 kg/mu of hybrid seed (18.75 kg/ha), which is half the usual rate used (2.5 kg/mu). He said that he has suggested farmers use only 1 kg/mu, but most think that this is too sparse. Some farmers, however, have reduced their seed rate to 0.9 kg/mu (13.5 kg/ha).

I asked about zero-tillage, and Gao pointed out one of Zheng's fields nearby that is **no-till rice**, grown in rotation with rapeseed. After harvesting the rape crop, Zheng sows the rice seed and covers it with rape straw. This suppresses weeds and conserves soil moisture, so this practice could become very popular. I suggested that farmers experiment with raised-bed/zero-tillage/ direct-seeded versions of SRI as is done by some farmers in India. Gao said they should try this.

Some of the broadcast plots looked good but not as impressive as I am used to seeing. I asked Zheng to pull up one plant so that we could look at its roots. These were not particularly large, and their color was a mixture of brown and white; the culm (base of the plant) was fairly black. It turned out that there was considerable lateral seepage from the canal running alongside the field, so that water control has not been very good. This cannot be avoided in some locations.

Gao said that he has set a goal of reaching 800 kg/mu (12 t/ha) and has offered a reward of 10,000 yuan ($133) for the first farmer who reaches this target. I told him about the national rice production competition in Madagascar, sponsored and funded by the President (himself an SRI farmer). All regional and national awards have been won by SRI farmers; non-SRI farmers have not come close to winning. The national prize is worth $13,000, a fortune in Madagascar. Gao was apologetic that his prize was so much less, but I said that for a district competition, this was in fact very generous.

We drove some distance to a 'country-cooking' restaurant for lunch and for a meal that was worth the drive. Gao told me something of the history of SRI in Jia Xing country. In Zhejiang province, CNRRI researchers began evaluations of SRI in 2001, and they participated in the first international SRI conference, held at Sanya in south China in April 2002, learning more about the concepts and methods. Papers from that conference reached Gao in 2003, and he did some experiment/demonstrations in 2004 on 625 mu in 312 locations (2 mu each). The average yield obtained -- 667 kg/mu (10 t/ha) -- got many people interested.

In 2005, there were 3,800 mu of SRI, of which 1064.5 mu were demonstrations. That year, plant hopper pests were very serious, but the yield on SRI demo plots nevertheless averaged 625 kg/mu (9.25 t/ha), very good under the circumstances. In 2006, over 30,000 mu were under SRI, with 1,000 demonstrations. Average yield was 708 kg/mu (10.62 t/ha). Now in 2007, there are more than 80,000 mu (5,333 ha) under SRI just in this township. This expansion is paralleled in other townships and counties in Zhejiang province, adding up to a total of 5 million mu (333,000 ha) of SRI use this year, an unprecedented spread.

The dissemination of SRI methods has been linked to the government's push to get hybrid rice widely adopted. But Gao volunteered that "Extending hybrid rice now depends on SRI." Because SRI methods add significantly to the benefits from using hybrid seeds -- cutting cost, saving labor and raising yield beyond what hybrid varieties can produce with conventional methods – the availability of SRI is making hybrids more attractive. An interesting and unexpected inversion, justifying the support that Prof. Yuan has given to evaluation and promotion of SRI.

Following lunch, we drove to the county Agricultural Bureau offices in the Jia Xing local government office complex. The director was not able to meet us, but we talked with two of his deputy directors for 45 minutes. There was no sign of any reservations about SRI methods, only an interest in quickly getting the most benefit from them.

While there is still no effort to shift entirely from inorganic to organic soil fertilization, efforts are being made to curb the present heavy utilization of chemical fertilizer. Deputy Director Ho said that 30 years ago, there was widespread use of organic methods, and farmers got good results. But this practice was crowded out by promotion of fertilizers for the past three decades. Returning rice straw to the soil is very important, he said. There is a local program is to mix pig manure with compost into granules that can be applied with long-acting effect. Cycling wastes and using crop residues is now strongly encouraged, reversing previous extension efforts simply to get farmers to apply more fertilizer.

How long it will take to transition back to more organic soil management cannot be known. However, the buildup of nitrates in the groundwater in some parts of China already **300 parts per million** (ppm) already, according to a USDA report I know about. The maximum level accepted as safe by the US Environmental Protection Agency is **50 ppm**, six times less, and some in the U.S. argue that this level is still too high. Meanwhile, Chinese farmers are putting on 300, 400, even 500 kg of nitrogen per annum in their intensively-farmed areas.

China needs more food, Ho said, a statement I heard repeatedly from officials and researchers. However, the marginal returns from fertilizer are definitely diminishing. At the start of the Green Revolution, by adding one kg of N to the soil farmers would produce 15-20 kg of additional rice. Now, one kg of N adds only about 5 kg to production, and this number is continuing to decline. So, while SRI is not intrinsically 'organic' – the methods can be used productively with chemical fertilizer – its demonstration of the returns obtainable from **increasing the organic matter in soil systems** is coming at an opportune time for Chinese agriculture.

