REPORT ON VISIT TO CHINA, AUGUST-SEPTEMBER, 2004 FOR REVIEW OF SYSTEM OF RICE INTENSIFICATION (SRI) ACTIVITIES AND PROGRESS

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HIGHLIGHTS

During a 3-week visit to China, August 21-September 11, much was learned about the evolution, acceptance and spread of SRI in this country, the leading rice country in the world. This report is written to give readers a sense of the many people involved in this process, not just of results.

1. The China National Rice Research Institute (CNRRI) based in Hangzhou, which began SRI evaluations in 1999 after reading the Tefy Saina article on SRI in ILEIA magazine, is putting together **a book on the research findings on SRI** from various institutions over the last five years, which it hopes to get published by the end of the year.

2. At a 10th meeting on Theory and Practice of High-Quality, High-Yielding Rice in China, held in Haerbin at the end of August, there was a special focus this year on SRI. I was invited to make a presentation, and half a dozen papers from different institutions around China were presented. Some of the reports included this information:

a. A **new high-altitude rice yield record** was set in Guizhou province in 2003 using SRI methods -- 12.9 t/ha at 1140 m elevation -- according to Dr. Zhou Weijia, director of the Guizhou provincial rice research institute.
b. Evaluation of **rice quality** by Dr. Ma Jun from Sichuan Agricultural University found that rice from all 3 spacings with SRI methods had **less chalkiness** than rice grown with conventional practices (30.7% fewer chalking kernels, and 65.7% less chalkiness in general) and **more outturn of milled rice** from paddy (16.1% more). The latter is a 'bonus' on top of the higher paddy yields being obtained. We have had reports of this from Cuba, India and Sri Lanka, but no data so definitive.

3. I learned more about the **3-S system** which is very similar to SRI in its principles and practices, developed independently in northern China during the early 1990s and popularized beginning in 1999. It now is used on 44,000 ha, with an average yield around 10 t/ha, compared to 6-7.5 t/ha usual yield, using single seedlings, wide spacing, reduced water applications, and more organic matter. The system was developed for cold-zone rice production as Heilongjiong province borders Manchuria.

4. CNRRI has a systematic demonstration-dissemination effort established in Zhejiang Province. I visited one of the locations, **Tian Tai county**, where the area under SRI has greatly increased from last year, with projected yields this year of about 11.0 t/ha. I was particularly impressed to find that some farmers are trying out and evaluating several variations within SRI: zero-till, direct seeding, and very wide spacing (50x50 cm). Farmers reported a 30-40% reduction in water use, and a 70% reduction in sheath blight, their major disease problem.

5. I met with Dr. Zhai Huqu, president of the **China Academy of Agricultural Sciences**, who while he was president of Nanjing Agricultural University was the first rice scientist in China to

learn about SRI and to encourage trials. He expressed strong interest in SRI and proposed a planning meeting for a national research effort on SRI during the upcoming international rice conference at Hangzhou in October.

6. The dean of the College of Agricultural Resources and Environmental Sciences at **China Agricultural University** in Beijing is doing SRI evaluations in Sichuan province, both lowland and upland, with very good results. The Center for Integrated Agricultural Development at CAU has done a socio-economic evaluation of SRI adoption in a Sichuan community. **In 2003, only 7 farmers in Xinsheng village used SRI methods; in 2004, there were 398**, 65% of all farmers there. 2003 was a drought year, and SRI gave a higher yield than the regular 2002 crop, while regular methods in 2003 suffered a one-third decline. This probably explains the rapid adoption. In 2004, SRI outyielded regular methods by 35.2%, with a water saving of 43.2% per mu. Perhaps most significant, in both the questionnaire survey and in discussion groups, farmers said that the most attractive feature of SRI was its **reduction in labor requirements**.

7. The **Sichuan Academy of Agricultural Sciences** has been doing SRI evaluations since 2001. This year it has over 100 locations where SRI is being monitored and evaluated. This is harvest season so not all results are in, but the first 60 reports show an average SRI yield of 10.5 t/ha, compared with 7.5 t/ha with usual methods, a **3 t/ha increase**, with less water and often less labor.

8. One of the pioneers for SRI in China, Mr. Liu Zhibin, farm manager of the Meishan Science and Technology Institute established by Prof. Yuan Longping, 'the father of hybrid rice,' who has tried **no-till, raised-bed SRI** this season. He showed me his official certificate for **13.4 t/ha yield**. (Liu developed the 'triangular' method of plant spacing that improves upon standard SRI 'grid' planting by keeping wide spacing but increasing plant population by 50% per square meter.) Liu also showed me a certificate for a SRI yield in Yunnan province of **20.4 t/ha**, attested by the Science and Technology Department and a professor from Sichuan Agricultural University. Two rice scientists whom I talked with reported **18 t/ha yields** certified in Yunnan province this year. Yunnan is considered to have the most favorable climate in China for high-yield rice production, so this cannot be a norm for China, but it shows the high potential that can be evoked from rice genomes.

9. At the end of the visit, I participate in an **international forum on hybrid rice** hosted by Prof. Yuan Longping, director of the China Naitonal Hybrid Rice Research and Development Center. It was held at Changsha and Huaihua in Hunan province. Prof. Yuan took participants to see a super-hybrid rice field with **13.5 t/ha yield**, where mostly SRI methods were used, including 11-day-old seedlings. He continues support SRI based on his own evaluations and experience.

10. At the hybrid rice forum, I spent some time with Dr. Nguyen Van Nguu, executive secretary of **FAO's international commission on rice** (for the International Year of Rice), who has had reservations about SRI it seems but who says that he is 'open' to SRI; the deputy minister of agriculture and rural development for **Vietnam**, Dr. Bui Ba Bong, who wrote for information on SRI in 2003; the head of the national rice program in **Uruguay**, Dr. Pedro Blanco; and professionals from **Iraq, Mongolia** and **Sudan** who all asked for information on SRI. So there were some useful contacts made beyond China.

REPORT FROM RICE SCIENCE CONFERENCE: This year, Northeast Agricultural University (NEAU) located in Haerbin in northern China hosted a 10th Conference on Theory and Techniques of High-Quality, High-Yielding Rice in China. One of the themes for the conference this year was SRI, which was why I was invited to attend and make a presentation. Dr. Jin Xueyong of NEAU, my host, took initiative to bring the conference to his university so that participants could observe rice being grown under a production system that he has devised, known as **3-S**, one very similar to SRI. Jin developed 3-S between 1991 and 1996. The provincial government accepted it, after successful on-farm demonstrations, in 1999, the same year that SRI was first tried in China. It has been spreading in Heilongjiong Province since then. The name, which stands for 3 'supers,' a shorthand term used in extension, is not very descriptive of the system. 3-S involves transplanting single seedlings widely spaced. Its careful water management reduces water use by about half, and it depends more on organic fertilization.

The main difference from SRI is that 3-S seedlings, raised in plastic trays, are transplanted when about 45 days old. Heilongjiong lies just south of Manchuria, and the cold temperature makes phyllochrons are longer. 3-S seedlings are started in greenhouses when there is still snow on the ground. Older, larger seedlings are needed because the soil is too cold for very young seedlings. The wide spacing is intended to 'make full use of low tillers,' enabling them to be fully active photosynthetically. Dr. Anischan Gani found in trials at the Indonesian rice research institute at Sukamandi that when he measured radiation within canopies with conventional spacing, the lower leaves did not receive enough illumination for photosynthesis. Their metabolism uses up some of the photosynthate from upper leaves, reducing what is available for grain production. With SRI spacing, all leaves were above the photosynthesis threshold and contributed to grain filling. This is one way in which SRI can achieve 'the edge effect' throughout the entire field.

At breakfast on Sunday, before the conference opened, I was welcomed by Dr. Zhai Huqu, president of the China Academy of Agricultural Sciences, and former president of Nanjing Agricultural University (NAU). We had first met in China in 1997 at a joint seminar of CIIFAD, NAU and China Agricultural University (NAU), and then again at Cornell in 1998. He was the first Chinese rice scientist to be told about SRI, and he organized a seminar for me when I visited NAU in December 1998. So one could say that he first 'opened the door' to SRI in China.

Also at breakfast, Dr. Lin Xianqing from the China National Rice Research Institute in Hangzhou, who helped organize the first national SRI workshop held at CNRRI in March 2003, briefed me on plans of a number of Chinese researchers working on SRI to produce a book. This will bring together what they have learned about SRI since starting evaluations in 1999. Lin said they would like me to contribute an overview chapter, which I will be pleased to do. Those who are working with SRI methods in China have gained a lot of confidence in the system, he said.

