Super crops created from irradiated natural polymers in Viet Nam

By Sasha Henriques

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— Nguyen Quoc Hien, Vinatom Research and Development Centre for Radiation Technology, Viet Nam

Looking to increase yield and eliminate disease, farmers in Viet Nam are now feeding their plants oligochitosan [O-LEE-GO-KITE-O-SAN] and oligoalginate [O-LEE-GO-AL-GI-NATE], substances made from irradiated natural polymers.

And it's working.

Oligochitosan and oligoalginate come from shrimp shells and brown seaweed, respectively. These, and other natural polymers such as sago starch, cassava starch and palm oil, are exposed to precise doses of radiation in controlled environments, which changes their molecular structures and gives them plant-enhancing properties. The resulting products are not radioactive, and are biodegradable and non-toxic.

The polymer chitosan (above) is found in shrimp shells. It is used to make sprays and additives that prevent and cure plant diseases and promote plant growth.
(Photo: S. Henriques/IAEA)

Oligochitosan, a bright yellow liquid produced by the Viet Nam Atomic Energy Institute (Vinatom), has almost eliminated the use of harmful fungicides in agriculture across the country, said Nguyen Quoc Hien, of the Vinatom Research and Development Centre for Radiation Technology. "It protects plants from fungal and bacterial infection, suppressing diseases. And it also stops the spread of the Tobacco Mosaic Virus, a disease which infects well over 350 different species of plants, not just tobacco."

Plants treated with oligoalginate, which has the deep brown colour of molasses, grow quicker and up to 56 per cent bigger than untreated plants, Hien said. One teardrop's worth of liquid oligochitosan dissolved in one litre of water can be used to prevent diseases in plants and significantly increase the rate at which they grow.

The widespread use of non-toxic products like oligochitosan, which leave no harmful residue behind, is ultimately better for consumers, and opens up greater possibilities for national agricultural exports. Oligochitosan can even extend the shelf life of fruits like mangoes and oranges, keeping them firm and attractive to consumers for longer periods. Oligochitosan and its associated products like Gold Nano and Silver Nano, which are made from the same base polymers but with the addition of gold or silver particles before irradiation, are used in a number of other ways. They can be added to the feed of farmed fish, chicken and shrimp to improve the animals' immune systems, survival chances, and propensity for weight gain. They can also be used to clean up water in aquaculture and kill bacteria where infection is already present.

Super water absorbents

Cassava starch is another natural polymer used to create products that improve agricultural productivity. The edible root cassava is the base material used to make super water absorbents (SWAs), which can take up an incredible amount of moisture and release it slowly over time to the roots of nearby plants. SWAs look and feel a lot like large sugar crystals, but when they encounter and absorb water (or liquid fertilizer) they expand: one grain becoming as large as the average little fingernail.

SWAs processed by radiation are particularly useful for agriculture in dry areas where there is little rain, or where there are frequent periods of drought.

Placed in the soil near plants' roots, 1 kg of SWA crystals can absorb and hold 200 litres of water from rainfall and irrigation. The slow release of water and/or fertilizer to plants reduces waste, reduces pollution of waterways, and saves farmers money. After nine months, SWA crystals disintegrate, leaving no residue and no harmful after-effects on the surrounding environment.

In Vietnam, SWAs produced by the Vinatom are used on rubber plantations and in home gardens, and are also exported to Australia, where they are used in large-scale farming of high-value cash crops. These farmers use 30–60 kg of SWA per hectare.

Nguyen Van Dong sells super water absorbents in his chain of supermarkets across Viet Nam. He also uses SWA to reduce the amount of time and water given to his rooftop garden. (Photo: S. Henriques/IAEA)

THE SCIENCE

What's a natural polymer?

Natural polymers are large molecules made up of long chains of repeated blocks of atoms. They are found throughout nature: the cellulose in plants and trees, and the starch in bread, corn and potatoes are polymers; the shells of shrimps, crabs and other crustaceans, and seaweed, all contain polymers.

These and other natural polymers are the perfect building blocks from which to develop new materials because they are abundant, inexpensive, biodegradable, locally available and renewable. They also have some remarkable inherent properties. Chitin, for example, is naturally waterproof and hard, yet flexible.

Products made from natural polymers are used in medicine, agriculture, environmental protection, cosmetics, and a variety of industrial applications.

Benefits of using radiation on natural polymers

Radiation processing is used to break chemical bonds and create new ones, making it possible to redesign natural polymers at the molecular level to serve a specific purpose.

This process, during which natural polymer-based materials are exposed to ionizing radiation, can change the chemical, physical and biological properties of the material without the need for additional chemical processing, and without making the material itself radioactive.

Radiation processing has several advantages over conventional chemical methods for developing and manufacturing new materials and products. It's simpler and faster, more precise, and much cleaner because it changes the molecular structure of materials without requiring chemical catalysts or extreme physical conditions such as high temperatures and immense pressures; it neither uses toxic chemicals nor generates noxious fumes, explained Agnes Safrany, a radiation chemist at the IAEA.

The IAEA is working with Member States around the world to promote the adoption, manufacture and use of non-toxic, biodegradable polymers derived from plants and animals.