Many people with whom I talked agreed that there needs to be more research and experimentation on ways to get more biomass grown on non-arable areas (it is, after all, one of the most renewable of resources) and to get it then collected, processed and applied to the soil to improve fertility -- and not just for rice. There is growing interest in moving Chinese agriculture toward more organic fertilization of its soil systems, but there is also great inertia on this issue. There are also commercial and bureaucratic vested interests in not changing course.

Wednesday, August 15
Most of the next day was spent with Lin Xianqing at CNRRI, working together to revise the first article that I had discussed on Monday with Zhu Defeng. Zhu is a co-author but most of the work of managing two years of factorial trials was done by Lin, with randomized block design and three replications of all treatments. The article was submitted to *Field Crops Research* in early 2006 and was rejected for publication on grounds that I think most scientists would consider slim.

Lin has been doing systematic empirical studies of SRI methods since 2002. Most of his articles have been published in Chinese journals (and in Chinese), but two have previously been published in *Field Crops Research*. However, they were evaluating specific SRI practices without explicit identification with SRI, which may have made them more acceptable to *FCR* reviewers. It is a pleasure to work with Lin who has agronomic knowledge and skills that I lack and who can bring the kind of scientific expertise to the evaluation of SRI that it deserves. With work and luck, perhaps we can get the article accepted in a revised draft that will be better because of the unusually detailed and harsh criticism that it received from the reviewers.

In the afternoon, Lin and I drove together to the Hangzhou airport so I could fly to Beijing for the last part of my visit. With my laptop and his memory stick, I was able to give Lin the report of Liu Daiyin on SRI in Sichuan Province that he had given to the SAAS seminar, and also powerpoint presentations on SRI practice in Punjab and Tripura states of India. Such cross-fertilization of SRI experience and ideas across state and national boundaries has been an important part of SRI's improvement and spread.

Thursday, August 16
The day started with a visit to the College of Humanities and Development (COHD) of **China Agricultural University** (CAU), which has been my main institutional 'base' when visiting China over the past ten years. **Xu Xiuli** was one of the colleagues with whom I spent the morning discussing both SRI and a new book by College staff on participatory curriculum development for community-based natural resource management. Xu was a member of the research team that conducted an evaluation of SRI in Xinsheng village of Jianyang County, Sichuan Province, in 2004. Lu Shihua, a member of the initial working group on SR in Sichuan, had informed someone at CAU about Xinsheng's remarkable experience with SRI, where the number of farmers using the methods had gone from just 7 in 2003 to 398 one year later. Their report is available at: http://ciifad.cornell.edu/sri/countries/china/cnciadeng.pdf

I briefed the CAU staff on what I had learned about SRI progress in Sichuan and Zhejiang on this visit and also showed them part of the powerpoint presentation made at CNRRI on Monday. This rekindled interest among the staff who had gotten to know about SRI from their evaluation of its impacts in a Sichuan village. They expressed willingness to undertake more socio-

economic evaluations of the uptake and impact of SRI and also to participate in any national seminar or conference on SRI, which we all agreed is overdue.

In the afternoon, **Prof. Jing Yuxiang** from the Department of Cell and Genetic Engineering in the Chinese Academy of Sciences's Institute of Botany came to CAU to meet me. He was a co-author of a very important piece of research published in *Applied and Environmental Economics* in November 2005 (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1287620). These researchers documented how when soil bacteria (rhizobia) infiltrate rice plant roots and migrate up the stem of the plant into the leaves (phyllosphere), their presence (compared with absence) is associated significantly with increased levels of *chlorophyll* in the rice leaves and with higher rates of *photosynthesis*, and with greater grain *yield* as a result. This throws new and important light on the plant-microbial interactions that microbiologists are beginning to document and understand better.

When I went through my CNRRI powerpoint presentation with Jing, everything made good and quick sense to him, since he knows a lot, much more than I, about plant-microbial relationships. Some of my comments were conjecture, but he considered them unsurprising. By the time we finished our conversation he was suggesting that we needed to have a national SRI network, and a national SRI conference to exchange information, and to embark on a more systematic research program in China. He is now retired but is full of energy and interest, so he can probably give some added push to the scientific work being done on SRI in China.

Friday, August 17
This day was spent interacting with PhD students at COHD, listening to summaries of their thesis research, some still in the planning stage. I was asked to comment on and critique their formulations of their research design, their methodologies, and their tentative conclusions where some field work had been done already. This was an enjoyable day, immersing me in the social science issues and work that preoccupied me before my interests were redirected by SRI experience. Previously, I served as chair of COHD's international advisory committee, and the College through its director, **Dr. Li Xiaoyun**, has been very supportive of my SRI activities in China. Indeed, without its logistical and other support, SRI would not be as far along in China as it is. So spending time with its graduate students was not only enjoyable, but a return of favors done for SRI.