Chinese rice scientists do very detailed analyses of rice plants. Some examples are the following tables and graph from a paper written by Dr. Zheng Jiaguo and colleagues in the Crop and Fertility Institute of the Sichuan Academy for Agricultural Sciences, reporting on some of their research findings (CK stands for check, or control). The phenotypical differences induced in rice plants by the use of SRI practices have been documented repeatedly.

Table 2. Different sizes of the leaf blade (unit: cm)

Item	3rd leaf		2nd leaf		Flag leaf		Average	
	Length	Width	Length	Width	Length	Width	Length	Width
SRI	64.25	1.57	71.32	1.87	57.67	2.17	64.41	1.87
CK	56.07	1.43	62.03	1.57	48.67	2.01	55.56	1.67
+/-	8.18	0.14	9.29	0.30	9.00	0.16	8.86	0.20
%	14.59	9.79	14.97	19.11	18.49	7.96	15.95	11.98

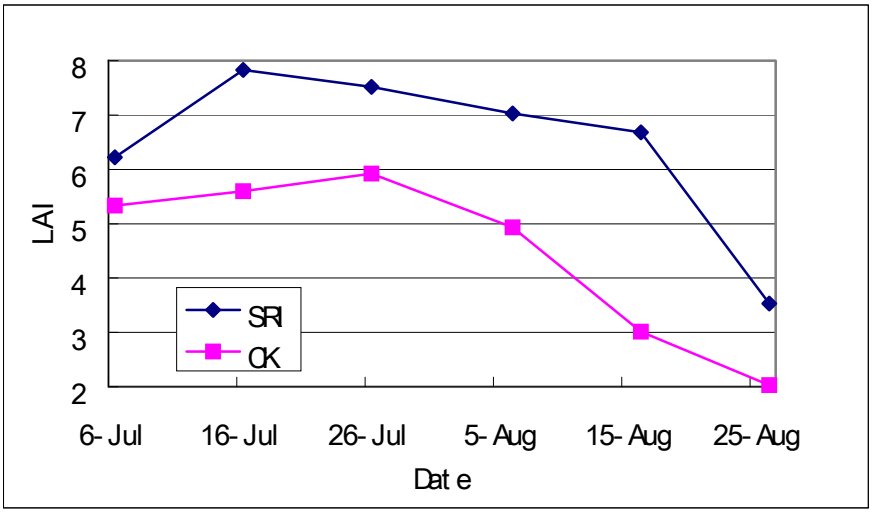

Figure 1. Change of leaf area index (LAI) during growth cycle

Table 4. Comparison of dry-matter accumulation between SRI and CK (unit: kg/ha)

Comparison	Rice stage	Stem	Sheath	Green leaf	Withered leaf	Panicle	Biomass
SRI	Full heading	6396.0	8055.0	7168.6	315.4	2361.7	24902.4
	Mature	4108.8	3265.6	3390.0	2667.3	13592.1	25407.3
CK	Full heading	3775.3	5594.5	3880.9	254.2	1204.9	14710.0
	Mature	2475.0	3064.6	1661.2	1639.6	7935.7	15832.5
SRI over CK (%)	Full heading	69.29	44.0	84.71	24.07	96.00	69.28
	Mature	990.1	6.56	104.06	62.67	71.28	60.48

At dinner the evening before the conference started, I got acquainted with Prof. Wang Bolun from Shenyang Agricultural University, who serves as Deputy Director of the China Crop Cultivation Research Committee, and Prof. Wen Xiong Lin, Dean of the College of Life Sciences at Fujian Agricultural and Forestry University, who both played leading roles in the conference. Both expressed interest in SRI after some discussion.

The opening session was entirely in Chinese. (I was the only foreign participant at the meeting.) After the break and picture-taking, Wen helped me follow presentations the rest of the morning.

Dr. Zhai's keynote address stressed food security concerns, noting that water constraints and reduction of cropped land area in China present serious challenges to continuing to meet the country's food needs. He said that policy-makers anticipate a 20 million ton deficit for rice production by 2030. Some argue that this amount can be met by imports, while others are less confident about depending on international markets. It would clearly be better if China could produce this for itself. (If China has to buy significant amounts of rice on the world market, this will surely raise the price of rice and have adverse effects on the poor in many countries.)

Since 1998, the production of rice, wheat and maize in China has been on the decline. Relatively low prices for basic grains have reduced farmers' incentives to innovate and invest. Also, loss of cropped area to non-agricultural uses is a factor. Water shortages and land degradation further contribute to the slackening of production. Shortfalls in recent years have been met by imports and drawing down reserves, but this is not a long-term solution. Zhai mentioned 'soil conditions' as one of the factors contributing to the problem. He also mentioned 'ecological security' as one of the goals of rice sector policy, listing resource degradation and reduction in biodiversity as concerns, along with quantitative and qualitative food security. Protection of land quality was mentioned along with advances in science and technology strategies to reverse the situation.

Somewhat surprising was his comment, as an eminent rice breeder, that 90% of the funds spent currently on molecular biology are "a waste" in terms of any practical use. Zhai commented that much of the research now undertaken is mostly for purpose of publication. Traditional breeding methods, he said, could give results more quickly. "High yield is a permanent issue in China," he said in conclusion, observing that there is still considerable potential for increase. While he made no reference to SRI, his assessment of the problems and opportunities in the rice sector makes SRI both relevant and timely in China.

The other morning presentations, by Prof. Ling from Yangzhou University, on precision cultivation, and by Dr. Zhu Wei from Northeast Agricultural University on technological change in Heilongjiong Province, reflected 'mainstream' perspectives on how agriculture can best be advanced and had little connection for SRId that I could determine.

After lunch, my presentation on SRI was the first one. As there was a long list of papers for the afternoon, the time allotted was 15 minutes for each paper. (Having had no prior information, I was prepared for half an hour.) With some time for interjections and elaborations in Chinese by Dr. Wen where he thought important points had been made and might be missed by participants, I had 20 minutes, plus 5 more for questions. In the limited time the basic ideas of SRI were mostly gotten across. Fortunately, the pictures 'spoke a thousand words,' as the Chinese saying goes. I said that details on SRI would be provided by other speakers coming after me, who would have the advantage of presenting SRI experience in China -- and of speaking in Chinese.

Dr. Jin's following presentation on 3-S took considerably longer than the allotted 15 minutes. He showed impressive pictures, matching mine, of the large root growth of rice plants when they are grown with wide spacing and unflooded soil. He reported 40% more photosynthesis in 3-S plants, reinforcing my point. His pictures of seedlings being started in plastic greenhouses while there still was a foot of snow outside were 'chilling.' He reported that there are already at least 44,000 ha under 3-S in Heilongjiong, with average yields about 9 t/ha compared with the more

usual 6 t/ha using conventional practices. Controlled trials showed yields of 10-11 t/ha. This shows that the methods which Fr. de Laulanié synthesized in Madagascar to tap potentials in the rice genome are not idiosyncratic; they can work well under a very different climatic conditions. One set of Jin's trials showed a 10.73 t/ha yield with shallow-wet-dry water application method, giving a 4.7% increase in yield with a 56.9% saving of water compared to shallow-deep-shallow irrigation.

Later that afternoon, Dr. Zhou Wei-Jia from the Rice Institute of the Guizhou Academy of Agricultural Sciences gave a paper on his and his colleagues' work with SRI methods in the south of China. Guizhou is a mountainous subtropical province. Two of the varietal comparisons using SRI and conventional methods showed SRI yield advantage of 14.66 and 10.52%. This is not as great as often seen elsewhere, but costs of production were reduced, making the increases more valuable. The paper also showed the 'theoretical yields' calculated for the respective trials. The SRI trials were much closer to this projection in one case and exceeded it in the other (the actual yield of 10,717.5 kg/ha was above the theoretical yield of 10,590.6 kg/ha). Of most significance was the yield of 12,873 kg/ha that Zhou reported using variety JY431, which "broke the yield record for rice in high-altitude areas."

During a break, Prof. Zhang Yuzhu, vice-director of the Hunan Rice Research Institute, located in Changsha next to the China National Hybrid Rice Research and Development Center of Prof. Yuan Longping, gave me his 'stick' to transfer my SRI powerpoint presentation to him. He said that he has been doing research on SRI for two years now, encouraged by Prof. Yuan. The other papers the first day had little relation to SRI, being focused on varietal differences, fertilizer application, etc. Dr. Wen's presentation at the close of the afternoon, however, reported his research on rice root growth with measurements of phytohormones. He is thus looking at factors that we consider important for SRI effects. He also asked for a copy of my SRI presentation.

On Monday, there was a whole day of paper presentations, most of which I could not follow. The most extensive paper on SRI was given by Dr. Ma Jun from the Rice Research Institute of Sichuan Agricultural University, on 'The Utilization and Demonstration of the System of Rice Intensification (SRI) in Sichuan Province." After three years of evaluations, he said that they have found a number of hybrid rice cultivars with high tillering ability, large panicles and high resistance to shattering that respond very well to SRI practices. They have found it too difficult to transplant very young seedlings, so are recommending transplanting of single seedlings with 4-5 leaves.

