

**REPORT ON FIELD RESEARCH VISIT TO CUBA, JULY 7-14, 2004, TO ASSESS
THE SYSTEM OF RICE INTENSIFICATION (SRI), KNOWN IN SPANISH AS
EL SISTEMA INTENSIVO DE CULTIVO ARROCERO (SICA) - Norman Uphoff,
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Summary Notes

1. While the number of farmers using SICA (SRI) in Cuba is still in the hundreds or low thousands, there is much interest in trying out these new methods, spurred by the kind of **results** that I learned about from farmers on this visit who are making the methods work well for them.
 - (a) At the agricultural production cooperative (CPA) 'Camilo Cienfuegos' in Bahia Honda, in Pinar del Rio province, this past season's **average SICA yield was 8.9 t/ha**, with one plot yielding 10.9 t/ha. Its rice yields before SICA averaged 4.6 t/ha.
 - (b) The economic benefits from this performance were more impressive than the agronomic indicators. **Cost of production** was calculated as US\$41.52/ton, and 1187.82 pesos/ton, which makes total cost just **\$87/ton** overall. Since the landed cost of imported rice from Asia is 3 to 4 times higher, this indicates that there can be tremendous foreign exchange savings from expanded SICA production.
 - (c) Higher **milling outturn from SICA paddy** at CPA 'Camilo Cienfuegos' is an added bonus. Conventional paddy gets converted into milled rice at a rate of about 60%; the rate for SICA paddy is 68-71%. This represents an **increase of 13-17%** on top of the increase paddy yield. We have thus been underestimating and underreporting the net benefits of SICA methods.
 - (d) **Labor costs of production** can be reduced with SICA once the methods are mastered. Rice production at CPA/CC has been doubled with the same labor force as before. With SICA methods, one person can transplant 1.6 cordels (one cordel is 400 m²) in a day, compared to 0.9 cordels using conventional methods.
 - (e) A new SICA farmer at CPA 'Alonso de Rojas' in Consolación de Sul, Pinar del Rio province, found that in a water-stressed season, his SICA rice plants are growing very well. At 60 days after transplanting, a plant that he picked out at random had **98 tillers**, and a very large and healthy root system. A neighbor who had already harvested his SICA test plot of 1.5 cordels (600 m²) produced 8 quintals instead of the usual yield of 3 quintals. The coordinator of *Arroz Popular* for the area said that he got 6.5 t/ha from his own SICA field compared to his usual 4 t/ha. So there is good experience to encourage further experimentation and adoption.
2. Much useful **experimentation** with SICA methods is being started so that this methodology can evolve to become better suited to Cuban conditions.
 - (a) Luis Romero, a farmer living in San Antonio de los Baños, has five trial plots established, one a control plot with conventional methods. He is evaluating **two different varieties** (VN2084, a spreading variety, and IACUBA29, an upright one) with **two different methods of crop establishment** (transplanting very young seedlings, 9-10 days old, vs. direct seeding of pregerminated seeds). These trials should show us how direct seeding, which can greatly reduce labor costs, compares agronomically and economically with the transplant method currently recommended with SICA.

- (b) At the INCA rice research station at Los Palacios, research is evaluating whether an adaptation of the water management regime for SICA, having **two week-long periods of continuous flooding after the crop is established**, can control weeds without reducing the rice plants' vigor and performance. Cuban farmers seem reluctant to undertake the kind of hand mechanical weeding that Asian farmers do easily, so we need to look at other means of weed control.
- (c) Researchers at the Los Palacios station and at the Institute for Rice Research (IIRA) are going to evaluate SICA methods augmented by **mycorrhizal inoculations**. The 'Camilo Cienfuegos' cooperative is already evaluating such biofertilization, and it plans to do its own evaluations of this with SICA next season. Everyone expects the mycorrhizal benefits for rice to be greater with SICA methods because of the more aerobic soil conditions.
- (d) Another issue to be investigated is whether SICA water management practices, together with the other practices, can **drought-proof rice crops**. Cuba has been experiencing more, and more adverse, climatic conditions. This year's long delay in the onset of rains created severe problems for rice farmers. Farmers with SICA are seeing that they can produce a better harvest with less use of water. Possibly also they can stimulate quick, deep root growth with SICA methods that will enable their crops to survive subsequent water stress. Some farmers in Cuba have already observed this effect, but it should be evaluated in a systematic way.
- (e) One innovation for crop establishment being evaluated by *Arroz Popular* is **tray nurseries**. These plastic sheets with deep indentations in which seedlings can be grown permit farmers to transplant very young seedlings, 5-6 days old, or to broadcast them, in labor-saving ways. One evaluation found that the labor cost of seed establishment can be reduced from 1500 pesos/ha to 60 pesos/day. The 'Camilo Cienfuegos' coop in its experiment with broadcasting pregerminated seed onto muddy paddies has cut the labor time from several days to 2 hours. It is supplementing this method with mycorrhizal inoculation.

3. One idea that occurred while visiting the 'Camilo Cienfuegos' CPA, and seeing workers threshing their SICA harvest by hand, banging panicles against the inside of steel containers, a very laborious task, was that the government could encourage the uptake of SICA by providing, or making it easy to buy, **mechanical threshers**, and reapers and dryers, to CPAs or CCSs that take up the new methods. As use of SICA spreads, the government should soon begin saving *millions of dollars* now spent on importing rice. Some of this saving could be used to encourage even faster transition to this higher-productivity methodology by providing, or facilitating the acquisition of, processing equipment to make farmers' handling the larger harvest easier. This would be a very sound investment of government funds.

4. The **cooperation between Cuban research institutions and with farmers** observed on this trip was impressive. I hope that this is indeed the norm and that it can be further strengthened. The evaluation and spread of SICA will be improved and accelerated by such collaboration.

