Proceedings of the Sustainable Rice Production System for the Northeast Workshop

July 25, 2009

8 am – 5 pm
Akaogi Farm
Westminster West, Vermont

Sponsored by a Northeast Sustainable Agriculture
Research & Education Farmer Grant

Table of Contents

Acknowledgements

- Thank you Lois Swales (Administrative Assistant, Cornell University), Carol Delaney (Farmer Grant Specialist, Northeast SARE), and Heather Darby and Vern Grubinger (UVM Extension) for helping organize this workshop.

- Thank you Roger Allbee, Tom Vogelmann, Marie Caduto, Em Richards, Sylvia Harris, Judy Doerner, Susan McCouch, Gen Onishi, Peter Hobbs, Randy Barker, Margaret Smith, Yolanda Chen, Christian Elwell, and Tatiana Schreiber for your participation in the workshop.

- Thank you Jiwon Ahn and Martin Roberts, Roberto and Elissa Gauthier, Jesenia Major and Robyn O'Brien for providing food for the workshop.

- Thank you Tim Merton and Carryn Francis-Merton for hosting dinner for our workshop speakers.

- Thank you Peggy Spencer, Tim Merton, Michelle Liechti, and Barbara Wright for providing musical entertainment for our out of town workshop guests.

- Thank you Pete and Judy Gianforte, and Yong Yuk and Jeana Park for their displays of their rice growing experiments.

- Thank you Jane Booth for your photos that not only document the rice varieties grown at the Akaogi Farm but also reveal your artistic interpretation.

- Thank you Mia Akaogi for compiling and editing these workshop proceedings.

Takeshi and Linda Akaogi

Workshop Agenda

8:00 – 9:00 am	**Registration and light breakfast** (Kheer)
9:00 am	**Introduction** Roger Allbee, Vermont Secretary of Agriculture
9:30 – 10:30 am	**Growing Rice at the Akaogi Farm** Takeshi and Linda Akaogi
10:30 – 11:00 am	**Rice Paddies in the Watershed Context** Marie Caduto
11:00 – 11:30 am	**Nutrient Management in Rice Paddies** Peter Hobbs
11:30 am – 1:00 pm	**Lunch** (various ethnic rice dishes prepared by local chefs)
1:00 – 1:30 pm	**Pest Management in Irrigated Rice** Yolanda Chen
1:30 – 2:00 pm	**The Integration of Conservation and Agriculture: Ecological Health and Human Values** Tatiana Schreiber
2:00 – 2:30 pm	**Available Machinery for Rice Growing and Harvesting** Gen Onishi
2:30 – 3:00 pm	**Rice Breeding and Genetics** Susan McCouch
3:00 – 3:30 pm	**Finding our Relationship with Rice: Economic Factors, Spiritual Perspectives. Rice as Teacher, Rice as Friend.** Christian Elwell
3:30 – 5:00 pm	**Closing statements, discussion, and future plans**

Workshop Speakers

Dr. Yolanda Chen
Assistant Professor, Department of Plant and Soil Sciences, University of Vermont

Dr. Chen received her PhD in Environmental Science, Policy, and Management from the University of California, Berkeley. Prior to her position at UVM she was an entomologist for three years at IRRI, in the Philippines, investigating host plant resistance. Dr. Chen is interested in understanding agricultural sustainability and how to farm with nature. Much of her research focuses on how historical ecological, evolutionary, and anthropogenic changes have facilitated insect pest outbreaks in agricultural systems. By contrasting the ecology of insects in their native systems with our current agricultural systems, we can start understanding how changes to the landscape, agroecosystems, crop plants, and the insects themselves have led to pest outbreaks. Humans have strongly influenced insect pest evolution and ecology through host shifts, crop domestication, change in cultivation practices, and human-mediated translocations. Dr. Chen's research studies these themes to determine how we can use ecological and evolutionary information to improve sustainable pest management.

Dr. Tatiana Schreiber
Environmental Studies, Adjunct Faculty, Union Institute & University

Dr. Schreiber is an independent scholar and part-time farmer in Westminster West, Vermont. She received her PhD in Environmental Studies, specializing in Environmental Anthropology, from Antioch New England Graduate School in 2005. Her doctoral research focused on the cultural, economic, and ecological context for survival and sustainability among organic coffee and cacao farmers in Southern Mexico. She currently teaches Environmental Studies, Anthropology and Agroecology at Union Institute and University, and Political Ecology at Keene State College. She is also teaching a course in ecological agriculture at her farmstead in Westminster West. She has also worked for many years as a public radio journalist, producing feature stories about agriculture and environmental issues, among others. Her long-term interests include finding ways to link the agroecological projects of farmers here in the Northeast with those in Mexico and Latin America.

Gen (Fumio) Onishi
Greenhouse Manager, McCouch Rice Research Lab, Department of Plant Breeding and Genetics, Cornell University (technical advisor of 2009 Northeast SARE Farmer Grant)

In Japan, Mr. Onishi was a rice farmer for 20 years and a business manager and assistant to the general manager in a fine chemical company (High Performance Liquid Chromatography Division) for 13 years prior to coming to the United States. He graduated from a technical high school (electric engineering) in Kyoto prefecture in 1965. After high school, Mr. Onishi worked at a cable company (high voltage electric wire) for ten years in Tokyo. He is now the greenhouse manager of the Rice Research Lab of the Department of Plant Breeding and Genetics at Cornell University. Mr. Onishi and his wife, Deidre, have three boys, Kosuke 19, a freshman at Doshisha University in Kyoto City, Genji 17, a senior, and Kengo 15, a sophomore at Ithaca High School.

Professor Susan McCouch
Project Director, Rice Research Lab, Department of Plant Breeding and Genetics, Cornell University (collaborator of 2009 Northeast SARE Farmer Grant)

Professor McCouch received her PhD from Cornell in 1990 and spent 5 years with the International Rice Research Institute (IRRI) in the Philippines before joining the Cornell faculty in 1995. Her research focuses on rice and includes publication of the first molecular map of the rice genome in 1988, early quantitative trait loci (QTL) studies on disease resistance, drought tolerance, maturity and yield, development of the essential repertoire of SSR markers now used globally as a genomic resource in rice genetics and breeding, and cloning of genes underlying critical traits for rice improvement. Her current work focuses on rice domestication and the identification and characterization of genes and QTL from low-yielding wild and exotic *Oryza* species that enhance the performance of modern rice cultivars. She has trained scores of young scientists throughout the world, was recently elected a fellow of the AAAS and has received numerous research, teaching and faculty awards.

Christian Elwell
Owner, President, South River Miso Company

Mr. Elwell was born into a vegetable farming family on Martha's Vineyard in 1946. In 1951 his family moved to the Boston area where his father developed a nursery/florist business called Arrowhead Gardens. During his youth he worked on dairy farms in Massachusetts and Vermont. He graduated with a B.S. from Cornell University, College of Agriculture, in 1969 with a major in Landscape Design. In 1981, he and his wife, Gaella, founded South River Miso Company on their farm in Conway, Massachusetts, which is now in its 29th year of production and distributing 100,000 pounds of miso this fiscal year. Their farm is also home to Natural Roots, a horse powered C.S.A., serving 215 households with organic fruits and vegetables. Mr. Elwell began growing rice in Conway in the early 1980's, having obtained seed from Dr. Peverly at Cornell. He has grown one variety continuously, and mostly by dryland cultivation, for over 25 years, saving seed year to year. As far as we know, he is the first person to grow rice in New England.

Workshop Participants

Roger Allbee: Vermont Secretary of Agriculture
Tom Vogelmann: Dean of the College of Agriculture and Life Sciences, UVM
Judy Doerner: State Conservationist, USDA-NRCS
Cheryl Bruce: Vermont Organic Farmers (VOF) staff member
Peter Hobbs: Adjunct Professor, Crops and Soils Dept, Cornell University
Margaret Smith: Professor, Plant Breeding and Genetics, Cornell University
Marie Caduto: Watershed Coordinator, Vermont Department of Environmental Conservation
Randy Barker: Professor Emeritus, Applied Economics and Management, Cornell University
Em Richards: environmental scientist, independent consultant
Sylvia Harris: Agricultural Resource Specialist/Basin Planner, Vermont Association of Conservation Districts

Photo credit: Susan McCouch

Workshop Background

For the past four years we have been experimenting with growing temperate rice in the Northeast USA. The last two years (2008 & 2009) we received Northeast Sustainable Agriculture Research and Education (Northeast SARE) farmer/grower grants "Introducing Rice as a Commercial Crop to the Northeastern USA." In our experiments in 2008 we produced more than two tons of rice per acre. Therefore we proved that rice can be grown productively in the northeastern USA and has the potential to become a commercial crop.

Our 2009 Northeast SARE grant enabled us to improve the production of currently available varieties on our farm and to assemble information about developing a sustainable, organic, rice production system. This integrated examination of rice production focuses on wetland wildlife and water management issues in addition to traditional agronomic aspects.

This workshop was sponsored by the Northeast SARE Farmer Grant to start a satellite rice growing experiment throughout the Northeast USA and establish a network of experts in all the three aspects (agronomic, wetland wildlife, and watershed management) of a sustainable rice production system. The workshop was a daylong event with speakers focusing on all three aspects of rice production.

Takeshi and Linda Akaogi

Workshop Proceedings

Breakfast

A breakfast of Kheer (Indian rice pudding) was provided by Jesenia Major and Robyn O'Brien. The recipe can be found in Appendix A, along with a recipe for Arroz con Leche (Spanish rice pudding).

Introduction: Roger Allbee, Vermont Secretary of Agriculture

This is intriguing. I don't know too much about rice other than years ago, I did some work for Zen Chu when they wanted to bring Japanese rice into the United States and make a value added product with it and weren't too successful. I grew up on the other side of the mountain and when two years ago somebody told me that Takeshi and Linda were doing rice trials here and that they were working with Cornell, I guess Susan and some others, I said, "In Westminster? This is my backyard!" I came over to visit not knowing much about rice but knowing that a lot of things have been done in Vermont and other parts of the Northeast traditionally, based upon people with new ideas. It was intriguing to see the amount of energy that Takeshi and Linda were putting into this effort to see what would work, what varieties would work, and how it would work. Even last fall, I think I came down and saw your drying operation and the pedal machine that you use to take the grain off the stalk. I said to Takeshi at the time, "Do you want to grow more rice here?" He said, "No, my vision is to have others grow it in other locations; in the Champlain Valley perhaps, or the Hudson River Valley." What is really intriguing to me is the collaboration he has engineered with Cornell, Tom Vogelmann is here from UVM, and others to see and to figure out what might work and what maybe needs to be done or what can be done going forward. I am here to learn too, but I am always intrigued when people are trying new things. Thank you Takeshi and Linda for doing that.

Growing Rice at the Akaogi Farm: Takeshi Akaogi

Thank you Roger for that opening. I will try to convince everyone that you can grow rice in the Northeast. Because there is limited time, I won't talk a lot about general rice growing but I will try to concentrate on cold climates and the challenges of growing rice in cold climates.

First, this farm is located in the southeastern part of Vermont and it is supposed to be warm but our altitude is 900 feet above sea level. The conditions at this elevation are probably equivalent to that of the St. Lawrence Valley in Quebec, which means that if you can grow rice here it will be able to grow over the entire Northeast and southern Canada, as well as the Pacific Northwest, southern South America, and central and northern Europe.

This Northeast climate is the coldest climate, so far, that we are able to grow rice commercially. In Hokkaido, Japan, there has been more than 100 years of rice research and breeding programs in a climate similar to the Northeast. It is only recently that they have gotten to a point where their rice is of high enough quality to compete with southern rice, but unfortunately most of the newly bred varieties of rice can't be obtained from Japan because of political reasons. There is quite a lot of information from Hokkaido about rice, but it is all in Japanese. I can read Japanese so I am able to get some information and translate it but it isn't enough. We need a more comprehensive evaluation of what information is available and more knowledge about how to grow rice in these cold climates in English. In rice research in Hokkaido, their main concern was and is still their cold, short growing season. This will also be the main issue for us. It is probably time for us to join in the efforts to figure out how to grow rice efficiently in cold climates from this side of the ocean.

I will now explain the process of growing rice here on the Akaogi Farm. In the middle of April, I start soaking the seeds in water for about a week or 10 days. After the seeds start to swell, just before they sprout, at that stage I sow them into 128 plug trays. For 3-4 weeks the seedlings are raised in flooded containers, which reduce the amount of watering needed (Photo 1).

Then they are transplanted. Last year I transplanted during the first week of May but this year I transplanted during the third week of May (Photo 2). By the middle of June, the rice plants have developed a little bit and have about 10-15 stems (Photo 3). From a single seed, 20-30 stems eventually develop depending on the variety, condition, and climate. At the end of June, the rice plants start to develop their panicle, starting with the bottom of the stems and gradually developing upward (Photo 4). Heading eventually follows. Last year heading occurred in early August, which is only a week from now. This year is an interesting year for rice research because the rice is about a week to 10 days behind in development. Unless we get an average August, the rice will be in a big trouble. Last year in the middle of September all three varieties, early, mid-early, and late, ripened nicely (Photo 5, Photo 6). This year I expect the early variety will be fine but the late varieties I don't know about.

Because this rice paddy system is a small experimental operation, I harvest the rice by hand. I cut the rice, make bundles, and hang the bundles in this greenhouse. Once the rice is dry I use this thrasher, which is a very simple and primitive machine that is very similar to a harvester. This man-powered thrasher removes the stem from the grain, with the husk still attached (Photo 7). Then there is another machine, the de-huller that removes the hull from the grain. At that point you will have brown rice. You will need another machine, a polisher, if you want white rice.

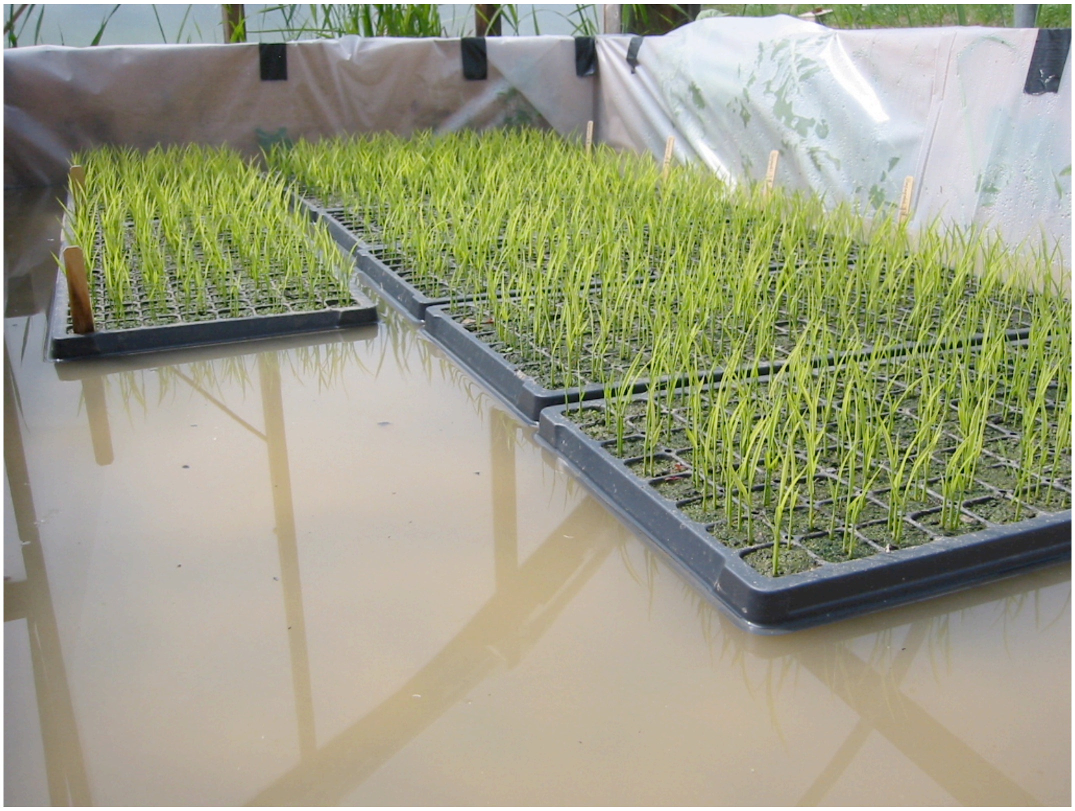
Photo 1. Rice seedlings in 128 plug trays, May 13, 2008 (Takeshi Akaogi).


Photo 2. Recently transplanted rice seedlings, May 25, 2008 (Takeshi Akaogi).

This year has been colder than usual and this creates problems for rice. There are two critical issues that rice growers in Hokkaido have had to deal with because of their cold climate. During the reproductive stage when pollen is being produced and the panicle is developing, which starts at the end of June and goes through July and maybe even into early August, if the temperature drops below 12 degrees Celsius for three days the pollen will be destroyed. Of course, this depends on variety. Hokkaido varieties are very cold tolerant and will be able to handle cold temperatures better than other varieties. However, if this happens it is still a serious problem. To prevent this from happening, one strategy is to gradually increase the water level in the paddy beginning in the middle of June. Having 6-8 inches of water will hold more heat and most of the time the paddy will be warmer than 60 degrees Fahrenheit.

The other issue with growing rice in cold climates is what happened this year. All through June it was cloudy and 5-10 degrees colder than average. Having these weather conditions for 4-5 weeks will result in a 7-10 day delay in rice development, which means that some varieties will not mature. That is why we need varieties of rice that are both cold tolerant and early maturing. Luckily, we have short grain varieties of rice from Hokkaido that have both of these characteristics. However, we would like to also have these traits in other types of rice, including jasmine, basmati and other aromatic rice varieties, because this would provide more options for both farmers and consumers.

Another major issue, which is very interesting to me personally, is to examine rice paddies as human-made wetlands and consider the wetland functions they provide. Rice paddies have the potential to support a broad range of wildlife and provide protection during flash flooding events. If we were to get two inches of rain tonight, with the soils saturated, this would cause major flash flooding problems. A rice paddy can hold 6-8 inches of water and so if you have 100 acres of rice paddies with 5 acres of reservoir, within the watershed, then a two-inch rain might not be a problem. In addition with the impacts of climate change we are seeing more variability in weather patterns and especially in the last 5 years, increasing amounts of precipitation. Although a two-inch rain would be significant in Vermont, in Asia getting 5-6 inches in a 24-hour period is not that uncommon. If such a thing were to happen here in New England we would have much greater environmental issues in addition to flash flooding. This means that not only rice paddies themselves but wetland management, in general, is a significant issue for the protection of fresh water resources. Without fresh water we cannot survive so it is important to make these connections and manage our land in a way that will take into account the impacts of climate change. It would be a shame to wait and see flooding events increase in both severity and frequency, at the cost of hundreds of human lives, when we know what needs to be done.

Our smallest paddy is four years old and the other two larger paddies are only in their second year. With just these three paddies, the number of wildlife species and wildlife populations are increasing. This summer a heron even starting coming and feeding, which means that there is more food available. Imagine if, instead of the $1/10^{th}$ acre paddy, there were even a couple acres. This would change the ecosystem drastically and the farmer could contribute to conservation efforts without any loss to production. It may seem a little too good to believe, but that is the progress I would like to see happen. If from today's workshop you start to believe that this might happen, then my efforts are working.

I still have some time so I would like to go by the rice paddy and explain how it was constructed and how it functions. This rice paddy system is a small-scale version, but the design will work at a much larger scale. I will explain what I have been doing this year and I can take any questions over there.


Photo 3. Rice plants about a month after transplanting, June 15, 2008 (Takeshi Akaogi).


Photo 4. Rice plants during panicle development, July 27, 2008 (Takeshi Akaogi)

At the Rice Paddy

This section of our land has always been on the wetter side but it wasn't a real wetland and there was no standing water. I couldn't use the land for farming so one year I decided to dig this smaller paddy by moving soil from the higher parts to the lower bank and planted rice. The first year I didn't do anything with the topsoil or hardpan or anything. Without any research or education I decided to just see what would happen. Luckily, this rice paddy holds water nicely. But that was just luck. I planted Koshihikari, a variety from Japan, and it grew very well vegetatively but it didn't head up until September 1st. By that time there was a frost and the cold temperatures continued for the following two weeks so I didn't get any seed. It was a failure. The second year I think I contacted Susan and got some seed from her and also from the Small Grain Collection in Idaho. During that second year, which was two years ago, the rice started to look better and some varieties even headed up. We were very excited at the time and thought that maybe growing rice here could be a real possibility. I think that summer we went to see Susan and discussed the potential for growing rice in the Northeast. At that point we started writing the SARE grant proposal.

Last year, I got more varieties of rice seed and constructed these two other paddies. For these paddies we actually spent some time designing the rice paddy system and we hired a local contractor to help us with the excavation. The land is sloped to the east with the highest point being on the western side. We dug up the sod and piled it over there. After that, we removed the topsoil and made another pile. Because we knew that there was hardpan underneath, we tried not to disturb it while leveling out the ground. Then we returned the topsoil. Even though we don't know the exact clay content of the soil, it doesn't matter because the paddy will still hold water nicely because of the hardpan underneath.

I didn't explain this yet, but a rice paddy needs to be able to hold water. If the paddy is unable to hold water then you can't control the water depth and it is very difficult to grow rice in this climate. In addition, in order to grow rice you need sunshine, not rain, because sunlight is one of the most important factors for plant growth. Some people think that all you need is water and therefore this year is a good year because of all the rain. But this is not true. Also, some people think that if you have a wetland you will be able to grow rice. This isn't true either because you have to be able to control the water level in the rice paddy from dry to any depth that is needed. If you don't have control over water then it is not reliable.

In the Northeast we can't rely on the rain to provide enough water for the rice paddies, especially during the months of July and August. This is why we have a reservoir. A certain portion of your land should be set-aside for this even if this results in a loss of growing area. It is much better to lose this small amount of land to the reservoir than to lose the entire crop. The reservoir works to store water but also warms up the water for free. As long as there is a certain amount of surface area, the water will heat up from the sun. The warmest water will be on the surface and the coldest water on the bottom of the reservoir. If you use the surface water for your paddy then the temperature in your rice paddy will always be 5-10 degrees warmer than the original water. This is very beneficial for the rice, which needs a warm environment. Even adding 5 degrees each day all through May-September will add up to quite a lot of heat.

Photo 5. Rice plants after heading and right before harvesting, September 16, 2008 (Takeshi Akaogi).

Photo 6. Close up of mature rice plants, September 23, 2008 (Takeshi Akaogi).

Within the rice paddy, water is needed not because the rice needs water to grow but because the water provides heat. Having two inches of water, especially during the first two weeks of May, makes a big difference. If your irrigation water is 50 degrees to start, then heating it up to 60 degrees will provide a much milder condition for the rice and you can avoid the late frost. You can also avoid the cold 50-degree nights by adding water up to ½ to ¾ the height of the plant. This is why it is so important to have a paddy that is able to hold water. Having these three things is especially important for growing rice in this marginal climate but if you go down along the Great Lakes or Hudson Valley this is a little bit less of a concern.

