GENOMICS & AGRICULTURE

SAFE, SECURE AND SUSTAINABLE FOOD FOR THE WORLD

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PRODUCING FOOD FOR THE WORLD IS MORE COMPLEX THAN EVER.

Growing populations and changing climates are straining the limits of current agricultural practices. Genomics is providing powerful tools to address the need to develop crop strains and livestock breeds that can support increased food production while resisting pests and disease and reducing the environmental footprint, in terms of toxic chemicals and carbon emissions, of traditional farming.

GENOMICS & CROPS

The use of genomics for crop improvement promises to increase quality and yield of crops while using less fertilizer, pesticides and water.

DNA tests based on the genome sequences of plants are making the selective breeding process more targeted and two to three times faster. In certain cases, genetic modification is creating plant strains with new properties that improve productivity and nutritional value.

SOYBEAN

Thanks to its high content of protein and oil, the soybean represents a major food source for livestock and for humans, and is the subject of extensive research. In 2010 it was the first legume to have its genome completely sequence. This new information is being applied in genomics-directed breeding to develop strains with disease and drought-resistance, healthier food-oil content, higher oil yield for biofuel production, and even to reduce polluting phosphorous in the manure of livestock that are fed soybean meal.

Soybean was also one of the first crops to be genetically modified to be 'Roundup Ready' by introducing a gene that confers resistance to the powerful herbicide, glyphosate. Other research on genetic modification of soybean by DuPont aims to increase the amount of oleic and stearic acid, which the food industry values.

POTATOES

As the world's largest non-grain food crop, the potato is the focus of extensive research to develop new varieties with increased disease and pest resistance and improved production and quality traits. While a number of genetically-modified varieties have been developed with useful properties, such as resistance to the potato beetle, opposition to using genetically modified foods in the fast-food industry has kept these potato varieties out of production. The production of pharmaceutical products, such as vaccines, by genetically modified potatoes has shown considerable promise and does not elicit the opposition related to food crops.

Classical selective breeding has yielded numerous production varieties with desirable properties, such as increased resistance to pests and viruses and improved appearance. The publication of the complete DNA sequence of potato genome in 2011 has fueled research to identify the genes that control important potato traits and his information will greatly facilitate and accelerate selective breeding of improved varieties that contain these favorable genes.

GRAPES

Grapes are the largest fruit crop globally and contribute an estimated $6.8 billion to the Canadian economy through the wine-making industry. The

publication of the complete DNA sequence of grape genome in 2007 opened a new era in the ancient practice of breeding better wine grapes. Researchers in Canada and across the world are using the genome information to identify which genes control important traits such as sweetness and colour, time to flower, frost and pest resistance, and ripening. As these all lend a slightly different element to the end result, the goal is to find the perfect blend of traits through genomics-assisted selective breeding for use in different growing conditions and for different wine drinking tastes.

CAMELINA

A member of the mustard family, *Camelina sativa* is a plant that is making headlines for its potential in a variety of industries. Camelina's high oil content and nutritional value make it a viable contender for use as a source of biofuel, an addition to feed for poultry, fish and other animals, and a healthy source of oil in our diets. While its DNA sequence has not yet been determined, researchers, including a project here in Atlantic Canada, are looking at genes responsible for a variety of its hardy traits with the goal of using this information to develop varieties best suited to different growing conditions and different industrial and food applications.

WHAT ARE GMOs?

Genetically modified organisms, or GMOs, are plants (or animals) whose genetic makeup has been altered by the insertion or deletion of DNA to confer desirable traits.

Since the introduction of the first GMO crop in 1994, the FlavrSavr Tomato, at least 25 GMO plants have been approved for production in the US. While the FlavrSavr, engineered to slow ripening and improve appearance, is no longer produced, roughly 90% of the corn, soybean and cotton now produced in the US has been genetically modified to resist herbicide treatment (improving weed control) and, in the case of corn, to repel insects. Herbicide-tolerant corn, canola, soybean and sugar beet are all approved and cultivated in Canada. Some of these GMO crops end up in North American food, usually as processed ingredients like oils or sugar.