An innovation in SRI practice that was originated in Sichuan Province by Liu Zhibin, a co-author of the paper, is to **plant 3 seedlings per hill in a triangular pattern** with 7 cm spacing between them, but ***in only half the hills*** within a 30x30cm grid. This increases SRI plant population by 50% over an ordinary grid pattern with 1 plant per hill at all the intersections of 30x30 cm rows. This preserves the exposure to sunlight and air that adds to yield. Careful water management after transplanting was emphasized, and a combination of organic and inorganic fertilization was recommended by Ma.

The triangular method of planting is a beneficial innovation within SRI, although I think, based on our studies in Madagascar and elsewhere, that researchers in China should not 'give up' too

soon on using very young seedings or on replacing inorganic with organic fertilization. The SRI yields that Ma reported with their methods are very respectable, 8-9 t/ha and up to 11.75 t/ha, but I think they can still do better it recommended SRI methods are used more fully. In 2001, Liu achieved a yield of 16 t/ha, certified by the Sichuan Provincial Department of Agriculture, with excellent use of SRI methods and hybrid seed on the seed farm that he manages at Meishan.

I was particularly interested in one of Dr. Ma's tables that reported the effect of different cultivation methods on **rice quality**, something we have not studied. The three SRI treatments (different plant densities), compared to two control treatment, all had lower percentages of chalky kernels (23.62-32.47% vs. 39.89-41.07%) and less chalkiness in general (1.02-4.04% vs. 6.74-7.17%). The percent of milled rice was higher (53.58-54.41% vs. 41.54-51.46%), as was head milled rice (41.81-50.84% vs. 38.87-39.99%). There was also a table on the activity of roots at different soil depths which was elegantly detailed, but it has little meaning to someone not versed in Chinese and molecular biochemistry.

A paper by Wu Cun Zan from the Wen Zhon research station of the Zhejiang Provincial Department of Agriculture had some tables that I could decipher on the effects of seedling age, other things being equal. 15-day seedlings produced 10.374 t/ha compared to 9.345 t/ha for 28-day seedlings, one ton difference attributable just to seedling age. Given the claim by critics of SRI that its methods lengthen the growing cycle, it was interesting to see that time to maturity for the variety used in these trials increased by one day for every 3 days of plant age: 12-day seedlings took 121 days to mature, 15-day seedlings 122 days, 19-day seedlings 123 days, 22-day seedlings 124 days, 25-day seedlings 125 days, and 28-day seedlings 126 days. Such numbers are always affected by variety, climate, etc. In India last winter (dry) season, SRI rice usually matured 7-10 days earlier than conventionally grown rice (same variety, same farm, same farmer), according to Dr. A. Satyanarayana, Director of Extension for Andhra Pradesh.

A paper by Dr. Zhang Yuzhu from the Hunan Rice Research Institute, with whom I talked the day before, had a number of very interesting tables and graphs, with SRI usually shown to be superior, but I could not tell in what respect. A paper by Lin Hua from the Rice Research Institute in Zhejiang, a co-author with Wu Cun Zan on the previous paper from Zhejiang, compared SRI methods and standard (control) methods for four different rice varieties. The SRI yields were always higher and averaged 12.8% more; however, there was no difference in grain weight, something that we have seen in many other countries. I hoped to learn more about these results when I got to Zhejiang Province.

After lunch, participants convened in two groups. SRI researchers joined the 'techniques' group rather than the 'theory' group, though I think SRI has a lot to contribute to theory of high-quality, high-yielding rice. The style of discussion was for individuals to make long, often impassioned interventions, apparently expressing opinions more than addressing empirical results. One who spoke in favor of 'precision agriculture' said he could not agree that we can have both more panicles and larger panicles. This inverse correlation between panicle number and panicle size has been a standard conclusion in the literature for many years. But SRI experience contradicts this. I felt it necessary to say so. Someone else expressed strong support for the use of super-hybrid varieties, noting that they require good 'technology' (management) to utilize their

potential. I did not comment that this is what the China National Hybrid Rice Center has concluded, finding yield advantages in managing hybrid rice with SRI methods.

Dr. Zhou from Guizhou spoke up to say that they see increased yield with less dense planting, and farmers now agree with this. He said that "if farmers grasp the technology of SRI, it will be easy to increase rice yields without requiring more or heavy inputs." I was pleased to hear such a positive statement based on several years of experience with SRI. Dr. Ma from Sichuan also spoke up to emphasize the need to achieve food security, as Dr. Zhai has stated. He said he was confident that this objective could be met with various technologies "like SRI," adding that it is important that the technology be suitable for the environment. This seemed to be an endorsement of SRI given what he said about it in his paper.

Someone got up to say that SRI cannot increase the number of grains produced per square meter, not just per plant, and this is necessary to get higher yield. He said that he had read this in an article somewhere (possibly a misunderstanding of the article by A. Dobermann in Agricultural Systems). In fact, we see such increases with SRI in the number of grains produced per sq. m. all the time. Fortunately, there is a growing number of Chinese researchers who can deal with such misstatements of fact. At the closing session that day, Dr. Zhai Huqu spoke again on behalf of the Chinese Academy of Agricultural Sciences. We agreed afterwards that I would visit the Academy next week when I got to Beijing.

The day was concluded with a traditional banquet for all the participants with splendid food and a lot of toasting (*gambei* -- bottoms up) with rice wine and beer, though the drinking was more restrained than at some banquets I have attended. This group was more interested in karaoke singing, and it was the most joyous banquet I have participated in, thanks in large part to Prof. Jin's enthusiasm and congeniality as host. I sat next to Hao Zaibin, who had given an interesting paper on rice roots the first day, having discovered a mutant rice plant with very different root configuration, e.g., almost no hair roots. This was permitting him to identify genes that control certain aspects of root development and function. Hao was accompanied by one of his students whose English was better than his so we could have some interesting discussion. He liked the root pictures in my powerpoint presentation so we exchanged PP files. Having done his PhD research in Japan, Hao did by far the best karaoke number, in Japanese.

RESULTS IN GUIZHOU PROVINCE: Tuesday morning, participants boarded two buses at 7:30 for a field trip to see some 3-S rice fields. I sat with Dr. Zhou Wei-jia so that I could learn more about his experience with SRI in Guizhou Province. Dr. Lin sat with us to help with translation. Zhou learned about SRI from attending our international SRI conference held in Sanya, China, in April 2002. I had not gotten acquainted with him or most of the 50 Chinese participants who were hesitant to speak in English. He had taken SRI ideas from the conference and applied them in his home province.

When I told him about an e-mail report I received just before coming to China -- from Nepal, a mountainous country with similarities to Guizhou, where some SRI plants have attained 135 tillers -- Zhou said they have had plants with as many as 110 tillers in Guizhou. He told me that the record rice yield reported in his paper given on Sunday, 12.9 t/ha, was attained at 1,140

meters elevation, on a farmer's field near the capital of the province, Guiyang. He said that they are looking for varieties that are particularly responsive to SRI practices and have found several.

I told him about efforts by farmers in Sri Lanka to use SRI to conserve rice biodiversity. With these new methods, high yields are being obtained with traditional varieties that are being lost, relegated to obscurity by newer, high-yielding varieties. However, people prefer eating the old varieties for their flavor, texture, aroma, etc., so they command market prices two or even three times more than modern varieties. Yields of traditional varieties are low with conventional practice, around 2 t/ha, because fertilizer and close spacing causes lodging. But their yields do not need to be as high as for the new varieties to be profitable. Yields with SRI are often 4-10 t/ha, even up to 13 t/ha. A farmers' association in Sri Lanka dedicated to the environment has started exporting 'wild ecorice' to Italy, earning more than double the price that they get for usual rice. Its members are ready to produce up to a dozen different 'wild' varieties, with colors ranging from red to black with yellow, orange and brown in between.

Zhou confirmed that there is great biodiversity of rice in Guizhou and neighboring Yunnan provinces, also in the adjoining Guangxi Autonomous Region that is borders on Vietnam and Laos. Rice originated in that part of the world. An immense variety of microclimates ranging from low to high elevations made for hundreds of local varieties. Zhou said that his institute can do evaluations with farmers to see which varieties perform best with SRI methods. We discussed the idea that rice can become 'the food of the future' offering diverse and attractive variation in grains, not simply 'white stuff' that is a homogeneous staple for mass consumption. If local varieties from different countries can be popularized with middle and upper-income consumers around the world -- for use in salads, desserts, casseroles and other dishes -- the demand for rice should increase as incomes rise, rather than fall as happens now when rice is regarded as a necessary but 'inferior' good. This change of image will take some marketing, but rice could be 'reinvented.' The rice plant has so much productive potential, realized with SRI, that it could help to feed the planet and also earn more income for farmers in environmentally friendly ways.

