Texas Rice

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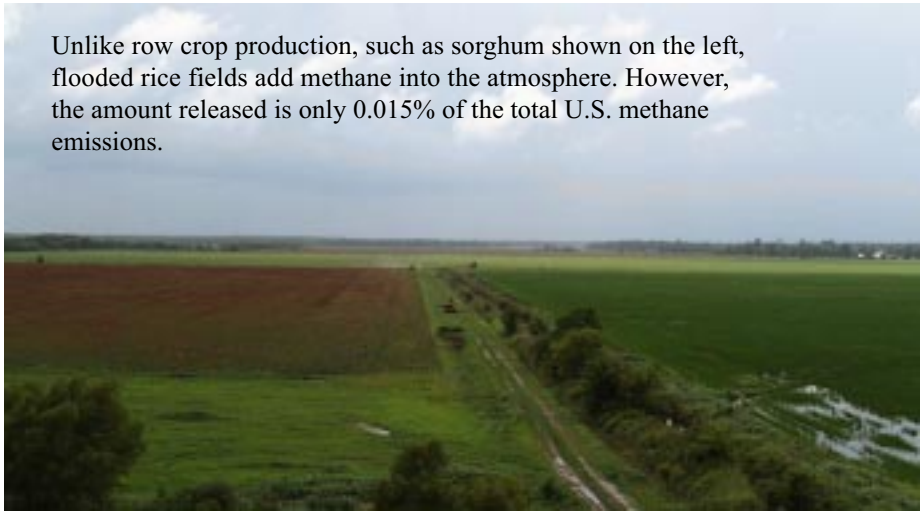
Global Climate Change and Agriculture

Many chemical compounds found in the Earth's atmosphere act as "greenhouse gases". These gases allow sunlight to enter the atmosphere freely. When sunlight strikes the Earth's surface, some of it is reflected back towards space as infrared radiation (heat). Greenhouse gases absorb this infrared radiation and trap the heat in the atmosphere. Over time, the amount of energy sent from the sun to the Earth's surface should be about the same as the amount of energy radiated back into space, leaving the temperature of the Earth's surface roughly constant. Without greenhouse gases, the Earth's surface temperature would be about –18 ºC, which is too cold to sustain life as we know it.

The problem we now face is that human activity is generating more of these greenhouse gases than would naturally be released into the atmosphere. As a result, more heat is trapped, contributing to the rise in the Earth's average temperature and causing the global climate to change.

Many gases exhibit these "greenhouse" properties. Some of them occur in nature (water vapor, carbon dioxide, methane, and nitrous oxide), while others are exclusively human-made (like chlorofluorocarbons used for aerosols).



Unlike row crop production, such as sorghum shown on the left, flooded rice fields add methane into the atmosphere. However, the amount released is only 0.015% of the total U.S. methane emissions.

The two main greenhouse gases generated by human activity are carbon dioxide (CO_2) and methane (CH_4). Since the industrial revolution of the 18th Century, emissions of these gases have substantially increased, particularly CO_2. We have also introduced two more greenhouse gases as a result of industrial development: nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). The table on page 5 illustrates the relative amounts of gas emissions for the U.S.

Due to their chemical composition, each gas traps a different amount of heat. One kilogram of methane traps as much heat as 21 kilograms of CO_2, while 1 kilogram of nitrous oxide traps as much heat as 310 kilograms of CO_2. (See sidebar on page 10.)

The following list shows some of the ways greenhouse gases are generated:

*Burning fossil fuels, coal mining operations, oil and gas production
*Clearing of land
*Farming and ranching
*Breakdown of wastes in landfills
*Industrial processes

Rice production contributes to the buildup of greenhouse gases in three ways: through the burning of fossil fuels to power equipment (CO_2), fertilizer use (NO_2) and methane emissions from the flooded fields. The warm, waterlogged soil provides ideal conditions for methanogenesis, and though some of the methane produced is then oxidized by methanotrophs in the shallow overlying water, the vast majority is released into the atmosphere.

Contrary to what is often reported in the popular press, the methane released from rice fields is a very small contributor to the

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From the Editor...

Welcome to the Winter issue of *Texas Rice*. In this issue, we provide a broad overview of global climate change, or as some people say, global warming. As part of this review, we address the possible impact of global warming on agricultural production and environmental quality. If global warming turns out to be greatly influenced by human activity, as many scientists and an increasing number of lay-people suspect is the case, the eventual impact could be great. However, the issue increasingly appears to be not so much one of identifying a problem; that has largely already been done through an increasing amount of scientific evidence. The issue is more one of working out how to convince people and governments to change what they do to control, dampen or possibly even reverse global climate change in a meaningful way. The crux of the problem is the inherent slowness with which global warming usually occurs. When measurable impacts accumulate slowly over decades, people don't perceive change and it is hard to convince them to take appropriate actions. As a result, by the time global warming is broadly recognized as a problem that demands fundamental change, the required effort may indeed require massive sacrifices.