While there is considerable controversy over GMO food production (no GMO crops have been approved in the EU and no GMO potatoes are grown because of french-fry consumer opposition), over three billion servings of GMO foods have been consumed in North America and the general scientific consensus is that GMO foods present no unique health risks over their natural varieties.

The majority of GMO crops are designed for improved production (herbicide-tolerant, pest-repellant). In the case of the papaya, genetic modification to 'immunize' the fruit against a fungus literally saved the papaya industry in Hawaii from being totally wiped out by a virus. A GMO zucchini engineered to resist three different viruses was approved and is produced in the US. Disease-resistant GMO crops, such as bananas that can resist the fungus which is threatening the global banana crop, are expected to be important objectives in coming years.

Ongoing research on GMO crops includes the development of new traits, such as Golden Rice engineered for increased nutritional value, flood-resistant rice in response to climate change, and Arctic Gold apples that don't brown when cut. While no GMO animals have been approved for market, Atlantic salmon engineered to grow much faster than wild salmon have received initial approval on the road to commercialization in the US.

Environmental impacts of GMOs are also a concern. However, scientists debate the overall risk to the environment, compared to non-GMO farming practices, which often require more chemical inputs, higher use of water and larger overall carbon footprint. The global debate is strong, but recent statistics indicate that concerns are waning as an increasing number of research studies provide evidence that farms are actually more sustainable with the use of GMOs.

GENOMICS & LIVESTOCK

Genomics can be used to speed up the genetic improvement of livestock traits, such as milk yield, meat quality and reproductive life.

The process is fairly simple: we can use DNA markers that are linked to the desired traits to identify the highest potential animals, and select those for production and breeding. This type of genomic selection has rapidly become a key strategy for breeders and producers to reduce costs and increase productivity of their herds across a range of species.

CATTLE

The bovine genome, completed in 2009, has provided the beef and dairy industries with powerful tools to undertake genome selection to improve desirable traits, including complex traits like health and fertility that could not be assessed using traditional methods. Within two years of completing the bovine genome, a new class of genomics evaluation tests became required information for all bulls presented as sires for artificial insemination (AI). This drastically reduced the time and cost of bringing AI bulls to market, and improved the accuracy of genetic predictions of traits over classic progeny-based evaluations, which are based on performance data on hundreds to thousands of AI daughters.

It has been said that genomic testing could deliver as much breed improvement in the next 50 years as has been achieved in the 8000 years since the domestication of dairy and beef cattle. The use of these tools has already provided annual benefits of over $180M to Canada.

And there is still much more potential for innovative uses of this genomic resource. In Nova Scotia, Performance Genomics Inc. is working with a global animal health leader to validate and commercialize a genomic marker test that allows farmers to select dairy cows with longer reproductive lifetime potential. Cows that have more pregnancies produce more milk per cow, and need to be replaced less often, so dairy farmers can derive more economic value from fewer cows while reducing financial costs and lowering environmental impacts.

SWINE

Raising livestock is expensive. Getting more from each animal raised can be a game-changer for farmers. Genomic research has led to the development of a DNA marker test that lets producers selectively breed pigs that have larger litters and increased lifespans of offspring, with obvious financial benefits.

Pigs are also known as major pollutants because of the high levels of phosphorous in their waste. However, some recent genomics studies have identified pigs that seem to thrive on lower phosphorus diets. This could lead to selective breeding that would create healthy, productive pigs that leave less environmental footprint.

MARKER-ASSISTED SELECTION (MAS)

The use of a molecular marker (e.g. DNA or RNA) linked to a trait of interest that can be used to identify the most favourable individuals to be used for breeding purposes.

SINGLE NUCLEOTIDE POLYMORPHISM (SNP)

A variation in a single base (Adenine, Thymine, Cytosine or Guanine) within a sequence of DNA. SNPs do not generally cause disease directly but some SNPs may affect an individual's susceptibility to disease or the response to the drugs and treatments.

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