We discussed also the political economy of staple grains. Wheat has been displacing rice in consumer demand around the world as people purchase more convenience foods and switch to breads and other baked products. This benefits mostly large-scale producers in the U.S., Canada and other better-off countries. Rice, on the other hand, is grown more in poorer countries and is still largely a smallholder product, which SRI can make more profitable for them. There are thus interesting worldwide income-distribution implications from the global choice among staple foods. An undeclared battle among wheat, maize and rice for global supremacy will be played out in the coming decades. While rice demand has been declining in Asia, it is picking up in Africa, where consumption rises when incomes increase. In Latin America, rice (with beans) is a staple for everyone. It will be interesting to think about long-term implications of this. Past patterns need not determine the future.

I asked which provinces in China have most interest in SRI. Sichuan may be in the lead, but Zhejiang, Hunan, Guizhou and Anhui are coming up, also Jiangsu and Hubei. The spread of 3-S in Heilongjiong should also be counted in this assessment. Jiling and Liaoning in the north are also taking up SRI I was told.

The 3-S fields that we visited when we arrived in Wuchang County after a two-hour trip were impressive. The seeding rate is 10,000 plants per mu, which is 150,000 per hectare, or 15 per square meter, about 25x25 cm spacing. Single plants are giving best results, with reduced water application. Prof. Jin offered to take Dr. Lin and me to see some of his 3-S trials the next day, an offer we gladly accepted.

3-S FIELD TRIALS: Wednesday morning we drove out of Haerbin to an area where the Northeast Agricultural University has some of its rice trials. Jin is doing controlled comparison tests on how different varieties respond to 3-S methods with very low levels of fertilization and with very low levels of water, a very important concern to test out. We discussed the similarities and differences between 3-S and SRI and agreed that they are essentially the same, based on the same principles, though 3-S differs due to the need to adapt practices to the colder climate in northern China. Wide spacing, less water and more organic matter all contribute to markedly greater root growth and probably to more soil biotic activity, though this has not been looked at with 3-S. Jin will get some students to start studying this.

Herbicides are used with 3-S to control weeds because it is believed that labor is too costly and unwilling to do manual weeding, even with a mechanical weeder. We discussed the benefits of active soil aeration, which is not achieved with herbicide use. In Madagascar, some comparisons of yield with number of weedings with the 'rotary hoe' have shown that additional weedings add 1.5-2.5 t/ha, where the effect is not so much 'weeding' as it is 'soil aeration.' We discussed some simple research designs that could assess the profitability (returns to labor) of using this weeder. With a ton of rice worth 1200 yuan and a day of labor costing about 30 yuan, there could be some demonstrable economic advantage in replacing herbicides with rotary weeding.

When we got back to the hotel, I showed them a picture of a four-row weeder built by a farmer in India, Gopal Swaminathan, which cuts labor time for weeding 50-75%. I told them about a motorized weeder built by Ariyaratna Subasinghe in Sri Lanka, using a Chinese motor and costing about $800. This permits him to 'weed' 2 hectares in one day. From two hectares, if three weedings add 6 tons to total yield, the capital costs could be paid off in one season, and there would be a tremendous increase in income in subsequent seasons. So, I encouraged Jin and Lin to do some trials to see how much yield increase could be stimulated by active soil aeration, combined of course with water control that creates a **combination** of aerobic and anaerobic soil conditions. This enhances N fixation, P solubilization and other processes, according to research that I have found in the literature.

ZHEJIANG UNIVERSITY: Thursday morning, Dr. Lin and I flew south to Hangzhou in Zhejiang Province, where we were met at the airport by Dr. Yang Jingping, a faculty member at Zhejiang University, one of the leading agricultural universities in China. Yang is in the College of Life Sciences, in its program on sustainable agricultural systems, and he recently returned from 10 months at Cornell University as a Humphrey Fellow. I had the pleasure of serving as his advisor. He took me to his university for lunch and a rest. At 3 o'clock, I gave an informal seminar on SRI for students and faculty in his college. Given its concern for eco-friendly farming systems, there was considerable interest.

Afterwards, we walked to some on-campus SRI trials being conducted by Dr. Wu Lianhuan. Wu hosted my visit to Zhejiang University in 2003. His trials are evaluating the effects and possible benefits of using rice straw as **mulch** within an SRI system to conserve water use and suppress weeds. It was too early to draw any conclusions, but the mulched plots certainly looked good, evidently better than the control plots using standard rice-growing methods.

Wu promised to send his results to Cornell as soon as the plots are harvested and said that he plans to continue further SRI investigations. Two of his PhD students accompanied us. They will do soil microbiology evaluations of the SRI and control plots, which pleased me. Yang was sorry that he could not show me on this visit the SRI trials that he has gotten started at the university farm outside the city since returning. That evening Yang, Wu and I had dinner with Dr. Jiang De-an, associate dean of the college and a plant physiologist by discipline. He had not been able to come to the seminar, so we had a lot to discuss about SRI and plant and soil biology.

ZHEJIANG PROVINCE FIELD VISIT: Friday morning, I met Dr. Zhu Defeng, senior scientist at the China National Rice Research Institute in Hangzhou and national coordinator for the SRI research and extension network, together with Dr. Lin, for a field trip to Tian Tai county in the southeastern part of the province. This is 300 km from Hangzhou. Fortunately the roads were excellent all the way so it took only three hours to reach Tian Tai City.

En route, Zhu explained how they have seven local centers for SRI evaluation and extension. Tian Tai is fairly representative of their experience so far. Last year the results were good, 10.8 t/ha on 3 ha of SRI demonstration fields in Tian Tai country through the evaluation of 7 rice scientists organized by the Zhejiang Department of Science and Technology. Farmers are gaining confidence in the new methods, which have been simplified to make them more readily acceptable. Seedlings as young as 10-12 days have not been accepted because of their small size, which farmers find difficult to handle for transplanting and which require very good leveling of fields for water management. So the compromise has been to recommend 18-20 day-old seedlings, younger than the 30-35 days that are now the norm.

Planting one seedling per hill has been readily accepted, and plant density is 8,000-12,000 per mu. The average density of 10,000 per mu represents 15 plants/sq. meter, or a 20x30cm spacing, though they plant wider rows and have less space between plants within rows. Water management is a core practice, with at least 30-40% reduction in water applications. They are not keeping a thin layer of water on the field after panicle initiation but continue the principle of keeping soil moist but not flooded. (I consider this a real improvement upon standard SRI.)

The biggest departure from recommended SRI practice, in my view, is the use of herbicides to control weeds rather than do mechanical hand weeding with the rotary hoe. This means that there is no active soil aeration, beyond water management that avoids soil saturation. Zhu and I discussed possible experiments to evaluate how much if any benefit could be achieved from soil aeration (conventionally called weeding). I think it would be worth checking this out, even with a wage of 30 yuan per day, since an extra ton of rice would bring in 1400 yuan. It would make sense to develop the kind of motorized implements such as described above from Sri Lanka.

Since it is more difficult for Chinese farmers to avail themselves of compost than in other countries, given differences in population density and land area per capita, the recommendation is to use as much organic matter as possible, but to rely still mostly on chemical fertilizer for nutrients. This is 'modified' SRI, adapted to Chinese conditions. It is giving good results, as I was to see when we got to Tian Tai. To me this means that there is still productive potential in SRI methods to be exploited (with younger seedlings and more organic matter) once farmers have gained confidence in SRI overall.

Earlier in the week, Zhu was invited to attend a big strategy meeting for rice development in China, convened by the Ministry of Agriculture in Beijing. There were representatives from the 12 provinces with greatest rice production and also representatives from research institutes. China's rice production over the last 5 years, as stressed in the Haerbin meeting, has been stagnant or declining, so there is some sense of urgency to restoring productivity growth. Zhu was pleased to report that there has been enough demonstration of SRI's merits that the Ministry recommended SRI as one of the 'short-list of technologies' that will be promoted in most of the 12 provinces in the new planned campaign. Each province will, of course, make its own decisions on what to promote and how. But this means that SRI has official blessing from the top in China, an important consideration. We prefer that it be extended through farmer participatory methods, with innovation and adaptation as part of the process, rather than as the adoption of a set package of practices. But that may be expecting too much from this system. We hope that farmers make their own modifications and improvements as a matter of course, as usually done anyway.