Global warming is obviously one of the most controversial issues facing our world today. As developed countries shift much of their economies to importing from developing countries, whose labor is much cheaper and whose environmental laws are often lacking or not enforced, global CO_2 emissions from these developing countries have increased. Some politicians argue that the developed countries should be charged for the increased carbon dioxide emissions being "exported" by the increasingly industrialized developing countries I think a better argument would be to charge a CO_2 tax levied against imports from these countries. This would foster a more environmentally neutral production system. Although this would slow the rate of economic growth of developing countries, the growth would be sustainable and would avoid many of the types of uncontrolled growth problems we are seeing China. This approach would also minimize some of the massive employment shifts that are occurring in almost all North American and Western European countries. If we do not take positive steps in this direction, we could see a second industrial age in the developing countries and with it will come the type of large-scale pollution that was so common in England and parts of U.S, particularly during the early stages of the first industrial revolution.

Not all of the impacts of global warming are negative. Detailed analyses suggest that global warming could increase agricultural production in temperate countries, but possibly decrease production in Asian countries. Increased temperatures would very likely resulting in an overall increase in land suitable for rice production in the U.S., although the rising sea-level would push much of the Texas rice acreage further North. However, the elimination of much of the coastal rice producing areas of Asia would be much more serious. Given that most, if not all, of the Asian countries do not have land available to replace what would be lost due to the rising sea-level, U.S. rice production would have the opportunity to greatly expand to meet world demand.

One of the negative effects that a significant level of global warming would have on agriculture in temperate climates is with the production of tree and vine crops that require winter chilling to produce fruit the following crop season. Another negative aspect would be the shifts in pest species that occur on crops. Temperate climates offer the advantage of cold winter months, which seriously curtail insect and disease populations, in some cases totally eliminating pests

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Inside This Issue

Cover Story:
Global Climate Change and Agriculture

Farming Rice

a monthly guide for Texas growers

Providing useful and timely information to Texas rice growers, so they may increase productivity and profitability on their farms.

How High Nighttime Temperatures Affect Rice Productivity

According to a May 2004 report issued by the International Rice Research Institute, increased nighttime temperatures have a negative effect on rice yield. Analyzing weather data and yield data at the IRRI farm from 1979 to 2003, researchers found that annual mean maximum and minimum temperatures increased by 0.35 ℃ and 1.13 ℃, respectively during the 25 year period. Further, they found that grain yield declined by 10% for each 1 ℃ increase in minimum temperature, while the effect of maximum temperature on crop yield was insignificant. This report provided direct evidence of decreased rice yields from increased nighttime temperature associated with either global warming or urban warming of neighboring areas.

At the Texas A&M Rice Research Center in Beaumont, graduate student Abdul Mohammed and whole plant physiologist, Dr. Lee Tarpley, are conducting experiments to uncover the physiological mechanisms behind this phenomenon. They are especially concerned about the negative effects of unseasonably hot periods that occur in some years in the Southern U.S., which might be increasing in frequency.

Specifically, they are exploring the possibility that increased nighttime temperatures decrease yield through 1) increased respiration, 2) increase in oxidative stress, 3) disruption of nutrient transfer within the plant, and/or 4) disruption of reproductive development.

To measure plant respiration, the researchers use an oxygen electrode in a closed chamber environment, which measures the amount of O_2 the plant or part of a plant consumes. During the day, the plant's main activity is photosynthesis, which involves the intake of CO_2 and the release of O_2. But at night, when the plant is using up photosynthate materials, the dominant process at work is respiration, which requires the intake of O_2, making the oxygen electrode an ideal tool for measuring nighttime respiration.

Mr. Abdul Razack Mohammed is pursuing a Ph.D. in Molecular and Environmental Plant Science at Texas A&M University under the guidance of Dr. Lee Tarpley. His primary research concerns the effect of high nighttime temperature and role of antioxidants on growth, respiration and carbohydrate metabolism of rice plants.

Oxidative stress causes similar damage in plants as it does in animals, where increased oxidant production is characterized by the release of free radicals that cause cellular degeneration. To combat this effect, the researchers apply antioxidants, such as vitamins C and E, through foliar applications to the plant. As part of their on-going research, Dr. Tarpley and his team plan to compare the performance of supplemented plants to that of check plants, which did not receive the foliar applications.

Decreased yields due to the disruption of nutrient transfer within the plant might prove to be the most difficult puzzle to unravel. The transfer of photosynthates, which leads to grain fill, is controlled by enzyme activities that

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distribute metabolites along particular metabolic pathways, such as the ones that are involved in starch synthesis. Think of enzymes as the catalyst, or engine, that makes the reaction happen. Metabolites are the biochemical compounds that are involved in these processes. To get optimum grain fill, the enzymes must be working at optimum activity, and in strict concert with one another. The researchers will examine enzyme activities at this crucial stage, and try to determine how the plant transfers carbohydrates to the grain. In addition, they must explore how enzyme activity affects sugar and starch degradation, which could lead to a reduction in grain fill, and therefore, yield.

Pictured above is the hypodermic-like thermocouple that measures the internal temperature of the rice plant.

Study of the viability of reproductive parts under elevated nighttime temperatures will be used as the starting point to determine the disruption of reproductive development.