Photo 7. Foot pedal thrasher used to remove the stem from the grain (Takeshi Akaogi).

Question and Answer

Audience: Did you size the reservoir to allow for a certain amount of storage or plan on needing a certain amount of water to flood the system?

Takeshi: A portion of the actual growing area needs to be the reservoir. In our case, we don't have running water all summer so we should have a much bigger reservoir but this proportion is good if you have a constant supply of water. Actually, I really can't tell what percentage you need to set aside for the reservoir. Bigger is better because it will ensure that your water supply is more secure. Also, you need to plan for other uses if the community wants to use the reservoir for fire emergencies or recreation purposes. You can combine both farm uses and other purposes to make a much better system.

Audience: Have you ever looked into or considered using some kind of covering or greenhouse structure over this, like how you grow the tomatoes and eggplants, for increased heat during the early and late part of the season?

Takeshi: Technically of course that is possible, but no one would do it.

Audience: Too expensive?

Takeshi: You would have to sell a pound of rice for 10 dollars or 20 dollars. If you can sell the rice then I think it would work. Then we could extend all the rice varieties. As I explained before, it is much more clever and cost-effective to use water and grow varieties that will mature even under the weather conditions we had this year. Of course, you can set aside several buckets in a part of your greenhouse for your own needs. But a commercial grower could not afford this and I don't think it is such a good idea either.

Audience: How does frost impact the seedlings?

Takeshi: This year I had a big problem with the seedlings. They can tolerate a light frost but it isn't really good for them. They will not be killed or delayed too much, but below freezing temperatures for rice at any stage is not good. The Hokkaido varieties, especially the early varieties, are bred to be more sensitive to heat and not to day length. During the 3rd or 4th week of raising the seedlings, during the very late 4th leaf stage, we got 80-degree temperatures outside. The Hokkaido website says that if this happens, premature heading will occur. Although you can't tell now, those seedlings stopped developing new stems and so there are fewer stems than last year. I have to be very careful about this plastic cover. If the outside temperature is going to be 80 degrees, to keep the greenhouse below that temperature is very hard even if I open all the sides. I didn't know about that at the time but now I know. That is one problem. Generally, 40 degrees is the lowest temperature. Right before harvesting, 32 degrees is the lowest because by then the plants are 4 feet high. They will be fine. Below 30 degrees will probably be a problem because the stems might be destroyed. You would be able to harvest but maybe while drying the stems will break off easily or thrashing will be messy. I don't know exactly but I would try to avoid it.

Susan: There is a 2-3 week stage where if it either goes above about 95 or below about 65 it will sterilize panicle initiation. Normally you only have that problem at the beginning and end of the season, but it can be a real problem if it spikes on you right at the time that they are in panicle initiation. Everything will come up, the heads will look fine, the panicles will look great and then everything will go sterile.

Takeshi: At the end you will be very disappointed, the rice will be very lightweight and the husks will be empty.

Audience: Will you save seed for the year?

Takeshi: Oh, I have to save seed.

Audience: Has cross-pollination been a problem?

Susan: In most situations, the plants will self-pollinate before the flowers (spikelets) open. This limits outcrossing, so that with low wind, you probably get less than 2% out-crossing. It's not like in the tropics where you may get typhoon winds during the rainy season.

Takeshi: So far my experience also tells me the same thing. This is fine. But if you see this row, this is not seed I saved. These seeds came from the Small Grain Collection and one plant is already heading up so the seeds got mixed up somehow, or perhaps the seeds cross-pollinated or a mutation occurred. However, as a whole you don't see so many.

Susan: It is really important if you order seeds from either the National Germplasm Repository or the International Germplasm Repository that when you first get those seeds you grow them out and select those that are "true to type". There will usually be mixtures for both good reasons and bad reasons, which we won't get into here. But seed management is always a problem and the assumption that they are all identical just because they are in the same seed pack is not a good one. It's more problematic for the wild species and landraces, which tend to be more highly out-crossing than modern cultivars. I agree though, that this is a good example of what you get when you order seed from the National Repository, and it shows you that you should purify the type, or extract to selections and clearly label them as different before you circulate the seed. We try to re-number and track seeds that have been selfed and regenerated before they are shared. If you are seed-savers and you want to exchange seed, seed tracking is really important.

Takeshi: In particular this variety should be an early variety, but it's not the same as the other Hokkaido varieties and more like the California varieties. So, the entire packet is probably not accurate.

Peter: Following up on Susan, if you grow that out as single seeds and you see an off-type, you have two options. You can remove the off-types and tag the ones that look the way that you want them to look and save that seed for the next year.

Audience: Sometimes an off-type might have important traits. It could be a mutant that you might want to keep.

Peter: You could save it and then test it further on but if you want to get good seed of one variety to give to your neighbor then you would want to do that.

Susan: This is an important point because most of the early breeding activity in any region is just the selection of off-types that perform better than the norm in a particular environment. Off-types are really where the geneticist's eye comes in because it can see the value of a particular plant or trait, where others might not notice.

Audience: If you are trying to push production toward colder regions, then you could evaluate the off-types that are northern inclined.

Audience: Didn't you say that there is a 2-3% chance of cross pollination but wouldn't there be a slight tendency for that to be exaggerated in a close and diverse planting like this as opposed to someplace where they were grown in a bigger field? So, if you are exploring a new climate and you have already grouped together some of the more cold hardy or short season varieties I would think that the off-types would be the most important ones to be saving because that's your breeding.

Susan: Yes, and there are different reasons why things appear to be off-types. It could be because they have outcrossed and give rise to offspring that are completely different than the mother plant. Or it could be that the wrong seed got stored in that package, but it still could be your favorite. I can tell you lots of stories about how good varieties came out of off-types. But I do agree with you that when you are doing variety trials with lots of diverse materials in a small area, the chance of outcrossing is higher and your seed management practices have to be different if you want to hold onto a particular type of plant. If you are growing a plot where the plants are all genetically identical and they outcross with each other, we don't call it an outcross because it doesn't have any genetic consequences (i.e., genetically it would be the same as a self-pollination). But when plants cross with neighbors that are genetically different, then the progeny will look different, and that is breeding, whether you control the cross or not, and it offers you a chance to impose selection.

Audience: Well, that is what I am thinking. If it comes in on seed that you are getting from some big outfit, it could have gotten mixed up any number of ways. But in this situation where you are taking the grain you get off of these plants and planting it as seed, it seems to me that you would get quite a bit of cross-pollination. I mean if you get 2-3% under average conditions and here you have all these different varieties close together, then you might get quite a few.

Susan: You normally won't even get 2-3 % unless you get significant stress (causing pollen sterility) or wind that moves the pollen in an unusual way.

Peter: Because they have already self-pollinated before they open.

Audience: When you are working with the landraces, they tend to represent genetically different gene pools, so you will see a lot of genetic diversity within these types of varieties. They offer you the chance to select individuals that are best adapted to your local microclimate.

Peter: I should clarify what I mean. If you had a mixture in there and you saw lots of variation, for example in flowering date, which could be very important. Then if you saw an off-type that was flowering a little bit earlier, obviously you would want to keep that one and it is almost like a pedigree. You tag it and see how it does. But if you saw some in there that hadn't flowered by September then those are not going to be adapted to the area. So, it is common sense really. You have to know what you are looking for.

Audience: Might you consider providing wind to promote cross-pollination?

Peter: You would probably want to do that through a breeding program and have controlled crossing. I worked a lot of time in South Asia where they have deep-water rice and one of the characteristics they use for controlling flowering is to have some form of photoperiodism in the seed. This means that it doesn't matter when you plant it or what the weather is like it, it will still only flower on that same date because it has photoperiodism. It looks for the amount of sunlight and the amount of light.

Susan: Photoperiodism in rice means that it won't flower under the long days that you have here. Rice normally requires short days (less than 12 hours) to flower.

Peter: As the days get shorter, the change in photoperiod triggers the flowering response.

Takeshi: The Hokkaido variety reacts to heat and that is why I had a problem with the seedlings. If it is too hot during the seedling stage heading will be triggered, but long days are not a problem and even beneficial for the plants. This means that in the Northeast or even Quebec, we can grow rice because we have a long, dry period from May to September. People don't usually think of it in that way because winter is so cold. But to grow these rice varieties, our only concern is from May until September, weather conditions, and how much heat we can get.

Peter: Growing seedlings is important because it can save you 30-40 days of field time. But if it starts to flower after 4 weeks, then one way to stop that would be to have some form of photoperiodism.

Takeshi: We have a really short growing season here and even if we use the full growing season, we just barely make it. So, that probably works better for lower latitudes like New Jersey or the Great Lakes area. In that situation another type of rice could be better instead of this Hokkaido variety.

Linda: We now have 45 varieties here on the farm and Sylvia is going to help with seed saving. If we want to maintain all 45 varieties, how much rice do we have to grow to maintain the seed? If one person has 1 bucket of rice, 1 seed or 2 seeds, can they then distribute that seed to their friends and call it that variety?

Susan: So you want to start a seed-savers exchange and you want to know what to call things?

Linda: First question is how much rice do they need to grow? How many plants in order to keep that seed?

Susan: One kernel of rice, if it germinates and grows well, will give you 500 kernels back. If you have 45 diverse varieties that actually flower here, then the question is how many varieties do you think you need? As diverse as these varieties appear to be, the genetic base of all that you are looking at here is infinitesimally small compared to the variation that is available in the species. There just aren't a lot of varieties that are adapted to the temperate climate because they have already been genetically bottlenecked during the process of adapting them to the long days and short growing season that is characteristic of the temperate zone. Only a small fraction of all rice varieties will flower under long days, because that is not their native habitat and it requires a mutation in the flowering time pathway to allow it to happen. We can expand the genetics by making crosses among individuals that are more genetically diverse but it seems to me that you could decide whether you want to do that as a community. I think you are going to be up against what I would call participatory variety selection for the next 10-15 years. Each of you are going to have a different microclimate and the one that does best on this farm might not be the one that does best in upstate New York or somewhere else. I think you should try to keep as much variation as you can handle, but there is a balance between variation and predictability, and most of you will want something you can count on to produce seed, so you won't be able to handle too much variation.

Linda: But if someone grows Hayayuki and has one plant and then another person grows the same variety but has 5 plants. Can they still call it Hayayuki after that point?

Susan: You can. I would advocate strongly for a designated pedigree system and seed management so that you know how many generations from your source seed you are. As a community you should keep a stock of source seed from which you all originally collected. Then the experiment and the excitement is what happens after 5 years of each of you growing what you think is the same thing. If we track the seeds, we can do the genetics and find out how similar they actually are after 5 years, and we can assess the adaptations selected for in each of your environments. This will tell you a lot about your genetic and environmental variability. Interestingly, this is how it is done all over the world because most farmers save seed. If you think about the most widely planted variety in the world, an indica variety called IR64, which is planted on, I don't know, 100 million hectares, it started at IRRI and the seed was given out just like seed savers. It was given out to farmers who have grown it all over Asia and saved seed over the last 40 years. We can go and collect seeds from 15 different countries, run it on sequencing gels, and look at it to understand how similar or different the accessions of IR64 are from different countries. At this point, it is incredibly, genetically diverse because the seed has outcrossed with regional varieties and been selected over the years by different farmers.

Christian: After how many years, since the IRRI variety was introduced, did you do that analysis?

Susan: We started looking at the variation after about 20 years had passed because that was the time when we first had the technology to do that. I think you guys are actually living in an incredibly interesting moment because you can use your own community agricultural system to ask questions about genetics, using what are now very cheap and effective genetic tools, and you can manage seeds not by engineering them but just seeing what works and why.

Linda: If Sylvia has 10 people working to save seed and we have 45 varieties and each person takes so many varieties, how many plants should they grow? Should they grow 10 plants?

Margaret: You have to realize that you are not going to have, in the way you would with a cross-pollinated crop like corn, that problem of inbreeding depression. Rice is a crop that is naturally inbred so you are not going to see a problem of genetic decline within a variety, very readily. Your genetic bottleneck might be how many different varieties are you going to keep here. That would be more likely where you would run into a bottleneck.

Linda: What we told Sylvia is that technically you could have one plant. You could save the seed with just one plant but if you grow three plants, then you could tell if one was different.

Susan: We would recommend a minimum of six plants. The reason is that this is both a row and if there are off-types you get a sense of quorum, what is the norm, because you will have seed mix-ups. So, if you grow 6 plants you would want to save 3. The other way that people do it is they grow a plot, for us this might be 20 plants, but then you can have borders. Generally, you save plants from the internal part of the plot because if they outcross, they've outcrossed with something that is genetically like them. But you have to have more land to do that. I would say plant 6 in a row, and space the plants so that your varieties are a little bit farther apart -- not so close that they are touching, when you are doing seed amplification.

Linda: Like 5 feet, 10 feet?

Susan: No, like 2 feet. Like the row spacing that you have right there.

Audience: One aspect that I think is really important is that the diversity could be beneficial. With the wheat varieties that I am working with, I am trying the pedigree or the identified varieties and then a mixture of varieties. From my data so far, the mixture is yielding higher and has less disease than any of the single varieties.

Susan: That's breeding. That's where we get into breeding. So, you are doing participatory breeding at some level.

Audience: Right, but I am just saying that its something for us to also put in the hopper as a community that might self-organize a seed saving initiative. There is value in the mixture as well as the importance of the individual.

Susan: And if they are actually all as genetically similar as I bet they are, you could sell them as mixed lines too. You could get lots of interesting mixtures as long as the cooking time is the same. That's the biggest issue. As long as you trial this in terms of how they cook up, mixtures actually may become your trademark.

Peter: There's a lot of research in wheat that mixtures are definitely better in terms of disease, etc. The problem is you want to make sure that they all mature at about the same time. One of the things I wanted to raise is, you talked about growing 30 varieties here, but to me it seems the important thing for this part of the world is to have a market for this rice. You got to have something that people are going to say, "Oh I want to get that rice." You may have 30 varieties here but they won't all have the same quality. You are going to have to decide which ones you are going to multiple and give to your neighbors and the quality will vary depending on the environment also.

Audience: I think that is an important consideration though, because if we aren't differentiating this rice then we are competing with rice that we clearly have no competitive advantage with. We are really only talking about people who are interested in having northern grown rice and other ways of differentiating it by flavor or taste or the aromatic rice you were talking about. Something that makes it special.

Audience: One thing very quickly, just going back to the question of minimum population. Most selfers you could technically save one plant and it is sufficient. I think we are talking about two different avenues of activity here because if you want to preserve a variety, I think it is very helpful to have a very accurate physical description to accompany that seed. So that if someone is interested in preserving that specific variety they can do that and if some off-type appears it can be rouged. At the same time what we are trying to do here is develop varieties that are suitable to the Northeast and that is a little bit at odds with keeping a variety pure. If you have an accurate description of the original characteristics of the variety then you will be able to compare in subsequent years or subsequent crops or in different areas what kinds of different expressions you get within that variety. That is also useful because you can see how it's evolving in different areas and select according to that.

Audience: If that's the case then you might not have all the genetic variability in every single plant so you actually may want a population so that you can keep the variability within the variety.

Susan: You want lots of different varieties, but if you are breeding you need to make populations. Because you are in a region where things are not very predictable weather wise, you probably need to manage 4 or 5 varieties every year because some years, some are going to do very well and other years others will do better. Whether you want to allow them to mix or keep them clean is a choice of how you market them and how each of you wants to manage it. If you just want to produce mixtures and want to be productive, you can maximize mixtures. If you want to keep varieties so that the consumer gets something that they can reliably call a specific variety, for example a consumer liked this one last year and they are looking for it this year and that is how you are building your market, then you will have to manage it differently. But I do think that every group in every location is going to want to grow more than one variety every year. The question is how you are going to manage your seed saving, which is a different question, I think.

Rice Paddies in the Watershed Context: Marie Caduto

I am the DEC watershed coordinator for this region and from the discussions that we've had so far, I am interested in figuring out what other benefits beyond a productive crop could come from this whole effort. When you look at the different aspects of what is ultimately a constructed wetland, can we make it something more than a crop? From my experience looking at water quality and agricultural issues, certainly the thing that comes to mind is the large land base of prior converted wetland areas that are used as active agricultural lands in the state. Farmers are not going to give up that land for production, but is it possible to use it in a better way that will serve more purposes? One of the things we have talked about is can we use this system of a constructed wetland that is growing a valuable crop, to do some water quality work, some watershed work? What I would like to talk about and would like feedback on is the concept of using this system to do some farm water quality treatment. You are growing a crop in a wetland that needs high nutrient levels. Can we use the runoff from the farm, run it through this system to pick up the nutrients and grow the crop, and the water that is coming out the other end has fewer nutrients in it to reach the watershed. Obviously there are issues with that. There are probably going to be bacterial issues with the crop. How do we deal with all of those things? Is this a feasible concept? Is this something we can fit into the system? I am not talking about chemical wastes but basically barnyard manure runoff, an organic product, can we use that to grow this organic crop? That's what we are talking about and I am here mostly to hear what you folks think. Is that something that could be done with rice? I'm looking for feedback on that to see where we could go with this. There is certainly a wildlife habitat benefit and a flood control benefit if we do it at a larger scale, but is there also a water quality benefit that we can gain from doing this? I am looking for input on this so that as we move forward we can study this and design research projects that could examine whether or not this might work. Any feedback or ideas you have on that concept I would be very open to hearing.

Audience: How do you manage the fertility of the rice in the paddy? Is it just rice after rice after rice every year and that works fine?

Takeshi: Every year I add amendments, similar to other crops, like manure and compost and till it in. You can spread it on the water surface or we are thinking about using liquid fertilizer or manure runoff. We have to calculate when, what kind of liquid fertilizer, and how much to use.

Audience: Can you grow rice in the same paddy year after year without rotating? Are you tilling in compost on a yearly basis or you haven't had to do that yet?

Takeshi: So far I have only used dried chicken manure that I spread from the surface. Of course you can mix the manure in but the problem is I don't have a tiller with the correct tines and tires for the conditions in the wet paddy. I have had to modify manure application based on what I have but there are many ways to do this. Once you construct the rice paddy, it will last forever as long as you provide minimum yearly maintenance, like weeding or hoeing in the fall.

Audience: Crop rotation is not a standard practice with organic rice growing?

Takeshi: Construction of rice paddy itself is an intensive process and it would take too much energy to change it every year. Also, there is no need because you are using water. Probably, someone today can explain about the magic of water and how it works for the crop.

Peter: I just want to add that rice is a very heavy user of nutrients, particularly if you want to get 5-ton yields or high yields. If you are okay with getting 1 ton or 1.5 ton yields then maybe the soil supplying capacity is sufficient. If you are removing all the straw and you are removing all the grain, you are essentially mining that soil of nutrients and you will need to put something back. If you continue growing rice without putting anything back, after a while yields will start to decline. Instead of removing that straw you can actually cut the straw and leave it in the paddy. When you prepare the soil later on, you can use the straw and you are putting back some of the nutrients. The roots obviously supply some nutrients and the straw but you are still exporting the grain. One big problem with returning organic matter to the rice paddy is that you are keeping the soil anaerobic, which increases methane emissions. Flooded rice paddies are one of the big human sources of methane. Methane is important to think about environmentally because it has 23 times greater heating capacity of the air than carbon monoxide.

Marie: In large rice paddy systems, how are the nutrients managed?

Peter: It depends on what yield you want. Many of the farmers in South Asia, if they are satisfied with a 1-2 ton yield they probably use compost and things like that. If they want to get 5, 6, 7, 8-ton yields, which may be needed to feed the world, then they usually use some form of chemical fertilizer like urea. Usually urea is a top dress because rice is a very heavy user of nitrogen. That relates to the nitrogen cycle, which we will talk about later, and what happens to nutrients in a flooded paddy compared to a dry field.

Audience: I worked for quite a while in ecosystem-based sewage treatment and I would be delighted to work on a cooperative research project. On our farm, we have a fresh supply of water, a stream, and are constructing a fishpond and we want to have the rice paddy as the treatment system for the fish wastewater and irrigate our crops after that. There are also a lot of aquatic food webs going on in a rice paddy, particularly right here. You have lemna, duckweed, which is 40% protein and when you feed it to chickens it makes the yolks really yellow. If you put in azolla it's an excellent aquatic cover crop. So really there is a lot of nutrient cycling and diversity that can be harnessed and utilized in an integrated system.

Judy: There are a couple issues in particular if you are looking at manure and runoff from dairy operations. The primary nutrient that needs to be dealt with is phosphorus and unless you have a pretty deep wetland to begin with, it's not going to address the phosphorus issue. If nitrogen is the nutrient that is needed, then what you want to be looking at is where you could use it in terms of field runoff and where you don't need to deal with phosphorus. You would really want to look at that issue. Of course if you are talking about a dairy operation, you are also talking about pathogens and you don't necessarily want those running through a rice paddy.

Audience: How would that apply to horse or chicken manure?

Judy: I don't know that much about horse, but probably the same issues.

Audience: They have been using fish in symbiosis with rice for hundreds, if not more years, is that true?

Peter: Oh definitely, there are a lot of places particularly in China and Vietnam where the rice/fish system is very important. The fish make channels in the paddies where they can go if the paddy should dry out. The fish provide waste and therefore nutrients, they stir up the surface, and help with weeds and pests. It would be very interesting to try some, but which fish would you put in here?

Marie: In Vermont that is very well regulated and we have one fish that you can put in.

Audience: I would advise that tilling in rice straw after harvesting while it is still fresh is a good practice. After that putting in hairy vetch and tilling that over in the spring is a little bit of crop rotation.

Audience: Aren't ducks also traditionally a part of the same fish and rice poly-culture?

Peter: Yes ducks are another one and you can also see ducks growing in paddies. They sometimes can eat the rice buds though.

Audience: In terms of water management, do you have to dry out the paddy completely at certain times?

Peter: It is probably a good idea to dry the paddy out. The problem is, coming back to the hairy vetch, you put in something like a hairy vetch and you increase the nitrogen content of the soil. When you have dry soil, the nitrogen is in the nitrate form. Then when you flood the field, the nitrate washes away and it can pollute groundwater. You can have the same problem if you dry the paddy out again and the ammonium nitrogen is transformed into nitrate nitrogen. People in China say that you have to plow up the soil and expose it to the sun because this is good for rice paddies. But it is really hard to plow heavy clay soils.

Takeshi: One thing we really have to keep in mind is this cold climate. Adding any organic matter like straw at the end of the season is hard because it will not decompose until the next spring and it will take time. Towards the end of the season is when decomposition really gets started and this may cause an oversupply of nutrients or pollution at that time. In Hokkaido now the big issue is the amount of organic matter and how it is used. Their official recommendation is to compost the straw before returning it to the paddy if you really want to add organic matter. Because of the cold climate here, it is best to compost chicken or cow manure first and then spread in the early spring.

