Stable nitrogen isotope helps scientists optimize water, fertilizer use

By Miklos Gaspar

Experts in a growing number of countries are using a nuclear technique to help farmers increase crop yields, optimize fertilizer use and evaluate varieties of rice, cereals and vegetables for their efficiency in making the best use of fertilizers.

Research has shown that less than 40% of the fertilizer applied globally is taken up by crops, while the remaining 60% is either lost to the atmosphere or to groundwater, or is left in the soil in a form that cannot be taken up by the crop.

"We have cut fertilizer use by around a quarter on the half-acre plot where I tried the new rice variety," said farmer U Kyaw Lay, from the central village of Thar Yar Su, Myanmar. "This represents an important saving for me and my family." In the next growing season, Lay said, he will devote more of his land to this particular rice variety, which he said was also tastier than the kind traditionally used.

Lay and 20 fellow farmers, who agreed to participate in testing best practices using the varieties, received seeds from the country's Department of Agricultural Research, which experimented with 106 existing varieties of rice and identified six that use nitrogen-based fertilizers most efficiently. This means that less fertilizer is needed for their growth, said Su Su Win, Director of the Soil Science, Water Utilization and Agricultural Engineering Division. Researchers have recommended varieties for use in Myanmar's various regions, including marginal lands, typically owned by poorer farmers.

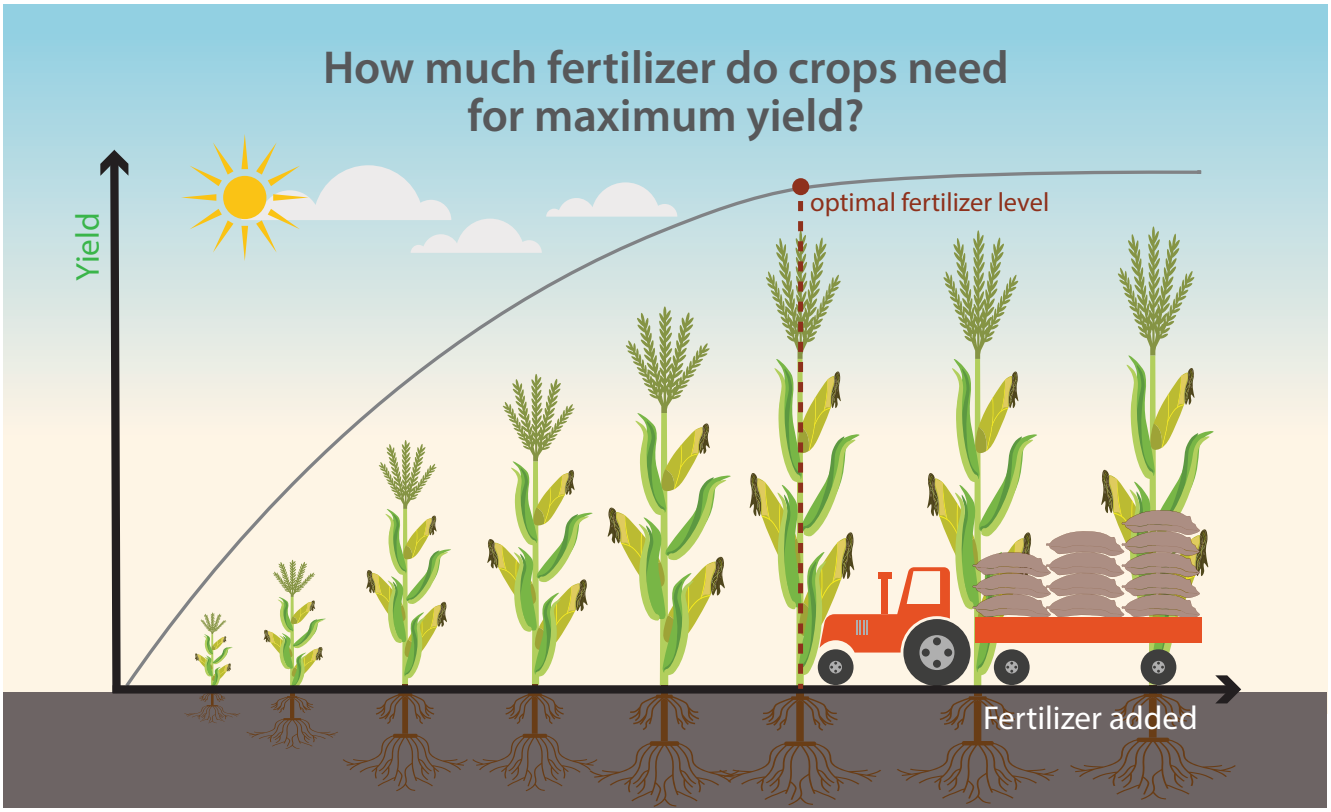
Nitrogen plays an important role in plant growth and photosynthesis, the process through which plants convert energy from sunlight into chemical energy. Nitrogen is often added to soil in the form of fertilizer. Using fertilizers labelled with nitrogen-15 (^{15}N) stable isotopes — an atom with an extra neutron compared with 'normal' nitrogen — scientists can track the isotopes and determine how effectively the crops are taking up the fertilizer. The technique also helps determine the optimal amount of fertilizer to use: after the crop has reached saturation with nitrogen, the remaining nitrogen remains in the soil and is prone to leaching (see graph).