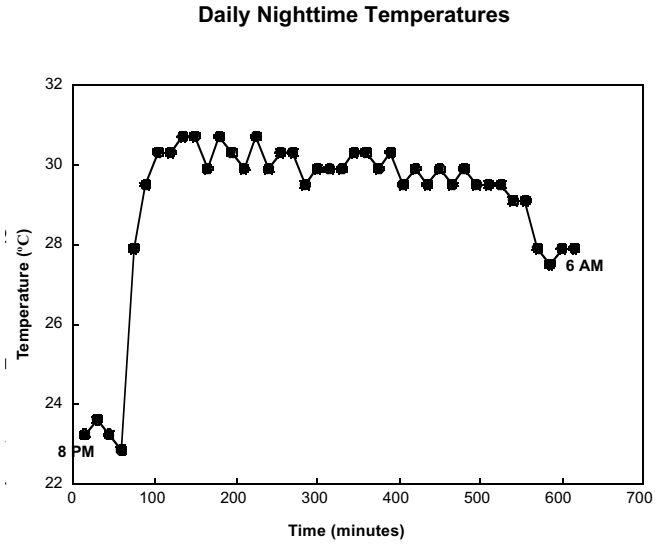
To evaluate the effects of high night time temperatures on rice yield Dr. Lee Tarpley developed an infrared heating system using the latest in computer technology. The system's infrared heaters are connected to a controller, which continuously makes adjustments to maintain the desired temperature. The ambient temperature is measured, as is the temperature within the plants. This is accomplished by a syringe-size thermocouple that is inserted into the culm.

All the data is automatically entered into an Excel spreadsheet. Through a serial server and Ethernet connection, the system can be accessed and controlled by any computer with internet capability.

According to Tarpley, this greenhouse system is better than using partial enclosures in the field, because you obtain a more responsive and higher level of temperature control, and also avoid confounding factors using an enclosure. He decided to use the infrared light to heat the system, because it closely mimics natural radiative heating.

Currently, Tarpley is evaluating two different temperature treatments on the variety Cocodrie.

For more information or references for this article contact Dr. Lee Tarpley at 409-752-2741 ext. 2235, or email ltarpley@tamu.edu. *



Daily trends of nighttime temperatures. The temperatures were maintained at 30°C (ambient plus 5°C) using infrared heaters. The nighttime temperatures were initiated 1h after the sunset until sunrise (8:00 pm to 6:00 am).

To minimize heating the water, which would confound the project's results, foam board insulation is cut to fit precisely around the rice plants.

overall U.S. greenhouse gas emissions. According to a 2004 report from the U.S. Department of Energy, methane accounts for 8.7% of total emissions, or about 26.2 million tons. Of that total, energy sources such as coal mining and natural gas production contribute 11 million tons, waste management (mostly landfills) adds 8 million tons, and agricultural sources add 7.9 million tons. However, 94% of that is attributed to livestock production. Rice production contributes 0.41 million tons, a scant 0.015% of the total U.S. methane emissions.

So, although farming is not a major contributor to the problem, it will likely be greatly impacted by increased greenhouse gases and global warming.

Consequences for Agricultural Production

Composition of the Atmosphere

The first direct effect of global climate change is the composition of the earth's atmosphere, such as the amount of carbon dioxide and ozone. However, gases such as methane, nitrogen dioxide and chlorofluorocarbon, are commonly believed not to have any effect on physiological processes. Indirect effects are climate parameters resulting from climate change, such as temperature, insulation, rainfall, and humidity. Other indirect effects due to the climatic changes include the increase in sea level, changes in ocean currents and increased occurrence of tornadoes.

Most scientists agree that agricultural shifts due to global warming are likely. CO_2 is expected to have positive physiological effects by increasing the rate of photosynthesis. Currently, the amount of carbon dioxide in the atmosphere is 380 parts per million. In comparison the amount of oxygen is substantially higher, at 21,000. This means that plants may often be starved of carbon dioxide, being outnumbered by the photosynthetic pollutant oxygen. The effects of an increase in carbon dioxide would be higher on C3 crops (such as rice) than on C4 crops (such as maize), because the former is more susceptible to carbon dioxide shortage. Under optimum conditions of temperature and humidity, the yield increase could reach 36%, if the levels of carbon dioxide are doubled.

A higher level of carbon dioxide would also allow plants to close their stomata or make the opening smaller, reducing the loss of water through transpiration without suffering photorespiration, which is due to too much oxygen in ratio to carbon dioxide in the plant cell's chloroplasts. Due to the carbon dioxide starvation, this not only halts sugar production, but destroys existing sugars, badly stunting growth and crop output. Higher levels of carbon dioxide would reduce this likelihood, allowing sugar production to increase.

However, other studies also show a change in harvest quality. A small but growing body of research is finding that elevated levels of atmospheric carbon dioxide, while increasing crop yield, decrease the nutritional value of plants. More than a hundred studies, for example, have found that when CO_2 from fossil-fuel burning builds up in plant tissues, nitrogen (essential for making protein) declines. A smaller number of studies hint at another troubling impact: As atmospheric CO_2 levels go up, trace elements in plants (such as zinc and iron, which are vital to animal and human life) go down, potentially malnourishing all those that subsist on the plants. This preliminary research has given scientists reason to worry about bigger unknowns. Few studies have been done on the effects of elevated CO_2 on other essential trace elements, such as selenium, an important antioxidant, or chromium, which is believed to regulate blood-sugar levels.