Peter: In China they will do the composting in a small section of the field. They have these pits in the corners where they put the straw and compost everything because you don't want to take that straw somewhere, compost it, and then have to take it all the way back again. You want to try and compost it close to the field to reduce the cost.

Susan: I don't know the specifics but you might want to take a look at the policies that were put in place in Australia. Australia has a very small rice growing area but it is temperate rice, much like here. Two features that might interest this group are: 1) they had the highest yields in the world and 2) they had an irrigated desert. The point I was going to make is in regards to the management of water. Water is so precious in Australia that every year the farmers are allocated a certain amount of irrigation water for rice. By the way, they are out of business now because of the drought so this is past tense. They were allocated a certain amount of water per season and then at the end of the season they returned all the irrigation water that they could and they got water credit back. They had to return that water through a filtration system and they had a way of metering the water so that what was lost to evaporation and to any kind of cleansing that was required, was paid for. It's costly but it depends on how much you value your environment and your water. There are ways to account for and credit clean water used and clean water back and I just think it might be useful to think about.

Audience: I was going to ask a little bit about that water use. Is there water cycling that goes on or does the water stay still in the reservoir.

Linda: Can you explain the water system? What are our sources of water for the fields, how do we use the water, and where does it go?

Takeshi: This is our farm right here and you can see water flows this way and the other side goes the other way. About 1,000 feet to the north is the ridgeline. Which means we are almost at the head of the watershed and so we do not have permanent running water. Usually we have seasonal running water and by this time it has dried up, but this year it is still running. If you have consistent supply, that's probably good. We use surface water plus water from a shallow spring and collect it in that holding pond so that we can use it for the rice paddy whenever it is needed.

Linda: Do you drain the rice paddy? Does that water ever have to run into the system?

Takeshi: This system, I call it a system because any growing method is a combination of factors including varieties, soil type, and type and amount of fertilizer. If you change even one thing, you change whole system. Whether it is better to dry or not to dry the paddy is not that simple. I don't dry until harvest time because of wetland issues. This rice paddy is functioning like a wetland and if you dry it out all the aquatic organisms will die, including the tadpoles and insect larvae. It may be better for the rice but we don't know how much of an impact this has on rice productivity and if it's only 5% or 1% loss in yield, then I don't mind. It all depends on how you want to manage the whole system.

Linda: I just want to add one thing. At the end of the season he doesn't drain the water in order to get in there with the machine, it naturally evaporates. He just stops adding water.

Takeshi: The result is that it gradually dries up. If there are 2-3 weeks without heavy rain then the rice paddy will dry up nicely.

Audience: In the winter these paddies are empty of standing water?

Takeshi: That is what I have been doing because of another issue.

Audience: Don't they just fill up with all the moisture in the winter and freeze?

Takeshi: If you plug the outlet then it will hold water and in the early spring you will have a nice shallow pond.

Linda: We did that one year and all the wood frogs came and laid eggs. We had to manually remove them in order to drain the rice paddy to get in there and till.

Takeshi: When you transplant rice you must have a very small amount of water. I transplant in the middle of May and the wood frog came in the middle of April. Of course if you don't care about wood frogs then you can just dry it or leave it wet. It all depends on your goals and what is important to you as a farmer.

Audience: When you run out of surface water do you use well water?

Takeshi: During July/August when water is needed the most I will try to get it any way that I can. First using surface water, secondly water from the shallow well, and then in the worst case using our house well, which is 50 feet deep. I really don't want to use that but one year it happened.

Audience: Is there topsoil on top of the hardpan and what do you transplant into?

Takeshi: The topsoil is 4-6 or even 8 inches deep, depending on your location and your soil. Also if you manage your soil well, you can gradually increase your soil even if you start with only 4 inches.

Peter: Most farmers would never do what you said. Take the soil off and then put it back again. What they do is something we call puddling. They plow the field when it is wet and this disperses the soil so that as it naturally settles, a plow pan forms.

Takeshi: I am saying that when I first constructed the paddy I did it that way. On a yearly basis, the way you explained is common in Japan too.

Peter: You can use a plank to move the soil and level it out.

Takeshi: That practice is very essential when your soil is not holding water well. The Japanese call a paddy that doesn't hold any water a "basket paddy". Puddling, by mixing the soil with water, creates a hardpan layer that slows down water percolation through the soil.

Christian: Also, old farmers used to spread clay over the surface to create farm ponds.

Takeshi: If you have that luxury of available soil, you can do that.

Audience: Talking about Vermont, I think of all these vernal ponds I have at our house that fill up in the spring. They are sitting in pine forests and fairly acidic soils. How tolerant are rice paddies to pH changes?

Peter: This is what we are going to talk about a little later, but essentially when you have the soil flooded and its anaerobic, the pH tends to be around 7. If you have acidic soil, it is when you dry it out that it becomes acidic. The beauty of rice paddies is that the pH is close to 7 and therefore nutrient availability is maximized.

Audience: I just have one quick question, in terms of using dairy manure. Are you talking about composted manure or straight slurry pit, or what?

Marie: The thing that came to mind for me is the Putney School. They have a farm where they separate their solids, which they compost, and their liquids they store and field spray. That is what I was thinking but I don't know. That is why I am here. I don't know if that is a concept that would even work or how that could be managed.

Audience: A question or concern about that would be how that would affect organic standards for time from spreading a non-composted manure until harvest. I don't think the time would work out, from time of spreading until the rice was harvested.

Cheryl: If the edible portion of the crop is touching the soil, which in this case it wouldn't be, then there is the 120-day requirement. If you could spread early enough, 90 days before harvesting, it could work for rice.

Linda: You could spread manure up until June and you wouldn't want to add manure any later anyway. Right?

Takeshi: Depends.

Marie: That is something we would definitely have to look at. There are a lot of things we would have to look at. Thank you for your input. This has been really helpful.

Nutrient Management in Rice Paddies: Peter Hobbs

Linda asked me to talk a little bit about nutrient management. For growing rice, I think the most important nutrient is nitrogen. Nitrogen in the soil comes in many forms. In soils that have very little oxygen, anaerobic soils, nitrogen gets reduced to the ammonium form. Rice prefers to take up ammonium nitrogen. On the other end of the spectrum, where the soil has oxygen, the nitrogen gets oxidized and becomes nitrate. So you go from ammonium to nitrate depending on whether the soil is flooded and anaerobic or whether the soil dries out and has oxygen. Those are the two major forms of nitrogen that exist in soils.

When you dry out the soil, the ammonium gets oxidized and goes through various stages. One of the stages that you get is nitrous oxide. I can't remember all the stages, but there is nitric oxide, nitrous oxide, nitrite, and nitrate. There are bacteria in the soil that actually convert the nitrogen to these different forms. One of the problems that we talk about with global climate change is carbon dioxide, but nitrous oxide is also a very serious greenhouse gas because it can warm the atmosphere 310 times more than carbon dioxide.

If you dry out the paddy during the growing season and you allow it to become oxidized then the nitrogen is going to be converted into nitrate. Nitrate is soluble in water and will leach easily when you get excess water. You lose nitrogen that way. In contrast, ammonia gets fixed onto the clay particles and doesn't get leached. In terms of nitrogen management it is quite important to keep the field flooded if you don't have a water constraint.

What we are finding in South Asia is that water is becoming more and more of a critical issue. You have probably heard of something called SRI or alternate wetting and drying. With this practice you can reduce the amount of water you use by wetting the paddy and letting it dry until it is just below saturation. A saturated soil is a soil that holds a certain amount of water and you don't lose the water by gravity feed. If you have more water than the saturation level, water will move vertically through the soil. For nitrogen management it is really important to understand the nitrogen cycle and nitrification and de-nitrification. De-nitrification is going from ammonia to nitrate and nitrification is going from nitrate to ammonia.

Another important thing is pH. When you keep the soil flooded and anaerobic the pH of the soil tends to be around 7 or neutral. Even if you have acidic soils, if you keep it flooded it will become neutral and this is also true for alkaline soils. Most of your nutrients, micronutrients, and major nutrients are most available at a pH of 7. With acidic soils you often add lime to get the pH closer to 7 so that you have more nutrients available.

One nutrient that is really important for rice is zinc and I think that possibly some of the fields out here have zinc deficiency. Usually it can be easily corrected by putting some zinc in the compost or dipping the seedlings in zinc oxide, when you transplant them. You can easily find out if you have zinc deficiency by taking a little zinc sulfate and spreading it on the areas where you think you have a deficiency. If it turns green then you know you have a zinc deficiency problem.

Question and Answer

Audience: You mentioned alternating drying and wetting. If you use that method, how would you prevent the nitrate from leaching out and the pH from going down? How frequently would you need to refill the paddy?

Peter: That's where the trick is, you need to let it dry to a point where you are not converting large amounts of ammonia into nitrate and then wet it again. Many of the farmers in South Asia rely on rainfall for water. If they drain out the water in their rice paddy, it may not rain for the next two weeks and then they have an even worse problem. I think for Vermont you really would want to choose a location where you could keep standing water throughout the growing season because of heat and water functioning in moderating temperature. You probably wouldn't want to consider wetting and drying. When I talked about draining the field, I talked about after the harvest and before the next crop.

Audience: I was just thinking that if you were in a location that was good but didn't have quite enough water, could you manage it that way?

Peter: You can definitely save water by wetting and drying but it depends on how well you have puddled the soil and reduced the percolation of water. If you got a nice heavy clay soil and you have really reduced the percolation of water, then maybe you can get away with less water. In sand, forget it. You would be wetting and drying all the time.

Susan: Also, the wetting and drying technique requires that you bring water back at just the right time before you lose that saturation. Water control is often much harder than just having water. If you are short of water, this may not be the best strategy because it is technically more demanding, depending on what your water management conditions are. If you know you have a water shortage and if the absolute amount of water is the limiting factor that's one thing. If it is just the reliability of the interval with which you have the water that is a different problem.

Peter: One of the biggest reasons for keeping the paddy flooded in South Asia is to control weeds. When you drain the water and the paddy dries out, this stimulates a flush of weeds. That's another thing you have to keep in mind. I don't know if you have problems with weeds here. Even if you don't have any problems at the moment, as soon you try to grow an aerobic rice, where you use less water, the number one problem becomes weeds.

Audience: What about algae?

Peter: Well the algae would probably dry out when water is removed. Algae can be important since some of these algae are nitrogen-fixing algae or bacteria. For example, the azolla is a synergistic relationship between a fern and a Cyanobacteria that fixes nitrogen. There are a lot of microbes that live in paddy soils that have many functions like this.

Audience: Another reason why you should dry out the paddy between seasons is to control the number of tillers. I think it depends on the variety but usually we plant rice and each plant has between 16-20 tillers. If we didn't dry out the paddy, the plants would make more tillers, which require more nutrients, or the number of rice grains in one panicle would not be good enough. That's what we do at our farm.

Peter: That's interesting. I think if you have a soil that dries out, try wetting and drying and see if it increases tillering. Interestingly enough, rice is not an anaerobic plant. It gets its oxygen by pumping it through very specialized cells down in the root, called aerenchyma cells. Rice will actually grow as an aerobic crop. However, growing rice under aerobic conditions results in problems with weeds, pH, availability of nutrients, and different types of diseases. I think what has happened is that most rice breeders have selected varieties under flooded conditions and so they are adapted to being flooded all the time.

Susan: Don't forget that Peter is talking about tropical rice and the varieties here at the Akaogi Farm are temperate rice. In Japan most farmers dry down their paddies early in the season in order to control tillering because their varieties, these temperate japonicas, are much more determinate than the indicas. This is a genetic by environment interaction. The Japanese farmers and probably many of the Korean farmers practice that because those varieties otherwise put out a lot of non-productive tillers. They don't want to support that extra growth and they want to restrict tillering to the productive ones that are going to have time to set seed before the end of the season. For those of you who are coming from the temperate region, this observation is kind of important.

Audience: At what stage of growth is that done?

Susan: About 5-6 weeks.

Peter: Usually during the tillering stage.

Audience: I think 2-3 weeks.

Susan: They keep them dry for 2-3 weeks?

Audience: Until the paddy surface starts cracking.

Susan: How old are the plants when they do that dry-down?

Audience: A couple weeks before heading.

Audience: Before flowering?

Susan: Yeah, before flowering. You don't want to do that at flowering.

Audience: A couple weeks before flowering?

Susan: You have to know when panicle initiation is.

Takeshi: Also, the drying is done because they plant many seedlings at each spot and so if the plants keep developing tillers it will become too crowded. At some point they want to control the number of stems and heads by doing that. But if you start differently, with fewer seedlings, then you don't need to do that. It always best to understand how your particular system works and we should be careful about applying a technique without understanding the reasoning behind it. Each technique will have different results depending on the context.

Christian: About duckweed or azolla as a cover crop, is there a tradeoff there between absorption of warmth and light for the paddy versus having the water covered? What do you think about that?

Peter: I don't think so, it is on the surface.

Takeshi: It does reduce the water temperature about 10 degrees or more.

Christian: Is that a disadvantage you think?

Takeshi: If the water surface were covered during the early stage, in June, when heat from the sun can get to the water it would probably be a disadvantage. Right now the rice is so tall that the paddy is covered by vegetation and it doesn't matter that much.

Peter: This is also another difference between tropical and temperate rice. For tropical conditions, you want to have cooler water.

Christian: Also, a question for organic farmers. What is the best way to input zinc?

Peter: Probably zinc oxide applied to the seedlings at transplanting or zinc sulphate.

Cheryl: I don't know off the top of my head, but I think there are different formulations, like zinc sulfate, maybe zinc oxide, that could be used.

Peter: To me those are good sources, but are they okay for organic standards?

Cheryl: That is a mineral, minerals are allowed.

Peter: Zinc sulfate would probably be the easiest to get a hold of or zinc oxide. We used to have very serious zinc deficiencies in Bangladesh. The women in Bangladesh put zinc oxide on their face to make them look pretty and so the Extension person told them to put the zinc oxide on the rice seedlings to make the rice look pretty. Just dip the seedlings in a suspension of zinc oxide.

Takeshi: I would like to hear from Peter the general pros and cons of growing upland rice versus flooded, paddy rice.

Peter: Upland rice is grown just like wheat, barley or oats. You plant the seeds into the dry soil and you don't flood it, you don't puddle the soil, you just grow it like other grains. It is grown in quite a number of upland areas in Asia. Upland rice is different and there are different varieties that are adapted to those conditions.

Takeshi: Why would farmers want to grow dry land rice?

Peter: If the land is sloping and there is no way that you can pond the water, then dry land rice might be the better option. In Nepal they grow upland rice on the sloping land or they make paddies by terracing. They plant paddy rice on the terraces. You have probably seen some beautiful pictures of terraced rice from the Philippines but there is also a lot of upland rice in the Philippines where they don't make the paddies and it grows like other cereal grains.

Takeshi: What is the difference in production?

Peter: It does produce much lower yields and has more problems with weed control. There are also certain pests and diseases. You would have to pick an upland variety. If you grew a paddy variety in the upland it probably wouldn't have good yields.

Susan: Upland varieties typically invest a lot more of their photosynthate into root development and they have a deep taproot, which allows them to access water that is deep in the soil because they can't get it on the surface. You also see differences in plant height. In order to have a deep root you also have to have a tall plant. The plants are tall to be weed competitive, they have early vigor to be able to come out of the ground fast, and they invest a lot in that taproot. That taproot is curious because it depends on your soil whether it is valuable or not. In mountainous soils, there is water deep down but you can't get to it without a taproot. There are also different types of uplands and upland varieties have developed different adaptations such as resistance to aluminum, which is very prominent in mountainous, dry soils that also tend to be acidic. There are a lot of other genetic characteristics that come with an upland variety. Even if you don't know that much about your soil, an upland variety will have a suite of traits that come with it. As Peter said they are typically lower yielding because they are investing so much in the biomass below the ground. That is a very interesting component for breeders right now and could we in fact, if we knew what to select for, take advantage of something like aluminum tolerance and through just crossing and selection could we move that trait over to a variety that you wanted to grow in a shallow soil where you didn't need the tap root? Right now most of the upland varieties are bred for these mountainous soils where subsistence farmers have no water or no reliable access to water so they depend on rainfall. In addition, they don't usually have access to fertilizer so they are producing low, reliable yields with little to no inputs. Usually zero input agriculture is associated with poverty in the rice-growing world, but interestingly in Brazil this is not true. Brazil has a huge amount of savannah land that is very inaccessible and isn't very fertile. Because they don't get much crop value if they have to add anything they grow almost all their upland rice with zero inputs. They import very little and they feed a good segment of the Brazilian population on this very low-yielding rice. In this situation, economically that is the best thing for those farmers to do with that land. I think those are good examples of optimizing yield and optimizing inputs and focusing on water management, in certain environments, may not be the answer you are looking for. I don't know.

Audience: Then why isn't upland rice being tried here? It seems like it's perfect.

Christian: I have been growing one variety of dry land rice, which I got from Cornell back in the early 80's, until 2 years ago. Two years ago I switched to the paddy. The yield is much lower and also the other difficulty is, still at least in this climate, for a reasonable yield you need to transplant. The labor of transplanting dry land rice is huge compared to just dipping it into the mud. That's another consideration. On a small scale it is very easy to do but there is also the labor of weeding.

Susan: Oh my goodness, the labor of weeding is enormous. We should also say that most of Africa is growing either upland or rain-fed lowland rice. Water can't be used as weed control because of water-borne diseases, like schistosomiasis and malaria, that are rampant in those parts of the world that are not plaguing the Asian populations. The casualty of women and female children who spend their lives weeding, whatever the crop is, it is not only rice, is a human tragedy that people are trying to address. Those girls never get the chance to even go to school because they have to weed the fields. I think this interesting component of weed management and water and soil is probably at the crux of the economics of what most of the cultures that are trying to produce it as a staple food are up against.

Audience: Right and probably in the savannah in Brazil if there is less water there, the weed pressure is probably lower than it would be here.

Susan: Also, they have bred really good upland varieties. They have strong early vigor and they out-compete weeds quite well. When they harvest, they combine harvest and clean afterward.

Audience: I'm thinking, especially if you find a temperate upland rice, that couldn't you have clover as an undercover or something like that to help suppress weeds and give it nitrogen too? It seems also that if it has a deeper taproot, especially for Vermont soils, unless you are in a valley, you are building your soil.

Susan: This is an interesting idea of a mixed cropping system for Vermont. I like this idea and maybe you could do a legume under-crop.

Audience: It seems a rice that could actually take inundation as well as dryness, like a hybrid upland. I don't know whether there would be a paddy rice that could take dryness or an upland that could take water. It seems that rice is partly very exciting for Vermont because a lot of the marginal landscape in Vermont that is not wetland that could grow rice is changing like this throughout the year.

Susan: You mean in terms of water table?

Audience: In terms of water table. The main reason I am here today is to figure out, at least try to get a sense of, what I can do on my land because that is exactly what it does. Less than 15% slope with a perched water table but during the growing season when you want to raise the paddy the water table is doing the opposite and then it is coming back up right at the end.

Susan: Gen aren't there some upland varieties from Japan, from the early days that aren't grown much anymore, that we could try to import?

Gen: I think 2%.

Susan: A very small percent of temperate rice is adapted to uplands. If you just think about the history, people grew rice for thousands of years in the uplands in the tropics. But when rice went into the temperate zone, it was a conscious human effort. It wasn't a slow evolutionary process. It was a very rapid change. It actually means that the bottleneck in temperate rice is that they don't have as many varietal options. It would be an interesting question of whether we could get something to start with and whether we could help breed it. You could select in your fields, but we could help try to import or bring in the varieties you need to start with. It is kind of an interesting option to interbreed and intercrop. As an ancient crop, rice is seen by humans as a monoculture, but this is only because we don't see the microbes. Of course it is never a mono-crop. It is the world's oldest single crop system that is completely sustainable under certain management systems. What you are starting to talk about is intriguing. I know that, at least in our area in New York, when we first seed alfalfa we plant oat and we take off one crop of the annual before. I don't know if you do that here. I can imagine that you sow a nice crop of legume and you over-plant with rice and maybe you only harvest that one season and then you let your perennial fill in. But that is kind of an interesting idea. Margaret, do you see that a lot? Have you ever seen anyone do it with rice?

Margaret: Yes, a lot of grasses serve as a nurse crop for establishing a forage or a perennial. It is not an uncommon one and it provides a lot of benefits to the grass too.

Peter: Just to add, in tropical areas, upland rice is very often grown as a mixture with various other crops. It is not just a sole crop and you see a lot of intercropping and mixed cropping with upland rice. I think one problem you have here with upland rice is something that I call the field date, the amount of time from when you put the rice in the field to when you harvest it. The problem here is that because you have a short season and you sow seed in the field, then you need to have an upland variety that matures in 90 days or 100 days or 120 days. Whereas by transplanting, you save 30 days by not having it in the field. That's why in parts of China and Korea and other temperate areas, to save field time they transplant seedlings.

Susan: The problem actually is that the plant doesn't have time to invest in that root. If it's got to produce seed in 90 days it is probably a self-defeating equation. There is an attempt, or there has been over the years, to capture perenniality and breed it back into rice. It wouldn't work here because your winter would be a killer. Although there are some wild rices that are annuals, most are perennials. The perennial nature of rice is easy to see. It is like a grass; if you mow it, it will tiller back. Gen takes care of our greenhouse and we have a population there that has been tillering for at least 20 years now because it is an interspecific. You can keep rice going. There are a lot of interesting ideas floating around that are both about genetics and your environment.

Takeshi: Our place is really marginal, the coldest climate for growing rice. But if you go to the Lake Ontario area or lower Hudson, you have another 30-45 days and upland rice could be something worth trying.

Audience: Is the upland rice, like the Himalayan region, you said you spent time in Nepal and Bhutan, does that have a longer day growing season there?

Peter: There are also problems with the length of the growing season as you go higher up in elevation. If you get to about 7000 feet in elevation, you don't see rice but there are cold-tolerant varieties of rice that grow up in the higher elevations.

Audience: What is the season length or maturing length for the rice that grows at 5 or 6,000 feet elevation?

Peter: It would be grown during the monsoon and it would probably be on those terraced paddies.

Susan: The difference is that you don't have the photoperiod problem. You have a temperature problem because you are at a more southerly cline. Here you have long, long days but rice normally flowers only under conditions of 12 hours or less of day length. You don't have a single day at 12 hours and by September 21st it is too late to trigger flowering because then it wouldn't set seed for another month.

Audience: Is that something that could be fixed with breeding?

Susan: Yes. That's why all these varieties will set seed in 20 days if it gets too hot. Thousands of years ago, breeders selected mutations that made photoperiod insensitive so it will flower under long days but as a consequence it can easily be tricked by temperature. There are normally two controls on flowering, one is photoperiod and the other is temperature. You take away photoperiod then you can trick it with temperature and the poor thing sets seed when it only has 4 leaves.

Takeshi: Yes it is quite a shock when you see it setting seed at an unexpected time.

