A never-ending season

An experiment that has been going on for 52 years could hold the answer to a most important question: how do you feed an overcrowded planet of more than 7 billion people with shrinking resources?

The LTCCE recently marked its 150th rice cropping season, making it one of the longest-running agricultural experiments in the world. It measures trends in yield and soil properties over its lifetime as indicators of the sustainability of continuous rice cropping on flooded soil. The data being collected from the LTCCE might not directly resonate with the public, but this experiment could actually answer perhaps the most important question of our time: how to sustain production of enough rice for a growing population?

There are over 7 billion people living on this planet with very finite resources. Current global trends in diets and population show that 60% more food will be needed in 2050. One way to meet this demand is by putting food production on overdrive: intensive agriculture.

In 1962, the LTCCE (then called the Maximum Yield Experiment) was created. The objective was to sustain high annual rice yield from a unit area of land using an optimum mix of rice varieties and cultural practices.

In March of 1966, IR8, developed by IRRI, was included in the experiment. IR8, also known as Miracle Rice, could yield up to 8.7 tons per hectare in high-yielding seasons. Succeeding IRRI varieties were used later on. The IRRI varieties were not only heavy grain producers. They also matured earlier and could be harvested in about 115 days. This enabled IRRI scientists to pioneer three cropping seasons in a year, a feat not possible with longer-duration traditional varieties.

Modern high-yielding varieties, fertilizer, irrigation, and crop protection have enabled many developing countries to achieve dramatic increases in agricultural production. But modern agricultural practices have been alleged by some as unsustainable and environmentally destructive. Concerns include suspected reductions in soil health due to use of manufactured fertilizers.

The LTCCE has enabled scientists to see through time that the productivity and health of flooded soils can be sustained during continuous rice cultivation with sufficient water, efficient use of fertilizers, and high-yielding varieties with disease and insect resistance. The soil organic matter content in the field did not decrease through 26 years (1983 to 2009) even though all crop residue left after each harvest were removed and not incorporated back into the soil. The continual balanced application of manufactured fertilizer did not adversely affect soil health.

Yields tended to decline in the 1970s and 1980s (Fig. 1). This was attributed to inefficient application of nitrogen fertilizer. Improved application of nitrogen fertilizer with efficient distribution of the nitrogen at critical crop growth stages increased yields from 1992 onward. Yields since 1992 vary from year to year, largely because of climate. Yields are higher in years and seasons with abundant sunlight. Insect pests and diseases have not been a major factor affecting rice yields because the varieties grown in the LTCCE are resistant. The varieties are regularly replaced with new high-yielding varieties that are pest- and disease-resistant.

The sustainability of rice cultivation in the LTCCE can be assessed by comparing measured yields with the maximum potential yield of a variety. Scientists estimate this potential yield with a crop simulation model and weather data for each season. This analysis reveals that yield in the LTCCE since 1992 has remained near 80% of potential yield (Fig. 2), which represents a target for achieving the highest profit with good crop and fertilizer management. A downward trend in yield in the last decade (Fig. 1) reflects changes in climate, and conditions with less sunshine. The LTCCE now serves as a living field laboratory for how a changing climate affects rice production.

In 2011, IRRI launched a research initiative on ecological intensification (EI) to develop new rice production systems capable of sustaining high yields with more efficient use of resources such as water, labor, energy, and fertilizer. The LTCCE now provides a benchmark for sustainable rice production against which the productivity, sustainability, and profitability of rice production systems emerging from EI research can be assessed.