Comparison of 100-Year GWP Estimates from the IPCC's Second (1996) and Third (2001) Assessment Reports

Gas	1996 IPCC GWP	2001 IPCC GWP
Methane	21	23
Nitrous Oxide	310	296
HFC-23	11,700	12,000
HFC-125	2,800	3,400
HFC-134	1,300	1,300
HFC-143	3,800	4,300
HFC-152	140	120
HFC-227	2,900	3,500
HFC-236	6,300	9,400
Perfluoromethane (CF_4)	6,500	5,700
Perfluoroethane (C_2F_6)	9,200	11,900
Sulfur Hexafluoride (SF_6)	23,900	22,200

Sources: UNFCCC, Second Assessment Report (1996) and Third Assessment Report (2001).

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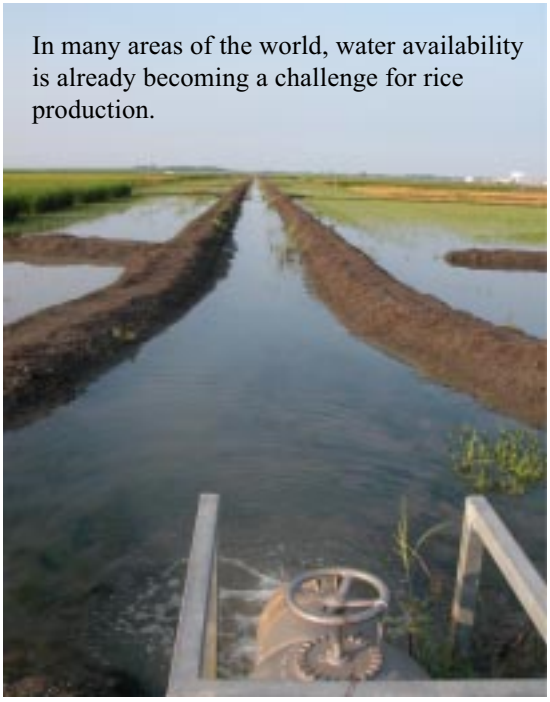
For rice, studies have shown the amylose content of the grain, a major determinant of cooking quality, is increased under elevated CO_2. Cooked rice grain from plants grown in high-CO_2 environments would be firmer than that from today's plants. However, concentrations of iron and zinc, which are important for human nutrition, would be lower. And as shown with other crops, the protein content of the rice grain decreases under combined increases of temperature and CO_2. Most of the decrease in proteins and elements, such as zinc and iron, would occur in the bran and not the starchy part of the grain. From a commercial production and working perspective, many of the anticipated changes in grain quality would be negated by how rice is processed in the U.S. Because the bran is largely removed during milling,, U.S. rice consumers would see little change in grain quality.



In many areas of the world, water availability is already becoming a challenge for rice production.

However, reduced nitrogen content in grazing plants has also been shown to reduce productivity in ruminant animals, as they depend on microbes in their gut to digest plants, which in turn depend on nitrogen intake to thrive.

The less-nutritious plants of a CO_2-enriched world will not be as much of a problem for rich nations, where "super-sized" meals and vitamin supplements are a dietary mainstay. But things could be very different in the developing world, where millions already live on the edge of starvation, and where the micronutrient deficit, known as "hidden hunger," is already considered one of the world's leading health problems by the United Nations.

Erik De Castro/Reuters

These Afghan children at a government-run orphanage in Kabul receive the majority of their caloric intake from rice. Indications are developing countries would be more severely affected by decreased nutritional content in their staple crops.

Higher temperatures

The effects are also different depending on the latitude. In temperate countries, effects are projected to be rather beneficial, while in tropical and desertic countries, they are in general projected to be adverse. Effects also depend on altitude, for example, crops at higher altitudes tend to benefit from a warmer temperature.

Duration of crop growth cycles are above all, related to temperature. An increase in temperature will speed up development. In the case of an annual crop, the duration between sowing and harvesting would shorten. The shortening of such a cycle could have an adverse effect on productivity because senescence would occur sooner. Temperature changes could also have serious implications for crops and trees that need vernalization. For a discussion of the specific effects on rice, see *Farming Rice* article on page 3.

Water distribution

Global warming would modify the global distribution of water, possibly leading to several effects, both detrimental and beneficial. Water is one of the major limiting factors in the growth and production of crops worldwide. In spite of better water efficiency use, higher summer temperature and lower summer rainfall, caused by global warming, would likely have adverse effects. The intensification of the extremes of the hydrological global cycle will have consequences, such as more frequent drought in northern subtropical areas or desertification extension in arid areas, while causing devastating flood in other areas.