Audience: If you could heat your water to any temperature that you wanted, a temperature that would help extend your growing season without causing problems of too much heat, what would be the ideal temperature? Just assuming maybe you had a solar system of tubes, what would you heat it to?

Takeshi: Around 20 to 25 degrees Celsius.

Audience: You would keep it that temperature as long as possible?

Takeshi: It is hard to keep the water that temperature from May to September.
Audience: What is that in Fahrenheit?
Audience: 70-75 degrees Fahrenheit.

Audience: Out of curiosity then, what is the lowest temperature that the rice would germinate?
Takeshi: For the Hokkaido varieties they usually say to soak the seeds around 10 degrees Celsius for 10 days. A total of 100-degree days, which is usually 10 days. You can increase the temperature and soak for a shorter number of days. When you sow the seeds it is just a matter of temperature. If it is cold, they will germinate slowly and if it is warm, it will be quicker.
Audience: What is the temperature of the water that you soak the rice in? Do you try to heat it up?
Takeshi: Just 10 degrees Celsius, 50 degrees Fahrenheit. The Hokkaido varieties need more soaking than the California varieties, which only need to be soaked overnight in most cases.
Susan: In the southern US where they seed their fields by airplane, they drop soaked seed that has already been pre-germinated. That seed is soaked at a higher temperature because the varieties are from sub-tropical germplasm. Fifty degrees is probably good for Hokkaido varieties but it would be a little cold for an *indica* or for a *tropical japonica*. I don't know exactly at what temperature they soak their seed but I suspect it is more like 15 degrees Celsius.
Takeshi: The Hokkaido scientists say that if soak at 12 degrees for 7 days, you will accumulate the same amount of heat but there are some consequences. In general 10 degrees for 10 days gives you most uniform germination. Speeding up germination can cause inconsistent germination and this is important because after transplanting you will get uneven plant growth, one plant will be tall and another will be short. On cold nights you will want to fill the paddy with water to protect the plants from frost and if the plants grow unevenly you won't be able to protect all the plants equally. Under these conditions, how level the paddy is becomes important. They say to make the soil level plus or minus 2 inches. If you plant the shortest seedling in the lowest part of the paddy, it will be under water all the time and will probably not make it. You really want to have uniform growth and that is not easy to master.
Audience: The water temperature is just for ideal germination right? There wouldn't be any subsequent damage to the seed or the plant at warmer temperatures? It is a little tricky to keep water at 50 degrees, if you had something like 60 or 70 degrees.
Peter: If it is too cold it won't germinate. You would have to get up to 40 degrees to cause damage to the seed. Some people actually use high temperatures to break seed dormancy.
Susan: Breaking dormancy is different. We usually do that without water. We do that with heat and you can do it with gibberellic acid sometimes. It is a whole other issue normally not done with water.
Peter: I think what you are saying is if it is 10 degrees for 10 days, that it is a 100 growing degree days. If it is 5 days at 20 degrees it is still a 100 growing degree-days.
Susan: When you hydrate a seed, you initiate a series of enzymatic changes. I actually do not pay too much attention to the temperature when we do it in our lab. We just use water right out of the tap, put the seeds in, and keep them at room temperature. I would say don't worry about it unless you are living in a really cold, cold house. They will be fine.

Peter: You do want to catch the seeds when the plumule is just coming out. You don't want it to be too far past that stage when you sow seed or you can damage the seed.

Takeshi: At the stage where you can just see a little bit of white coming. If there are some seeds that already have plumules that are 2-3 mm long, they can break easily.

Audience: How many gallons of water do you think you use in this paddy, or if you have already extrapolated to an acre?

Takeshi: I don't know.

Peter: This is one of the major problems in tropical rice growing areas, particularly ones where they are relying on groundwater or ice-melt from the Himalayas, like the Punjab area of India. The problem is most of the fresh water that is available, say 75% of the fresh water, is used for agriculture and a very large percentage of that is used for growing rice. There is going to be a need, if they are going to grow rice in those areas and maybe rice isn't the best crop, to grow rice with less water. Then we start looking at how we can get good rice yields by growing it aerobically rather than by flooding. Then we run into all sorts of problems of physiology, nutrition, weeds, and germplasm.

Takeshi: If you look at this from another perspective. For example, the United States has lost half of its wetlands in the last 200 years and we continue to lose more every year. If we recover some of the lost wetland area by putting in rice paddies then we are helping with this important environmental issue.

Peter: You can do that on the East Coast but in California and other areas they don't have enough water.

Takeshi: They shouldn't do it but it seems like we are getting more rain and we really need to understand change and adjust to the easiest or most efficient way so that we can survive. One way would be to create a method that uses less water or a breeding program that creates varieties that use less water. That's one way to go.

Audience: It is slightly different because this is land that is above the water table. If you are not feeding it water, it's dry so that is very interesting. We are talking about a system where we are bringing water either from the surface, somewhere else, or the ground and evaporating it to some extent by growing rice. That becomes a real limiting factor, besides the farm, the exact amount of water.

Takeshi: The main target right now is previously converted land, which used to be wetland and has been converted to agricultural use in the last 200 years. We are just trying to bring back some of the wetland functions that used to exist in those areas while at the same time growing a productive crop. Of course water may be an issue. We need to understand how much water we should use and we shouldn't go beyond that. That watershed calculation has to be done very carefully and coordinated with agriculture needs.

Peter: Maybe with global climate change it is going to get warmer here. I am from the UK and in the southern part of England, we could never grow grapes before. But in the last 5-10 years, grapes have been doing very well there and in fact there has been a problem of growing wine grapes in France because it has gotten warmer there.

Randy: Historically rice has moved north and we just moved south.

Takeshi: If they can grow citrus there, maybe they can grow rice too.

Peter: That is why I was asking if you grow coffee here.

Audience: What about weeds in the paddy, reed canary grass that sort of thing?

Peter: Weeds are a big problem. Many farmers in Asia will harvest the weeds to feed their animals so there are certain benefits. But for every gram of weed there's one gram less of food for the crop.

Takeshi: Around the rice paddy edge there is a hump where grass should be removed. If you cut the grass and leave it on the edge, the soil will get better and better by itself because water is always available. This will encourage voles to come and they will dig holes. That is why it is important to keep the bank as poor as possible. You need to think about how to use that grass to feed to the animals or as mulch. It isn't really mowing or weeding but grass harvesting and it is important to think of the rice paddy as a whole system.

Susan: For those of you who have ever been to a traditional rice terraced system, they grow their vegetables along the perimeter. It is really beautiful in the countryside if you see the rice paddy and the levees around it, especially a terraced hillside, and on those levees all kinds of vegetables are growing. They will be out there in the paddies and they will take a break under an umbrella and they will be eating a cucumber or something right from the garden. It works in terms of labor as well because they plant vegetables and they work communally to plant their rice because it is a huge transplanting system. They manage those two so there is an integrated seasonal commitment to managing the paddy, managing the vegetables, eating the vegetables, and getting the rice. By the time they have used up their rice harvest from the previous season, they get their vegetables and their sweet potatoes and other things that are staples.

Audience: Where is that?

Susan: I'm just thinking of where I recently was in the Philippines, which is a traditional growing area. But this happens all over.

Randy: In the Philippines they have sweet potatoes in the whole paddy field, during some parts of the season. So it is a combination of rice in one season and sweet potatoes in another.

Audience: Can waterfowl be used for weed management?

Peter: Yes, a lot of farmers use ducks.

Susan: And you get the ducks coming in and out. In some parts of Asia there are gleaners, humans who come in to take the grain that has fallen on the ground after the harvest. In other societies they allow ducks to come in and then the ducks eat that fallen grain and they help fertilize during that period after the harvest. I don't know how familiar you are with the California system, but California has a very small percentage of the rice production in the United States and it is temperate. They grow the rice right in the Sacramento Valley, right outside the populated areas. For a while they were using herbicides and the people in Sacramento were noticing an off flavor in their water even though it was well below what was designated as safe. There was a very antagonistic relationship between the environmentalists and the agriculturalists for a long time and then finally they got together and banned the use of the herbicide which basically created a much more organic system. They use very low inputs and no pesticides. Because it is an irrigated desert, which is not a natural system for rice, they can manage it that way. The point is that in the off season, which is winter, they leave the leftover grain in the fields after harvesting and they have seen an increase in the migratory bird populations coming through. They now monitor their migration and the environmentalists are very pleased because that grain is now attracting the migrants that continue on down. Now the rice farmers are really into the ecology of their region and they are attracting a kind of ecotourism that is linked to agriculture and it all started with a rice group.

Peter: They also set aside some wetland areas just for wildlife and they manage it for tourism. They have a rice paddy here and next to it a natural area where you can see all sorts of birds and other wildlife.

Audience: What about geese as a pest during the growing season?

Susan: I don't know what would happen. We have lots of geese. Margaret what do you think about geese?

Margaret: I think that it is a different issue in California than it is here. We certainly have zillions of them here that are not even flying, they are just residents. I don't know how much of a pest they could be.

Audience: So what do they do in the paddies?

Peter: We don't grow rice outside at Cornell.

Lunch

Lunch included various ethnic rice dishes prepared by local chefs including: Jiwon Ahn and Martin Roberts, Roberto and Elissa Gauthier, Jesenia Major, and Robyn O'Brien. The recipes can be found in Appendix A.

Pest Management in Irrigated Rice: Yolanda Chen

Abstract

Tropical irrigated rice hosts an incredibly diverse insect assemblage. While irrigated rice in temperate systems may be less speciose, the system is likely to function similarly. Flooding of the waters stimulates the activity of organisms involved with decomposition. Within a couple weeks of flooding, adult aquatic insects emerge, which are preyed upon by predators such as spiders. As the rice canopy closes, the activity of the detritivorous insects slow and predators switch to prey upon insect herbivores. Therefore, the aquatic nature of the rice crop strongly contributes to a very robust level of natural biological.

New crop introductions in a given area are likely to benefit from a pest-free period, but the number of insect pests on a crop will likely increase over time. Some of the possible insect taxa that may become insect pests are planthoppers and leafhoppers, as they typically feed on grasses. The main rice-growing regions in the US are in California, Texas, and Arkansas. Some of the major pests of rice in the US include the rice water weevil, rice stink bug, and rice stalk borer. Among these pests, the rice water weevil leads to the most serious losses. In Arkansas, severe weevil infestations can lead to crop losses of around 1000 lbs/acre. While the weevil has invaded into other regions, such as southern China, it may not be able to expand into the Northeastern US, because of the cold winters.

In addition to managing insect pests of the rice crop, irrigated rice in the Northeast could expand habitat for mosquitoes. Immature mosquito (larvae) thrive in warm stagnant water. Mosquitoes are not widespread problems in rice-growing regions, suggesting that the composition of aquatic communities might be quite important in determining mosquito populations.

Further Reading

Y. H. Chen. 2008. The unsung heroes of the rice field. Rice Today 7(1): 30-31. http://beta.irri.org/news/index.php/200803305622/rice-today/science-shorts/the-unsung-heroes-of-the-rice-field.html.

D. R. Johnson, J.Bernhardt, G. Lorenz, G. Studebaker, and J. Greene. 2006. Management of the Insect Pests of Rice. University of Arkansas, Cooperative Extension Service, http://www.uaex.edu/Other_Areas/publications/HTML/FSA-2068.asp

S. P. Lawler and G. C. Lanzaro. 2005. Managing mosquitoes on the farm University of California DANR Publication 8158; online at http://anrcatalog.ucdavis.edu/pdf/8158.pdf

W. H. Settle, H. Ariawan, E. T. Astuti, W. Cahyana, A. L. Hakim, D. H. Hindayana, A. S. Lestari, Pajarningsih and Sartanto, Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. *Ecology* **77** (1996), pp. 1975–1988.

Presentation

Linda:	This is Yolanda Chen. We are very luck to have her. She just recently, last year or the year before, came to the University of Vermont from IRRI and she never thought there would be rice growing in Vermont.
Yolanda:	I think I was in Burlington for about a week or so and someone said, "Hey can you come, there are some people who want to grow rice in Vermont?"
Linda:	At the time we were talking to Don Ross to see about soil testing in saturated soils.

Thanks Linda and Takeshi for inviting me. My background is that I am an entomologist. I spent four years at the International Rice Research Institute (IRRI) working on insect problems. My experience is mostly with tropical rice but I did a little bit more background review to try and figure out what might be applicable to this location. One of the first things I want to impress upon you is that rice is an amazingly robust system in terms of the pest management of irrigated rice. A lot of it is because it is an aquatic system.

If you can imagine rice has been grown for thousands of years in Asia giving rise to major civilizations because of water availability. Water coming from the Himalayas feeding the Bamcutra that goes to South Asia, the Yangtze, the Yellow Rivers feeding into China, and then the Mekong. All that water is coming from the Himalayas, which is a really stable source of water, but the crop itself is also incredibly stable because the system inherently has some things that leant itself to very robust biological control. I posted some pictures up here. I will talk about them now and later you can come up and look at some of the pictures in depth. These are some pictures of the rice system up close. This top one is looking at the aquatic nature of the crop and some of the major players in the system that you notice in there are basically natural enemies. There are a lot of spiders. I have one picture in particular that I think is quite interesting because you see that the spider has its web basically parallel with the water surface and that's part of the key to understanding how the system works.

Before I go too much into the system itself, I want to tell you that a lot of the concerns around pest outbreaks have actually been due to disruption of the system. There have been, at different times, excessive amounts of pesticides used and a lot of it is ultimately fueled by cheap pesticide prices.

The latest case is in China where there is an entire ministry around pesticide production and China is flooding the world now with cheap pesticides. We are seeing now, mostly in China but also in Southeast Asia, which is one of the outlet markets for Chinese pesticides, an increase in outbreaks of insects. This is because the system and the inherent biological control that's within the system is now being disrupted. One of the key pests, the brown plant hopper, you can see here in this picture. All these little white dots in the picture are clusters of at least hundreds of these small little plant hoppers. Insects such as these only have an outbreak when pesticides kill off their natural enemies.

So, how does the system work? This diagram shows that organic matter is really what fuels everything. Organic matter gets broken down by all these insects, bacteria, and protozoa. There is an entire aquatic food web and then there is also a terrestrial food web. Anybody that likes to fly fish knows that in the evenings things emerge from the water. These chironomid insects are really the main food source for a lot of the predators. You might have spiders there and the spiders might be there within a week of flooding. You will see there are no other insects feeding on the plants, so what are they feeding on? They are actually fishing and they are fishing for all these chironomids that are emerging from the water. Later on, as the canopy closes, that activity from the water tends to slow down and then those predators switch to feed on insect herbivores. That is how the predators are able to get into the system earlier before the herbivores really get established and they have a leg up ahead of the herbivores. It is a really wonderful system. I know in tropical systems it really helps to contribute to the robustness of it. In temperate systems it works also but there are some more issues around climate and weather and when everything happens. But, I would say that really wherever you go this is what happens.

There are some graphs here that show that the predators are able to increase their populations before the herbivores arrive. When you spray, what happens is it knocks back the predators but the herbivores are able to grow more quickly. Plant hoppers are a major pest in Asia. Any of them that are in egg form inside the plant are able to hatch a couple of days later and then basically grow and have babies in an enemy free environment. Suddenly there are no more natural enemies there and they won't knock them back anymore. There has been previous work done that has shown if you add a lot of organic matter, for example spreading about 2 tons of manure down, you can actually because you have more material in the system help boost up the detritivore populations. That means more insects emerging from the water, which leads to more predators. So, there are ways to enhance that biological control system and organic matter seems to be a big part of that.

In trying to predict what might happen here in Vermont, right now I think you guys are enjoying a really nice pest-free period. I have a picture here that shows where rice is grown commercially, in green. It shows where the major rice growing areas are. I think the most relevant insect pest that might colonize up here would be things that are already well established in the U.S. Now one of the key pests, there's a picture of it here, is the rice water weevil and it is native to the U.S. I have a slide up here to illustrate that when you introduce a crop to a particular area, over time you will see the number of insect pests go up. As the cropping time and area increases, you will see a certain level of colonization. Over time, insects will recognize rice as a food and they will shift to it. The insects that will most likely shift to rice will be things that feed on grasses because the chemistries are so similar and there are a lot of things that feed on grasses. This rice water weevil was formally feeding on grasses in wetland areas and now it's actually a worldwide pest. It's found in the U.S., in California, Arkansas, Louisiana, Texas, and it's also in Japan, China, India and Italy. It has the capacity to deal with winter so it could be coming up here.

I think that there are pretty well established programs addressing how to deal with pest management for these insects. The young larvae, the immature form, feed on roots and tend to be in areas near the margins of the field and levees, where water is deepest. One of the recommendations that they have, that would be applicable if you wanted to grow things organically or use cultivation to manage the pest, is to drain the field. That can actually help. In Texas, especially, they use a lot of pesticides and so there is a lot of seed treatment for things. The average loss from one report is about 300-500 pounds per acre. Typically in the conventional systems they have a threshold of one larva per core. If you were to take a soil core or you dug down right by the roots, the number of larvae that you picked up would tell the density level and help you estimate how much loss you might have on an acreage basis.

A lot of the management strategies appear to be around managing the water levels. If you have really shallow levels of water, you have less damage and if you plant later, there is also less damage. Then there are also some varieties out there that are more tolerant of root damage. Unfortunately, these are mostly varieties that do well in the south and they are more of the *indica* variety so I don't know what would be appropriate for up here. That might be something to look at. There are economic injury levels out there and they basically help you figure out at what level should I do something. When you go out and scout and you find two larvae per core or something like that, you can calculate based on how much you think you will be able to get in return for the crop, if it is really worth it or not. There is a whole list of pesticides people use against it but for organic means, I don't really think there is as much research done on that.

Audience: Are there any natural predators that have been introduced?

Yolanda: Of the rice water weevil? It is natural and native to the U.S. I think that there must be but I think that would be usually at the larval stage where they would make a bigger impact. Probably the typical things, spiders and things like that. I think because they are aquatic they could probably escape some of the predators and maybe some of the aquatic predators might be able to get them. But I don't think it is very well studied because most of the programs in Arkansas, Louisiana, and Texas are very pesticide-based. So, you know that they are not looking in that direction.

Audience: Do they actually survive in this area through the winter? Is that known?

Yolanda: There are no reports of them being up in Vermont.

Audience: They haven't really been observed up here?

Yolanda: Yeah. I don't think anyone has followed on that. It's one thing to look at. When you see grubs in the roots, it could be this weevil.

Audience: But it isn't here now?

Yolanda: Not that I know of.

There are some other insect pests out there and some of them I think will be more important than others. There are some other borer insects. If you see signs on your stems of little areas that are yellowing and you cut that open, you may find some moth larvae feeding in there. These basically tunnel things out and cause disruption of the photosynthates to the grain. You get a case like this where you have a panicle that doesn't look like it was filled properly, it is all white, and it could have been because there was a borer in there. From my experience in Asia, these are typically not huge outbreaks. I don't think they are really as significant here in the U.S. but the treatment is always really difficult because they are inside so you can't just inundate them with sprays and stuff. Typically when people want to spray for things, they look at when the moths are flying. That is an indication that in a very short amount of time they will probably be laying eggs and larvae will hatch. Some of these I think will only come up during the summer time and probably won't be able to over winter, just based on wild predictions.

Because it is an aquatic system, there are a couple things to think about. I was telling you that in an aquatic system the insects are beneficial in a way that they are feeding the predators, but there are some aquatic insects that could be damaging. There is a seed midge and this is a picture of it. It is related to the chironomids I was telling you about that feed the predators but these actually damage seedlings. They are found in California and also in Texas and Louisiana. They are also a big problem in Australia but I don't know if they are going to be a problem here. Another thing to think about is that there could be more mosquitoes coming. Mosquitoes love freshwater and so by growing an aquatic system, depending upon the entire community of organisms you have in there, you could be breeding more mosquitoes. I don't think there is enough information out there to figure out what balance of things you need to control the mosquitoes. Sometimes in California there have been issues with mosquitoes that are bothering people.

I have just some general recommendations that I was able to get from people on the management practices that might be available to organic growers. Generally they say you should have a high seedling rate to dilute the weevil pressure. I guess you can saturate them so that if you have a lot more seedlings there, they might feed and not damage as much of the plant. They tend to benefit from grasses in surrounding areas so some of the recommendations are to have a sanitized environment to control the weeds surrounding the crop. Some people say have a long rotation between crops. There are also resistant varieties for the weevil. These are based out of some of the breeding programs in Louisiana and Texas. Also, you can manage the flood depth. For armyworms you can increase the flooding depth. This will force the larvae to crawl upwards where they might be exposed to more predators. For the rice water weevil you may actually want to drain the field. It really depends on scouting to see what's going on. I guess in summary we are just going to have to wait and see what happens.

Question and Answer

Linda: Did you see anything out there?

Yolanda: I have to actually go in there and actually collect or suck things off with a vacuum kind of tool so it was a little hard to tell.

Audience: These pests that you are finding in Texas and the South, how do you expect they will travel? Do they travel in rice seed?

Yolanda: Well, lots of things migrate. They have wings, like the armyworms. There are a lot of armyworms that migrate with the summer rains and they get blown upwards. The armyworms come up on successive summer rains. One thing to think about is the weather patterns that are affecting Texas and Louisiana. Would they actually bridge over to curve and hit Vermont or not. The same thing with the rice water weevil. It is now in Italy, India, and Japan but these patterns can change. Some insects are able to go high up into the sky and almost go into dormant states where they are almost like propagules and can get carried pretty far. I think it is usually just a matter of time.

Audience: Just out of curiosity, what stage of the water weevil is damaging? Is it the larval stage that does the damage?

Yolanda: Yes, when they are young they are basically feeding on the roots. The damage to the roots will really affect the crop.

Audience: What happens to the adults? I don't know how big they are as adults, but is that something that you can easily check for on the surface of the water or do they live underwater?

Yolanda: I think they are on the surface of the water, they are not aquatic. They have a semi-aquatic larval stage and they come up to pupate so you would be able to see them. They are not very strong flyers so I think they will tend to be on top of the plants. I think it is one of those things where there will be a pest-free period for a while so you might want to capitalize on that if you can.

Audience: Can you tell us anything about bird or grasshopper damage, if Takeshi or Christian have any experience with that?

Yolanda: From what I know of tropical rice, birds are really a problem later on when the rice is heading. At IRRI they would usually pay one person to hang out next to a field, all day, to scare away the birds. In a lot of fields, farmers would have very elaborate systems where you basically pull one string and this would trigger shiny, loud, clanking things. I don't think that people have quantified that they have had significant yield loss due to birds. Grasshoppers will feed on the leaves but the leaf damage itself is not necessarily going to affect yield because plants are able to tolerate quite a bit of leaf loss. If you took a plant and even cut off half of all its leaves, many varieties would actually be able to re-grow and you would only see a very minuscule amount of yield loss due to the removal of leaf material. That is what we call tolerance and rice is really quite tolerant of any damage and leaf removal. A lot of the insects that scrape at the leaf or chew on things a bit actually don't end up causing significant yield loss.