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Through arrangements made by Dr. Rena Perez, the volunteer coordinator for SICA promotion in Cuba and food security advisor to the Ministry of Sugar, and with an invitation from the Rice Research Institute (*Instituto de Investigaciones del Arroz*, IIA) of the Ministry of Agriculture, I was able to spend one week in Cuba talking with researchers and farmers about their experience with this new system of rice production. SICA, as SRI is known in Cuba, has had much success in other countries, and I was able to participate this time also in planning for future research and evaluation on this system in Cuba. This was my third visit to Cuba on behalf of SRI/SICA, having attended international conferences in Havana in July 2002 and May 2003 that gave me an opportunity to interact with IIA researchers and with farmers who are starting to use SRI/SICA.

Wednesday, July 7: After a short, 40-minute flight from Miami (in a plane with only 7 other passengers, due to recently imposed travel restrictions by the U.S. government), I was met at Havana airport by *Dr. Miguel Socorro*, IIA's deputy director for projects. After stopping by the hotel, we drove about 45 minutes to the rural community of **San Paul**. This is in the municipality of San Antonio de los Baños near IIA headquarters at Bauta. We went to **the home of Luis Romero**, whom I had visited during my two previous trips to Cuba as he was one of the first farmers in Cuba to experiment with SICA. Also there to meet me besides Dr. Perez, were IIA director, *Dr. Rubén Alfonso Caraballo*, and *Dr. Telce González Morera*, an IIA staff member who has become involved in SRI research, some of it with Luis on his farm.

Luis handed me a pair of tall rubber boots, just big enough for my large feet, so that I could visit his SICA plots across the road from his house without getting too muddy. Since the last visit, he had installed an impressive sprinkler system, which he demonstrated, that can provide the minimum amounts of water needed for his SICA plots, not keeping them continuously flooded as is the norm for irrigated rice production. (The control plot will be kept flooded, however.) He showed me four plots with young rice plants growing, each plot 12m by 15m (360 m²). These had different combinations of plant establishment methods (transplanting of young seedlings vs. direct seeding of pregerminated seed) and different varieties (VN 2084 and IACUBA 29). The planning and management of the five plots for evaluation is being done with the cooperation and support of Telce from IIA.

This evaluation will be very useful since the greater labor required for transplanting is one of the main constraints on SICA adoption in Cuba. Like other farmers, Luis doesn't like transplanting. Last year, he got a 'brainstorm' for how to build a mechanical seeder that can plant pregerminated seed at fixed intervals in a square pattern. The seeder, built in the backyard workshop of a neighbor, planted seeds at 40x40 cm spacing. This turned out to be too wide as it allowed too much weed growth. This season, Luis is using 25x25 cm as his SICA spacing for the more upright IACUBA 29, and 30x30 cm for VN 2084, which spreads, compared with 15x15 cm spacing in the control plot.

It will be good to know whether direct seeding used with other SICA practices can give as high a yield as with transplanting. In fact, even a lower yield could be acceptable since not having to

transplant lowers cost of production. It will be also useful to know how these two varieties, both popular with SICA users, perform under the different crop establishment methods, both being compared with a control-plot yield.

The first time Luis used SICA methods, he got a paddy yield of 14 t/ha on one of his plots, the best in the island so far. He understood very well how to manage plants, soil, water and nutrients so as to achieve larger root growth. Last year he did not get access to land for planting until a month after the season had started, so this plus seasonal water shortages kept his SICA yield down to 4.5 t/ha. This was, still, 50% higher than the 3 t/ha achieved by other farmers around him in that water-short season.

Before lunch, we visited a neighboring farmer, *Jorge Lopez*, who had assisted Rena in producing a video on SICA by planting a small SICA plot on his land for her to film. He pulled up one of the remaining plants to show us its large and healthy root system. He has much more rice land than Luis and said that he will plant it all as SICA once the rains begin because the SICA-planted rice had 55 tillers compared to only 24 using his standard methods.

On the walk back to Luis' house, we met *José Angel Gomez*, another neighbor who has been cooperating in the spread of SICA. He is the neighbor who built in his backyard workshop the three-row rice seeder that Luis used last year. Luis' experiments this year with direct seeding should give everyone a better idea of how successful mechanized direct seeding can be.

I asked what were the results from last year's direct-seeding trials. Luis said that cattle had gotten into the plots and ate up everything. So they have no yield figures to report, but they did see how much larger was the root growth, which confirmed for them the value of SICA methods. They are currently evaluating ratooning with SICA. This involves protecting the plants after first harvested so that they can regrow, to ascertain what yield they be attained with very little additional labor. (From Peru, a 70% ratoon yield has been reported, 5.5 t/ha following 8.0 t/ha; in the Philippines last March, a farmer reported to me that he had gotten a 7.6 t/ha ratoon yield following a 8.2 t/ha first harvest. So this is an area for systematic evaluation.)

After a splendid home-cooked meal on Luis' veranda, complete with rice and beans, prepared by his elderly mother and assisted by Rena, we drove to the **agricultural production cooperative CPA 'Gilberto Leon'** a few miles away and met with *José Garcia Borrego*, its manager who has returned to agriculture after retiring after 35 years as a functionary. Rena knew him many years before when she was working with the Ministry of Agriculture on animal nutrition issues.

José knew about SRI but not had a chance to try it yet. The CPA produced about 193 tons of paddy rice last year, with a yield of 3.4 t/ha (and a milled rice result of 2.5 t/ha). José said that he is quite persuaded about SRI from all that he has heard about it from others and having seen Luis Romero's results. For his farming operation, water is a serious constraint, so the possibility of water saving makes SICA attractive. They currently use 20- to 24-day-old seedlings, having previously used 30- to 35-day seedlings. He is reducing plot sizes within 60 ha of rice land so that they can maintain better water control. Weed control will be the main problem if they don't use flooding. They tried some SRI last year on a large plot and had poor results because water control was not sufficient.