After a fine lunch with county agricultural extension officials in Tian Tai City, we proceeded to Jie Ton township and to Bu Tou village, where farmers have planted 300 mu (20 ha) of SRI rice. The two hybrid varieties being used are Nei 2 You 6 and Liangyoupeijiu. The SRI fields were splendid. The 10.8 t/ha yield from last year will probably be exceeded. Zhu said that estimates were for yield of 11.0-12.0 t/ha. The extension officer noted that they have had less problem with pests and diseases using SRI. Sheath blight is a big problem in the area, but has not been a problem with the SRI crop. They have had some typhoon winds but the SRI crop in particular has withstood these because of the strong stems and good root systems. Several of our hosts walked into the fields, pushing aside the large panicles, to show me that they are keeping the soil just moist, with no standing water.

The highlight of the field visit was the special SRI trials laid out by the demonstration-farmer (master farmer in U.S. extension terminology) for the village. Nie Fu Qiu is assessing the net benefits, if any, of benefits vs. costs (changes in yield vs. changes in labor and other inputs) for five different treatments that he was curious about:

1. SRI with direct seeding by hand (instead of transplanting),
2. SRI with direct seeding by machine (which he designed for this purpose),
3. SRI with direct seeding by hand and zero-tillage by hand,
4. SRI with direct seeding by hand and zero-tillage by machine, and
5. SRI with 50x50 cm spacing.

My own anticipation is that SRI will evolve over the next 5-10 years in these directions, to go from hand transplanting to direct seeding (probably by machine) and to get away from plowing

with its many negative effects on soil structure and soil biota, using some appropriate form of zero-tillage, probably supported by mulching to conserve water and suppress weeds (and maybe enhance soil nutrients) -- the kind of trials that Dr. Wu has started at Zhejiang University. To find a farmer on his own experimenting with and evaluating these options was wonderful.

When we sat for a while in his house afterwards and drank bottled water (it was as very hot day), Nie showed me the technical drawings that he had made of the mechanical seeder built for this trial. (It reminded me of the seeder that Luis Romero in Cuba had designed and constructed himself for planting pregerminated seed at 40x40 cm spacing this past year.) Nie can sow one mu in 30 minutes, so it would take only an 8-hour day to plant 1 hectare. His test plots looked as good as the other SRI rice we saw, so if the yield results are even close to those from hand-transplanted rice, this will be an immensely valuable innovation, making SRI labor-saving rather than labor-intensive. I reiterated the view that SRI is 'not yet finished' but instead is still being improved by scientists and farmers alike (and hopefully, together). On the way back, among other things we discussed Zhu's several visits to North Korea (DPRK) this past year and his introduction of SRI ideas there. I hope that these methods can help to alleviate the food crisis that is gripping that country.

Saturday was a free day, to catch up on email and do some writing. Sunday morning I flew up to Beijing, where I planned to spend some time at China Agriculture University with the dean of its College of Humanities and Development, Dr. Li Xiaoyun. Li was one of the first persons in China to take an interest in SRI, having been trained as a plant physiologist though now he is functioning mostly as a social scientist.

CHINA ACADEMY OF AGRICULTURAL SCIENCES: On Monday afternoon of my first day in Beijing, I spent an hour with Dr. Zhai Huqu, CAAS president, whom I had seen while in Haerbin. He had several of his deputies join us for the powerpoint presentation that I had given at Haerbin (and that Zhai had not seen). At the end of the presentation and ensuing discussion he suggested that CAAS would organize a small meeting on SRI during the international rice conference being held in Hangzhou mid-October, which I will be attending. The meeting would formulate a national program for SRI trial-demonstrations. I suggested that this be worked out with Dr. Zhu Defeng, the national SRI coordinator at CNRRI, which Dr. Zhai said he would do.

This will be another very important step for SRI development and spread in China. CAAS works with all of the provincial academies of agricultural science, many of which have their own rice research institute, and with the agricultural universities, so it can mobilize a huge amount of scientific talent. Dr. Zhai himself has for some time been pointing out directions for agricultural development that are similar to those which SRI suggests.

CHINA AGRICULTURAL UNIVERSITY: During Monday morning I met with a research team for CAU's College of Humanities and Development that had just returned from Jianyang County in Sichuan Province, evaluating socioeconomic aspects of SRI use there. Dr. Qi Gubo, Dr. Xu Xiuli and Li He said that their data were probably not as conclusive as we would like because many of the farmers interviewed are not yet using all of the recommended SRI practices, or not using them all as recommended. They could only give impressions at that point because they had just arrived back from the field and had not had time to analyze all of their data yet.

They promised to do this before the end of the week so that I could review the findings of their study before I left Beijing.

The general results that they could report already were impressive. Yields had increased substantially with less use of water, less seed requirement, and even some saving of labor. I questioned them on the latter since SRI has generally been considered to require more labor. They said that Xinsheng farmers did not consider SRI to be more labor-intensive for them. It saves them time particularly in transplanting since they use fewer seedlings; however, they are not using seedlings as young as we recommend. Any time farmers can increase their yields with a reduction in inputs, this is welcome.

The main constraint that farmers were encountering in the village studied was water control. Many said they would like to adopt SRI because they know the methods offer benefits, but they also know that good water control is necessary for best results. Many of the rice fields are very large and not well leveled. Watering the higher parts of these fields requires submerging the plants in the lower parts, and very young seedlings cannot survive this. I commented that we do not expect SRI to be applicable everywhere. However, if higher yields can be demonstrated with SRI methods, it should be profitable for the government to invest in improving rice paddies, making plots smaller and more level, suitable for SRI water management. Since this would save water as well as raise yields, it should be easy to make an economic justification for this.

Tuesday morning I met with Dr. Zhang Fusuo, dean of the College of Agricultural Resources and Environmental Sciences. He has been working with SRI since receiving a copy one of my early papers on SRI, given him by Prof. Yuan Longping from the China National Hybrid Rice Center. He showed me pictures of both lowland and upland rice in Jianyang County in Sichuan where he is working with SRI methods, adapting them to local conditions. In lowland cultivation, SRI is raising yields from 7 t/ha to 10-11 t/ha, with fewer inputs.

Of more interest, because it involves more innovation, are the upland yields of 8 t/ha that he is getting with some adaptations of SRI methods, particularly using plastic mulch to conserve water and control weeds. He has documented water saving of 20-30% with SRI and higher nutrient-use efficiency. Zhang is interested in farming systems, not just rice, and has integrated SRI rice with other crops rather than follow only the standard rice-wheat rotation. Oilseed rape and potatoes are proving to be a good combination with SRI rice. Potatoes are grown between rows of rape, not planted in the soil but just put on the surface with lots of SRI straw put on top as a mulch. This gives farmers 3000-5000 yuan ($375-625) of added income per hectare.

Zhang has worked for many years on roots, rhizospheres and soil biota, so we had a lot to discuss. I invited him to contribute a chapter to the book that I am editing for publication next year by Marcel Dekker on biological approaches to sustainable soil systems. He has a lot of data on synergies between different crops when inter-cropped, looking at the complementarity of their different kinds of root systems. He will expand his research on SRI evaluation and concurred in all of the points (some of them conjectures) that I offered as possible explanations for SRI's remarkable performance. SRI is just getting started as an area for systematic scientific inquiry. It will be good to have some contributions from CAU, given its depth of experience and talent in 'cutting edge' areas of research.

On Wednesday afternoon, I met with two faculty member of the College of Humanities and Development, Prof. Liu Yonggong and Prof. Wang Dehaim, to discuss a master's thesis done by one of their star students, Xu Shihong. He documented and evaluated a farmer-devised rice system in Guangxi Autonomous Region in the south of China where farmers establish their crop without tillage, just by broadcasting the seed. Grain harvest is 4-5% higher, and as much as 10%, Xu found. His measurements showed a more developed root system, greater root oxidative ability, higher light penetration in the canopy, slower senescence of the flag leaf, more dry matter accumulation, a higher harvest index, more panicles per plant, more grains per panicle, and less disease, all features of SRI rice. But this system does not involve transplanting young seedlings.

We discussed how some SRI concepts might be adapted for such a system. I have hoped for some time that SRI can move toward direct-seeding with zero-tillage to save labor. If this can be done without significant loss of yield, it will surely become an important option for rice farmers. I agreed to help Liu, Wang and Xu finish off an article on this system for publication.

Friday morning Xu and Li had finished their data analysis, and we even able to give me a 12-page write-up in quite good English. Their results were much positive than the impression they had given on Monday, being cautious. In the village of Xinsheng, Sichuan province, only 7 farmers tried SRI in 2003, at the suggestion of scientists from the Sichuan Academy of Agricultural Sciences. Most of these were members of the village committee or relatives of the village head. The next year, 2004, 398 or the village's 612 households (65%) used SRI.