Audience: I am curious Linda and Takeshi, have you noticed an increase in the mosquito population since the paddy construction?

Takeshi: The overall answer is probably no. But, this year has been very interesting. In the early part of the season, during May up to sometime in June, there were a lot of mosquito larvae in the rice paddy, which I didn't have last year. Afterwards, they decreased to almost nothing. Maybe it is because there are many different species of mosquitoes or it is the increasing number of frogs and tadpoles. For some reason, right now you probably don't see any.

Yolanda: You have a lot of tadpoles out there. Pretty much more than I have seen anywhere else.

Takeshi: Gray tree frog tadpoles.

Yolanda: You have a lot of tadpoles in there so I think that community ultimately influences whether you have a mosquito population problem or not. Randy wanted me to make a little plug. IRRI puts out a publication called Rice Today and it basically keeps folks current about what is happening both at IRRI and with rice in general. It is actually free online. For anyone who wants to get more involved and connected.

Randy: What she hasn't told you is that she has an article in there.

Yolanda: This is proof that I was actually in the Philippines. This was the only time I wrote for this magazine. It is great because you can get a visual sense of what rice is like in Asia.

Linda: And IRRI has, I think I mentioned this in the references, books that are downloadable. You can get a lot of books if you aren't on dial-up like us.

Yolanda: Because it is a non-profit research organization, they have many many books downloadable on Google Books.

Linda: We have one of IRRI's books, a basic rice growing book. It has pictures and it is a really good book for basic information.

Audience: I just had a general rice question at this point, as we are thinking about wetlands. Have there ever been any comparative studies of the wild rice systems and the wetlands in Minnesota? I am just thinking in terms of temperate climate, I know they are totally different breeds of rice, in terms of pest management and insects.

Yolanda: Wild rice in Minnesota is a totally different species. Different genus, it is a *Zizania* and cultivated rice is *Oryza*. I actually have a project right now looking at wild rice in the Mekong Delta in Vietnam. It is really wonderful because you get a sense of what the entire Mekong Delta looked like before it got diked and drained and everything like that. When we look at the system, it is a completely different community. Because it is a perennial species, it is really heavy in organic matter. Every year it grows on top of the organic matter from the previous year. This is not true of wild rice everywhere. Wild rice can grow in clumps and in ditches. It can grow as an annual and some grow more like a perennial. At least where we are working in the Mekong Delta, we are going out on these islands, which are semi-floating on the water because of all the organic matter and vegetation. One of the key differences is the number of ant species. Ants seem to be really dominant there, where you don't find them in cultivated rice at all. A lot of it is because of the permanency there, its not tilled and completely disturbed. But, a lot of the species are quite similar, some are a little bit different but overall I would say you see a lot fewer herbivores and a lot more diversity and more predators, in general. It's really different because cultivated rice is such an annual system that it's hard to compare in that way.

The Integration of Conservation and Agriculture: Ecological Health and Human Values: Tatiana Schreiber

Abstract

The potential introduction of rice cultivation to the Northeast United States bears an important relationship to the work that farmers in other parts of the world are engaged with in polycultural production systems including other rice-farming systems, and cacao, coffee, and fruit agroforestry. The work is linked through the interdependency of ecological relationships, which can be seen, for example, in the reliance of migratory birds on agricultural and forest habitats in the Northeast U.S. as well as in Mexico and Central America.

Maple sugar production in the Northeast is similarly connected to such polycultural and diversified farming systems elsewhere in that sugar bushes too serve as important habitat for migratory birds. However, it is only when the farmers involved in these systems are aware of and nurture a conservation ethic that innovative and environmentally sound farming methods will evolve and endure; those farmers whose values do embody this ethic need to be encouraged, recognized and supported, both economically and in terms of public awareness of their critically important work.

Further Reading

Hagenbuch, Steven. (2009) "Implications of Maple Sugarbush Stand Structure and Composition for Neotropical Migrant Forest Bird Populations in Northern Vermont," Masters Thesis, Antioch New England Graduate School, Keene, NH.

Harvey, Celia A., Oliver Komar, Robin Chazdon, Bruce Ferguson, Bryan Finegan, DanielGriffith, Miguel Martinez-Ramos, Helda Morales, Ronald Nigh, Lorena Soto-Pinto, Michiel Van Breugel, and Mark Wishnie, (2008) "Integrating Agricultural Landscapes with Biodiversity Conservation in the Mesoamerican Hotspot" Conservation Biology, 22: No.1, 8-15.

Mendez, V. E. (2008) "Farmer livelihoods and biodiversity conservation in a coffee landscape of El Salvador." pp. 207-236. In C. M. Bacon, V. E. Mendez, S.R. Gliessman, D. Goodman & J. A. Fox (eds.) Confronting the coffee crisis: Fair Trade, sustainable livelihoods and ecosystems in Mexico and Central America. MIT Press: Cambridge, MA, U.S.A

Perfecto, Ivette, John Vandemeer and Angus Wright, Nature's Matrix: Linking Agriculture, Conservation and Food Sovereignty. Earthscan, 2009.

Toledo, V. M., B. Ortiz-Espejel, L. Cortés, P. Moguel, and M. D. J. Ordoñez. 2003. The multiple use of tropical forests by indigenous peoples in Mexico: a case of adaptive management. Conservation Ecology 7(3): 9. [online] URL: http://www.consecol.org/vol7/iss3/art9/

Vandermeer, J. and I. Perfecto. 2007. "The agricultural matrix and a future paradigm for conservation." Conservation Biology." Vol 21: 274-277.

Schreiber, Tatiana. (2005) "Grassroots Polycultures: Sustainability and Resilience in Chiapas, Mexico," Ph.D. Dissertation, Antioch New England Graduate School, Keene, NH

Presentation

Linda: As a part of the SARE grant we have had rice workshops for two years in a row and Tatiana is a graduate, along with Sylvia, of last year's workshop. She grew rice in a bucket and now she has become a convert and she made her paddy this year. She has been helping us a lot this year with all kinds of stuff, helping us with the workshops and coming to speak today.

I wanted to talk about the concept of the integration of conservation and agriculture. That is what the Akaogis wanted me to address and it is something I care deeply about. I am a small-scale grower of organic vegetables here in the village of Westminster West, which is right outside the flood zone so it is a very wet area. So, I am speaking from that perspective but also as a researcher in the field of Environmental Anthropology where I am looking at the relationship between cultural values and land management issues and the potential for sustainability and the resilience of landscapes. I did my doctoral research in Mexico with organic coffee and cacao farmers and I was really struck, when I heard about this project, by how similar it seemed in certain respects to what the farmers in Latin America were doing with the coffee and cacao agro-ecosystems, even though that is an agro-forestry system and this is a paddy rice system. Something about looking at the whole bioregion and ecosystem that the agricultural system was in, struck me as similar.

In my own farming, I am trying to practice a type of ecological agriculture that attempts to mimic the natural landscape as much as possible in terms of structural diversity and species diversity. One point that has come up, though it hasn't come up yet today, is this idea that we might be introducing a non-native species to our region. I thought that was interesting because as farmers and gardeners practically everything we grow is non-native, tomatoes, eggplants, peppers, and everything. Yet, I feel that the methods that I use are providing a diverse habitat that supports a lot of native insects and birds and amphibians and everything else. What was interesting to me is that many researchers are now looking at the role of farmers in protecting and providing important ecosystem services, especially in certain biodiversity hotspots in Meso-America. My research was in Chiapas and the farmers were right next to a very important biodiversity hotspot. I wondered if the rice system could do something similar in terms of protecting the biodiversity in our region.

I think today at this workshop we have farmers here and we have conservation biologists and we have natural resource managers and we may have some consumers of rice. It is a good moment to talk about what values we hold in common and how we could integrate them more in the work that we do. In terms of conservation, I was thinking that most of us are interested in conservation of plant and animal diversity in the region, maintenance of habitats, ecological communities and ecosystems and the functions of those habitats and communities, protecting existing habitat, such as the wetlands, and maintenance of connectivity between different habitats for different species, and also retaining a landscape that is resilient to disturbance and change, such as climate change. Our goals with regards to agriculture are to grow something that is going to contribute to our economic livelihood and produce adequate yields and also contribute to diversification of what we are doing, reduce reliance on external inputs and reduce our vulnerability to natural disasters and again to climate change.

I provided a list of references that includes some recent research, primarily in Latin America, from researchers who are looking at how we could support that type of integration of conservation and agriculture. I don't know if this is true here, although judging from what people have been talking about today I think it may be true, but in Latin America there are more and more academics and allies of small farmers, arguing for a different way of thinking about landscape management. Instead of thinking about conservation on the one hand and agriculture on the other hand, really trying to consider our goals together with a view towards the creation of resilient and sustainable landscape mosaics that include the agricultural system and intact ecosystems. They include forest lands, riparian habitats, wetlands, managed agro-ecosystems, like this one, and orchards, maple sugar operations, dairying, vegetable production and maybe paddy rice.

One of the references that I gave was for an article by Victor Toledo who is an ethno-botanist. There are a lot of different words for what kind of work he does, but he talks about the indigenous multiple uses of the tropical forest ecosystem as a case of adaptive management, in the sense that farmers are trying to adapt to constantly changing climate and ecosystems. When I heard Takeshi talking about what he was doing here in terms of climate change and the potential for more rain here, I thought that is exactly what he's doing. He is trying to figure out how to adapt his management style to what is going on in the environment. Toledo did an exhaustive study of a wide range of different systems of small-scale farmers that used tropical habitat and he found that with this patchwork mosaic, which included primary and secondary forests, fallow tracts, vegetation, corridors, water bodies, home gardens, and as well as coffee agro-ecosystems and cacao agro-ecosystems, the human-created systems not only maintained biodiversity but in some cases enhanced it.

A lot of you I am sure know this but coffee agro-ecosystems are often repositories for a lot of migratory bird species, also different kinds of trees, epiphytes, mammals, birds, and insects. In those cases, a lot of the biodiversity in the system is useful to the humans in terms of not just the crop but also for medicine, lumber, construction materials, forage, mulching materials, domestic items, artwork, and ornamental uses. We haven't talked that much about how rice can be used in those ways but I just saw how you have been using the rice straw for mulch over there. It looks very beautiful and I know there are ways of using the rice straw for tools and in artwork and there are a lot of different things we could do with it. In terms of yield, they may have less yield, in terms of the specific crop but much more yield if you look at all the different uses of the system.

These systems also tend to endure over time because people can adjust and emphasize more or less of the system. In my own research, with coffee and cacao farmers, I found that some of them really had a very strong conservation ethic that influenced the kind of agriculture they were engaged with and their decision to protect intact forests with their systems. A lot of them had very important health concerns, about their own health and their childrens' health, which influenced their decision not to use chemicals. But they lamented the fact that other people in their region didn't necessarily share these values and if the values weren't communicated and shared on the whole bioregional level, it wouldn't be that useful. What's exciting to me about this project is that the Akaogis have this vision that includes not just a crop that can support their livelihood but conservation goals as well. I see the rice as having the potential to add an important component of diversity to our ecosystem with many of the same benefits as these landscape mosaics that Toledo describes.

Right now we are at the stage where we don't have a lot of research to support that but a lot of ideas have come up today for the kinds of research that we need to do. You had mentioned the birds and the rice in California and of course there have been some studies of birds and rice in other places. For example, in Uruguay there was a study that found that when comparing rice paddies to wetland, to wet meadow, and to wild bushes, they found that rice paddies were used by 42% of all the species that they found in the area during the study period. Outside of the study period they found that 92% of all the bird species known to be in that region used the rice fields at some point. Some of those were species that were rare or scarce in the area. Probably the rice played some role in those bird species' survival. Interestingly, someone I know, Stephen Hagenbuch, who is the conservation biologist here in Vermont, has been doing some research with maple sugaring operations and birds. He found not really dramatic statistics, but he has definitely found that the more diverse the maple sugar bush is the more bird species use it and those diverse sugar bushes may be playing an important role in the survival of certain important or endangered bird species. I think that one area that would be very interesting to look at would be the role of these diverse agro-ecosystems in supporting bird populations both here and in Latin America and see how many birds are dependent on both habitats.

The important point is that these agro-ecosystems don't exist by themselves, they exist within a larger matrix that includes conventional farming and all kinds of non-agricultural uses and we can't look just at what an individual farmer is doing but what's happening in the larger matrix. Especially in terms of populations of species like amphibians that are dependent on vernal pools. If we lose some vernal pools we might lose that species unless they have the opportunity to migrate between different pools. If we have more rice paddies there will be more opportunities for those species to migrate between those areas. I am wondering and hoping that the rice can serve some of those roles and other ecosystem functions that have been mentioned today. We have talked about flood prevention, groundwater recharge, and about nutrient filtering, all of those things we need to research more to see how much rice of a role rice could play in our region. I think that could be very important. I thought the role that it might play in preventing a flash flood here was particularly interesting.

Given all that, my question for us to talk about is how can we support the work of farmers who are really interested in this type of integration of conservation and agriculture. One way of course, is the exchange of information and ideas. We talked at lunch about the idea of forming an alliance of rice growers in the Northeast, or some kind of group that would link people who were interested, not just in growing rice, but also in this integration of rice and conservation. Another thing that would be important is the focus on how to market the rice as a niche product that is grown in a way that is environmentally benign or that enhanced the environment. I was thinking about bird-friendly coffee and wondering if we could have bird-friendly rice or amphibian-friendly rice. Spotted salamanders are very charismatic amphibians so maybe we could have a spotted salamander type of rice or something like that.

Another idea concerns the concept of payment to farmers for ecosystem services, which has been done in certain areas. In Costa Rica they have a system for paying farmers for their role in protecting existing forest but I think that concept has to be expanded to include different types of agricultural management. For example, if farmers are doing something that helps to reduce the vulnerability to flooding or other natural disasters or the effects of climate change, maybe there should be some way of rewarding farmers for that work. Of course, there also needs to be technical assistance and capacity building for farmers who are doing this work.

I mentioned to some people that I am interested in doing a demonstration project for rice in the Westminster West Village, which would be a very public location right next to the elementary school there. There is a landowner there who offered his land for this purpose. It is right next to a wetland and it is between the wetland and the school. If anyone here has ideas on how to get something like that off the ground that would be exciting. I think that it is really exciting to have this vision. This farm is kind of a model for what a lot of us want to do in terms of the integration of conservation and agriculture. One thing that has been said is that people might not want to grow rice because they might not get enough yield, it might be too labor intensive for us in this region. Is that the only thing we are trying to do, produce maximum yield from the rice or are there a lot more things that we are trying to do by our efforts? Do we have a larger vision that includes the conservation of our habitat for a wide range of species? If so, how can we bring this vision to fruition?

Question and Answer

Audience: In terms of yield and production, I often think about the scale of grain agriculture and it seems like rice is one of the few grains that is more amenable to small-scale grain growing. Would you say that is accurate and compatible with conservation?

Tatiana: Well, I don't know. It seems like you can get a pretty large amount for a pretty small area. You were sharing some of the yields that you have gotten so far.

Audience: No, I mean in terms of land needed for rice, there's less.

Tatiana: Right, you can get a lot from a very small area, especially if you are growing for your own needs. I mean even from a few buckets, you can get quite a lot. I think the ideas that came up earlier about intercropping are very interesting in this regard because one of the things that is so interesting about those agro-forestry systems in Latin

	America is the number of different species of edible and useable crops you can grow in one system. I think it would be interesting for us to experiment with that.
Audience:	Has anyone looked into the rotation of cranberries with rice production systems?
Tatiana:	I don't think yet, but that is an interesting idea.
Susan:	Cranberry bogs are really acidic. I think that would be contrary purposes.
Tatiana:	But not necessarily. One of the things that is really interesting about this landscape here is that we have such diverse soils in a very small area. I have 6 acres and I have totally different soils. I have this mucky hydric soil in one area and really sandy good drainage soil in other areas and so I think in one farm you could have cranberries in one area and rice in another area, contributing to the overall ecological diversity of the farm system.

Smaller Scale Equipment for Rice Production in Japan: Gen Onishi

I am Gen Onishi. My family and I came to the United States in 1993. Since 1995, I think, I joined the Susan McCouch rice lab at Cornell. I am the greenhouse technician and help the graduate students, and now my work is mainly crossing. I am going to talk a little bit about my background.

This is a Google map and this yellow line is Hokkaido. Takeshi talked about Hokkaido in the morning. I was born in a suburb of Kyoto City, about 800 miles south of Hokkaido, where it is very hot and very humid, which is good for rice. In the morning Takeshi talked about processing the rice, planting rice, and transplanting rice by hand. I moved to the United States in 1993 but every year I went back to Japan to help plant rice until 1997 because I had promised my dad I would do that. I have some pictures. This is a typical mid-sized, mid-scale rice farm in Japan, which uses rice transplanters and an irrigation system (Photo 8).

Photo 8. Mid-scale rice farm in Japan (Gen Onishi).

After I graduated from technical high school, I went to work for an electrical engineering company in Tokyo. One day my mom called me from Kyoto and she had a problem because my dad had bought an old, small truck. It was good because he was managing about 3 hectares, about 8 acres, of rice paddies. The problem was that he didn't have a driver's license. I didn't answer immediately because I was working at a company but if he got into an accident, or hit someone, he would go to jail. My family and I were worried so I made the decision to quit my job and I went back to Kyoto to work in the field in 1970.

It was very hot but sometimes good. All farmers in all countries have a difficult time managing financially. My dad and I had different ideas about farming and we fought every day. Eventually my dad was getting too old and he gave me the business. I went to the bank to borrow money and then I went to the Kubota dealer in my town and asked what equipment I need for 3 or 4 hectares of rice paddies. My friend, Yamada, who was working at the Kubota dealer said $100,000. It was a lot of money and he told me that I would be able to use the machinery for about five years. It was a pretty big investment but we had to do it. I can't plant rice by hand. We decided to borrow the money from the bank. That was in the late 1970's. At that time it was not difficult to get money from the bank. Nowadays it is very difficult. In the United States, in Japan, it is the same because they need a 100% guarantee that you will return the money.

So, we started and my farther was still my partner. I couldn't do it by myself. It wouldn't have been fun. The positions just changed. First my dad was the main person and I was the assistant then it switched. I don't know how many of you are farmers here, but I would consider it a very expensive job. The equipment is expensive too, especially the tractor and combine. We found out that we had extra time so we helped out other families that didn't have any equipment because they had given up doing it by hand. I think at the maximum we managed about 5 hectares of rice paddies, about 12 acres. It wasn't all in one spot, but spread out around this small town in 20-25 different spots. It was as lot of work transporting the machinery. That's the story of how I started growing rice and did it for almost 20 years.

At that time Japanese rice was 5 times more expensive than international rice and so we got some profit. Recently, farmers in Japan haven't gotten a good profit from rice because since 1995 the price of Japanese rice has gone down sharply. That is good for the consumer. Pesticide and herbicide prices are going up while the price of rice is going down. That's a recent problem. It is difficult to manage and find a job in Japan. A recent article said that 12% of farmers quit last year because the people working in the field were more than 65-70 years old and they couldn't work anymore. Then financial problems because of the economy forced them to quit. It is a big problem. I think it was just two weeks ago that a dairy farmer in Susan's neighborhood quit farming. An agricultural newspaper in June, I think, said that 20,000 farmers quit in one year. Fortunately, in my family's case, my nephew took over my rice business.

I was born in a suburb of Kyoto and growing up when I walked outside, all I could see was rice paddies. So, I knew about rice since I was born but I didn't know how to grow it. When I decided to manage the rice farm myself, I asked my friend Mr. Uchida, a good rice farmer in the town, to please teach me how to grow rice and how to manage a rice farm. He had a side business, a Korean style barbeque restaurant. I would help him every night after work, part time for a little money, but we talked about rice every day. That is how I learned how to grow rice.

I think some of you are thinking about growing rice seriously in the Northeast and what type of machinery you will need. Two years ago I took pictures at a Kubota dealer. This is a used binder. I found it about two years ago and we imported it to the U.S. but there was a small problem because it was a used machine. If it had been new, there would have been no problem. Takeshi and Linda called me to tell me that the binder went to Newark, New Jersey. It had arrived in New York City and then it went to Newark to go through customs because they needed to make sure that no rice was still left inside.

Takeshi: But they didn't open the box because it was so well made.
Linda: They had used lots of nails.
Takeshi: They used an x-ray machine and checked it from the outside.
Linda: But you telling them that it was cleaned in Japan helped a lot.
Gen: I asked them to clean it completely before they shipped it.
Linda: We didn't think about that, but of course there are going to be things in the equipment, especially if it is a combine type.

I think using wetland areas for rice paddies is a good idea but you shouldn't think about profit. A professor in Japan once said, "Why do you produce a rice that is five times more expensive? Why don't we just import rice?" Another professor said, "No, rice is not only a profit. The rice paddies are culturally part of the landscape and they work to protect from the flooding because the paddies are like dams. That is the idea and it is also very beautiful.

Two years ago, my two boys, went with me to travel to Hokkaido. This is a night train, a sleeping car. It is very good for the 17 hours from Tokyo to Sapporo. You can just sleep. I took pictures. It is actually a very similar landscape to Vermont. Of course you know of Hokkaido as a snow country. I think it is colder weather than Vermont. Takeshi is growing a Hokkaido variety and I am sure it will work out. This is the modern method of planting rice with a transplanter, automatically. This is the transplanter, a five-line transplanter (Photo 9). I don't know how much it is now, but 20 years ago, it was pricey. This is another transplanter, a 2 line used one (Photo 10). If you think about it, it is hard to transplant by hand. I can't do it anymore. Before we came here I visited the Kubota.co.jp website. They still are manufacturing these types of binders, one line, two line, three line. I don't know how much. If you are interested, I can ask. Also, this is a harvester, thrasher with caterpillar crawler (Photo 11). This machine can move.

Takeshi: Do they still produce this binder/harvester even now?
Gen: Yes. If it is broken, you can buy a new one, no problem. Also they have parts.

This is Japanese harvester/combine. Only the grain comes out. When rice paddy is about 80% gold in color, we start harvesting with this machine. We need another machine, dryer, and this is costly. It is the housing that is expensive and it uses electricity and fuel oil. I think my town is several villages. In some villages I had my own equipment because bank leant me money. But some villages did not have that many rice fields, just one acre or a half-acre. They bought mid-size machine and then they shared it. That was a very good idea because the machine is so costly. Then we can use for a while, after 10 years it broke down and we had to renew it.

Photo 9. Five line transplanter (Gen Onishi).

