Fewer toxic pesticides thanks to Genomics

Pesticides have been making headlines in recent years. We've heard about glyphosate, the main active ingredient in Roundup herbicide, atrazine, a herbicide toxic to humans and neonicotinoids, the infamous "bee killers."

These products may be great at eradicating weeds and pests in agricultural fields, but they can also be detrimental to animals, plants and people living nearby.

But how can we make sure we produce the food we need without compromising the environment or human health? With its sophisticated tools, genomics science holds part of the answer to this question, since it can help reduce the use of pesticides.

WHEN DID PESTICIDES BECOME SO POPULAR?

The use of pesticides in agriculture started in the early 1940s with the arrival of synthetic molecules, such as DDT and 2,4-D. Over time, insecticides, herbicides and fungicides became a staple in agricultural systems around the world, as they resulted in increased crop yields and, consequently, greater food production for a constantly growing global population.

A DOUBLE-EDGED SWORD

Many scientific studies have, however, shed light on the darker side of pesticides. For one, their toxic effect is not limited to the area where they are applied. Some chemicals, for example, contain volatile compounds, parts of which can be carried away by the wind over long distances. Other pesticides, such as glyphosate, spread through soil erosion and runoff water and go on to build up in surface waters.

Moreover, DDT and chlordane, which have been banned for several years now, can still be found in coastal environments around the world. Their toxic residues, even at very low concentrations, can contaminate aquatic species and their environment.

Lastly, pesticide exposure remains a significant concern for public opinion given the uncertainty surrounding the safety of these products for humans. Their use poses a challenge for the agricultural and public health sectors.

GENOMICS TO THE RESCUE

Genomics science can play an important role in making better use of pesticides in several ways. Recent breakthroughs in molecular biology have led to the development of sophisticated genomics tools to help farmers with their agricultural production.

One of these tools, molecular detection methods based on PCR – or Polymerase Chain Reaction – are useful for reliable and accurate identification and quantification of many pathogen species. PCR is extremely helpful since it can be employed to characterize a species at any stage of its development, whereas traditional methods require the visual inspection of its evolution to adulthood. These tools can also be used to identify resistance genes in insects, paving the way for better targeted pest control products.

Metabarcoding is another method used, this time to characterize many species living in. an environment. Similar to a scanner at the grocery checkout, metabarcoding can detect and monitor the spread of foreign insects brought into the country during international transport.

Genome editing technologies (GETs) are used to genetically modify plant immunity. For example, CRISPR-cas9 and TALEN tools have been employed to produce plants capable of resisting powdery mildew or white rot, a disease caused by a fungus.

Genomics can also be used to characterize entire microbial communities present in plants and in soils. This major advance has, among many things, made it possible to identify microbial strains that can break down pesticide residues in an effective manner.

ALTERNATIVES TO CONVENTIONAL PESTICIDES

As is the case with antibiotics and bacteria, the excessive use of pesticides has led some species of pests to develop resistance. To circumvent the problem, pest control management programs may turn to biopesticides as an alternative to their chemical counterparts. Biopesticides can be made with bacteria, fungi, algae, viruses or other microorganisms. To date, some 3,000 pest-fighting organisms have been identified using genomics.

What are the advantages? These microorganisms are not toxic for the environment and most are not harmful to the organisms not targeted – including pollinating insects. In addition, the microorganisms that make up the biopesticide sometimes end up settling in the ecosystem, where they enrich the soil microflora and promote plant growth.

However, some biopesticides come with a drawback: they are very slow at destroying the targeted organisms. To address this issue, genomics tools are employed to insert genes coding for the production of insect-specific enzymes, toxins or hormones.

BRINGING GENOMICS TO THE FARM

At the moment, the use of genomics science in agriculture remains low.

Several factors are slowing down recourse to the technology. The high cost of some of the equipment, the expertise required for the analysis and interpretation of data and the time it takes to obtain results are all obstacles to its integration.

If genomics is to become a powerful, accessible weapon in pest management, the various genomics techniques will need to be included in an integrated and comprehensive management approach to agriculture, involving, among other things, investments in research and in a network of genomics labs. The implementation of oversight mechanisms is also essential to ensuring the proper use of genomic databases and the development of partnerships among various sector stakeholders.

To learn more about the subject,
we invite you to read the complete document.