The Consequences of Global Warming

Global climate change and its expected consequences in rice-growing regions have become a growing influence in much of IRRI's current research. Average temperatures are expected to rise by up to three degrees Celsius. There will be more carbon dioxide in the atmosphere, and increased ultraviolet radiation.

One fear is that yields could fall by 50 percent if air temperatures rise to 37 °C while the plants are flowering. So a search of germplasm has begun in the International Rice Genebank to see if genes exist that control the time of day at which rice flowers. The hope is to develop plants that flower only in the cooler parts of the day.

Not least among other concerns is the continuing scientific debate about the part rice farming plays in global warming by the emission of so-called "greenhouse gases." At one time, rice farming was thought to be one of the main culprits because of the amount of methane gas emitted into the atmosphere from flooded paddies.

However, research begun by IRRI in the early 1990s measured methane emissions from flooded paddies, and they amounted to only 12 percent of the global total, considerably lower than previously thought. Management practices have been developed to help minimize emissions, mainly involving water and crop-residue management. Methods have also been developed to assess the effects on emissions that result from changes in farming practices.

Alongside global warming, the growing scarcity of water for agriculture is a major environmental issue affecting world rice production. But there is little comfort in the fact that draining paddies at times during crop growth both reduces methane emissions and saves water.

Drying the flooded soil sometimes gives rise to an even worse gaseous emission: nitrous oxide. The gas is produced in a complex process involving nitrogen from both organic matter and fertilizers that remain in the soil as it becomes aerated when paddies are drained. Whereas one molecule of methane is 21 times worse than one of carbon dioxide in its contribution to global warming, nitrous oxide—better known as laughing gas—is 310 times worse than carbon dioxide.

So the question among IRRI's soil and water scientists is, Should the hardware and methodology used to fix the amount of methane rising from flooded paddies be shifted directly into measuring the nitrous oxide rising from rice soil that is partly dry and partly wet?

According to the deputy head of IRRI's Crop, Soil, and Water Sciences Division, soil chemist Dr. Guy Kirk, nitrous oxide emissions from rice fields are not a serious problem in continuously flooded systems. However, since rice farmers face the need to save water, this cannot be dismissed as a problem in the near future.

IRRI scientists are currently preparing for a water-scarce future by perfecting a rice plant that will grow in aerobic, or dry and aerated, conditions, much like wheat or maize *(see* "Aerobic" Rice: Preparing For a Water Crisis, *page 20)*. It is envisaged that the aerobic rice will be irrigated and will need fertilizer.

"Water-saving practices are going to push us toward nitrous oxide emissions," Dr. Kirk says. "But we don't yet have the necessary information to quantify the problem. We are therefore developing research plans.

"One problem is that nitrous oxide emissions are very transient, so you need continuous measurement to record them."

IRRI crop ecologist and modeler Dr. John Sheehy agrees.

"Interfering with water use by changing flooding to irrigation is rather difficult and dangerous because water stress is the main factor limiting yield in agriculture and, if irrigation is continuous, it's not likely to save water," he says. "Furthermore, we will have to consider the effect on gas emissions with every proposed change in crop management. We will have to ask, What is this going to do to nitrous oxide emissions, on the one hand, or methane emissions on the other? Like it or not, rice crops will always grow at the interface between aerobic (with oxygen) and anaerobic (without oxygen) conditions."

Dr. Sheehy is eager to investigate the benefits to rice farmers that may arise from global measures to mitigate emissions of greenhouse gases. He notes that provision has been made for so-called "clean development mechanisms," in which developed countries, or even polluting industries, can pay for projects that reduce emissions in other parts of the world.

The resulting reduction in emissions can then be reckoned as part of that developed country's promised contribution to global reduction. For instance, an industry that emits 100,000 tons of carbon dioxide into the atmosphere every year can pay for the planting of a new forest in another part of the world that will capture 100,000 tons of carbon in its trees, thereby reducing the industry's "carbon balance sheet" to zero. The developers of the forest reap the monetary rewards.

Trading in "carbon credits" began in January 2000, and Dr. Sheehy believes that the market will soon be worth billions of dollars per year.

"I think rice straw and rice hulls have potential in this area," he says. "We must be able to work out how to sequester the carbon in straw and hulls. Perhaps we turn it into building material or wood substitutes, and save trees. Perhaps we use it to produce ethanol, as a fuel, thereby reducing the need for petroleum.

"Rice farming produces 500 million tons of straw every year," Dr. Sheehy adds. "If the carbon in it is worth ten dollars a ton, that makes it worth five billion dollars. That's a bit better than dumping it back into the paddies and fueling methane emissions."