This farm is already using biofertilizers and biopesticides, following what are thought to be 'sustainable agriculture' practices. José commented that they cannot afford chemical fertilizer because the price keeps going up and up. Three years before, this whole farm was in sugar cane. But now the government is cutting back on sugar production, having closed half the mills and taken much of the cane land out of production, because most was uneconomic. José told us, "I dream of more rice production."

The CPA has already gotten facilities for processing its own rice so it can turn out 4 tons of milled rice a day, having the bran for animal feed. He showed us a fish pond being dug for raising tilapia. In 20 more days, electricity should be extended to the bunkhouse/office where we were meeting. So he was optimistic that the land, labor, capital and water under his responsibility can be made more productive than before. We told him that we hoped SICA could help him achieve these 'dreams.' We returned to Havana, and I had dinner that evening with Rena and her husband Orlando.

Thursday, July 8: The IIA driver picked me up at the hotel at 9 o'clock to go out to the **Rice Research Institute**, where they had scheduled a presentation to IIA staff on SICA experience and ideas from other countries. Before the talk, the director, Rubén Alfonso Caraballo, presented me with a certificate of appreciation. He said that thus far, they have treated SICA from different disciplinary perspectives, "in different pieces," but now it is clear that there needs to be more multidisciplinary work on SICA, and more exchange between researchers and producers. (He did not use the usual word 'campesinos,' which has a less exalted connotation.) He reinforced my explanation of SICA as being a set of ideas, rather than a set of certain practices.

The seminar and discussion went from 10 to almost 12:30, when we had to break for lunch. From the discussion it was clear that one of the priorities for research and experimentation needs to be on non-transplanting methods for SICA crop establishment, given the objective constraints of labor availability and the subjective constraints of what farmers are currently willing to do. Also, weed control is a key consideration. Cuban farmers have not used since many years the rotary weeder that we recommend for use with SICA, to aerate the soil as well as remove weeds. There was also interest in compost and possibilities for mechanization of some SICA practices.

The most interest was in a system of crop establishment that I reported on from Sri Lanka, developed by Ariyaratna Subasinghe, a farmer near Anuradhapura. Ariyaratna broadcasts pre-germinated seed onto his muddy field at a rate of 25 kg/ha, more than used for usual SRI but less than standard practice. Then at 10 days, when the young plants are growing well, he 'weeds' the field just as he would with usual SRI, figuring 25x25 cm spacing between plants. This plows up (turns under) most of the new rice plants, leaving only 1 plant, maybe 2 or 3, at the intersections of the weeding swaths cut through the field perpendicularly to one another. This creates post facto a grid pattern of plants and has the result of creating 'the edge effect' throughout the whole field. Ariyaratna reported at a national SRI workshop in Colombo in December that he could get 7.5 t/ha assuredly with this method, and was able to save considerably on labor costs by not having to make a nursery or to do transplanting. This was attractive to many persons at the seminar.

Over lunch and afterwards, Telce and I discussed many questions related to SICA. The two varieties being evaluated on Luis Romero's farm, are quite different in their response to SICA practices. IACUBA29, the upright variety, has good tillering but lower yields because fewer of its tillers become fertile. VN 2084, locally known as Bolito, has rapid tillering and also very few infertile tillers. It will take more research to understand why this difference. Telce said that when he first learned about SICA, he had "many, many questions." Now he is satisfied that there is much merit in it, but still many questions remain. I agreed. Spacing is something to be varied according to local conditions (correct). Varietal differences remain to be fully evaluated (yes). Use of organic nutrients is growing in Cuba; how can this best contribute to SICA?

On my last trip, I brought a good microscope to the Institute, which has little such equipment, that Telce can use for assessing aerenchyma formation and its effects in rice roots. Rice is genetically programmed to form aerenchyma (air pockets) in response to hypoxic conditions. How much flooding is necessary to trigger their formation? This begins a process of root degeneration that can be significant in rice, up to 3/4, by the time of flowering, according to research by Indian rice scientists, published 30 years ago. From several references that Telce cited, it was clear than even with the isolation that Cuban has to cope with, he is following research elsewhere fairly closely. We also discussed what other Cuban researchers are doing interesting work on soil biota, mycorrhizae, nematodes and other organisms.

At 3, we left to go back into Havana for a meeting with the **FAO representative in Cuba**, *Robert Arias Milla*, a Salvadorean with many years of development experience, and his assistant representative, *Ana Maria Navarro*. We had a fruitful hour-long discussion, during which time Robert indicated that FAO may be able to give some support to SICA extension activities in Cuba, in connection with the FAO-promoted International Year of Rice. This was extremely good news, as Rena was certain that such funds can be put quickly to very good use.

Friday, July 9: At 7:45, Socorro, Rena and I left for a field trip in Pinar del Rio province west of Havana. En route, Rena reviewed with me the country's rice production statistics. In 1959, at the time of the Revolution, rice production was 170,000 tons of milled rice, meeting about half of consumption needs. Thirty years later, this reached 270,000 tons, most of it grown on large-scale state farms and cooperatives, heavily depending on mechanization and chemical inputs. After the collapse of the Soviet Union, when petroleum imports to Cuba for fuel and for making fertilizer fell dramatically, the rice sector went into a crisis.

After trying without success to raise production in the state sector, the government recognized the production potential of small-scale (private) farmers and began supporting a program called *Arroz Popular* (Popular Rice) in 1997. Small-scale producers are now contributing 300,000 tons of milled rice annually for national consumption, while the state sector is producing only 50,000 tons. To meet demand, Cuba imports 400,000 tons of rice, more than half of its consumption. This represents a huge drain on Cuba's scarce foreign exchange, about \$100 million. The fact that SICA does not require chemical fertilizer to raise yields is very attractive to farmers and to the government. Rice production had become highly mechanized, with transplanting a forgotten art for most farmers. However, the national percentage of transplanted rice production has recovered from about 10% in the early 1990s to over 45% now. The leadership of *Arroz Popular* is now satisfied that SICA can greatly increase rice production and is promoting it island-wide.