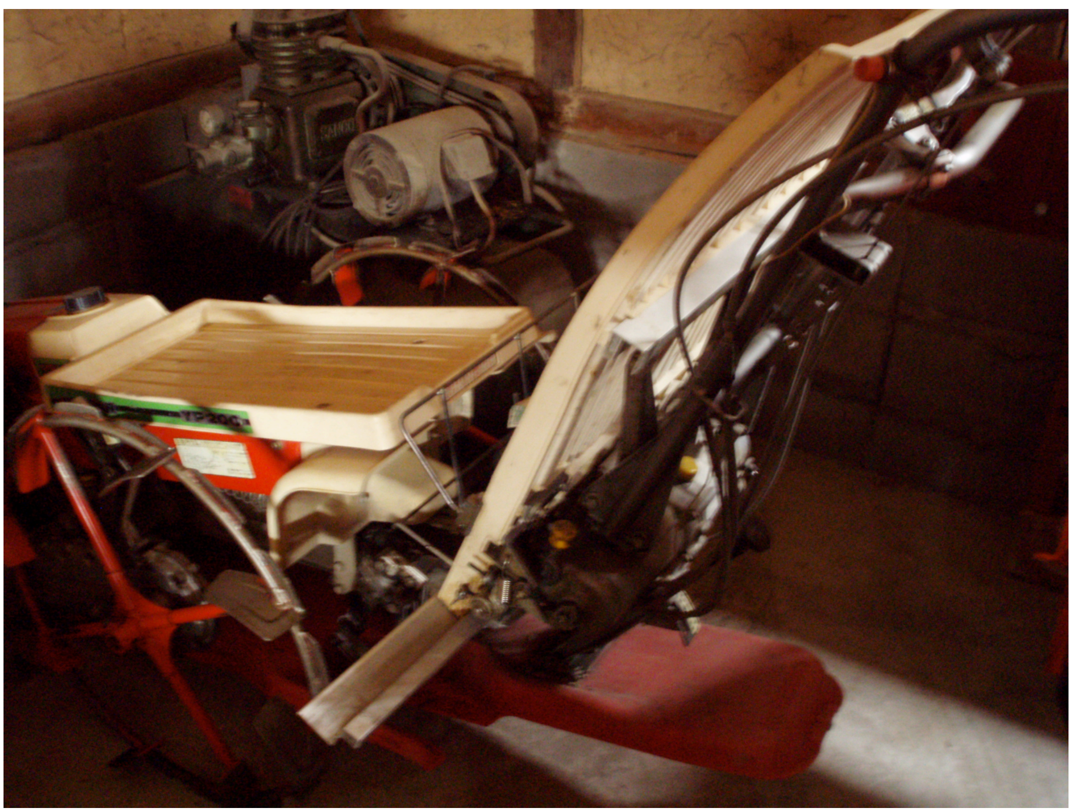
Photo 10. Two line used transplanter (Gen Onishi).

Finally, a little bit about the Japanese rice-breeding program in Hokkaido. We owe a special thanks to Doctor Toshiro Kinoshita. I think that Takeshi and Linda's rice came from Doctor Kinoshita's breeding and his collection.

Linda: Some of them. Actually thanks to Susan and her work there.

This is Doctor Kinoshita and his wife just two years ago. He is probably 88 years old this year. Finally I will talk just a little bit about the rice program in Japan in 1895. My younger brother Eto, found two panicles of rice from the variety Akage that didn't have any awns. I think within two acres, he found this by chance. Five years later Eto planted it on his property. The result was no good so he gave up. But one of the peasants, I think his name was Nakata, when he moved to another village or another town he got the seed from Eto, the no awn seed. He cultivated it and the result was very good. That is the variety called Bozu. Maybe Susan knows Bozu. Then this variety was used wildly by rice-breeding programs in Japan and other varieties like, GinBozu, GimBozu, HashiriBozu, were developed. Bozu usually means monk and monks don't have any hair. That's the era of the Hokkaido agriculture experimental center's development of direct seed plants. This was very useful because there were no awns. Awns didn't drop the seed.

Susan: They probably don't know what awns are.
Gen: Awns are hairs on the top of the rice. This is still useful. I believe 4 years ago one of the graduate students used GimBozu.

Photo 11. Rice harvester, which has a thrasher and caterpillar crawler (Gen Onishi).

Rice Breeding and Genetics: Susan McCouch

Abstract

There are two domesticated species of rice, *Oryza sativa* and *O. glaberrima*. *O. sativa* was domesticated from its wild ancestor about 10,000 years ago in Asia, while *O. glaberrima* was domesticated approximately 3,000 years ago in West Africa. The two species look and taste very similar, but crosses between them give rise to semi-sterile progeny, underscoring their diverse origins. Rice is produced in a wide range of locations and under a variety of climatic conditions, from the wettest areas in the world to the driest of deserts. Thousands of different varieties of *O. sativa* are farmed, and different varieties of rice are preferred by different people for historical, biological, ecological and cultural reasons. In the world as a whole, rice occupies 1/10 of the arable land, but in the majority of Asian countries, it occupies 1/3 or more of the total planted area. Ninety percent of world rice production occurs in Asia, where much of it is farmed on parcels of land 1 hectare or less. The vast majority of rice is consumed within the country where it is grown, with less than 7% traded internationally. This helps maintain the diversity of grain characteristics that are typical of each rice-growing region. Different grain shapes, sizes, textures and cooking qualities are associated with different culinary traditions and climatic conditions. The rice breeding and genetics program at Cornell focuses on the characterization of genetic diversity in *O. sativa* and *O. glaberrima* using a combination of molecular markers and phenotypic characterization. Our objective is to better understand how diverse genes and traits have been selected over the course of domestication and to point the way toward more efficient utilization of the natural variation found in wild relatives of both Asian and African rice. We are particularly interested in learning more about the potential for rice production in southern Vermont and in helping to establish a participatory breeding program that would enable us to work with growers to select varieties that are particularly well suited to the ecological, climatic and cultural conditions of this region.

Presentation

I am Susan McCouch and I am going to tell you a little bit about what we do at Cornell with our rice-breeding program. First I want to acknowledge that one of the reasons for the great successes of the rice-breeding program at Cornell is Gen Onishi. Gen has the hands of the breeder and when he first came from Japan he didn't know how to cross rice. He knew how to farm, grow, manage, teach, all those things, but he didn't know how to cross rice. What was exciting, I think for both of us, was when we started working together, his skills and my skills and his interests and mine started to take off in interesting ways. We have had almost 18 years of collaboration and it has been really wonderful for me because he brought a lot of the skills that have made our program work. For many of you who have had the opportunity to talk to students and staff who are here from our program, you will know how much Gen's help and skill as a teacher has meant to the success of the program. I want to acknowledge that up front.

What I thought I would do is walk you through a few things about what we do in our plant-breeding program so I can give you an idea of the kind of research we do and then why at Cornell we work on rice when we don't grow any rice in New York state. That may change, and I would be happy for that to change. It would be really exciting for me. The first stage of any plant-breeding program is to collect and evaluate diverse germplasm. If you are trying to actually create new varieties for release here, you might limit the germplasm that you bring in by selecting the kind of germplasm that you know is already adapted to the temperate zone. That is why we started with the Hokkaido varieties, because we knew they would probably flower and set seed in the field in Vermont.

But, the work that I do is actually involved with a much broader array of diversity. It would never set seed in the field anywhere in the United States, not in Arkansas, not in Texas, not in California, and certainly not in Vermont. Almost all of the work that we do is done in a greenhouse where we can manage the photoperiod and the temperature. The reason for this is if you put it outside, that will be the end of that line because you wouldn't get any seed. The second reason is because a lot of the material we work with is wild or weedy and we are prohibited from planting it anywhere in the United States. It is heavily quarantined and the number one biotic stress in the U.S., the number one economic loss to farmers growing rice in the U.S., is weed competition from wild, red rice. They just call it red rice. It lowers the price of rice because the red grains have to be polished, and polished, and polished, and polished to make them look white and then they don't cook like the other rices that you have harvested. This lowers the quality for the consumer and you are penalized heavily if you have red rice in your harvest when you bring it to the mill. Actually, when it comes in, before it goes to the mill, they will calculate how many red grains based on an infrared scan. The price will be determined partly by the number of red grains that you have. I do a lot of work with red rice because red rice is the ancestral color. All wild rices originally had red pericarp. It is too small to see, but, if you take off the husk and you look underneath the husk, the color of the grain, which you normally call brown rice, is red if it is wild. It isn't brown, it isn't beige, it isn't tan, it's a deep red that sometimes looks brown. It can look purple, like the purple sticky rice we had today. That is a special quality of rice that is quite rare, but the red rice is absolutely the norm. It's not what you see on the outside, it's not the hull, it's after you de-hull it and what you see underneath. Those of you who are familiar, if you go to the market and pay for a Bhutan red rice, you are buying the red pericarp rice. We can pass these around. Takeshi do you want to tell what this one is?

Takeshi: Takachi Kuromomi and this is Yukihikari, which we ate yesterday.

Susan: What you see here are two temperate japonica rices, one with a red pericarp and one that you would call brown rice or what we would call the white pericarp.

That red color is indicative to the eye and it is easy to see. It is also indicative of it being a weed but, there are red rices that have been selected by early farmers, and they are not weeds, so don't get confused. However, the average grower and certainly the average quarantine officer in the United States, considers a rice with a red pericarp as a weed, as a noxious weed, and it's under quarantine and it is not allowed in the field. Those red rices which are cultivated, and have lost all of the other weedy traits, what we will call weedy syndrome, and only retain the red pericarp, have two features that make them less attractive to poor rice eating people around the world. One reason is that they cook much more slowly. When you cook the red rices you have to cook them longer and they need more water because the anthocyanins and proanthocyanins that give it that red color are oxidized tannins and they make the seed coat very hard. The compounds that your eye sees as red also confer a level of disease resistance and insect resistance to the rice grain, which is favorable in the wild. But for people who have to walk miles to get water or fuel, the idea of spending more water, more time, and more fuel to cook your rice is just absolutely a non-starter. That is actually one of the transitions that we talk about.

One thing we do at Cornell is collect seed. Sometimes we actually go to the field and we undertake collections in parts of the world or regions of the world where people haven't actually collected for official germplasm collections. I thought I would just mention this because it is a lot of what makes the program that I run kind of special. The other way we get seed is we simply import them from collections that other people in other countries have been doing for the last 50 or 80 years. When we go collecting, we go collecting under a whole series of agreements with the countries where we go collecting. We have to have funding of course, but we also have to have permission because bio-piracy is an issue. There are intellectual property rights, based on the Rio convention, and they have to do with ownership of genetic resources. Usually there are agreements with the country in which we are collecting. For instance we went to Borneo and collected in a very, very remote area of the island to ask the question had the green revolution rices, which have inundated the world's high yielding production environments, reached as far as these very remote villages. The people living in these villages are not connected to the world economy. We wanted to know whether the rice distribution system among farmers meant that those people had gotten and considered valuable the green revolution rices. We went out walking for days, up rivers for days, using little tiny airplanes to get into the backwoods where they still grow those upland rices on the hillsides. The answer interestingly was no. There were no green revolution rices there and that tells us something quite profound. Despite the fact that humans are moving technology around, and we have all kinds of information flows, with only 'six degrees of separation', there are still places in the world where they are so far outside the market economy that kind of germplasm hasn't penetrated.

We collect only rarely. Most of what we do is bring in germplasm that has already been collected. Our primary source of germplasm is the International Rice Research Institute in the Philippines because that is the largest publicly available collection of rice in the world. It has about 200,000 or 220,000 different varieties. I think only about 8,000 of them are wild species and those are not all species because many of them are the same species but different populations collected in different places. Other than the USDA, my program is the largest single importer of rice into the United States. We import more exotic varieties than the USDA does on a yearly basis. We are at the top of the quarantine officer's red flag list. When I get off a plane, no matter where I am coming from, someone from the United States government walks up to me with a dog, greets me and says, "Hello Doctor McCouch are you carrying any rice today?" I must be on everybody's radar screen. I am really careful and I tell you this because when you import rice you have to go through a lot of paperwork. You have to wait a long time because you have to get things in through quarantine and there are grow outs and all kinds of things. Our lab at Cornell and our greenhouse at Cornell, the greenhouse that Gen and I manage together, is actually a quarantine greenhouse for the USDA. We can bring things in and do the grow-out that is required before seed is distributed. If Linda, Takeshi, and I want to collaborate and I want to help them bring rice from overseas, I have all that paperwork, all the connections, and all the required permits. I can bring it in and then I have to do a generation of grow-out before I can hand the seed to them. You are not allowed to bring seed in from overseas and put it in the field. I tell you that in case you weren't aware of that.

We bring in quite a bit, about 5,000 or 6,000 thousand varieties just in my own little germplasm repository at Cornell. We do quite a bit of evaluation at both the genetic and phenotypic level. What do we mean by genetic evaluation and what do we mean by phenotypic evaluation? Phenotype is the actual characteristics that you can observe. Sometimes we do that in collaborator's fields, sometimes we are doing that in terms of multi-location trials, and sometimes we are doing that in pots in the greenhouse. Many of the things that we are observing or characterizing have to do with whether things flower synchronously. Unless they flower synchronously, you can't go on to stage two and make any kind of crosses. If you want to cross two things and they are from different parts of the world, you have no idea how to plant them so that they will both be in flower at the same time. One may take 11 months to flower under the same photoperiod and temperature conditions that the other flowers in 3 months. You have got to figure that out first so that is why we go through a field evaluation under greenhouse conditions where we know what the light and temperature is. Most of our materials are going to be crossed under controlled conditions anyway because almost all the work we do is with interspecifics, or with the wilds.

Evaluation for us is the phenotypic characteristics, what you can observe, what you can measure, and what you can see. Traits like pest resistance and others that are potentially of interest to us or to our collaborators. But we also do a lot of genetic evaluation. What is genetic evaluation? A phenotype is the result of the genetics but we can also use molecular markers and increasingly we are using things called SNPs, which are single nucleotide polymorphisms, that basically detect changes in the Gs, Ts, As, and Cs along the genome. Rice as a genome was the first crop that was sequenced and so it has given us, as geneticists, a lot to work with. We have worked with lots of different types of molecular markers. Just to make sure, I should mention that it has nothing to do with transgenics or genetic engineering. Molecular markers are used to determine ancestry. When you go to take a paternity test, if you have ever had to do that or get involved in that, they take a little bit of blood, they run a PCR profile on you, and then they try to match you with putative parents. That's a lot of what we do here. We extract DNA from plants, usually from leaf tissue, and we run molecular markers. Then we look at ancestry and we determine which clusters of germplasm are closely related to which other clusters and then we look at how those clusters of germplasm, that are genetically similar, perform under field conditions. That's how we know, for instance, that *temperate japonicas* are going to perform in a certain way. We can look at the grain, but the grain doesn't always tell you.

It also tells us quite a lot about the evolution and certain things about adaptation and which clusters of germplasm are likely to have useful traits. It is a very interesting phenomenon when you stop and think about evolution. I want to just ask you to do that for a moment. I mean the concept of evolution in plant breeding is really, "Where was the ancestor that had a given set of alleles and how were those alleles then distributed in the offspring?" If you go back far enough, all living things have one ancestor. But, we are not going that far back. If you go back to before rice was domesticated, when it was still a wild species that is the ancestor of cultivated rice. We work, in our program, with that wild species that was the ancestor and then all the derivatives, which are the cultivars that have come out of that. We trace those alleles back and we ask, "Which part of Asia, for instance, do most of the disease resistant genes occur. For instance, one of the big ones in the world is rice blast disease. It hits farmers who are subsistence. They have very little water and they live in the upland soils, which are nutrient poor. Blast disease can wipe them out. Where do we find the best sources of resistance? It is in certain gene pools.

We can use our molecular markers to hint at which types of rice are likely to have certain traits of interest. That's the first phase. We do a lot of that kind of sleuthing, and just to stay abreast of all the interests that we have, this is a continual process. We then move on and initiate crossing and population development. There, as I said before, you have to learn to synchronize the flowering. How many of you have made a cross with rice? Not so many, well you have made crosses with wheat and it is sort of the same thing. I don't have a big blowup of this but you can look at it later. This is a spikelet, or a flower or a grain of rice, before it fills. This is the awn that Gen was talking about, the hair. Inside that little spikelet, before it gets filled in, there are six anthers, the male parts that carry the pollen, and there is a female part down there. It is basically a hermaphrodite. It is showing you a flower that is open but this flower normally remains closed and the pollen, when it becomes mature, falls onto the female in a completely closed container. It basically self-pollinates before the flower even opens. Then later the flower opens, the anthers emerge, and the extra pollen flies in the air. Normally at that point the egg, which is down here, is already self-pollinated. The grain is filling from the stem end up and the milky endosperm is coming in, being fed by the mother plant, up through the stem with the photosynthate coming from the flag leaf.

When we make a cross, the problem is you got to capture this before it self-pollinates. Making a cross in rice is not the norm. The norm, in rice, is that it will self-pollinate. In order to make it cross, you have to remove the anthers before they mature and spill their pollen onto the female. We clip the spikelet when it is still green, kind of like what you see out there, but before. If you hold an immature spikelet up to the light, you will see whether the anthers are part way up or all the way up. There is a little shadow inside the green spikelets that is visible when you shine light on it. You cut the hull of the spikelet before the anthers have grown all the way up, when they are still only half way up the length of the spikelet. Then we use a vacuum emasculator and you suck out those anthers and it doesn't hurt the rest of the plant. You cut off the hull, got rid of all six anthers (if you leave any anther it will self) and at that point, the female is exposed. Then you bring another plant, that is now going to serve as the father, and it must also be at the right flowering stage, with the pollen about to mature at the right time, and you put the panicle of the plant that will be used as a father (pollen source) under a bag along with the emasculated female flower. The emasculated flower (where you removed the anthers) no longer has male parts, so we call it a female in this hermaphroditic world that we live in. You bring that flower together with the one that's about to spill its pollen. You put them under a bag to keep other pollen out. You seal up the bag and then, this is part of what Gen does so well, every morning you go in and flick the bag because the pollen is only viable until about 10 or 11 o'clock and hopefully something will fall on that female. That will be the pollination event and then that seed will fill. Then it will give you the F1 or the crossed seed.

Christian: How does it fill if it's clipped?
Susan: It fills because it is coming from the stem end of the female. So, it is still able to fill.
Christian: In the milk stage?
Susan: It fills quite well without the hull and it takes actually the same shape but the hull is half way. It is like an egg in an eggcup. It is filled by the cup and then it continues to fill on up and we call it naked seed because you see the brown or red grain inside the hull. It will fill because it is coming from the mother.

As breeders, in order to make any cross, we have to go through the process of emasculation, extraction of anthers, and bringing in the pollen. Gen and many others in my lab do this every single day, every single morning, in the greenhouse. It is a big job when you have challenging crosses to make like with interspecifics, which also may shatter. The minute a grain is ripe it falls off of the spikelet. There are numerous other challenges that await the rice breeder.

Audience: It sounds like rice self-pollinates very easily and that cross-pollination is a rarity within nature. Does that suggest that ancestrally, people used to do the same thing that you are talking about to get the 220,000 varieties?
Susan: No.
Audience: It all happened naturally over time?
Susan: As far as we know people didn't really understand about crossing until certainly after Mendel. Mendel understood. What do you say Margaret, pollination in crop plants probably began around 1920?
Margaret: A hundred years ago.
Audience: So, this many varieties have come around since then?
Susan: These are the result of natural out-crossing and selection by farmers.

I should back up a moment. The wild species outcross 30-50% of the time. There is a phase of going from the wild through the domestication process to what we call cultivated today. The land races in the intermediate stages are much more likely to be out-crossing. They have extruded stigmas, the female is extruded, there is generally more out-crossing in those, and they are never purified. We were talking about that earlier, they are mixtures to begin with and then that out-crossing is much more common. What has happened since about 1920 is people have started selecting pure lines and managing seed differently. It is the management of the plants, the populations and the seeds that has changed. Out-crossing still happens, but now with controlled crossing you can move more quickly because you increase the probability of bringing traits together that you actually want. It is just probabilities. What we are doing is allowing us to manage a cross rather than having it happen by chance where it only happens 1 or 2% of the time. What we think about next is what kinds of populations we want and why we make crosses. Sometimes we are making crosses because we are actually interested in recombining traits.

Audience: Why did you say earlier then that there were less inbreeding bottlenecks with rice than corn?

Susan: Corn is a naturally out-crossing species. Every generation it exchanges pollen with a genetically different individual. You know the male has the tassels at the top and the cobs down at the bottom, so it is really hard for it to self-pollinate. The pollen is released to the wind, and pollen from all the plants in a field mix in the air, and some pollen eventually lands on the female silks. But the pollen that lands on the silks of the female is usually not from the same plant. Don't forget that in corn, the male and female flowers are physically separate and independent. If you have a very vast expanse of genetically identical and homozygous material, it would essentially be crossing with itself. But corn is not generally grown that way. We could talk about hybrids and that kind of thing if you want, but the main thing is that corn is a natural out-crosser. It is like humans in that it has got males in one place and females in the other and they got to get together. But in rice they are all in the same place. We have natural tendency towards selfing in rice and a natural tendency towards out-crossing in maize. When you want to self maize, you have to bring the pollen from the tassel around and make that cross and put that bag on just to make that self. You do the same thing in maize, essentially, but you have to make it happen physically. Margaret you want to add anything? She is a maize breeder.

Margaret: I was just going to say that the earlier comment about the genetic bottleneck was kind of in the context of if you have a variety, how many plants do you need to save in order not to lose the diversity inherent in that variety. Most rice varieties that you would find now are pure lines. Within a variety there is very little diversity. Maize varieties, aside from hybrids, are very genetically diverse. If you are not saving seed from 50-100 plants in a maize variety that is genetically diverse like that, you are going through a genetic bottleneck. On the other hand with rice we talked about 3 plants. You could save seed from 3 plants because those 3 plants are probably genetically identical in a rice variety.

Susan: This is all genetics. Maize is a population and rice is a line because rice is breeding true just by default. Nature does it that way, not only breeders.

Audience: When you say wild rice, do you mean the kind of rice that grows in water, that Native Americans grew? What do you mean by wild rice?

Susan: American wild rice, *Zizania* is a genus and a species that is entirely different. It has many of the same habits. It is a water loving species, an aquatic species. It has many, many similar habits but you can't cross it with Asian rice.

Audience: It is not at all what you mean when you say wild rice.

Susan: I was thinking just of the ancestral rice, the ancestor of Asian rice. As I wrote in the abstract that I included, there is a form of rice that was domesticated independently in Africa and it has a wild ancestor as well, which is completely different from the wild ancestor of Asian rice and different from American wild rice. The term wild rice is not a very useful term.

Peter: We are talking about rice within different species.

Susan: Both African rice and Asian rice are species within the genus *Oryza*. American wild rice is an entirely independent genus, *Zizania*.

Audience: The wild rice that was *Orzya*, was that in some kind of aquatic situation, way, way, way back?

Susan: Yes.

Does anyone know what the closest relative to rice is? It is kind of interesting when you think about it because some of our grasses have relatives that are domesticated crops. For example, maize and sorghum are close and sugarcane and wheat, barley, and rye are kind of close. Bamboo is the closest living relative and so when you think about it, rice is off in a tribe of its own. There are a number of characteristics that they derive, genetically, from a common ancestor. We have talked about crossing and population development and I just want to say we do quite a bit of this.