Finding nutrient-efficient and high-yielding rice

Su Win and her team used the nitrogen-15 isotopic technique, with support from the IAEA and the Food and Agriculture Organization of the United Nations (FAO), to determine the nitrogen uptake of different kinds of rice.

"Rice is the most important crop in Myanmar and important for both food security and industrial development," Su Win said. Many of the varieties traditionally used in the country are so-called fertilizer-responsive high-yielding varieties — crops that have a high yield only when supported by fertilizers — but farmers often cannot afford fertilizers, so the yield and farmers' earnings remain poor. With the help of the nutrient-efficient new varieties now identified, farmers will have access to crops that have a higher yield without excessive fertilizer use, she said.

Nuclear techniques provide data that enhances soil fertility and crop production while minimizing environmental impact.
(Photo: M. Gaspar/IAEA)



Initial results have shown that the judicious application of nitrogen to rice crops led to fertilizer savings of around 30% and reduced the amount of fertilizer lost to the environment by 20%, while also optimizing yield, said Joseph Adu-Gyamfi, a soil fertility specialist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

The IAEA and the FAO support the use of this technique around the world, providing assistance through the IAEA technical cooperation programme and acting as a platform for research collaboration through numerous coordinated research projects. Currently, experts from over 100 countries are benefiting from this assistance.

Farmers in Botswana benefit from nitrogen-15 technique

In Botswana, soil scientists are in the earlier stages of using the technique to determine the amount of fertilizer required for green pepper, spinach and other horticultural crops and soils.

"Soil types are different all over the world, so we cannot just use results obtained elsewhere," said Kelebonye Bareeleng of the National Soil Laboratory. "We need to find the right amount of nitrogen needed by our particular crops."

The experiments are still ongoing but, from the initial results, Bareeleng estimates that between one quarter and one half of the fertilizer used on cereal fields could be wasted. Not only does this represent an unnecessary additional expense for farmers, but the unused nitrates could also spoil groundwater near agricultural areas. "For a country like Botswana that relies on underground reservoirs for its drinking water, this is too risky," she said.

In the fledgling horticulture sector, where producers are trying to compete with imports from South Africa, fertilizer represents the highest input cost, so cutting its use significantly has the potential to make the industry much more competitive, Bareeleng said. "This may be the key to the development of this sector in Botswana," she said.

Cabbage in Viet Nam

In Viet Nam, results obtained using the nitrogen-15 technique showed that as much as half of the fertilizer applied to cabbage fields was lost to the environment, creating water pollution and food safety problems, Adu-Gyamfi said. "As a result of a technical cooperation project with the IAEA, local officials are now taking action and advising farmers on the most efficient use of fertilizers."

In agriculture, Myanmar has participated in 10 regional projects related to improved soil and water management and climate proofing of crops, and in 5 national projects dedicated to the improvement of rice crops. Over the past decade, 68 fellowships and scientific visits have helped build Myanmar's capacities in applying isotopes and radiation in food and agriculture.