The average plot size for SRI increased from 0.07 mu in 2003 to 0.99 mu in 2004. A wealth ranking of village households indicated that 8.5% of the SRI users were poor, compared with 10% in the village population; 32.3% of SRI users were classified as better-off, compared to 30% for the village. These were hardly significant differences. Of the 75 SRI users chosen at random and interviewed in depth. 86.6% said either that they planned to expand their SRI area or that they would keep their entire rice area under SRI practice, a strong vote of confidence.

The adaptations of original SRI methods made were principally use of the 'triangle' method of transplanting, discussed above, and the use of black plastic mulch (by many, not all) to control weeds, conserve moisture, and improve soil temperature. SRI users, both in the survey questionnaire and in the focus groups conducted separately, ranked labor saving as the greatest advantage of SRI, with water saving next. Problems with water management was given by non-adopters in their focus group as their main reason for not using SRI, with lack of knowledge of its methods or benefits as the other main reason. Disadoption does not appear to be an issue.

SRI yields, even without young seedlings or active soil aeration, were 47% higher in 2003, a serious drought year, and 35% higher in 2004 than conventionally grown rice in the village. Gross income per household was 110.3% higher in 2004 than the 2002 pre-SRI level, and 108.6% higher per mu. The SRI yield in 2003 matched the previous year's non-SRI yield despite the drought conditions, which helps explain why the very rapid spread in this village, from 7 to 398 farmers in one year's time.

The cost of production analysis showed SRI costs 8.03% lower per mu, based on questionnaire results, but this was calculated with a reduction in labor requirements of only 1-2 days/mu. In the focus group, when SRI users compared its labor requirements, operation by operation, with conventional rice growing, they came up with the figure of 9-11 days/mu saved with SRI, a great difference. Also, surprisingly, in the analysis, farmers' expenditure for fertilizer, pesticides and seeds went *up* with SRI. Discussion with Xu disclosed that the Farmers' Association promoting SRI in the village, advised by SAAS scientists, was at the same time promoting the use of fertilizer, pesticides and an expensive new seed variety, none of which is necessary for good SRI performance. So the cost of production with SRI was considerably inflated in their data over what it would be if farmers reduced their chemical inputs with SRI as usually happens.

Water savings were calculated at 46.0% per household and 43.2% per mu, so this plus even the underestimated reduction in labor requirements made SRI on balance more profitable. If farmers made as much reduction in costs as is attainable, their profits would soar. Gross margin per mu was calculated to be 3.66 times greater with SRI when deducting labor costs, or 1.48 times greater with labor costs not deducted. However, these numbers I suggested needed to be adjusted downward since they were calculated with a 60% higher rice price received in 2004 due to the government's price hike. Even with such an adjustment, the gross margin was substantially higher with SRI.

The focus groups considered also gender impact. Men's labor was said by 5% to be morem by 38% to be less, and 34% said it was unchanged, with 23% having no opinion; the figures for impact on women's labor were 17%, 22%, 35%, and 26%. Men seem to have a definite net gain, and women a little net gain. Xi and Li will try to get the actual harvest data to use in place of the estimates made in the field so that this report can be published, with Dr. Li Xiaoyun, who planned and set up the study as a co-author.

SICHUAN PROVINCE EXPERIENCE WITH SRI: Following my visit to CAU, I flew the next morning to Chengdu in Sichuan Province, where Dr. Zheng Jiaguo, director of the Crop Research Institute of the Sichuan Academy for Agricultural Sciences, met me at the airport. We drove directly to Guanghan county, 40 km north of Chengdu, the capital of Sichuan, where we had a very nice lunch. He gave me the afternoon free for writing while attended to some work in the field with Mr. Wang, deputy agricultural extension head for the county. We came to Guanghan because the Provincial Department of Science and Technology had organized a large meeting of rice specialists for Sunday, the next day. Given the good results with SRI this year (and previously), there is growing interest in SRI. Zheng told me during the drive that this season, there were about 20,000 mu under SRI in Sichuan Province this year, and he expects next year to reach 200,000 mu, based on good results this year. The hotel where we stayed, where the meeting was planned, was a splendid new hotel, built in traditional Chinese style with fish ponds, landscaped gardens, etc.

Next morning, we left on a field trip about 8 o'clock, driving an hour to Xinlon township. The first field visited was an SRI plot for which they estimated a yield of about 11 t/ha. The planting had been done in a triangular pattern, 3 plants per hill with about 7 cm distance among them, and with 40x40 cm spacing. The tiller thickness was impressive, but there was some lodging as a result of some recent rain. Lodging is not common with well-grown SRI rice. Also, when I

pulled up several plants, they did not offer as much resistant as expected from SRI plants. The roots were neither large nor deep, and more brown than white. So it seems that the water management was not as rigorous as recommended with SRI, though the results were not bad.

On the bus ride to Xinlon township, I had the good fortune to sit next to Dr. Zhu Zhonglin, a retired agronomist but still professionally active. She said that she serves as honorary president of the Sichuan Academy of Agricultural Sciences. While others visited other fields, she and I sat and talked about SRI and soil biology, a subject that she knows a lot about.

When we got back to the hotel about 11, there was a formal program, for which I was asked to sit on the dais as an 'honored guest.' But since I could not understand the presentations, Zheng brought me to his room where they were doing a yield analysis from the SRI plot visited. They had to measure moisture content to adjust the yield estimate for 13% moisture content. The result was 11.64 t/ha. Since this was with less water and with less chemical inputs, the yield is very respectable.

Zheng said that the average yield for rice n Sichuan Province is 500-510 kg/mu (about 7.5-7.6 t/ha). There have been SRI trials in over 100 locations this season, and he has gotten reports from at least 60 of them already, with an average about 700 kg/mu, which amounts to about 3 t/ha more than usual, about 10.5 t/ha.

A number of SRI users have done considerably better. Liu Zhibin, whom I visited at his hybrid rice farm at Meishan in 2002, where he had reached 16 t/ha the season before, had yields of 842.21, 840.99 and 876.09 kg/mu, the highest being 13.2 t/ha. A farmer whom I met during my February 2004 visit, Li Chengde from Leshan village, who was very enthused about his previous SRI results, got 805 kg/mu, or 12.1 t/ha. Prof. Ma Jun, who gave the paper on SRI in Sichuan at the Haerbin meeting, got 748 kg/mu on his own plot (11.22 t/ha). So, the potential for further increases is evident, especially if the soil and water management practices support better root growth than I saw at Xinlon.

Zheng told me that at Luzhou in the south of Sichuan, which I visited in 2002 to see their experiments with rattooning (regrowth) of rice, to get a second harvest from the same plants, they got a SRI yield of 724 kg/mu (10.86 t/ha) in the main season. To this should be added another 150 kg/mu which was produced from a second harvest, adding 3.75 t/ha to the total. The investment of inputs yielded 14.6 t/ha all together. I told Zhen about the rattooning results reported by a farmer when I visited the Philippine Rice Research Institute in March 2004. This farmer had gotten 8.2 t/ha from his first SRI crop, quite impressive, but then also 7.6 t/ha more from a ratoon crop. A 90% harvest from regrowth is unheard of. That farmer's soil could well be supercharged biologically, and his plants must have developed tremendous root systems.

That evening when we got back to Chengdu, we attended an informal dinner hosted by the Vice-President of the Sichuan Academy of Agricultural Sciences, Dr. Ren Guang, and several other SAAS officials. Thanks to Zheng, all knew about SRI, and we had both a splendid dinner and some extended conversations about SRI.

The next day, Monday, Tang Yonglu, an associate of Zheng in the Crop Research Institute of SAAS, accompanied me in the afternoon on a trip to Meishan to meet Liu Zhibin, farm manager for the Meishan Institute of Science and Technology, established by Prof. Yuan Longping. Liu has been one of the 'pioneers' for SRI in China, having developed the 'triangle' method of plant spacing discussed already which has produced yields as high as 16 t/ha.

On the drive, Tang told me that he had recently visited Leshan, a district about 50 km further south than Meishan, where SRI has been picking up. I had met the lead SRI farmer in Leshan, Le Chengde, when I visited Sichuan in February. He had gotten a 12.2 t/ha yield the previous season when 10 mu (2/3 of a hectare) were planted to SRI. He predicted then that 100 mu would be planted to SRI this season, but Tang said the number was 300 mu in the area where Leshan is located. Zheng had told me that Le himself got a yield of 805 kg/mu (12.1 t/ha) this season. Farmers in Leshan said to Tang that SRI methods are very good, saving water and labor while increasing yield. They said that adopting SRI was "not very difficult," perhaps in part because they are not yet transplanting seedlings as young as we recommend (just 2 leaves), transplanting instead at the 3-4 leaf stage. But still, the results are more than good. Almost every farmer in the world would be pleased to reach 12.2 t/ha.