En route to Pinar del Rio, we stopped at Los Palacios to pick up the *Arroz Popular* coordinator for the region, *Lazaro Manuel Lazo*. In the vehicle, he told us how he had himself planted SICA, despite the objections of his father-in-law, who dismissed the methods as foolishness. Referring to the small green brochure on SICA that Rena had prepared and gotten widely distributed, the old man has told his son-in-law, "Put away that little green book. It won't help you grow rice." But now with a SICA yield of 6.5 t/ha, compared to the previous 4 t/ha, the father-in-law has become more respectful." "Now," Lazo told us, "my father-in-law tells me to keep on reading it."

We got to the **state cattle farm 'Baro' in the town of Alonso de Rojas** in the municipality of **Consolación de Sur** at 9:45, a little ahead of schedule. As we drove in, I saw among the many slogans painted on buildings, 'Lucha contra la gigante,' and was able to guess which 'giant' was being referred to for battling against. Rena said that the manager here, *Manuel (Manolito) Perez*, is very innovative, and he had taken the unusual step of transferring use of state farm land to individual farmers on a usufruct basis for growing rice. This will help ease the food and income crisis caused by the closure of so many sugar mills, and as a bonus for the farm, its cattle will have better stubble to graze on in the dry season after harvest. *Ventura*, in charge of rice for the municipality of Consolación de Sur, also joined us. As noted already, 2004 has been a bad year for rainfall. On the farm, they had planted 4 acres to SICA, but three had to be abandoned for lack of water. One still is doing all right, while all the other rice already planted in the area has failed.

Rena and Telce gave a training program on SICA at this farm in November 2003, to 85 rice growers. Each agreed to try the new methods on at least 1 cordel (20 m²), but the delayed rains have changed plans. Manolito told us that some SICA users were able to save their plots by making special efforts to preserve some flow of irrigation water, to be able to evaluate the results and show their neighbors. One farmer recently harvested his 1.5 cordels of SICA rice and got 50% more than with the traditional system, so he is very happy and will continue with SICA. His neighbors will also take it up, having seen it survive with so little water.

The main limiting factor in the area is water, even in good years. Manolito spoke of 'gran posibilidad' for SICA here. Farmers have been counting tillers, and one informed him that at 30-35 days, some plants already had 50 or more tillers. Once the rains start, people plan to sow a lot of land. I commented that from India and Cambodia, we have had reports that SRI crops mature in 7-10 days less time, which could be an added benefit.

The total rice area for this farm is 480 ha. They now get 3-3.5 t/ha, with a lot of inputs. If they can get 8-9 t/ha with SICA, this will solve a lot of problems. They could even put less land under rice and diversify production, Manolito said. Already they have found that harvesting SICA by hand is easier than traditionally-grown rice because the panicles are bigger and more regular. The by-product of straw, which is much more with SICA, is very valuable to the farm as cattle fodder. And they use the rice hulls after milling for bedding.

We walked to the assembly hall for a meeting with farmers who had been gathering to talk with us. The slogan on the wall at the front of the hall was: "Our principal battle is on the field of ideas," from Fidel himself. As staff started to arrange chairs for the meeting in a conventional

pattern, with the chairs for guests and meeting chairman on a raised platform at the front and those for farmers set out in rows like in a schoolroom, I suggested that, instead, all the chairs be arranged in a circle -- so that we could have better discussion. This was rather interventionist for a guest to propose, but it has always been our experience that ideas flow better in a circular pattern than in a two-way seating arrangement. (And Fidel himself was advocating the importance of ideas.)

When we were all settled there were 28 farmers in a circle with us and with Manolito, Ventura and other officials. In my opening remarks, I noted that SICA is a matter of ideas, not a fixed or finished technology. "We have developed SICA so far maybe only 25% of the way to where it will eventually be. We need and welcome farmers' ideas on how to continually improve SICA."

I asked how many had experience now with SRI? Eight hands went up. What was this experience? *Luis Suarez*, whom Manolito had referred to already, spoke first. He said he had planted 10-day-old seedlings as recommended, at 33x33 cm spacing. From his 1.5 cordels, he had harvested 8 quintals. His previous paddy yield from this area was 3 quintals, so this was a 167% increase, not a 50% increase as Manolito had reported. Luis agreed with my suggestion that the crop had probably looked pretty 'terrible' at first. The first month, his neighbors had criticized him, and he admitted that he was himself at first 'not happy' with the crop. But now everyone was happy, he said. I noted that in Cambodia, a wife had left her husband after he first planted SICA rice, but she returned after a month when the profuse tillering began.

I asked Luis whether he had ever pulled up his plants to look at their roots? He had not, and none of the other farmers said that they had inspected their roots. I gave my standard talk on the importance of roots, and on how keeping the soil aerated not only encourages root growth but also the growth of soil organisms. Farmers listened eagerly as Socorro translated my comments on biological N fixation, P solubilization, mycorrhizal fungi, protozoa, etc.

Alexis Diarmis was the next to report on his experience. He planted 8- to 12-day-old seedlings. At heading stage, there were more than 40 tillers per plant. He hasn't harvested yet, but the panicles are very big, and he is quite optimistic. He described how he planted at 33x33 cm spacing, and carefully put the seedlings into the soil, not pushing them down, which would cause the root tip to invert upward. Instead, he laid the root in flat, to have an L-shape instead of J-shape. Farmers here do not have mechanical push-weeders (rotating hoes). Alexis said that he just weeds by hand, but it is no big problem. He has planted LP 5 (Los Palacios 5), which does well. A neighbor added that there is "good color," that the plants are healthy, and this is a good system.

I asked about other experiences and was told that some of the results are not so good, but farmers are just learning the methods, Manolito said, and there is enough visible success for more to want to try the methods. Ninety percent of this area has irrigation, so in normal years, it should be possible to have enough water and also to control applications. "This year is exceptional," with just 2 mm of rain in 2 months, he said. "The reservoir is too low to make irrigation issues."