The first generation of crossed seed, which is the naked seed, the one where you have just made the cross and harvested it, is called the F1 or the first filial generation. That F1 seed, if you just plant that seed, that essentially is like any of us. We are all F1s. We are a cross between two parents. In rice, if you plant the F1, from that F1 you would get 500 or 1,000 seeds. Every one of those seeds would give rise to a genetically different offspring. The F1s are genetically identical, if you make that cross between two inbred parents, but the offspring of the F1 are all genetically very different. They are siblings but they are all different. That's the starting point for the plant breeder, where they start to impose selection.

When we talk about plant breeding, we are talking first about evaluating and bringing in our diversity, physically making the cross, and the population is the offspring you harvest after the generation where you made the cross. This is the seed you have achieved by making the cross. The next generation is the segregating population that then allows you to exert selection. There is no way to exert selection unless there are differences. Almost all these differences start to show up in the F2. If you self the F1 it gives rise to a F2 and plant breeders, at least rice breeders, typically do a series of self generations after that. They tend to save 10-20% of the F2s that they look at as favorable selections. Each plant that they save gives rise to 500-1,000 seed and they have got to figure out how many of those they are actually look at in the family row for the next generation. If you don't throw away 80-90% every generation, considering that you are getting back 500-1,000 seeds from every single plant that you save, you wouldn't have space on the planet to look at all the offspring. So, really the job of the plant breeder then, is to throw away. What are they going to save and what are they going to throw away? Then try to save the families that you think look like they are carrying either alleles or genes that are favorable traits or use some kind of genetic selection.

Our program has actually been one that continues to develop tools for looking at what genes these plants, naturally bred plants, carry. Our lab develops a lot of the tools that allows you to look and see which genes they carry. So that, as you are going down in generations and you are becoming more and more inbred, those tools can help you make selections even before or even if you can't plant them in the field and do multi-location evaluations. There has been a trade-off over the last 10-20 years between the cost of field evaluation and the cost of genetic evaluation. Today it is much cheaper to do genetic evaluation. Field evaluation is all about labor and replication and managing all the things that you all know. It is very labor-intensive. We can save time and still impose the kind of selection we want by using genetic tools to help us as we move through that breeding process.

I will give you an example. Let's say that we are actually breeding for a specific disease resistance. If the water weevil were the problem and you guys were facing a water weevil infestation and we were trying to breed together, we might find a source of water weevil resistance. We would then cross it with one of these lines that you like that are doing well here. We would go through a program where we would select the offspring that confer the resistance to the water weevil. There would be two ways to do that. You could grow that out in a water weevil ridden soil, generation after generation and choose the survivors. But, you better make sure you got a lot of water weevils. That means you have to maintain a field with tons of water weevils. Or we do that experiment once, we use our molecular markers, and we find markers linked to the gene that confers the resistance to the water weevil. From then on, every generation, we use the markers to tell us which offspring carry the allele that confers the water weevil resistance and we save those individuals and you can look at them in a healthy field for all the other traits that you think are important. There are lots of reasons and there are lots of examples of this but this is a lot of what my lab does is to develop the markers and the tools and the genetic understanding. My students spend a lot of time figuring out which markers are linked to the genes that the breeders are interested in so they can use the markers to assist them in their program as they move through this process. We also are interested in the genetics and the discovery of how genes work to actually confer traits of interest. It becomes fascinating in its own right. I want to talk briefly about multi-location trials.

Audience: At which generation do you start using markers to do selection?

Susan: It depends very much on economic value because here you have many more families that you have to track. Often we will start in the very first generation. If we are very sure of the markers, for example in the rice breeding world in the United States you have to breed for quality. In Japan you have to breed for quality. In India you have to breed for quality. Now there are countries where you don't have to breed for quality but if you want the quality rice that people are going to really want to eat and that is going to be marketable, we already know which alleles you need to have fixed in these varieties to get this quality rice. If you want Indian basmati, there are different alleles. The U.S. rice industry, for instance, uses the markers coming out of our lab a 100% of the time to tell them which ones to keep in terms of quality. Then they look at those and look for all kinds of other traits. It's much cheaper for them then having a panel of individuals, 12 years later, figuring out which of these things along the way tastes good to a taste panel.

Audience: I was just curious if you would start already in the F2?

Susan: You can start there but for some traits you don't want to start so early. Some traits that are governed by many genes require that you wait until later generations to evaluate. If a trait is quantitative and you have to recombine many, many genes to find what you are looking for, you may have a strategy that says I am going to look for certain components of that genetic variation in the F2 and then I am going to wait and recombine them. Or you can find two components that you need to recombine that are not coming up together in the F2, you can choose them and cross them on purpose. There are lots of ways.

Audience: Do you just take a line that people like in a certain area and then put the genes in them, the disease resistant genes?

Susan: We do it through crossing. We don't do it through transgenics. Lots of people put things in through transgenics, it's another way to do it.

Audience: Are you developing cold hardiness or identifying markers for frost tolerance or short season ripening? Is that a focus of your lab?

Susan: No it hasn't been, but there are several people that I know who do that work. One of the things that you can do if you wanted to look at that is the literature. We can pull out what is known and find out which marker. The markers are out of our lab, but the correlation between the marker and the trait is often not. I know that the markers are sitting in our refrigerator. Most people try to publish their work and then you can pick up what they have published and you can try to see if it actually correlates in your material and your environment. Those are the collaborations that can happen. These are ongoing things that take a little time to get started because you have to collect the right material and get the right markers.

Audience: Could you repeat what happens at the F4 stage? I am missing the link between the process you go through and then how you finally get something stable that the grower could use.

Susan: The F1 selfs and gives rise to thousands of offspring. You typically generate a very large F2 population and you select certain families that perform well. Those families that you chose you will self and they become F3s. You evaluate the F3 and select the best lines. Each of those F3s will produce 500 or a thousand offspring. Every generation, I will save the seeds from the plants or families I have selected the generation before, and I will let them self. I am not crossing anything after the initial cross, I am letting my selected individuals self each time, giving me F3, F4, and F5, etc. Every generation I am looking at the offspring from each of those families and most of the families will be eliminated. I will keep only the very best. The family that ultimately gives rise to a varietal selection, has less and less variation as you self more and more within the family. What you are doing then is making small refinements as you go down the road.

Audience: In theory you could take the rice from F4 or F5 and it could be grown here and it could go through a few generations that are relatively stable where you are not seeing a huge amount of variety in the offspring.

Susan: We have to do this with some field evaluation every year. We have to choose 2 or 3 locations every year and try to grow out the offspring, not in the F2. But from this F2, I now have thousands and we have an opportunity to partition that and look at that in different farmers' fields and evaluate which of these families look the best. That becomes a participatory breeding project. The seed is derived from the same families, it is allocated or partitioned, everybody looks at it and they report back which of the families look the best to them in terms of hardiness, flowering time, etc. You could go through a whole quality assay, but you usually don't do that until later. You start looking at agronomics and performance. Mostly in these environments you are just looking at whether or not this sets seed over time as the weather fluctuates year by year and your locations, soils, and management changes.

What I was going to say is that in some breeding programs those multi-location trials are completely managed by the breeder and in other breeding programs those are managed by the community. In other words, if it is a participatory approach, then the trial and the feedback is done collaboratively. If it's managed by a breeding program, then they have designated regions and trialing areas every year and they accumulate data. Usually if the breeder is managing it the data is a little less noisy because they manage it similarly. The environment is a variable but they try to keep the management more or less similar so that they are not adding another layer of variation. I think that doing an evaluation of germplasm in multi-locations and seeing which germplasm does well is the first step for you. Once you know which of the 45 lines do well across a couple spots in Vermont and maybe some are always going to do better in some places and some always in another, only then can you start actually thinking about what kind of crossing program makes sense. You are not going to do crossing until you know what, of all those things over years and environments, what you can count on. Crossing isn't as easy as I said. Allowing things to outcross and harvesting mixtures is interesting but they are not very stable. If you want to go back to them, one year they might be good and another year they might not be good. They are moving targets and there are pros and cons to that.

I was going to say something about how we normally fund public breeding programs. Some people think that public breeding is a dying breed. That sounds funny but another way of thinking about it is, if we don't maintain public breeding programs we won't train breeders who are needed by the private sector. There is a new awareness, as the number of breeders trained in public breeding programs reaches an all time low, that the private sector is so in demand for breeders right now that every single person who graduates out of our program is getting a job immediately. The private sector is now coming to us and saying could we please just put money in your program so you can train more breeders because we don't have enough. There has been an interesting shift because for the last 10-15 years it went the other way. The private sector said we don't need public breeders. Well now that there are so few public breeders, they have realized they need public breeders. I would say funding public breeding programs is an interesting question and it is in flux. Normally we are funded by state and federal funds. Breeders have had mandates through both the land grant system, with responsibility to the local and state environments in which they are housed, to deliver varieties for either niche markets, which are not served by the private sector, increasingly for the organic market, and for certain types of crops where the private sector sees no investment possibilities at all. Cornell, interestingly, has been a very major player in apple breeding. Most apples that are bred for the northeast are bred at Cornell. We have a major influx now of USDA money to breed grapes and the wine industry as you probably know in the Finger Lakes Region is expanding and doing very well. We are breeding better reds now. We only had whites for a long time, but now we are breeding better reds. We have rootstock breeders as well as scion breeders. We have active programs in most field crops and some vegetable. We have seen major shifts in many of our crops from public breeding towards private breeding. On the other hand, you might be surprised to know we have an onion breeder. We have a potato breeder, wheat, alfalfa, birds foot trefoil and some of the legumes, maize, and some vegetables.

Audience: Anyone working with nuts?

Susan: Not at Cornell. And we have rice, which is even more bizarre. I thought I would come back to that. I am certainly not funded by the state to breed rice for New York state. Taxpayers of New York have never seen that as a priority. I have never had that kind of funding. People like me are funded largely by the NSF, the USDA, and then foundations.

Linda: What is the definition of a public breeder?

Susan: A public breeder works for a public institution and releases varieties through the public variety release system.

Margaret: It is essentially somebody who is not working in a private company, where the varieties they develop are the proprietary property of that company. Susan and I and most of the other public breeders work at land grant universities and the genetic materials that come out of our programs would generally be broadly available. There might be licensing terms, like you might have to pay a royalty on them, but we don't lock those materials up and say that this is our proprietary germplasm that you can't have.

Linda: Then would you go to Cornell to get that seed or would you go to the USDA?

Susan: Cornell.

Linda: So you distribute seed, Cornell does?

Susan: We have a seed distribution system. Cornell has royalties, so we do collect royalties on most of our varieties. That royalty is the flow back that used to support our breeding programs. That is now in the past tense. They have just found a way to take the royalties away from the breeders and give the royalties back to somebody else. It is a difficult time right now, in general, but royalty flow is important.

Audience: How do you go about contacting Cornell or other public breeding institutions to get seed and is it available through your e-mail?

Susan: Google. You can just go online and type in "Cornell apple breeding" or "Cornell potato breeding" or "Cornell maize breeding" and you will find it right away.

Linda: But you don't have rice yet?

Susan: I don't release any varieties but I try to help anybody who comes to me. For example, you guys just out of the blue one day contacted me and asked if you could get some rice seed. I am always interested in who wants it and why. I have some materials I can't distribute, but most of the things I bring in, I can. I can only give you a small amount because I don't have a big field and so I give you what I can and then I ask you to please amplify it.

There are all kinds of agreements under which we have to work in relation to each other. If I bring something in from IRRI, these thousands that I bring in, I bring them under a materials transfer agreement (MTA). A MTA is a legally binding agreement that says I am freely able to distribute that material to someone else but when I do, the next person also has to sign the MTA that says that they acknowledge the original source and that it is a public commodity. They cannot patent it as it is. They can use it in a breeding program and they can distribute it, but they have to tell the next person every time what the rules of the game are. Then they have to go on record as having agreed to those rules. That is to prevent any downstream litigation that might require IRRI to call in lawyers and spend millions to defend something that they gave away from the beginning. Most of these things are coming in under agreements so I think it begins to be a little bit tedious, but I hope you begin to understand that these agreements are just so that we can distribute the seed.

I just wanted to finish up. The other is foundation funding. Sometimes we can get foundations to fund collaborative work. One of the things that I wanted to recommend to this group is that many of you do know sources of funding for collaborative research and potentially collaborative breeding programs. We would have to sit down and fund the research. It would be very difficult for you to take on a major responsibility in a varietal trial without some incentive to do so and in my case I am prohibited from taking on certain types of work unless I can pay my way. I have to pay for my greenhouse, I have to pay Gen's salary, and I need to be able to make sure my program is paid along the way. When we talk about trying to undertake research we have to also talk about how we might fund it.

If after the workshop you come together and you guys want to form a network of people to help coordinate and transfer seed, watch for 2 or 3 things. One is red rice contamination in your seed because you don't want to be spreading red rice around to other people's fields. Watch the quality of your seed and make sure that you are managing your seed stocks as purely and as carefully as you can. The second thing is that there is something called the rice panicle mite. Rice panicle mite (RPM) is not quite microscopic, but it is transparent and very difficult to see. It comes right at the point when the panicle is emerging and it is pretty much ubiquitous in all rice growing areas. The USDA has quarantined anyone's field where that rice panicle mite is found. Last winter we were quarantined at Cornell and it went out all over the website. They quarantined us and they made us shut down the greenhouse and we had deal with having almost no plants for over a month or maybe two months. It cost me a lot of money so be careful of the rice panicle mite. There is a simple way to control it and it is worth it. When your seed comes out of the field, dry your seed. Make sure it dries down to 14% moisture or below. You can dry it in a seed dryer or in a vegetable dryer. Then put it in the freezer for 2 days or for 72 hours, I guess that is 3 days. Put it in the freezer for 72 hours and that will kill any mite that is on it when you harvest it out of the field. If you set up a seed distribution mechanism, make sure you are freezing that seed before you send it out anywhere because the last thing you want is to be shipping that mite around and have some quarantine officer come in and shut down your whole network. It would just be silly and it is so simple to prevent.

Christian: Freezing doesn't hurt the viability of the seeds?

Susan: Not if they are dry. If they are too wet, it will.

Christian: Freezing meaning 32 degrees?

Susan: I put it in I guess it is a -20 degree freezer that I put it in.

Margaret: Your standard freezer.

Susan: I put it in a -20 degree Celsius freezer, so a really cold freezer. You should get in the habit of managing your seed that way and you will not regret it. It's cheap and it's easy to do. It just means you have to purchase a freezer but it is going to save you somewhere down the road and the seed viability is not affected.

Audience: How does a home grower know about the moisture content in the seed?

Susan: Do you have a vegetable dryer? When you harvest it dry out of the field, meaning that it already turned yellow and everything, then you dry it for say 3-5 days. Gen what do you do?

Gen: I think that after harvesting, one week outside with natural air is enough. Then the water content should be about 15% or something.

Audience: What if it rains all week?

Susan: I would put it in the seed dryer just to be sure. Margaret what do you do for yours?

Margaret: I was going to say you want to make sure that the seed dryer is not too hot because that will kill your seed. If you get up to 40 degrees Celsius, you will kill your seed. We are drying corn seed and it is a lot bigger seed but we would usually put it in a dryer at maybe 35 degrees Celsius, which is about a little higher than room temperature around a 100 degrees Fahrenheit, for 5 or 6 days.

Audience: Correct me if I am wrong but the seed will be quite hard if it is dry enough. If it dents at the push of a fingernail, then it's probably too moist.

Gen: Also you can bite it and do a teeth test.

Audience:	Christian is also saying that you can get a little device that measures the amount of moisture in the seed.
Susan:	Actually that is a good thing to get right because managing seeds well has everything to do with germination and viability and then productivity. In the end you want that germination to come through.
Audience:	It is not for consumption purposes?
Susan:	Right, it is for shipping seed anywhere. It is for the seed not for the consumer.
Audience:	How about the seedlings, giving out the seedlings?
Susan:	You mean if you have a nursery and you want to give the seedlings?
Audience:	We grow rice and we gave some seedlings last year.
Susan:	Every seed in our program is now managed through freezing because by law I have to do that now as a result of the quarantine. I am just warning you that it is best not to have to go through it by law. I have a USDA officer that comes and visits me every single month and checks my records and checks my greenhouse. My collaborators in Texas, they have gotten shut down for the second time this year. It is just not worth it. I don't know why the USDA thinks that they have enough money to worry about this panicle mite that doesn't really amount to much but I am suggesting no matter where you are going to give that seed, process it through a freezer and then whoever you give it to, the seed will be fine. That is what I would suggest.
Audience:	Have either of you had the wild red rice in yours?
Takeshi:	I don't think so, so far.
Susan:	You will know because it looks just like the cultivated rice when it is young and it starts to bolt just before flowering. It will shoot up and it will emit this huge inflorescence and then it will shatter seeds all over and all of this will happen really fast. If you walk out there and you got red rice, you will see it because it spikes itself right up, then its panicles come out, the seeds are red, and they shatter. I should finish the story on the red rice. The reason that people are so worried about it is because it has got shattering, it has got seed dominancy, it has got red pericarp, and those seeds can be dormant in your soil for up to 7 years. It is really hard to get rid of them once you got them because no matter how many times you rogue that you are just going to be rogueing them forever. If you see them, if something really spikes up, this rogueing idea is partly to get rid of that weed. That is a lot of what it is about.
Linda:	I just want to repeat what Susan said about seed. We have had several people write and call us about bringing seed into the country. It is so easy to put it in your suitcase or carry it from other places but it is important to get it from the USDA. Please get it from sources you know and do correctly.

Finding our Relationship with Rice: Economic Factors, Spiritual Perspectives. Rice as Teacher, Rice as Friend: Christian Elwell

Summary

What does the market say about the potential for locally grown rice and locally made rice products in our area? We will look at some numbers gathered from local stores, restaurants, and food processors, who sell rice directly to consumers and/or use rice in their products. We will also look at rice in the context of the national rice crop. See Appendix B.

What does rice itself have to tell us about ourselves and our economies? We will consider the astonishing adaptability and reproductive capacity of rice as a model for an economy of Love, Abundance, and Community (Appendix B). This will help to lead us into finding a relationship with rice that can bring healing to ourselves and to our environment.

What is our relationship with rice? To whom are we listening?
Some stories about rice. Reading: Lucien Hanks, *Rice and Man*.
Can we open ourselves to the idea that nature is not passive? That rice is coming here to help us, even guide us on our journey? Developing a personal relationship with rice: Rice as teacher, Rice as friend, Rice as healer. A view of the potential of medicinal rice from Anastasia.

<u>The bottom line</u>: "Body / Land: Not Two." Who says?

Further Reading

Grist, D.H. 1953. *Rice.* (London: Longmans, Green)
Hanks, Lucien. 1972. *Rice and Man.* (Chicago: Aldine/Atherton)
Ishida, Eiwan. 1989. *Genmai, Brown Rice for Better Health.* (New York: Japan Pub.)
Megré, Vladimir. 2008. *Anastasia.* (Kahului, Hawaii: Ringing Cedars Press)
Shurtleff, Wm., and Akiko Aoyagi. 1983. *The Book of Miso.* (Berkeley: Ten Speed Press)
Takenaka, Masao. 1986. *God is Rice.* (Geneva: World Council of Churches)

Presentation

(There is a handout in your packet for my presentation, if you could please pull it out. It is entitled, "Finding our Relationship with Rice.")

Let me introduce myself. My name is Christian Elwell. I live in Conway, Massachusetts, which is about an hour south of here. Back in 1981, my wife, Gaella, and I founded the South River Miso Company. We have been making miso commercially for close to 30 years. We use 32,000 pounds of rice a year in our miso production; 32,000 pounds of rice, which is almost 7 acres worth of rice according to Takeshi's yield records from last year.

I want to speak about economic factors of rice in our area, and I also want to talk about rice from a spiritual perspective. Namely, how do we relate to rice itself? What is our relationship to rice? We must not leave rice itself, the *being* of rice, out of our picture. If we relate to each other as human beings, in order to know each other, we do not ask, "How much do you weigh," or, "How many dollars do you have in your wallet?" We can measure and weigh all kinds of things, but to really know each other we need to find a different approach. We would, of course, have to spend time with each other. We would need to share stories. We would need to know each other through many seasons. This is what I have been doing with the rice since the early 1980's. I obtained a handful of seed from Dr. Peverly at Cornell and started growing rice around 1982. I grew mostly one variety, and I grew it mostly by dry-land culture. (The photos displayed are from 2002.) Then, after seeing Takeshi's rice paddy, I switched over to paddy culture last year. I will talk more about this later, but first, as they say on the Marketplace program on NPR, "Let's do the numbers."

I would like to "do the numbers" with you on rice. Please take out Table A. We gathered this information by making a few phone calls to our contacts in the natural foods industry. If you look at

Table A, the Putney Coop, for instance, sold 2,470 pounds of rice last year, 748 pounds of which was short grain brown rice of the *japonica* type we can grow here. The Putney Coop, is the most local food coop in this area. Even if it were all *japonica* rice, their total rice sales could be grown on half an acre of land. If you look at a restaurant in Montpelier: they use 2,800 pounds of rice a year, which also could be grown on half an acre. As I said before, the 32,000 pounds we use in our miso production would require about 7 acres. It is very interesting to translate the usage of rice from pounds into acres of land. This gives us a picture of what our rice consumption might look like in the New England landscape.

Now, onto Tables C, D, and E: What is the dollar value of rice? At South River Miso we pay FOB Conway $1.09 per pound for organic, short grain brown rice, which comes from California. The coop sells this same rice for $1.62 a pound. There are also some figures (Appendix B) on the national rice crop. The field-run value of rice per pound is about 16.5 cents. If you take these numbers and tab them out in Table E, it shows that for your generic field grown unhulled rice, you would get only about $965 an acre. But let's say that you grew some Jasmine rice… (You can't grow Jasmine rice in Vermont, not yet!) But let's say you developed a specialty rice in your valley in Vermont. Let's say it had special, unique qualities, and appealed to people just because it was locally grown. And let's say you grew just a small amount of it, which you could sell pound by pound at the farmer's market, or, over the internet. You might get as much as, for instance, this family in Texas which sells their Jasmine rice through online sales for $4.49 per pound (Table D). That's $21,013 per acre! (Table E) Table E shows the range of what you might get for an acre of rice based on the price per pound.

Take a look also at table F. This shows plot sizes and yields for homestead rice. If you and your family use about 100 pounds of rice a year, you will need a plot about 900 square feet to grow your own.

As far as the national rice economy is concerned, direct tax payer subsidies to the rice sector have averaged 1 billion dollars per year since 1998 and are projected to average about 700 million dollars per year through 2015. I don't know how these figures affect the economy of rice, but obviously if we got an infusion of only a million dollars into the Vermont rice project, it would change the playing field!