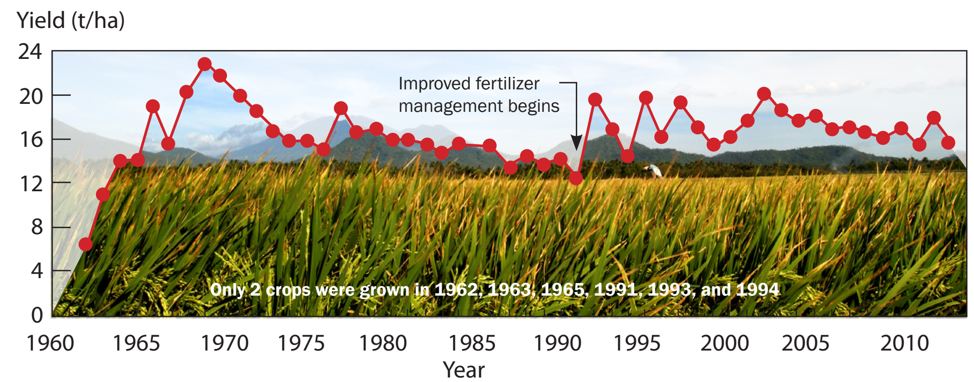


Fig. 1. Annual rice yields at LTCCE, 1962-2013.

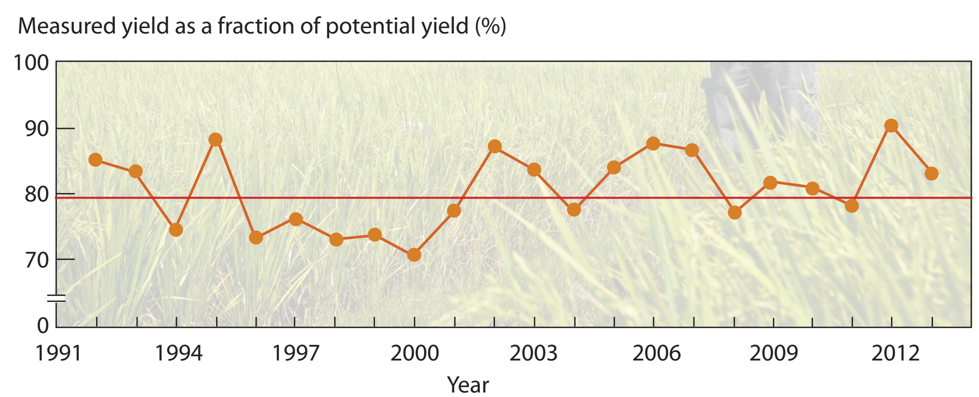


Fig. 2. Measured yield as a fraction of the potential yield in dry season, 1992-2013.

150th Crop

Long-Term Continuous Cropping Experiment LTCCE

1962-2014

Welcome to ground zero for sustainable rice farming

The LTCCE started in 1962 when rice scientists wanted to see the feasibility and productivity of rice with three continuous crops per year, using the best available management practices and rice varieties. To this date, the experiment continues—and with good reason—to determine how intensive rice production can be sustained under changing climate conditions and with diminishing resources. The experiment now serves as a living field laboratory to help answer the question: how do we sustainably continue feeding the billions of people who depend on rice for daily nourishment?

Ceremonial harvest of the 150th crop of the LTCCE, 15 April 2014.

What we learned so far

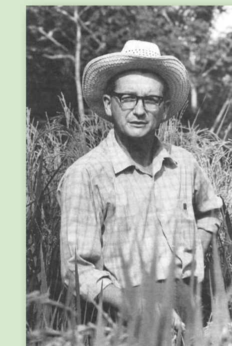
- The productivity of irrigated rice ecosystems can be sustained with intensification up to three crops per year
- The soil organic matter content, an important measure of soil fertility, has not decreased since 1983 even with three crops per year. This proves that intensive rice cropping with fertilizer and good management practices will not create barren wastelands as some have feared.
- Soil organic matter was maintained even when all rice crop residue were removed and not incorporated into the soil.
- Microorganisms, unique to flooded fields, provide sufficient input of nitrogen from biological fixation of nitrogen in the atmosphere for rice plants to produce 2 to 3 tons per hectare per crop. Application of fertilizer at an optimal rate for high profit can more than double this rice yield.
- Proper application of fertilizers, sufficient irrigation water, modern high-yielding rice varieties, and good crop management practices are essential for sustainable rice production.