I commented that, sadly, 'exceptional' years are likely to become more 'normal,' so water-saving methods for growing rice will become ever more important. Rena reported that the CPA 'Camilo Cienfuegos' in Bahia Honda had just harvested its SICA crop and had gotten 10.9 t/ha on one

field. Manolito commented, "From an economic point of view, SICA is good because both farmers and the state benefit." The state will benefit from reduced need to import rice. "If we know something is good, we will try it."

When the meeting adjourned, farmers shared in the delicious cut fruit and other refreshments that had been offered to us when we arrived. We drove to the field of *Luis Mena*, who had 1.4 ha of SICA rice growing nicely in a new field, being grown jointly by six farmers. They transplanted seedlings at 10-14 days, with 9 plants/m² (33x33 cm spacing), but not in careful rows. They have since done intermittent irrigation, with some hand weeding but no mechanical weeding. The field was relatively weed-free, and the plants were magnificent.

Luis said that the plants now had up to 90 tillers, but when he pulled up one plant so that we could inspect the roots (which were large and light-colored), he counted the tillers. There were 98 on this plant just 60 days after transplanting. He agreed to protect one corner of the field after harvest to see what kind of ratoon yield they might get from such plants. They have used only organic fertilizer and have had no pest or disease problems. The variety used is LP 5, the same one that the Bahia Honda cooperative has used, with yield up to 14 t/ha. As this was pasture land before, the soil would have had some cow manure. Manolito used machinery to dig quickly some irrigation canals for the farmers, who will reimburse him for the non-capital costs of this work.

When asked about labor requirements, Luis said that for them, SICA is requiring **less labor per hectare** than conventional methods. I pressed him for numbers but got only comparisons for the different operations. Land preparation, he said, is fairly demanding the first time, to get the field very level; but once this has been done, it should be easier next year. When rice is conventionally broadcast, there is much more need for weeding than with SICA. The SICA transplanting went fairly quickly after the first day or so of learning. He could see no disadvantages to SICA, only benefits. I said that I will be pleased to learn their harvest results. Rena said that she will make sure that I get them. We took along with us the SICA plant that had been uprooted.

After a fine lunch provided by Manolito at the CPA guesthouse, we drove to a farmers' credit and service cooperative, **CCS 'Epifanio Rojas.'** This is in the municipality of *San Luis*, near to the southern coast. Rena and Socorro had held a training program on SICA there a month before at the invitation of the farmers' organization. Traditionally, they have used 30- to 40-day-old seedlings and have kept their fields continuously flooded. These farmers are very interested to try the SICA methods they now know about but delayed onset of the rains has held them back.

We discussed the principles behind SICA, including the advice for organic farming that rather than 'feeding the plant,' one should 'feed the soil, and the soil will feed the plant.' A number of the farmers have had experience with organic farming methods and were very much agreed. When it started to rain, the first precipitation in several months, we redeployed to the nearby home of *Roman Amelo*, known colloquially as 'Bigote' for his magnificent mustache. His wife served us all very delicious fresh-sliced pineapple, mango and papaya.

Riding back with us from the meeting was *Pablo Torres Gonzalez*, coordinator of *Arroz Popular* for the San Luis municipality. He said that there are 5,000 farmers in the area ready to try SICA.

This first season, now that the rains are beginning, they may start with a few dozen demonstrators; but once the results have been seen, there should be widespread adoption.

From San Luis we drove back to *Los Palacios*, where we had stopped in the morning, to overnight at **the rice experiment station of the National Institute of Agricultural Sciences (INCA)**. This has a very attractive facility rebuilt a few years ago by station staff with financial support from Los Palacios' sister-city in Spain. The director, *Dr. Rodolfo Castro*, who had hosted my visit last year, was not there when we arrived at 7, but he came by the time we had finished supper, so we met in his office from 8:30 until after 10. He was joined by three researchers, *Guillermo Diaz, Richardo Polon, and Miguel Angel Ramirez*.

Miguel has worked with mycorrhizal inoculation of rice. I asked how well this succeeds with flooded rice, since mycorrhizae are fungi, and thus as aerobes need oxygen. He said that he has gotten some positive results with flooded rice, because the roots themselves can provide a little oxygen to the fungi, which acquire nutrients that are shared with the plant through the extended filamental systems of fungal hyphae that give access to a larger volume of soil. But he agreed that mycorrhizae should give much better results with SICA, which does not keep soil flooded.

Los Palacios researchers have been examining different aspects of SICA, including the use of seedlings planted in small pockets of soil in plastic trays (resembling egg cartons). Guillermo has tried to obtain weed control with SICA by using different irrigation schedules. The best yield he has gotten is 10.4 t/ha with 40x40 cm spacing, intermittent irrigation, and 28-day-old seedlings. (The control was 5.5 t/ha. That 28-day seedlings performed better than younger ones may be a consequence of his using longer flooding periods than recommended for SICA; usually 15-day seedlings will outperform 28-day ones.) Guillermo thinks that Cuban farmers will not or cannot transplant seedlings just 8-12 days old. However, we have seen farmers plant seedlings as young as 5 days, even 3 days, in other countries, successfully and happily with the results. So what farmers will or won't do should be considered as a variable, not a given.

Guillermo had had best results with the following irrigation schedule: after transplanting seedlings into muddy soil, the field was left with no water for 3 days; then for the next 12 days (two cycles), he irrigated and dried the field for 3 days each. After this, he kept a layer of water on the field for one week, and then drained the field for two weeks; he flooded it again for one week, and then drained it for two weeks. This eliminated most weeds. Shortly before panicle initiation, he started maintaining a continuous layer of water up to harvest. (He also applied some chemical fertilizer during the two long dry periods.) This idea of using an extended period of flooding to control weeds is an interesting deserving more experimentation.