When we arrived in Zhangkan, the village near Meishan where the farm of the Science and Technology Institute is located, Liu was very keen to show me his zero-tillage, raised-bed SRI plots. One had just been harvested, with officials present to certify the results. He showed me a report that certified the yield of 876.09 kg/mu that Zheng had told about. This works out to be 13.1 t/ha, with water content calculated at 19%. He then showed me also a certificate attesting to an even higher yield in Yunnan Province, attested to by Prof. Tian Yan Hua from Sichuan Agricultural University. Liu had sent a technician who knows SRI methods to Yunnan to give instruction. The yield certified there was 1359.3 kg/mu, which represents **20.4 t/ha**, surely a record for China. Only the yields of Ralalason in Soatanana, Madagascar, have exceeded this.

Liu is persuaded that the raised bed, no-till method is going to become the best method for SRI. He greatly reduces his irrigation water use, by 40-50%, needing very little to establish the nursery and relying on rainfall during as much of the growing season as possible. Liu uses a lot of organic matter on his fields, putting all the straw back but also putting other plant material on the field post-harvest (also to protect the soil from the rain that follows). He rotates his rice crop with rapeseed, a popular crop in the region, recognizing the value of such rotation for the soil's fertility. He still uses some chemical sprays on his crop, though not, he said, on the plots he grows for his own household consumption.

I told Liu that a District Agricultural Development Officer in Nepal had emailed me shortly before my trip to say that some of the 'early' rice plants grown with SRI methods in Morang District had reached 135 tillers, with an average of 80; the 'normal' SRI rice, planted a little later, had already at 40 days an average of 40 tillers per plant, with some plants having as many as 65. Liu said that he has had SRI plants with 130 tillers. I asked what was the largest panicle he has gotten. He said one had more than 800 grains, almost as many as the one produced by Premaratna in Sri Lanka that I had held in my hand in 2002 with over 900 grains. Liu and Premaratna met at the Sanya conference in 2002 but could not converse much because of the language barrier. Both are extremely innovative, making important contributions to SRI.

The township director for science and technology, Mr. Tang, telephoned during the visit to say that he would like to meet me before I left, so we drove to the Institute's office in Meishan where we had a ceremonial exchange of felicitations. As we left, Liu asked me to return next year at harvest time, saying that he hopes to be able to show me an SRI field with a yield of 1500 kg/mu, which would be 22.5 t/ha. Since he understands well the value of soil biology, he might do it.

That evening, I joined a dinner party given by the director of SAAS, Dr. Li Yue Jian, for a group of visiting CIMMYT scientists who are collaborating with SAAS on agroecosystem approaches. They are focusing on the rice-wheat rotational farming system that is of major importance in Sichuan and other parts of China as well as the Indo-Gangetic Plans. Craig Meissner and Larry Harrington, who have spent time as visiting fellows at Cornell, were there, quite a surprise, as was Raj Gupta, coordinator for the South Asian Rice-Wheat Consortium and an attendee at the Sanya conference was there.

I was pleased finally to meet Ken Sayer, CIMMYT/Mexico, with whom I have corresponded for several years to learn more about the raised-bed method for wheat devised by farmers in the Sonora Valley that he has documented. Ken had written that the wheat yields hardly varied with seeding rates as different as 25 kg/ha and 200 kg/ha; sparser plants expanded to fill available space. This was helpful for understanding how rice plants perform so well under SRI conditions. Ken said they are now finding that, after several years, the volume of microbial biomass in undisturbed raised beds, i.e., planted but not plowed, is **4-5 times greater** than in newly-made raised beds. This suggests one way that soil fertility can increase over time without adding chemical inputs, through the management of plants, soil, water and nutrients in ways that support soil biota.

On the drive to the airport the next day, Zheng and I discussed the super-yield reported from Yunnan. The area where this was attained, he said, has especially favorable climate for growing rice: lots of sunshine (I never saw the sun once during my three days in Sichuan), with high daytime temperatures and low temperatures at night, and low humidity so that pest and disease problems are few. Grain filling was very high, 94%. All these are favorable factors for surpassing the 20 t/ha mark which has been thought impossible to break, like the four-minute mile in previous decades. But SRI methods helped add several tons to the output, without special inputs to the soils. These must be very rich biologically. I suggested that a good extension message, translated into Chinese, could be: *Living soil is a partner for achieving highest yields*. Zheng agreed that they need to get such messages across to farmers, and to scientists.

INTERNATIONAL FORUM ON SUPER-HYBRID RICE: A staff member from the China National Hybrid Rice Research and Development Center met me at the Changsha airport and took me to the hotel. The list of international participants had over 50 names, a number of whom I knew and looked forward to meeting. There were several hundred participants in all. Among the materials provided was a book on the Hybrid Rice Center in which I found, tucked away in the corner of one page, a picture from our April 2002 SRI international conference. I was glad to that Prof. Yuan identified himself and his Center with our efforts. This forum, however, was focused entirely on hybrid rice, Prof. Yuan's contribution to improve rice production in China and around the world. I hoped to get at least some of those attending to take an interest in SRI.

Throughout the event, I had repeatedly fortuitous seatings. At dinner the night before the forum opened, I happened to sit next to Dr. David Mackill, head of IRRI's rice breeding program, so we had a good discussion of SRI and what are apparent reasons for its success. While waiting for the first session to begin next morning, Dr. William Padolino, deputy director-general of IRRI, sat down beside me, and we had a good conversation about SRI and the attitude of IRRI toward it. I emphasized our continuing interest and willingness to cooperate with IRRI on SRI evaluation.

During the break, I met Dr. Nguyen Van Nguu, executive secretary of FAO's International Commission on Rice, which is overseeing the International Year of Rice activities during 2004. Nguyen has previously been unwilling to give much credence to SRI, according to my contacts within FAO. His skepticism was clear from our discussion, although by the end of our chat, he said that he is 'open' to SRI. He will have a chance to learn more about it at the World Rice Research Conference in Japan in November, because the executive director of the conference suggested that Nguyen be included on our SRI panel, to include a skeptic (and I readily agreed). Nguyen said that he is looking forward to that meeting.

In the bus ride back to the hotel for lunch, I happened to sit next to Dr. Liu Ping, Deputy Director-General of the Ministry of Agriculture's Development Center for Science and Technology in Beijing, who was representing the central government at this affair. When I started telling him a bit about SRI, he expressed interest and asked if I had pictures. I booted up my laptop and went quickly through the presentation that I had made at Haerbin. At lunch, we happened to sit together again, so we got better acquainted. He was a classmate of Dr. Zhang Fusuo, dean of the College of Agricultural Resources and Environmental Resources whom I had met at CAU in Beijing the week before, so we got into a discussion of roots and soil biology, which was a shared interest.

That afternoon, there was a field trip to visit some fields where super-hybrid rice is being grown under typical rural conditions. During the two-hour bus ride, I sat with Dr. Pedro Blanco, head of the national rice program of the National Institute for Agricultural Research in **Uruguay**. Some of INIA's rice scientists are now working on the benefits of soil inoculation, which Pedro said is giving very promising results. So he was 'primed' to be interested in the soil biological aspects of SRI. I will send him materials on SRI when I get back to Cornell so his rice program can try out these methods in Uruguay. The fields visited were estimated to yield 13.5 t/ha. The management practices being used looked like SRI methods, starting with 11-day-old seedlings.

That evening after supper, on the bus ride to the station to travel overnight by train to Huaihua for the second day of the forum, Bui Ba Bong, vice minister of agriculture for **Vietnam**, sat beside me. He had emailed me in early 2003 to get information about SRI after Howie Bouis of IFPRI told him about it. I had heard nothing more and guessed that SRI not made enough sense to him or his associates. But he assured me that they have started some trials. We had a chance to discuss the emerging understanding of why SRI produces such good results, so there will probably be more interest in these methods now in Vietnam. Minister Bui asked whether I could come to Vietnam to demonstrate SRI but I said that this should not be necessary. Anyone who knows how to grow irrigated rice can do SRI just from reading about its principles and techniques. It is a matter of making changes in the way that irrigated rice is grown rather than

learning and doing something entirely new. I suggested that our colleague Dr. Koma in Cambodia could be more helpful than I.

Next morning, before the opening session got started, I found myself seated next to Abdelgadir Babikir el Amin from the Ministry of Agriculture and Forestry in **Sudan**, and Bayunmunk Altangerel from the Institute of Biotechnology in **Mongolia**. We discussed SRI, assisted by my powerpoint presentation, until the forum started. Both expressed definite interest in SRI after seeing the pictures and hearing the rationale for such high-performing plants. Bayunmunk was pleased to hear about 3-S, the system similar to SRI developed in Heilongjiong for cold-zone production with a short growing season, as this is the constraint they face for growing rice in Mongolia.