What we need to know for the future

- Can we sustain productivity of rice in a changing climate?
- What are possible negative consequences of intensive rice cropping, which can be identified and solved before they appear in farmers' fields?

The LTCCE's creator: His life made a difference

James Moomaw was an agronomist at the University of Hawaii specializing in tropical pastures and forage crops, and had never grown a rice crop. However, Robert Chandler, IRRI's first director general, knew he was the right man to become the Institute's first agronomist, in 1961. The North Dakota native specialized in soil fertility and developed a first-class research program at IRRI for investigating continuous rice cropping management practices involving fertilizer response, water management, and weed control.



His expansive knowledge was matched by his passion to search for solutions to poverty and hunger. Dr. Moomaw believed that knowledge holds the answers. He proved this with the LTCCE, which he pioneered, by producing 18.8 tons per hectare of rice from 3 crops in a year, in 1966—the first rice scientist to do so—using improved rice cropping technology.

He knew that global hunger was a constant threat. "If your technology fails for whatever reason at just one time, you have a disaster on your hands," he once said. Fifty-two years later, the LTCCE, in line with Dr. Moomaw's conviction and vision, continues to update and validate rice production practices for a changing climate and in keeping the threat of global hunger at bay. He passed away prematurely at age 55 in 1983.

Brief history of the world's longest-running rice experiment

1962

James Moomaw begins the Maximum Yield Experiment (MYE).

Beatles make their broad-casting debut on BBC radio.

1963

MYE is renamed the LTCCE.

Valentina Teresh-kova, first woman in space, returns to Earth.

1966

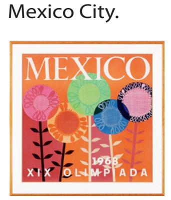
IR8 is planted in the LTCCE. Three cropping seasons per year become possible with modern rice varieties. LTCCE produced 18.8 tons/ha—considered a record at the time.

Mihir Sen is the first ever to swim Palk Strait between Sri Lanka and India.

1968

S.K. De Datta becomes leader of the LTCCE.

Summer Olympic Games open in Mexico City.



1969

The year that had the all-time highest yield across the 3 crops at 22.7 tons/ha.

Neil Armstrong is the first human to set foot on the moon.

1986

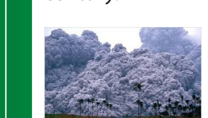
Golden apple snail becomes a major pest in the Philippines.

Experimental airplane Voyager, piloted by Dick Rutan and Jeana Yeager, completes the first nonstop, round-the-world flight without

1991

Ken Cassman becomes leader of the LTCCE.

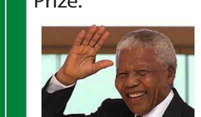
Mt. Pinatubo in the Philippines erupts. It is the second-largest volcanic cata-clysm of the 20th century.



1993

A comple-mentary long-term experiment started on sustainable diversification from continuous rice cropping to a rice-maize rotation.

Nelson Mandela and South Africa president F. W. de Klerk are awarded the Nobel Peace Prize.



1996

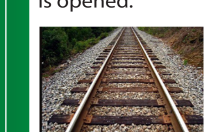
Osamu Ito becomes leader of the LTCCE.

IBM computer Deep Blue becomes the first computer to win a game of chess against a reigning champion, Gary Kasparov.

2000

Roland Buresh becomes leader of the LTCCE.

The first passenger rail link between India and Bangla-desh is opened.



2008

Study shows that over a 15-year period there was no decline in soil organic matter. (Soil Sci. Soc. Am J. 72:798-807).

Barack Obama, is elected the 44th U.S. President.

2011

LTCCE serves as the benchmark of sustainable productivity for ecological intensification (EI) research initiated at IRRI.

World popu-lation reaches 7 billion.

2014

150th crop of the LTCCE is harvested demonstrating the sustainability of intensive rice cultivation.

International Rice Congress to be held in Bangkok, 27 October-1November.