I explained that in Japan and Korea now, it is recommended that rice paddies be alternatively flooded and dried during the period of reproductive growth, *after panicle initiation*, while keeping the paddies continuously flooded during the period of vegetative growth. This is the opposite of SICA. I think that if vigorous root systems have been achieved by alternate wetting and drying during early growth, then alternate wetting and drying during reproduction could be even better. I encouraged the Institute to experiment with different water management regimes.

When I showed them a picture from India of a spectacular SRI plant, with over 100 tillers and large panicles, Guillermo said that they have had some similar plants at Los Palacios. In the north central part of the country, there was a 5 ha SICA field which gave great results in the first (summer/rainy) season, but then in the following (winter/dry) season it gave poor results. They are not sure why, but they want to investigate inter-seasonal differences some more. Also, they have found, as have others, that their LP5 variety does very well with SICA management, but another popular variety, Reforma, does not. One LP5 plot on station averaged 56 tillers/plant.

Ricardo said that since the 1970s, he has been working on water reduction in rice production. He understands the importance of getting oxygen to the roots, and his experiments have showed that with conventional irrigated rice, water application can be reduced by 30-35% without yield loss. Thus it was quite easy for him to understand SICA. He has found that water stress up to 30-40 days can increase yield by 1 t/ha, with an associated lengthening of roots by 10-25 cm.

Miguel has been working with inoculation of rice seeds using the hormone chitin. He has seen this increasing mycorrhizae and other microorganisms by 20-40%. Also, this enhanced plants' own mechanisms for resistance to pathogens and to stress. I was pleased to learn about such research being done here at Los Palacios. Miguel has worked also with *azospirillum*, a N-fixing bacteria that also confers other benefits. Our discussion was still going strong past 10, but we adjourned as Rodolfo had to drive back to Havana that evening. He and his colleagues are very serious about exchanging ideas and experience concerning SICA/SRI, and we will maintain closer communication in the future.

Saturday, July 10: After breakfast, we drove from Los Palacios, over some beautiful mountains, to *Bahia Honda*, on the northern coast. This was my third visit to the agricultural production cooperative CPA '**Camilo Cienfuegos**,' which has been the 'vanguard' user of SRI in Cuba. Unfortunately, the director of the coop, José Antonio Espinosa, known as Nico, had had to leave at 4 am for a funeral. *Juan Francisco Reambau*, the coop's agronomist, and *José Luis Martínez*, manager of its rice operations, met us and spent the next five hours with us.

The coop had just harvested its spring crop (it is now producing three crops per year), and the overall average was 8.9 t/ha, with one field producing 10.9 t/ha. More impressive were the **cost of production figures** that Juan read off to us from his records, calculated the day before. The dollar cost per ton of rice was \$41.52 plus 1,187.82 pesos per ton. At the official exchange rate of 26 pesos per US\$, this made the cost of production about \$87 per ton. Rena gasped since just the cost of shipping a ton of rice from Asia is \$35-50. The purchase of a ton of rice for import is another \$200-300, depending on prevailing market prices. Juan said that they now get in one season what they previously got in a whole year (with three crops).

Rena pointed out that this has been accomplished with only 'partial SICA.' The coop was already transplanting single seedlings rather than planting multiple plants together in a clump. It is not able to manage water carefully because the irrigation system does not give much control, and anyway, there is no water scarcity that would encourage economizing on water. And for unclear reasons, their fields have few weed problems, so weeding is not necessary. Just using young seedlings, with wide spacing, and compost applications, has been enough to achieve these gains. Initially, the coop workers refused to transplant at less than 25 days. José had to plant 15-day

seedlings himself to demonstrate the advantage of using young plants. Within a month after transplanting, the greater tillering was obvious enough to settle this issue. They now use 15-20 day-old seedlings, all under 25 days. Before they used to transplant seedlings at 35 to 60 days! The seed rate has been cut in half, from 5 lbs per cordel to 2.5 lbs, Josée said.

I was interested in their labor requirements with SICA. Juan and José both insisted that labor costs have declined with SICA. Transplanting in particular has been speeded up as one person can transplant 1.6 cordels in a day, compared with 0.9 cordels before. With the same labor force for rice, they have been able to double production, Juan reported. The coop is now working on a 2 plantings-3 crops schedule, where the winter crop planted in December or January is left after harvesting in April to produce a ratoon crop. With SICA root systems, they can get a 4-ton "free" yield this way. After harvesting this second crop, they plant another with the summer rains.

They told us about a new set of trials applying some of the concepts from SICA and drawing on their SICA experience. They have broadcast pregerminated seed at a much reduced rate, only 11 kg/ha. Juan said that they see now that they can reduce this even more. This plots which would normally have taken several days to plant were broadcast in just 2 hours, and after 20 days the plants already had 4 tillers. They were very interested in my description of Ariyaratna's method of crop establishment in Sri Lanka where he broadcasts pregerminated seed and then 'thins' the plants into a grid pattern by 'weeding' as done usually with SRI in perpendicular passes.

We drove out to the rice fields, stopping first at a set of paddies with very fine plants growing. These were not SICA but rather plots where organic fertilization and inoculation are being evaluated. The plants were inoculated with a commercially available mixture containing mycorrhizae and azospirillum. Some plots were treated also with a P-solubilizing bacteria. They plan next season to try these inoculations with SICA management methods, an experiment that should be very interesting. I suggested that they include trials with wider spacing than otherwise.

We saw the ratooned fields, which should give about 4 t/ha, and the plots where pregerminated seed have been broadcast. The latter had mycorrhizal inoculation as well. The stand was uneven because parts of the lower fields had not been well enough leveled, and plants in the low-lying areas were suffering. But the results could be very good.

