Reducing greenhouse gas emissions in agriculture with the help of nuclear techniques

By Matt Fisher

Farmers are increasingly using sustainable agricultural methods to boost productivity while also reducing greenhouse gas emissions. In a series of research projects, coordinated by the IAEA in cooperation with the Food and Agriculture Organization of the United Nations (FAO), the effectiveness of environment-friendly farming methods is verified by stable isotope techniques.

Agriculture, particularly large-scale commercial operations, typically involves monoculture in conjunction with the use of large amounts of chemical fertilizers – often to the detriment of ecosystems. Monoculture is a practice in which the same crop is grown on the same plot of land year after year, leading to lower soil fertility. Farmers compensate for this reduced soil fertility by applying excessive quantities of chemical fertilizers, which contribute to climate change through their release globally of 1.2 million tons per year of nitrous oxide, a greenhouse gas 260 times more potent than carbon dioxide.

Cows grazing harvested paddy fields in an integrated cropping-livestock system.
(Photo: M. Zaman/IAEA)

The sustainable agricultural practices at the centre of the research projects offer cost-effective solutions to boost productivity while fighting climate change.

Brazil: organic fertilizers reduce costs and minimize environmental impact

Chemical fertilizers provide the soil with additional nitrogen to grow crops. Their use is often considered necessary in order for agriculture to be economically viable. But repeated use or overuse of these fertilizers is both expensive and bad for the ecosystem. In Brazil, farmers are turning to a technique known as green manuring, which involves the natural phenomenon of biological nitrogen fixation.

They plant various types of legume crops, such as jack beans and velvet beans, that have bacteria in their roots converting nitrogen captured from the air into an organic form suitable for consumption by other plants, hence fertilizing the soil. After the legumes are harvested and the crop residues left behind, primary crops such as grain and cereals are planted on the same field and benefit from the nitrogen now available in the soil, with only minimal amounts of chemical fertilizer added.

“Recent studies in Brazilian agriculture show that over 76% of all nitrogen in harvested grain and cereals is derived from biological nitrogen fixation, and less than 20% is from chemical fertilizers,” said Segundo Urquiaga, a research scientist at the Brazilian Agricultural Research Corporation. Green manuring is also helping farmers save money: organic manure is estimated to cost only about US $1 per kilogram of nitrogen, which could lead to savings of up to US $13 billion per year, he added.

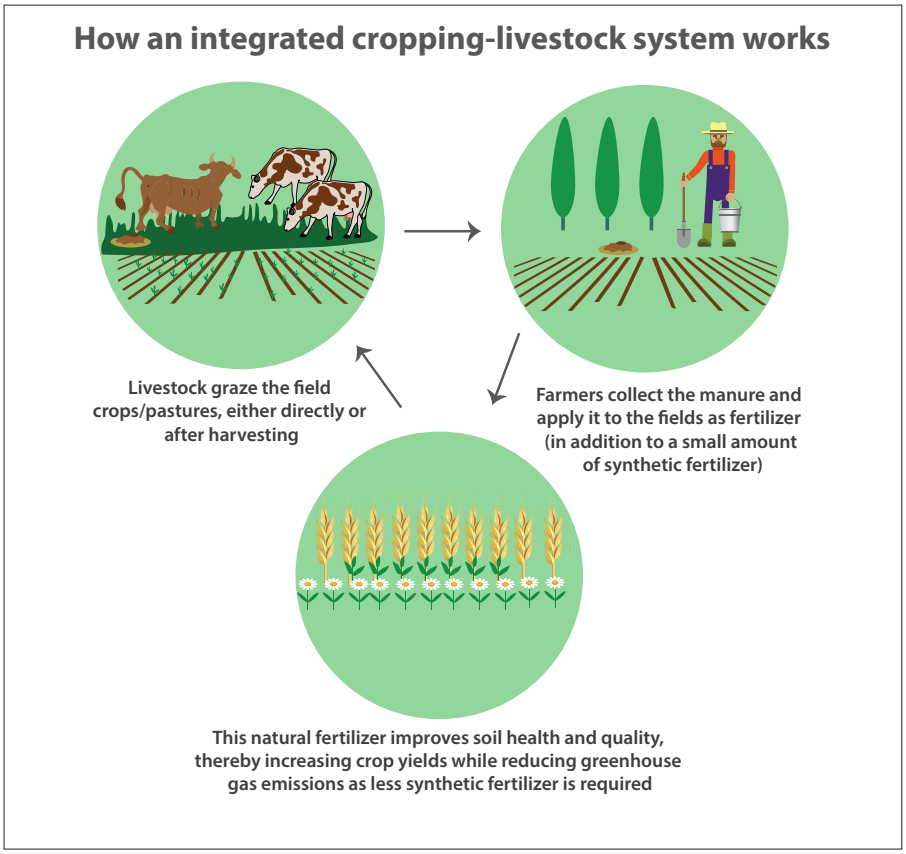
By embracing green manuring, Brazil is getting closer to achieving its greenhouse gas emissions target – a reduction of 43% by 2030 compared with 2005 levels. As agriculture is responsible for around 24% of

global greenhouse gas emissions, the growing implementation of this practice will help Brazil meet this goal.

Integrated farming systems fight climate change and boost crop yields

Integrated cropping-livestock systems are another sustainable agricultural practice supported by nuclear techniques in the framework of a coordinated research project involving Argentina, Brazil, India, Indonesia, Kenya, Uganda and Uruguay. These practices are based on a simple concept: that crop yields can be maximized by recycling nutrients present in both animal manure and crop residues. This reduces the need for chemical fertilizers that release large quantities of greenhouse gases and thereby contribute to climate change. In an integrated cropping-livestock system, livestock may either graze the field crops directly or may be fed the crop after harvesting. Farmers then collect the manure from the livestock and use it as fertilizer, thereby returning many of the nutrients to the soil.

Farmers in Brazil are using integrated cropping-livestock practices in order to use their land more efficiently "We are moving towards the implementation of conservation agriculture, and we have seen the feasibility of such an approach involving integrated cropping-livestock systems," said Jeferson Dieckow, a soil scientist from the Federal University of Paraná in Brazil. As a result, greenhouse gas emissions from urine and dung have been reduced by 89%. Juan Cruz Colazo, a scientist at Argentina's National Institute of Agricultural Technology, says that Argentina has been able to cultivate crops that are more resistant to the effects of climate change. "We have benefited from this project by improving our agricultural soils through crop rotation," he said. "We have observed a 50% increase in organic carbon content in the soil, which enhances the resilience of the cropping system to climate variations that may otherwise impede crop yields."



(Infographic: R Kenn/IAEA)

THE SCIENCE

Isotope tracers

To measure the impact of integrated crop-livestock practices and green manuring, scientists use stable isotopes which do not emit radiation, such as nitrogen-15 and carbon-13, on small experimental field plots. This allows them to track and analyse how efficiently crops consume nitrogen and how well carbon accumulates or is stored in the soil.

Using the nitrogen-15 technique, scientists can observe, over a period of several months, the amount of this isotope absorbed by the plants. This enables them to advise farmers on exactly how much animal manure and/or chemical nitrogen fertilizer they need to apply to their crops.

Carbon-13 is used to assess soil quality. As the soil is fertilized by the application of animal manure and crop residues, its content of organic carbon increases. By tracking the carbon-13 isotope, scientists are able to determine the stability and sources of carbon in soil and hence the status of the soil's fertility, which is crucial to ensure the optimal application of these sustainable agricultural practices.