In developed areas of the world, agriculture and competing industry and municipal users, mine fossil water supplies. In coastal areas, deep water wells also re-

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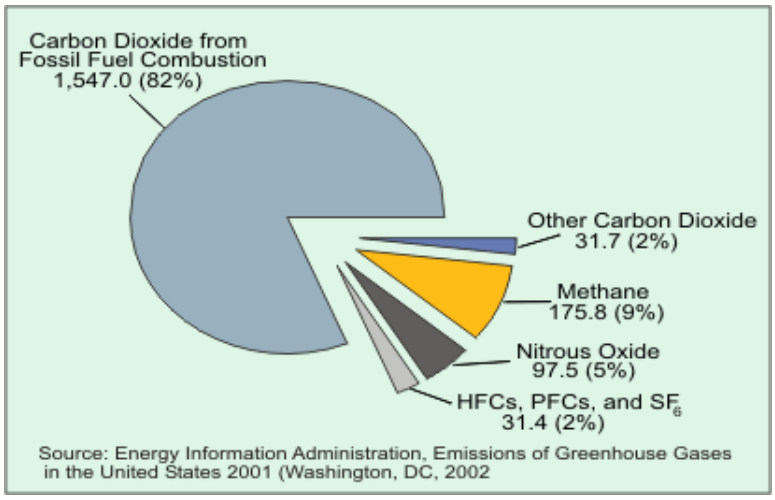
verse normal ground water flow toward the ocean, leading to saline water intrusion into aquifers. Further increases in usage would force societies to conform ground water usage to actual recharge rates.



Forecasting the Impact of Climate Change

If global warming happens, many believe the general ability to predict weather patterns will decrease, due to more extreme weather. This would make it more difficult to plan agricultural actions. If extreme climatic conditions become more frequent, there would be more intense rainfall, droughts and heat spells in different parts of the globe or times of the year.

Climate change is likely to increase the amount of arable land near the poles by reducing the amount of frozen lands. Sea levels are expected to rise by up to one meter by 2100, though this projection is disputed. Rises in sea level would result in agricultural land loss in particular areas, such as South East Asia. Erosion, submergence of shorelines, and salinity of the water table due to the increased sea levels, would mainly affect agriculture through inundation of low-lying lands.

Some scientists think agriculture could be affected by any decrease in stratospheric ozone, which could increase biologically dangerous ultraviolet radiation B. Excess ultraviolet radiation B can directly effect plant physiology, and indirectly through changed pollinator behavior. (See article "Studying How UV Radiation Affects Rice Plant Development" on page 13 in the August/September issue of *Texas Rice*.)

Due to the extremes of climate that would result from global climate change, the increase in precipitation would probably result in greater risks of erosion, according to the intensity of the rain. The possible evolution of the organic matter in the soil is a highly contested issue. While the increase in the temperature would induce a greater rate in the production of minerals, lessening the soil organic matter content, the atmospheric CO_2 concentration would tend to increase this valuable soil component.

A very important point to consider is that weeds would undergo the same acceleration in cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most weeds are C3 plants, they are likely to compete even more against C4 crops, such as corn. On the other hand, some results make it possible to think that weed killers could gain effectiveness as temperature increases.

Global warming would cause an increase in rainfall in some areas, which would lead to an increase in atmospheric humidity, and the duration of the wet seasons. Combined with higher temperatures, these could favor the development of fungal diseases. Similarly, because of higher temperatures and humidity, there could be an increased pressure from insects and disease vectors.

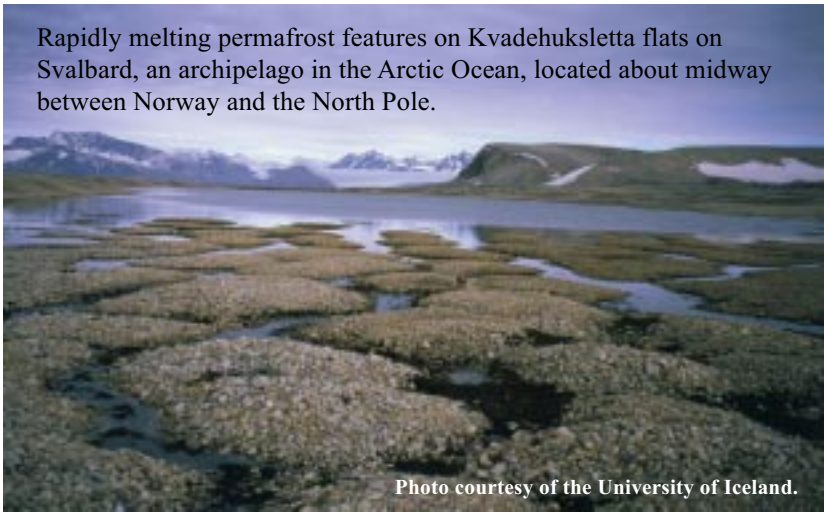
Conclusions

Most researchers believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there will be enough time for biota adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaption.

Given all the unknowns, and the possible detrimental consequences, there is no doubt that global warming is a serious issue, and needs to be addressed immediately by government bodies, and by individuals.

For more information, or a list of references contact Jay Cockrell at 409-752-2741 ext. 2272 or email j-cockrell@aesrg.tamu.edu. *

Melting Peat Bogs "Tipping Point" for Global Warming



Rapidly melting permafrost features on Kvadehuksletta flats on Svalbard, an archipelago in the Arctic Ocean, located about midway between Norway and the North Pole.