On the way back to the coop office, we stopped at the rice warehouse and talked with the workers there. The large drying floor was covered with rice, and the bags of rice were twice as many as when I had first visited the CPA almost exactly two years earlier. Of special interest, and confirming what has been reported from India and Sri Lanka, the **milling outturn rate** with SICA paddy is significantly higher. In Andhra Pradesh, India, millers report that their yield has gone up from 67% to 75% when milling SRI paddy, because it has fewer unfilled grains (and thus less chaff) and also there are fewer broken grains resulting from the milling. Here in Bahia Honda, the coop is finding that **its usual rate of 60% is now up to 68% at least**, and sometimes even 71%. This is an increase of 13 to 17%, a bonus on top of the yield increases previously reported for paddy harvested per hectare.

It is no wonder that we received such a hearty reception. I know that the CPA is very hospitable to any and all visitors, but ours was a special treatment. Juan and José hosted a delicious meal,

served at the coop's social center, an attractive bamboo structure overlooking the reservoir they have built. The meat, vegetables and root crops served had all been grown on the coop and were as fresh as food ever gets. About 3, we finally took leave and drove back to Havana.

Sunday, July 11: Socorro picked me up at the hotel and we drove out to the **Rice Research Institute (IIA)** at Bauta, where about 10 o'clock we met with the IIA director, Rubén Alfonso Caraballo, and Telce, the IIA researcher overseeing SICA research and were soon joined by *Luis Aleman*, director of the national *Arroz Popular* program, who has become also a strong supporter of SICA's application in Cuba.

We discussed research needs and priorities for several hours. I suggested as priorities the evaluation of different methods of **crop establishment** -- alternatives to transplanting that still use SRI concepts and principles as much as possible -- along with experimentation on different methods of **weed control**. Related to these, and worth investigating in its own right would be the adaptation and optimization of **water management**. The idea that Guillermo Diaz is pursuing at Los Palacios -- purposefully maintaining a period of flooding after SICA plants are established, to eliminate weeds -- is worth pursuing. Also, **evaluating different varieties** in terms of their responsiveness (or non-responsiveness) to SICA methods is important. This is where I would put my effort at this stage. Such research is very straightforward, not complicated, and should have high payoff in adapting SICA to local conditions and making it more attractive and accessible to Cuban farmers.

A related suggestion was that they follow up the data from CPA 'Camilo Cienfuegos' about the lower **cost of production** with SICA methods, since farmers will find such data more motivating than agronomic yield figures. I added that it seems a shame that 'Camilo Cienfuegos' farmers are still threshing their rice by hand, beating panicles against the inside of metal barrels in the hot sun, very tiring work and something much better done by machine. Socorro and I figured that the foreign exchange savings from 15-20 tons of SICA rice could pay for a thresher.

It would be a great incentive for farmers to adopt these new methods, helping the government to save precious foreign exchange, if some of these savings could be used to acquire threshers -- and also reapers and dryers -- for CPAs or CCSs that could save farmers the arduous task of threshing their larger yields with SICA. Given the way employment is provided in Cuba, there would be no displacement of labor, and the labor saved from reaping, threshing and drying once machines replace hand work could be deployed to other activities, less mindless and numbing and more productive. Farmers seldom complain about greater harvest work when yields are increased; they are pleased to have the higher return from their previous labor investments. But mechanization should encourage further spread of SICA and help the country save eventually all of the \$100 million now spent on importing rice to meet consumption needs. This would be a win-win policy for the government and the people.

Aleman brought with him a plastic tray to show me how they are now experimenting with this method for crop establishment. The 'cups' in the tray are filled with soil and a single seed, which 5-6 days after germination is then broadcast onto muddied soil. This is being done in China and Vietnam and could be adapted to SICA/SRI ideas. I suggested that Ariyaratna's system in Sri Lanka could be used, with weeding done later to thin out the young plants into a grid pattern, so

as to get 'the border effect' throughout the whole field. Telce showed a picture that I had given him of the four-row weeder developed by Gopal Swaminathan in Tamil Nadu, India, which greatly increases labor productivity in weeding/soil aeration operations. This could make the tray method even better. Aleman said that using the tray method is cutting the labor costs of transplanting from 1500 pesos/ha to 50-60 pesos, a phenomenal gain. A worker who previously could establish only 400 m² per day can now plant one hectare!

Transplanting is being promoted in many parts of Cuba, as evaluations have shown that yield can be expected to be 1.11 t/ha more compared to direct seeding. There are tradeoffs to consider, however, as labor saving with direct seeding may be valued more than the yield differential. There will be no single best solution for all farmers, or for all parts of the country. This is why I suggested research and evaluation on crop establishment methods as a top priority.

There are a number of more basic scientific lines of research that could be pursued, such as on aerenchyma, mycorrhizae, and biological inoculations. Cuba has been working along these lines for some years now, since the exigencies of losing access to inexpensive petroleum forced its agriculture to become more 'organic' after the collapse of the Soviet Union. The ideas associated with SICA are very congenial to persons who have worked on organic methods that enhance soil biological activity. Cuba has a good number of excellent scientist involved in such research. We agreed to try to have more communication with them, to engage them in helping understand and evaluate SICA.

Socorro brought in from his truck the rice plant from Luis Mena's field in Consolación de Sur that we had visited on Friday. Its having almost 100 tillers only 60 days after transplanting was indeed impressive. The roots were light and fine as well as massive, almost resembling a woman's hair. We agreed that in research and extension activities in Cuba, more attention has to be given to roots, particularly lifting up SICA plants in the field to reveal their underpinnings. This is one of the 'secrets' of SICA plants' growth and healthy color and status that needs to be widely revealed.

Alfonso shared with me a draft program for the 3rd international rice congress (*encuentro*) that he and colleagues are planning to be held in Havana in July 2005. We discussed until after 1 organizing a roundtable on SICA to share what has been learned with participants from all around the world and especially from Latin America. This will mean returning to Cuba next year, also to see what progress has been made by the farmers who were visited on this trip.