Now, I want to switch gears a little bit. What does rice itself have to say about economy? Suppose you get a seed of rice from Takeshi and take it home with you. Next year, you plant this one seed in a five gallon bucket or in a square foot plot of ground in your garden. You will get a return of at least 650 seeds at harvest time next year. Besides that, by taking care of this one seed, this one plant of rice, you will begin a close relationship. You will begin to know the rice. And, who knows? Perhaps the rice will begin to know you! Now, 650 seeds is the quantity of seed I was getting in my returns for upland, dry land rice. Actually it is probably much more than that for paddy rice. 650 seeds is a conservative figure, as I understand it. Susan was saying 500 to a 1,000 seeds, but let's use 650. So, to repeat, if you start with one seed, next year you are going to have 650 seeds.

If the following year you plant those 650 seeds, you will need a space of about 180 square feet. That's a plot about 12 by 18 feet. From that plot you would harvest about 24 pounds of rice. So, year one, you plant one seed; year two, you plant 650 seeds, and you harvest 24 pounds of rice. Now, hold onto your pants: In year three, if you planted out your 24 pounds of rice, you would need about 2.7 acres of land, and you would harvest over 7 tons of rice! Wow! Is there something wrong with my calculator?

Randy: That assumes, of course, that you take care of it.
Christian: Absolutely.
Randy: My point is this: there is an old Chinese saying, "Rice is like a woman, if you take care and are kind you will benefit, but if you don't, watch out."
Christian: That is exactly right. We are playing with numbers here. We are not actually growing the rice!

Nonetheless, the numbers are staggering! It is hard to grasp: the numbers go from one seed to 7 tons of rice in three years! Of course, as Randy says, there is much that must fall into place for this to happen on the ground. But just contemplate the potential. The staggering productive capacity of rice, indeed, of Nature… It is nothing short of *Awesome*! I call the economy of rice, *the economy of love*.

In our talks today, and in our discussions, if you think about the motive that is behind our thinking, a lot of it has to do with this: How can we get more profit from the rice? We want to grow more per acre. Then, we need somewhere to sell it at a good price, make it marketable, and so forth. This is a valid utilitarian perspective, which we may need to exercise to some extent. But we must not forget our relationship to the plant. We are in relationship with the rice. Our *human* being and the being of rice can be separated only to the peril of both.

There is a great book on rice, a really wonderful book, *Rice and Man*, by Lucien Hanks, which I am happy to introduce here, because Lucien Hanks taught at UVM, and he also taught at Cornell. Lucien Hanks wrote this book in 1972 about his study of rice culture in Thailand, mostly a certain community in Thailand, the evolution of their culture in relation to rice and rice culture. Lucien Hanks writes:

> Seen in an ecosystem, man is no longer the measure of all things nor the master of nature. He is bound intimately to the grain he would grow, for without his sensitive observation of wilting and flourishing, these plants might have dwindled to extinction like the passenger pigeon and the buffalo grass. Without the magnificent adaptability of rice and its responsiveness to man's nurturing, certain tropical civilizations (Golconda in India, Srivijaya in Java, and the Khmer of Angkor in Cambodia) based as they were on riziculture, could never have come into being. Little wonder that the greatest horticulturalists have come from the Orient, where nature is not considered passive. Like the haiku poets who converse with a still pond, they believe that man properly trained develops sensitivity to the voices of plants and plants can hear man's entreaties. (page 23)

This is a profound picture of our potential relationship with rice. It is clearly not a one way street. And what does it mean, for instance, when he says, "…nature is not considered passive"?

It was an incredible experience to come up here two years ago to see Takeshi's rice paddy for the first time. I realized in a flash that this wasn't just about rice. There are so many living things attracted to the ecosystem of a rice paddy! It's like a powerful magnetic field in the environment attracting human beings and creatures alike!

This spring, I constructed a rice paddy right in our backyard by hiring a mini-excavator. It is a 36 foot diameter circle with two holding ponds. Water feeds into the holding ponds from a small stream. What has happened in our environment since we installed the rice paddy and the holding ponds is amazing, in terms of the way nature has responded. When we pave over the earth with a parking lot, or, when we spread herbicides and pesticides over our croplands, living nature responds by leaving. Dead nature sets in. Such actions invite barrenness and death. But when we create a rice paddy, nature responds with an abundance of life and diversity. Either way, Nature is not passive to our deeds.

We have lived in Conway for 30 years, and for 30 years, I have never heard the sound I first heard one evening this May. The sound was something like the baby that was cooing here a short while ago. I wondered, *what is that*? It sounded like some tropical bird had arrived from Costa Rica. The sound was coming from one of the holding ponds. I followed the sound under a rock with a flashlight, and there, hiding in a crevice under the rock was a gray tree frog. I learned to identify it by Google-ing "tree frog" on the internet. There is actually an audio clip of the gray tree frog song! What an amazing creature! Takeshi, of course, knows the gray tree frog. He's had hundreds of them coming to birth out of his rice paddies for the past several years. At our home, all this spring, there were about a dozen adult tree frogs that set up camp around our rice paddy. One was living in the lilac tree right outside my bedroom. Their chorus is an unbelievable sound, quite different from the spring peeper for instance. The coming of the tree frogs was, for me, an affirmation from Nature. "Thank you very much for creating this rice paddy," the frogs were saying. "We like what you are doing and we want to help!"

[Author's note: Later in the season, soon after the rice conference, at the very same time the flowers were first emerging from the rice plants, beautiful, gem-like, tiny green tree frogs emerged from their tadpole stage in the water and perched on the leaves of the rice plants by the dozens. Simultaneously, larval nymphs crawled up the stems of the rice, and after molting in the sun, flew off as dragonflies! This led me to the profound insight: flowers are to the plant, as the frog is to the tadpole, as the dragonfly, or, butterfly is to the worm.]

Lucien Hanks talks about a rice harvest, as I remember, I think it was in Cambodia. A group of women were harvesting upland rice by hand. They carried baskets, and they were harvesting the rice one head at a time with a small hand-held blade, which had a little wooden handle shaped like the head of a bird. They made their way through the field harvesting the single heads of rice into their baskets. Lucien Hanks asked them, "Why are your knives shaped like a bird?" They said, "So we don't scare the rice!" What a tender, loving relationship these women must have had with the rice!

Grist, in his book on rice, comments that so many varieties of rice developed just because people were gathering the rice head by head. When you harvest rice one head at a time, you notice things, differences, in the individual rice plants. One may have a different color, another may have a different growing habit, or shape. Another may have unusual awns, and so on. Observant farmers would save the seed and select for these different variations that appealed to them aesthetically, inwardly, and at the table too: the way the rice cooks and tastes.

One could go over the hill into a valley and there would be a particular variety of rice the people and the soil favored. Then, over another hill in the neighboring valley there would be another variety of rice. Thousands of varieties of rice could develop in that way from direct seed-to-hand-to-mouth relationships that each farmer, each family, and village clan might have with the rice. Thousand of communities grew together around the necessities and out of the gift of rice culture. This is a picture of a nourishing circle and a nourishing cycle of co-creation.

A friend asked me last week if she could come and make some flower essences of the rice plants when they come into bloom. I am really looking forward to this. When she makes the flower essences she goes through a kind of meditative research process. Over time, qualities and healing properties associated with the plant are assigned to it. Here enters another dimension of the rice plant we have not considered.

When I was preparing to plant seed this year for our rice paddy, a friend from Ohio came by to visit, out of the blue. I said to him, "Oh, I am about to plant the rice seeds." (I had soaked the seeds and I was just about to put the seeds into the seed flats.) He said, "Have you read *Anastasia*?" (He pronounced it in phonetic Russian: *On-a-star-see-ya*.) I said, "No! What's that?" And he showed me this book, *Anastasia*. He said, "You have to read this before you plant the seeds." I told him, "I can't read this! I have to plant the seeds today!" So Bob proceeded to share with me what Anastasia is all about.

This is about a healer in Siberia, real or imagined; it doesn't matter. What she says is this: *The plants no longer know who they are serving*. She has come to find that when people eat the food that they themselves are growing, the foods are able to respond to the condition and the needs of the people who are growing them. She says the plants need input, feedback, from us, in order to "know" what to give back in return. There are now millions of acres of rice and of cereal grains, of food plants that no longer "know" who they serve. There are ways to mend this feedback loop, and this is what Anastasia suggests we do: Take some seeds and place them under your tongue for 9 minutes. Then hold the seeds between the palms of your hands for 30 seconds. Next, hold the seeds in front of your mouth and breathe on them. The seeds will absorb all kinds of information from your soul-spiritual bodily being as you do these things. Finally, take the seeds and hold them up under the celestial heavens while standing barefoot in the place where you intend to plant them. This is pretty far out. Why not?

I said to my friend, "I have a few thousand seeds. I can't put them all in my mouth!" That's all right he said. "Just take a few of them and plant those seedlings among the others. They will communicate everything to the other plants."

I followed Bob's instructions with a dozen seeds and planted those seedlings in different areas of the paddy. Of course, now in this stage of their growth, if you go and scratch the soil between the rice plants, the roots of all the rice plants are intermingling. They are all physically in contact. They are not separate from each other, they are grown together, and, presumably, they are communicating. They are probably talking about the guy who put them in the ground!

I don't know if these procedures will affect the yield, but I will tell you this: *it affected me*. It affected me to follow this procedure with the seeds. My relationship with the rice deepened. Now, as I contemplate eating this rice in the fall, I have an entirely new orientation. Whatever this rice brings forth, I am open to receive it *as a gift* for my healing and nourishment in the process of becoming.

Everything we do as human beings that brings us into a closer relationship to the plant, the animal, even the mineral, the stone, deepens our relationship, not only with that outer being, but with our own inner being as well. In my summary, I wrote, the bottom line is this ancient Japanese wisdom-saying, "Body, Earth: not two."

Takeshi, do you know that saying in Japanese?

Takeshi: Yes. *Shindo fuji*. (身土不二。)

"Body, Earth: not two." In dualistic consciousness we separate. We split everything apart. Our physical senses tell us, I am separate from you, I am separate from the rice plant, I am here, and it is over there, and there is no conscious awareness of our intimate connection. But our spiritual being says we are not two, we are not separate. We need to listen to our spiritual life, especially in this time of extreme disconnect from Nature. Please see the movie *Food Inc*. It is enough to motivate us to get on another track in our relationship with our food and our food plants. Perhaps you will start your own rice paddy! I highly recommend that, first, you take a single seed of rice (or two or three seeds) and grow them in a bucket. Seven tons of rice in a five gallon bucket! Think about it! Do it!

I am going to close with this thought. This month they have been celebrating the 40th anniversary of the Apollo landing on the moon. Forty years ago you could not buy brown rice. You couldn't find it, even if you were looking for it. Now we are growing it, right here in Vermont, of all places! A lot has happened in forty years. So, there was a radio program commemorating the 40th anniversary of the Apollo landing on the moon. I was listening to it as I was driving along the highway. The reporter asked the astronaut "Was it really worth it?" The Apollo program cost billions of dollars. The reporter wanted to know: what is the pay back? The astronaut could not give him a direct answer. He said, "We have to take a very long view to see the payback for something like this."

In my estimation what Linda and Takeshi are doing here is of greater significance than landing a man on the moon. And, yes, we have to take a long view to see the implications, the so-called 'pay-back'. The Northeast is virgin ground for the culture of rice. It would be foolish to look to California or Arkansas as models to copy. Our aim cannot be to grow a million acres of rice. That isn't what I want to do. I am very happy with a small plot. What we can do is grow sustainable communities, and the rice can grow with us in that direction.

Finally, I would like to pay tribute to Linda and Takeshi, for the work that you have done and for all that the rice is doing: bringing us together, Susan, Randy, Peter, Gen, and others from Cornell.
Who is doing this? Let's ask the rice!

Closing Discussion

The presentations went an hour later than planned and therefore the closing discussion was much shorter. The following is a short summary of participants' thoughts and ideas about how to encourage sustainable rice production in the Northeast.

During the discussion the following topics were brought up:

- Develop maps that overlay important natural resource criteria to determine suitable rice growing areas.
    - Examples of relevant parameters include: soil type, water availability, average temperature, and growing degree day.
- Compile data about when rice is seeded, transplanted, and harvested, so that comparisons can be made across years and farms.
- Write bio-security protocols that will protect farms from the spread of diseases, pests, and weeds.
- Monitor the distribution of seed from farm to farm for seed-saving records.
- Determine what state and local regulations are applicable to rice paddy construction and water management. Need to consider existing wetlands, wetland permits, and regulations relating to diverting surface water.
    - Add this information to the Guide to Environmental Law in Vermont, New Farmer Guide, developed by the Vermont Law School.
- Write additional grants, possibly Northeast SARE Research and Education grant.
- Create website that provides rice growing resources and is a vehicle for rice growers in the Northeast to share information.
- Write a grant that would fund a rice researcher from Hokkaido to do research and education in the United States.

Appendix A: Rice Recipes from Workshop Breakfast and Lunch

Breakfast

Kheer (Indian rice pudding)

Recipe can be found in The Complete Asian Cookbook by Charmaine Solomon.

Ingredients:
1/2 C. short or medium grain rice
8 C. milk (sheep's milk can be used)
4 cardamom pods
1 and 1/4 C. sugar (sugar can be reduced for breakfast)
2 T. slivered blanched almonds
1/4 t. ground cardamon
1/4 t. freshly grated nutmeg
1 T. rose water or few drops rose essence

Directions:
Wash the rice and boil for 5 mins in water. Drain well. Bring milk to boil with the cardamons in a large saucepan, add rice and simmer, stirring occasionally, for 1 hour until the rice is very soft and the milk quite thick. As milk thickens it will be necessary to stir frequently with a wooden spoon, scraping thickened milk from bottom and sides of pan. Add sugar and almonds and continue cooking until the consistency is like that of porridge. Remove from heat, pick out the cardamon pods. If you think the flavor needs intensifying, add ground cardamon. When half cool stir in the rose water. Serve warm or chilled, in a large bowl or individual sweet dishes, the top sprinkled with a little grated nutmeg.

Arrox con Leche (Spanish rice pudding)

Recipe can be found at http://www.whats4eats.com/desserts/arroz-con-leche-recipe.

Ingredients:
4 cups milk
½ cup short grain rice
1 cinnamon stick
2 strips orange or lemon peel (optional)
pinch salt
¼ cup raisins
½ cup sugar
2 tablespoons butter
1 teaspoon vanilla

Directions:
1. Place the milk, rice, cinnamon stick, orange or lemon peel and salt in a medium saucepan and bring to a boil over medium heat. Immediately reduce heat to very low and simmer, stirring often and scraping bottom, for about 45 minutes.

2. Add the raisins and sugar and simmer for another 15 minutes. Stir often to keep from sticking to the bottom of the pot.
3. Remove from heat and stir in the butter and vanilla. Adjust sugar to taste and serve hot or cold, sprinkling the top with some ground cinnamon.

Lunch

Red Rice and Beans

Recipe provided by Roberto and Elissa Gauthier.

This recipe is good with a long-grain rice.
The red kidney beans are best made from scratch, not from a can. If preparing the beans yourself, soak the dry beans in cold water overnight.

Try using a pressure cooker to prepare the beans. I season the beans and add onions, green pepper, a spicy pepper, garlic, salt, pepper, tomato and fresh cilantro.

Using a two-to-one ratio of water to rice, either use an electric rice cooker or a pot over fire to cook the rice.

First, bring salted water and rice to a boil, then lower the flame and cover the pot until the liquid is absorbed.

A classic Caribbean way to enjoy rice and beans is to mix both of them together on the same plate.

Buen provecho!

Risotto: a classic Italian short-grain rice recipe

Recipe provided by Roberto and Elissa Gauthier.

<u>Cooking tools</u>: Use a heavy-bottomed pot with a smooth, thick, enamel coat & a long-handled wooden spatula with a straight edge for proper stirring.

<u>Cooking process</u>: *Risotto* requires your attention for at least 20 to 30 minutes. This is not a dish that you can start and allow to cook by itself. It needs you.

Step 1. Make a *soffritto* of onion. Dice an onion and sweat it in butter until golden. Olive oil can be used instead of butter, but it is not the classic ingredient.

Step 2. Grate some Parmigiano-Reggiano cheese and set aside. Do this before you cook the onion or while you're cooking it.

Step 3. Boil 2 cups of water and pour it into a bowl with a handful (1 ounce) of dried porcini mushrooms. Leave for 30 minutes until the mushrooms are soft. Take the mushrooms out of the bowl by hand, squeezing as much liquid from them as possible. Chop into ribbons. Using a strainer lined with a thin paper towel, filter the flavorful porcini-infused water into a measuring cup. Set aside.

Step 4. Add raw short-grain rice to the soffritto and stir the rice and onion in the dry pot for a few minutes without burning your ingredients.

Step 5. Add warm chicken broth with a ladle to the rice and onion and stir until the liquid nearly evaporates. Then, add more liquid, alternating with the porcini-infused water, always stirring until the liquid dissipates. You can also include dry white wine as a liquid with the others.

Step 6. After stirring liquid into the rice for at least 20 minutes, the rice grains will absorb flavorful moisture from the broth and the porcini-infused water.

Step 7. The risotto is ready when the rice takes on a "wavy" texture. At this point, add the grated cheese and stir. Then, drop in some sweet butter and stir.

Step 8. Taste and get set to serve the risotto. The outer part of the rice grain is silky and soft, but the inner part still has substance and an al dente bite.

Step 9. Enjoy your risotto. You might like the effect of freshly-ground pepper. *Buon appetito!*

Bibimbob

Recipe provided by Jiwon Ahn.

1. Cook the rice: any kind of rice would work, even cooked barley too, but short grain with stickiness tends to work better for mixing.

2. Prepare toppings of your choice. Stir-fried bean sprouts, sliced and sautéed mushroom, julienned and stir-fried carrots, or any other kinds of cooked or fresh vegetables (torn-up lettuce, sliced cucumber, thinly sliced bell pepper) can be used as topping. Two things to be careful about in preparing toppings: the color of different ingredients (so that toppings collectively have a variety of colors), and seasoning of each topping (each ingredient needs to be seasoned properly with salt or soy sauce).

Two popular toppings:
1) spinach: blanch spinach in boiling water for less than 1 minute, move into a bowl of cold water to stop cooking, then drain well. Don't squeeze the blanched spinach. Season the spinach with a pinch of salt, 1 tsp of sesame oil, 1/2 teaspoon of minced garlic, and a bit of minced green onion.
2) beef: marinate ground beef (about 1/2lb) with 4 teaspoon of soy sauce, 1 teaspoon sugar, 1 teaspoon minced garlic, and 1 teaspoon sesame oil for at least 20 minutes up to overnight. Brown the beef in a hot pan quickly so that the beef is sealed and juice doesn't come out. If you like, you can add a bit of thinly sliced onion and mushroom into the beef and stir-fry them together.

3. Fill a small rice bowl with the cooked rice. Remove the rice into a larger bowl. On top of the rice, arrange toppings without mixing them up yet. Try to arrange the toppings so that the colors of different toppings are nicely contrasting from one other. Put a teaspoon (or less, depending on your preference) of Korean chili paste (go-chu-jang) and a tablespoon of sesame oil on top of the

topping. Then put one fried egg (sunny side up) on top of the topping and sauce. Serve with a small bowl of soup.

Appendix B: Figures from Christian Elwell's Presentation

U.S. Rice Crop 2008 [1]

2.995 million acres planted
2.976 million acres harvested
Over all average yield: 6846 lbs per acre
Price per cwt: $16.50 (16.5 cents per pound paddy rice)
Field run value per acre: $1129.59 (68.46 X 16.50) [my figures, ed.]
Total value U.S. Rice Crop 2008: $3.39 Billion

Rice Subsidies [1]

"Direct taxpayer subsidies to rice sector have averaged $1 Billion per year since 1998 and are projected to average $700 Million per year through 2015."

Rice Economy 101,[1]

The Economy of Love:

One Grain, Ten Thousand Grains:
7 Tons of Rice in a 5 Gallon Bucket

Year	# of Seeds/hills	Area needed	Yield
1	1	1 sq. ft or one 5 gal bucket	650 seeds (5 heads x 130 seeds per head)
2	650 ÷3= 216 hills ÷2= 325 hills Avg.	 12 X 12 = 144 sq. ft. 12 X 18 = 216 sq. ft. 180 sq. ft.	24 lbs.
3	650 X 650 = 422,500 seeds ÷3= 140,833 hills ÷2= 211250 hills Avg.	 230 X 375 = 93750 sq. ft. 300 X 470 = 141000 sq. ft. 117375 sq. ft. = 2.7 acres	15795 lbs. = 7.8975 Tons!!

[1] USDA National Agricultural Statistics Service (www.nass.usda.gov)
[2] Cato Institute, Trade Briefing Paper #25, November 16, 2006 (www.freetrade.org)
[3] Christian Elwell, ed., South River Farm, Conway, MA, July 25, 2009.

Table A

Food Co-op	2008 Ttl. Lbs. Rice	acres (at 4680 lbs per acre)*	Short Grain Brown Rice (japonica)	acres (at 4680 lbs per acre)*
Putney Co-op (VT)	2470	0.53	748	0.16
Greenfield's Market (MA)	13377	2.86	3548	0.76
Hunger Mountain (VT)	21230	4.54	8791	1.88
Upper Valley (VT)	4659	1.00	1851	0.40
Onion River (VT)	19804	4.23	3894	0.83
sub ttl	61540	13.15	18832	4.02
Restaurant				
Northampton (MA)	8000	1.71	8000	1.71
Montpielier (VT)	2800	0.60	2200	0.47
sub ttl	10800	2.31	10200	2.18
Processor				
South River Miso (MA)	32000	6.84	32000	6.84
total pounds/acres	104340	22.29	61032	13.04

Table B

Distributor (37 varieties available)				
A (NH)	366392	78.29	55102	11.77

Table C

Value per pound: Organic Short Grain Brown Rice		
South River Miso	FOB Conway, MA	$1.09
Co-op	retail price	$1.62
Lundberg mail order	retail price	$1.42

Table D

Organic Heirloom Rice: online price per pound **	
Kalijira Brown (Bangladesh)	3.39
Forbidden Black (China)	3.59
Bhutanese Red (Bhutan)	3.59
Jasmine Brown (Raun family, Texas)	4.49
* *www.tropicaltraditions.com	

Table E

Values per acre*		
price per pound		value per acre
$0.165	field run	$965.25
$0.65	hulled,	$3,042.00
$1.09	cleaned,	$5,101.20
$1.62	packaged,	$7,581.60
$2.00	and	$9,360.00
$2.50	ready	$11,700.00
$3.00	to	$14,040.00
$4.49	eat	$21,013.20

Table F

Growing your own Homestead Rice (Based on yield of 4680 lbs hulled rice per acre)*		
plot size	square feet	Yield
10 X 10	100	10.5 lbs.
20 X 20	400	42.5 lbs.
30 X 30	900	96 lbs.

* All figures in these tables for yield per acre are based on figures from Akaogi Farm (see summary from their 2009 Northeast SARE Farmer Grant) with average yield of 5847 lbs per acre of unhulled paddy rice, which represents about 4680 lbs of hulled rice.