Photo courtesy of the University of Iceland.

A vast expanse of western Sibera is undergoing an unprecedented thaw that could dramatically increase the rate of global warming, climate scientists warn today. Researchers who have recently returned from the region, found that an area of permafrost spanning a million square kilometers (the size of France and Germany combined) has started to melt for the first time since it formed 11,000 years ago, at the end of the last ice age.

The area, which covers the entire sub-Arctic region of western Siberia, is the world's largest frozen peat bog and scientists fear that as it thaws, it will release into the atmosphere billions of tons of methane, a greenhouse gas 20 times more potent than carbon dioxide.

It is a scenario climate scientists have feared since first identifying "tipping points" - delicate thresholds where a slight rise in the Earth's temperature can cause a dramatic change in the environment that itself triggers a far greater increase in global temperatures.

The discovery was made by Sergei Kirpotin at Tomsk State University in western Siberia and Judith Marquand at Oxford University, and was reported in *New Scientist*. The researchers found that, what was until recently, a barren expanse of frozen peat is turning into a broken landscape of mud and lakes, some more than a kilometer across.

Dr Kirpotin told the magazine the situation was an "ecological landslide that is probably irreversible and is undoubtedly connected to climatic warming". He added that the thaw had probably begun in the past three or four years.

Climate scientists reacted with alarm to the finding, and warned that predictions of future global temperatures would have to be revised upwards. "When you start messing around with these natural systems, you can end up in situations where it's unstoppable. There are no brakes you can apply," said David Viner, a senior scientist at the Climatic Research Unit at the University of East Anglia.

"This is a big deal because you can't put the permafrost back once it's gone. The causal effect is human activity and it will ramp up temperatures even more than our emissions are doing."

The intergovernmental panel on climate change predicted a rise in global temperatures of 1.4ºC-5.8ºC between 1990 and 2100, but the estimate only took into account global warming driven by known greenhouse gas emissions. "These positive feedbacks with landmasses weren't known then. They had no idea how much they would add to global warming," said Dr Viner.

Western Siberia is heating up faster than anywhere else in the world, having experienced a rise of some 3ºC in the past 40 years. Scientists are particularly concerned about the permafrost, because as it thaws, it reveals bare ground that warms up more quickly than ice and snow, and so accelerates the rate at which the permafrost thaws.

Siberia's peat bogs have been producing methane since they formed at the end of the last ice age, but most of the gas had been trapped in the permafrost. According to Larry Smith, a hydrologist at the University of California, Los Angeles, the west Siberian peat bog could hold some 70 billion tons of methane, a quarter of all of the methane stored in the ground around the world.

The permafrost is likely to take many decades at least to thaw, but calculations by Dr Sitch and his colleagues show that even if methane seeped from the permafrost over the next 100 years, it would add around 700 million tons of carbon into the atmosphere each year, the same amount that is released annually from the world's wetlands and agriculture.*

Exerpted from an article by Ian Sample, The Guardian.

Carbon Dioxide May Not Be the Main Culprit

During the Eocene epoch, around fifty million years ago, temperatures soared to unprecedented levels and the seas became a staggering 12ºC hotter than today. But some researchers suggest this massive warming had little to do with carbon dioxide, the main cause of today's climate changes. The trigger was instead rising levels of methane, ozone and nitrous oxide; gases that are accorded relatively scant attention by current climate treaties.

"The fact Earth got so hot because methane and other gases were increasing is worrying," said Professor David Beerling, of the University of Sheffield. "We are rightly obsessed with carbon dioxide, but clearly we risk missing other dangers."

The discovery was made by Sheffield and Bristol, researchers who were investigating Earth's ancient greenhouse crisis. Scientists had already discovered the stifling temperatures that existed 50 million years ago by studying marine fossils. Oxygen trapped in their shells leave a distinct isotope pattern that reflects the warmth of the sea at the time.

In this way, researchers have built a precise picture of Earth's past temperature fluctuations and found that 50 million years ago it reached levels that dwarf Earth's current climate crisis. Most experts assumed carbon dioxide, whose levels fluctuate naturally in the air, were responsible. Global warming today is blamed on industrial outputs of the gas, after all.

The Ginkgo tree is the only living representative of the order Ginkgoales, a group of gymnosperms with its earliest leaf fossils dating back to 270 million years ago in the Permian period. Though it's range declined rapidly after the dinosaurs became extinct, it was still found in parts of Asia during the Eocene period 50 million years ago.

Beerling decided to investigate and used a breakthrough made by his colleague Professor Ian Woodward, who had discovered that stomata, the pores on a plant's leaf, decrease in number as carbon dioxide levels rise. "That gives you a perfect way to study carbon dioxide on ancient Earth," Woodward said.

Beerling's group grew ginkgo trees in different concentrations of carbon dioxide and then compared their leaves with those of ginkgo fossils from the Eocene. What they discovered is that carbon dioxide levels were no different 50 million years ago than they are today, yet the planet was much warmer then.