Monday, July 12: Socorro and I left the hotel at 8 to join in a field trip for an international workshop on selection of rice varieties with farmer participation, organized by IIA, the *Arroz Popular* program, and the International Center for Tropical Agriculture (CIAT) which is based in Colombia. The evening before I had met the head of CIAT's rice program, Lee Calvert, at the hotel, and we met again during the field visit.

Workshop participants were visiting the CPA '27 de Noviembre' beyond Güines, which is about an hour and a half from Havana. I had visited this cooperative two years earlier, during my first visit to Cuba, because it has ongoing collaboration with IIA. Extensive varietal trials have been

laid out on the cooperative's fields to give farmers a chance to see the phenotypes of as many as 150 genotypes, involving them then in setting and applying criteria for selection. This is an interesting effort to interface with farmers in a plant breeding program. We had a fine lunch at the Institute of Animal Sciences, not far from Güines, where Calvert expressed his continuing interest in SICA and in getting trials going in several Latin American countries through CIAT.

Tuesday, July 13: This morning, Socorro drove me to the **National Institute for Basic Research in Tropical Agriculture** (INIFAT), more than an hour outside of Havana. This year, INIFAT observed its hundredth anniversary, having been founded in 1904. We met with *Rafael Martínez Viera*, a microbiologist who works on biofertilization, using selected microbes such as azotobacter, acetobacter and azospirillum. In acid soils, such as common in the tropics, he said, microbial populations can be very low, so inoculation can have some dramatic effects. He showed pictures and cited data on the effects of inoculation in Colombia with rice and cotton, which were impressive.

The applications do not always 'take,' Rafael said, but he cited 25% increases in yield for cassava and potatoes that are attributable just to increased numbers of certain bacteria in the root zone. He has recently published an article documenting such effects in controlled experiments with bananas, a crop for which N fixation through bacterial activity has not been known before. Foliar analysis showed that 25% of the nitrogen in the leaves was from atmospheric sources, in isotopically marked N¹⁵ form, that had been fixed by bacteria. What I told him about SICA and the contribution to plant performance we attribute to soil biological processes made a lot of sense to him based on his own research. We discussed his contributing a chapter to the book that I am currently editing on biological approaches to sustainable soil systems.

Next we drove to the **National Institute of Agricultural Sciences** (INCA), also a ways outside of Havana. We were met by its director-general, *Dr. Roberto Martín Triana*, whom I met on my previous visit. We were joined by *Mariana Perez*, who helped with translation (and translated for my visit to Los Palacios last year), *Dr. Ramon Rivera*, director of research, and *Dr. Felix Fernandez*. Both Ramon and Felix work on mycorrhizal biofertilization, and we had a lively discussion on their experimentation and experience. They have worked with the commercially distributed inoculant Ecomic, that was being tried at CPA 'Camilo Cienfuegos' in Bahia Honda, and that is being used now in 14 countries of Latin America. They have documented that when using mycorrhizal fungi to enhance roots' access to soil nutrients and water, the use of chemical fertilizer suppresses their effectiveness. They have not used Ecomic with SICA yet, but look forward to this because the aerated soil conditions with SICA should make the mycorrhizae more effective. With soil aeration, they have been able to increase the rate of root colonization (a good thing) from 20% to 90%.

The concept that they are working with is how to improve soil (also plant, water and nutrient) practices to get ***better management of the symbiosis between plants and microorganisms***. They have found that just by inoculating seeds, they can enhance grain weight by 6-10%. We had a long discussion, followed by a fine lunch in the INCA cafeteria, about how to advance the knowledge about and practice of such methodologies. They also agreed to contribute a chapter to the book on biological approaches to soil system management. They gave me a book of theirs on results from research on mycorrhizal symbioses, with case studies from Cuba and other countries in the Caribbean. It was very encouraging to learn about the systematic and detailed research

they are carrying on. They were as keen to get more involved with SICA as I was to follow up their soil microbiological work. We think that this holds promise for make great improvements not just in rice production but in agricultural cropping systems more generally, taking SICA/SRI principles into other crop domains.

Concluding Observations: It is hard to know how widely the use of SICA has spread in Cuba because this is still an 'uptake' stage. Rena, Socorro and Telce have given many training programs in the past year. There is obvious demand coming from farming communities and various government and non-governmental organizations. The government's program for small producers, *Arroz Popular*, is now promoting SICA, as is the Urban Agriculture program. NGOs like the Council of Churches are also spreading SICA ideas. The main rice research institutions, IIA and INCA (Los Palacios), are both involved in evaluations and are working with farmers. The media have given SICA some attention. (An article by Rena on the SICA experience of CPA 'Camilo Cienfuegos' was published earlier this year in the national newspaper of ANAP, the national farmers' organization [Vol. 44, No. 1], with 30,000 circulation.)

There was limited time to visit SICA users. Those with whom I talked, who have used the methods for several years or who have just started, have **remarkably positive results to report**, in both agronomic and economic terms. There is much economic pressure on Cuba to reduce its imports of rice, to save up to \$100 million, and to do this without reliance on petrochemical inputs, which are now extremely costly. There is also incentive to reduce the water-intensity of rice production due to heightened uncertainty of rainfall and water stores. So SICA is an innovation practically custom-made for Cuban conditions.

The labor-intensity of transplanting and weeding practices currently associated with SICA represents an obstacle for many farmers to adopt it, although a number have already figured out ways to make desirable adjustments and adaptation. We look forward to further innovations and their spread that can 'fit' SICA better to local circumstances and farmer interests. As good results have continued to mount, extension programs such as *Arroz Popular* and research institutions like IIA and Los Palacios are getting more engaged with its opportunities and challenges. Given the high level of education and motivation of Cuban farmers, there could be a lot of innovation and uptake in a fairly short period of time. Within another year or two, we will have a better idea of how far and how fast this transformation in the rice sector can occur in Cuba.