Saturday, August 18
At 9 o'clock, I went back to China Agricultural University to meet **Dr. Liu Xuejun**, professor of nutritional ecology and soil fertility in the Department of Plant Nutrition in the CAU College of Natural Resources and Environment. He and two CAU colleagues, not currently in Beijing, contributed a chapter on "Rhizosphere Management as Part of Intercropping and Rice-Wheat Cropping Systems" to the book I had edited on *Biological Approaches to Sustainable Soil Systems*.

It turned out that Liu knew a lot more about SRI than I imagined because of his connection to Dr. Lu Shihua in Sichuan Province, one of the first scientists there to become involved with SRI evaluation. Liu said that when he had visited Lu and seen for the first time SRI rice newly transplanted in the field, he could not imagine the crop doing anything good. But when he came

back a few months later, the plants had 'exploded' and had an average of 70 tillers. When the crop was harvested, its yield was 12 tons/hectare, twice what farmers were getting in their fields with conventional methods. That persuaded him something new and useful was going on.

We discussed the reluctance of Chinese farmers and scientists to give up their dependence on chemical fertilizer, particularly for nitrogen. I commented on the buildup of nitrate (NO_3) in the groundwater as a result of overuse of N fertilizer, discussed with Agriculture Bureau officials in Jia Xing. Liu said that the average application of N fertilizer in China is now 180 kg/ha, more than three times higher than the level in the U.S., 50-60 kg/ha. Chinese fertilizer factories are producing 30 million tons/year and have an interest in further expanding its production and use.

He asked about articles critical of SRI that have appeared in the literature, particularly in *Field Crops Research*. I explained the methodological and sampling flaws that led to their erroneous conclusions. He was relieved to know this critique in detail, because he as pleased and impressed with that he had seen of SRI. He was also glad to know that there are now more accurate articles on SRI performance being accepted and published in the peer-reviewed literature. I gave him files of an article with Indonesian data that will appear soon in the *CAB Review of Agriculture* and one with Myanmar data, to be published in October in *Experimental Agriculture* as well as one already published in the *International Journal of Agricultural Sustainability* with data from The Gambia.

Some of Liu's own research focuses on the emission of greenhouse gases (GHGs) from crops and fields. Currently he is studying irrigated maize. He was thus interested in talking about the impacts of SRI methods on GHG, particularly the potential tradeoff between producing less methane (CH_4) but more nitrous oxide (N_2O) when rice paddies are not kept flooded. This decreases methane, but nitrous oxide is probably increased to some extent, and it is a 'meaner' GHG, causing more warming effect per molecule. Since with SRI there are not large applications of nitrogen fertilizer, probably additional N_2O emissions would be small. But this is an empirical and complex question, with impacts varying according to soil type, temperature and other factors.

Liu agreed that this was an important and researchable question, and he said he would try to get a PhD student to do a thesis on this, since it should also be very fundable research. There is a lot of pressure on China these days to reduce GHG emissions. Since its farmers are rapidly adopting SRI (for economic more than environmental reasons), if this has a net positive environmental impact, it would be helpful for China to have this quantified and be able to show that its changed agricultural practices for rice production are reducing factors causing global warming, and to how much this is contributing to impeding climate change. Such information would be useful to have for SRI utilization and support in other countries. This morning meeting with Liu could become one of the more important 90 minutes spent so far on behalf of SRI.

Concluding Thoughts

After spending the rest of the morning working on this report, I went to the airport at 2 for my return flight to the U.S. Reflecting on what had been seen and heard, it was clear that SRI is progressing impressively through the efforts of many colleagues and many farmers, each acting on his or her own, but often in cooperation with each other. SRI's merits are speaking for themselves.

Many persons in China understand the broader purposes of SRI, which include more than just producing more rice. While this will both benefit farmers and consumers and will help the government meet its objectives, especially under conditions of diminishing water availability, SRI is also about improving agriculture in general, making farming a more remunerative and secure livelihood, and contributing to a better environment: healthier soil, cleaner water and air -- leading to healthier plants and healthier people as well as environmental sustainability.

Why has SRI progressed more rapidly in China than in other countries? It got an early start (with first demonstration of SRI benefits in 1999 at Nanjing Agricultural University), and it then accelerated partly because scientists and farmers there seem more willing to proceed pragmatically, with less constraints of *a priori* reasoning, seeking positive results with fewer preconceptions, possibly with less deference to theory and authority. Such pragmatism has contributed to the rapid economic growth and transformation of the country. There are many bureaucratic, institutional and cultural impedances, as elsewhere, but nowhere else have so many persons, many of them in high positions, been open to new ideas as in China.

As seen in this report, hundreds of thousands of farmers and probably hundreds of scientists are now taking the insights of Fr. de Laulanié seriously, applying them, adapting them and improving upon them, something that he would have approved of completely. My presentations on SRI usually begin with the caveat: “SRI is a work in progress – it is not finished.” A lot can be learned from the experiences, dynamics and opportunities unfolding in China (and elsewhere) as the principles of SRI in their many different incarnations and applications ‘take root.’