Using climate models developed by Britain's Hadley Centre for Climate Prediction and Research, Beerling and his collaborator, Professor Paul Valdes, at Bristol University, analyzed the meteorological parameters for the Eocene and concluded that there must have been much more ozone, methane, and nitrous oxide in the atmosphere then.

Molecule for molecule, these gases are much more effective at trapping solar heat than carbon dioxide. So even modest elevations will produce striking temperature hikes. At the time Earth was covered in wetlands, which produce high levels of methane. This was one of the major contributors to the runaway global warming that gripped the Earth, the Sheffield and Bristol groups conclude. Today, ruminants, landfills and farming are major sources of the gas.

How Earth restored its atmosphere to a cooler level is not known. But it is clear that although the planet regained climatic equilibrium, it endured a dramatic interval of sustained warming - which shows that greenhouse gases other than carbon dioxide can have very powerful effects on the climate.

"That is why this discovery is so important," said Beerling. "We are currently attempting to control emissions of carbon dioxide to stop global warming. But our obsession with it is making us overlook the dangers posed by methane and the others."

"Methane is being produced in increasing amounts, thanks to the spread of farming and ranching in the tropics. Car exhaust gases and nitrogen fertilizers are also increasing the other gases."

"So even if we control the problem of carbon dioxide, we could still be in dire straits thanks to these gases, which receive much less attention from politicians and campaigners. That is the real lesson of this research." *

More about No-Till and Greenhouse Gas Emissions

The type of fertilizer used, and the manner in which it is applied, can make or break reduced tillage's ability to control greenhouse gases, USDA Agricultural Research Service (ARS) scientists report.

No-till and reduced tillage are promoted as a way farmers can reduce greenhouse gas concentrations in the atmosphere by storing more carbon in soil. But there has been limited information on how tillage or other farm practices affect soil emissions of greenhouse gases other than carbon dioxide.

A study conducted by ARS soil scientist Rod Venterea on the effects of long-term tillage techniques and fertilizer practices has shown that, if not done with care, reduced tillage practices can increase emissions of more powerful greenhouse gases, particularly nitrous oxide. At 300 times the strength of carbon dioxide, nitrous oxide can easily offset the benefit of carbon dioxide reduction. Venterea works at the ARS Soil and Water Management Unit in St. Paul, Minn.

Farm fields are the biggest source of nitrous oxide emissions in the United States, with up to one-third of the agricultural emissions coming from farms in the north central region of the country. Venterea and colleagues have shown that farmers using no-till should inject nitrogen fertilizer more than 4 inches below the soil surface, beneath the layer of soil that is most conducive to nitrous oxide production.

In field tests, Venterea and his colleagues compared the nitrous oxide emissions from three different tillage systems in combination with either anhydrous ammonia, urea nitrogen fertilizer pellets, or liquid urea ammonium nitrate.

Anhydrous ammonia caused about double the release of nitrous oxide than the other two fertilizers. But combining no-till with anhydrous ammonia injected 6 to 8 inches deep emitted the least nitrous oxide of the three tillage-anhydrous ammonia combinations tested.

In contrast, spreading urea nitrogen fertilizer pellets on a field's surface caused higher nitrous oxide emissions under no-till compared to more intense tillage. Tillage had no effect on emissions when liquid urea ammonium nitrate was applied to the surface.

Venterea conducted the studies in southeastern Minnesota from 2003 to 2004, using soil chambers to capture nitrous oxide emissions. The research was published in the Journal of Environmental Quality. *

From the U.S. Department of Agriculture, Agricultural Research Service.

Units for Measuring Greenhouse Gases

Emissions data are reported in metric units, as favored by the international scientific community. Metric tons are relatively intuitive for users of English units, because 1 metric ton is only about 10 percent heavier than 1 English short ton.

Emissions of most greenhouse gases are reported in carbon dioxide equivalents. Carbon dioxide equivalents compare the amount of heat different gases in the environment capture compared to what an equivilant amount of CO_2 captures. Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane) by its estimated global warming potentials (GWP).

Global warming potentials are used to compare the abilities of different greenhouse gases to trap heat in the atmosphere. GWPs are based on the radiative efficiency (heat-absorbing ability) of each gas relative to that of carbon dioxide (CO_2), as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of CO_2. The GWP provides a construct for converting emissions of various gases into a common measure, which allows climate analysts to aggregate the radiative impacts of various greenhouse gases into a uniform measure denominated in carbon or carbon dioxide equivalents.

The table on page 5 of this issue compares the GWPs published in the Second and Third Assessment Reports of the Intergovernmental Panel on Climate Change. *

From the report Emissions of Greenhouse Gases in the United States 2003, December 2004, U.S. Department of Energy, Energy Information Administration.

State, National and International News...

Trade Can 'Export' CO_2 Emissions

Researchers found that U.S. imports of goods from China cause a greater production of carbon dioxide than if the goods were made in the U.S. because factories in developing countries tend to use more energy than in the west.

The researchers say emissions control measures, such as the Kyoto Protocol, could "export" carbon-intensive industries to the developing world. This has long been a contention raised by critics of the Protocol.