The morning presentations by Prof. Yuan, Dr. Nguyen, Minister Bui and others were very informative about hybrid rice. It has been spreading fairly rapidly, being used now on about 60% of Chinese rice area, and on over 1 million hectares in other countries, 600,000 ha of this in Vietnam. The yield gain is usually 1 to 1.5 t/ha, up to 2.5 t/ha, according to the reports. This can make a significant difference in production over large areas. However, it is about half of the yield gain being reported in Sichuan Province this season with SRI. The CheckRice system that Dr. Nguyen spoke about reduces N fertilization by 20% and seed rate by 50%, so it is moving in the direction of SRI with good results. It is promoted through farmer field schools. which are very appropriate for SRI.

At lunch, I sat by chance with Dr. Ish Kumar and his wife. Dr. Kumar is on leave from India, working with the hybrid rice breeding program at IRRI. He happened to hear my presentation on SRI at IRRI in March 2003, so he knew something about it already. He had, understandably, many questions and some skepticism. When I went through the powerpoint presentation to give some visual support to my arguments, his interest got more intense and personal when I got to the picture of a massive root system on a MTU 1071 rice plant grown at the Maruteru research station in Andhra Pradesh, India. This variety, which responds very well to SRI methods, was developed by Dr. P. V. Satyanarayana, who it turns out did his PhD. under Dr. Kumar. P.V. is now one of the most active and articulate promoters of SRI in Andhra Pradesh. What a small world it is. Dr. Ish, who will return to India at the end of this year, said that he would like to keep in touch on SRI when he gets back, adding that he understands and agrees with what I was saying about the importance of roots and soil biological contributions to rice plant performance.

That afternoon during tea break, I met Khidhir Hameed from the Al-Mishkhab Rice Research Station in Najaf, **Iraq**, and his colleague Shaher from the State Board for Agricultural Research in Baghdad. Both indicated interest in knowing more about SRI after seeing some of my pictures, so this could be another country where SRI methods are put to good use.

At the end of the afternoon, we were taken by bus to a large village of the Tong ethnic minority outside of Huaihua for a splendid supper and cultural performance put on by the villagers. They presented this in honor of Prof. Yuan, whose hybrid rice they said has been of great benefit to them. In talking with Prof. Yuan between servings, he told me that unfortunately his travel plans are not definite enough yet for him to be able to accept my invitation to chair the panel on SRI that is planned for the World Rice Research Conference in Japan in November.

However, Prof. Yuan assured me, as I thanked for having invited me to the forum, that the super-hybrid rice fields that we had visited outside Changsha on Wednesday are "modified SRI." I had guessed this from the plant spacing, the unflooded fields, and the signboard data showing that the seedlings had been transplanted when just 11 days old. The main modification used was the 'triangular method' discussed already -- Liu Zhibin's innovation for increasing plant population over what it would be with just one plant per hill.

Prof. Yuan's approval of these changes in cultural practice should help to get them spread, at least in China. The practices such as spacing or scheduling of water issues that are used to implement SRI's principles can and should vary, according to local conditions. SRI is based on certain concepts and insights rather than any specific set of practices. The objective is to promote root growth and to stimulate soil biotic activity in support of rice plant productivity and health, depending less on external inputs than with standard 'modern' practice.

After the gala evening at the Tong village, some of us returned overnight to Changsha by train to make flight connections the next day. I shared a compartment with Bui Ba Bong, Dr. Nguyen and a third Vietnamese colleague. On the taxi ride from the train station back to the hotel Friday morning, I rode with Dr. Yang Ren Cui, dean of agriculture at the Fujian Agriculture and Forestry University in southern China. I had met him on my first visit to Changsha, after he had heard my SRI presentation at the Hybrid Rice Center's winter breeding station on Hainan Island.

Dr. Yang said that he has been doing SRI trials since than and has had good results. He said that he would send me some papers on SRI that he and a PhD student have done. They have done SRI trials also in Yunnan Province, and he mentioned a yield of 1200 kg/mu, which would be 18 t/ha, which would be really impressive, though several others appear to be getting those kinds of results in Yunnan with SRI methods and hybrid seeds, given the favorable growing climate. One more fortuitous chance to meet people with knowledge of or potential interest in SRI. The forum was indeed a very productive opportunity for my learning and for others'.

As it turned out, Dr. Nguyen from FAO was booked on the same flight to Beijing that afternoon, so we had a chance for more discussion of SRI and the methodology that he currently favors, called CheckRice, which is oriented to farmer learning as a key driving force similar to that with SRI. We also stayed and the same hotel near the airport and had dinner together, so had indeed long talks about SRI and new strategies for improving rice production around the world. This was an opportunity unanticipated when I accepted Prof. Yuan's invitation to attend his hybrid rice forum.

The whole three weeks in China, my longest visit there, were very informative and productive. Putting together a book on SRI experience and results in China will be an important next step. I have been invited by the director-general of the China National Rice Research Institute in Hangzhou, Dr. Cheng Shihua, to participate in the international rice conference CNRRI has scheduled for October 15-17, and Dr. Zhai, president of the China Academy of Agricultural Sciences, has suggested having a special SRI workshop or meeting during that time. So that will also help to advance knowledge and practice for SRI in China.

ANNEX: SRI RESULTS REPORTED TO PROF. NORMAN UPHOFF DURING CHINA VISIT, 2004

LOCATION	Reported by	T/ha	Variety	Comments
Heilongjiong	Dr. Jin Xueyong Northeast Agric. University	12.47 10.03	Dongnong 423 Variety not reported (NR)	3-S system is a Chinese version SRI principles, adapted for cold-zone; see table on 3-S for range of results; this system is being used now on 44,000 ha in Heilungjiong
Guizhou [Guiyang]	Dr. Zhou Weijia Guizhou Rice Research Inst.	12.87	Jinyou 431	New record for high-altitude rice; trials showed significant increases in number of spikelets, and 10.5-14.6% increases in yield
Sichuan	Dr. Ma Jun et al. Sichuan Agric. University	11.75	NR	Density of $13.5x10^3$/mu, which was 35.4% above the control ($18x10^3$/mu); $4.5x10^3$/mu density gave -12.1% than control
Zhejiang [Wen Zhon]	Dr. Wu Cun Zan Dept. of Agric.	10.08 - 10.37	NR	12-19 d seedlings + SRI methods vs. 9.35 - 9.96 t/ha with 25-28 d seedlings and SRI methods
Zhejiang	Dr. Lin Hua Dept. of Agric.	8.85 - 9.93	4 varieties	SRI with different SRI vs. 7.89-8.84 t/ha for controls (same variety); ave. increase was 12.8%; effective tillering 89.3% with SRI vs. 82.5% control
Zhejiang [Tian Tai]	Field visit with Dr. Zhu Defeng CNRRI	11.0-12.0	Nei2You6 and Liangyoupeijiu	Projected average yield for 300 mu; 10.8 t/ha in 2003; some fields could reach 13.5 t/ha
Sichuan [60 locations]	Dr. Zheng Jiaguo, SAAS	10.5	Many varieties	Average from over 60 locations reporting, out of 100+ evaluations of SRI in province this year; 3 t/ha more than the 7.5 t/ha usual yield
Sichuan [Xinlon]	Field visit with Sichuan Prov. rice specialists	11.64	NR	Crop cutting, adjusted for moisture content, witnessed by rice experts attending annual SAAS meeting on rice improvement
Sichuan [Meishan]	Liu Zhibin, Meishan Inst. of Science & Tech.	13.2	Super-hybrid	Raised bed, no-till adaptation of SRI, with applications of organic matter; had a certified yield of 16 t/ha in 2001
Sichuan [Leshan]	Tang Yonglu, SAAS	12.1	NR	Li Chengde, farmer-demonstrator, predicted 100 mu this season after getting 12.2 t/ha yield on 10 mu in 2003; the village had 300 mu under SRI in 2004

Sichuan [Jianyang]	Dr. Xu Xiuli CAU/COHD	7.61	NR	Increase of 25.6% over non-SRI with water saving 43.2%; based on sample of 82 out of the 398 SRI users in this village where only 7 farmers used SRI in 2003
Hunan	Prof. Yuan Longping, CNHRRDC	13.5	Super-hybrid	Fields shown to participants in international forum on super-hybrid rice; 'modified SRI' with triangular plant spacing, 11-d seedlings, reduced water use, etc.
Yunnan [Taoyun]	Dr. Zhu Defeng, CNRRI	18.0	NR	Crop-cutting observed and certified by researchers and officials; a similar yield was reported by Dr. Yang Ren Cui, Dean, Fujian Agriculture and Forestry University
Yunnan	Liu Zhibin, Meishan Inst. of Science & Tech.	20.4	NR	Certificate of yield signed by Yunnan Dept. of S&T officials and Prof. Tian Yan Hua, Sichuan Agricultural University