In a briefing just before the UN climate negotiations in Montreal, President Bush's chief environmental advisor, James Connaughton, told reporters that setting targets for emissions may "...cause a shift offshore of some energy-intensive industries. This probably equates to a net increase in greenhouse gas emissions, as it's a shift to countries which are probably less efficient than the US," he said.

This issue of "carbon leakage" is matched in controversy potential by another related argument; that western countries own up to emissions produced within their shores, when in fact they should be responsible for all emissions connected with the goods and products which they consume. They are "saving" their own emissions, the argument goes, at the expense of developing countries.

The U.S. has put itself outside the Kyoto treaty, but conventional trade issues are inducing a shift toward imported goods and away from domestic manufacturing. "The U.S. cannot compete with China on prices, so the U.S. trade deficit with China is increasing," said Shui Bin from the National Center for Atmospheric Research (NCAR) in Boulder, Colorado.

"The U.S. has the largest trade deficit of any country in world, so we suspected it might be responsible for a larger proportion of emissions than normally seen," Dr Shui said. Between the years 1997-2003, the U.S. "saved" 1,711 million tons of carbon dioxide emissions by importing goods from China rather than making them within U.S. borders.

That equates to a reduction of just over 3% in US emissions across the seven-year period, with the exact proportion rising year on year, as the trade deficit increased. But this reduction in U.S. emissions was more than matched by an increase in Chinese emissions.

Dr. Shui calculates that global emissions were higher by around 720 million tons during the seven year period. If anything, this analysis may underestimate the true picture as it excludes fuel used to transport goods halfway around the world.

If this is happening to a trade unaffected by the Kyoto Protocol, what are the implications elsewhere? Could the European Union, through its financial instrument, the Emissions Trading Scheme (ETS), be playing a dangerous game? "Frankly I haven't studied this, so it's just a rough thought; but it is possible that Kyoto countries could import more goods from overseas and see a rise in global CO_2," said Dr Shui. "That is what we are worried about, and why we want to stimulate more discussion about flaws in the global carbon accounting system."

Michael Grubb, from Imperial College London, believes rates of "carbon leakage" are likely to be small. "The idea that there are leakage effects has been comprehensively discredited," he told the BBC News website.

The Carbon Trust, a UK government-backed company of which Professor Grubb is policy director, has researched the likely impact of emissions trading on European business. "What people do talk about is 10-15% leakage - that's the Intergovernmental Panel on Climate Change (IPCC) estimate - but those are model-based estimates, and in reality, you don't even get that," he said "As a reality check, Europe has had more expensive energy than just about everywhere for decades, yet we still produce virtually all our own steel and our own cement."

Professor Grubb also points out the difficulties involved in measuring and calculating emissions according to end user rather than producer. Nevertheless, Shui Bin is adamant that the global community should have a try; the way carbon emissions are measured currently is flawed, she believes, and could penalize developing countries unfairly. "The equity issue should be addressed in the Kyoto Protocol," she said, "but the current protocol is based on a flawed accounting system. A country can intentionally or unintentionally decrease its CO_2 emissions by reducing its domestic production but increasing its trade. Total CO_2 emissions would increase, but the current carbon accounting framework will show a decrease."

From an article by Richard Black, BBC News website

From the Editor continued...

which must then reinvade each spring and summer from southern areas. A major increase in temperature would lessen the positive impact of a cold winter. Previous research has shown that even a small increase in temperature can be sufficient to elevate an insect pest from being an occasional problem to one of being a reoccurring problem. Some years ago, when I was heavily involved with grape research in the Western U.S., one of my students demonstrated that a 1˚C increase in temperature was sufficient to increase the population size of spider mites on grapes by as much as 50-fold. The level of temperature increase that many scientists are predicting will likely occur due to global warming is far greater than 1˚C, suggestion a much greater impact.

Will global warming became such a problem that it will rearrange the face of the earth, while at the same time shifting agricultural production further away from the equator and more into current temperate climate area? Possibly, but I hope not! I am reasonably optimistic that the people and governments of the world will increasingly view global warming as a problem that can be solved and will move in a direction that provides a positive global solution.

Please continue to send us your suggestions for new articles.

Sincerely,

L. T. Wilson

L.T. Wilson
Professor and Center Director
Jack B. Wendt Endowed Chair
in Rice Research

31st Rice Technical Working Group Meeting

February 26 - March 1, 2006
Marriott Hotel
The Woodlands, Texas

The Rice Technical Working Group (RTWG) meets biennially to provide for continuous exchange of information, cooperative planning, and periodic review of all phases of rice research and extension being carried on by the States, Federal Government, and cooperating agencies.

It develops proposals for future work, which are suggested to the participating agencies for implementation. Researchers, government agency representatives and farmers are encouraged to attend.

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1509 Aggie Drive, Beaumont, Texas 77713

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Professor and Center Director: L.T. (Ted) Wilson
lt-wilson@aesrg.tamu.edu
Ag Communications Specialist: Jay Cockrell
j-cockrell@aesrg.tamu.edu
Texas A&M University System Agricultural
Research and Extension Center
1509 Aggie Drive, Beaumont, TX 77713
(409)752-2741
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Texas A&M University System
Agricultural Research and Extension Center
1509 Aggie Dr.
Beaumont, TX 77713

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